**Standards for Monitoring Nonbreeding Shorebirds in the Western Hemisphere**

Program for Regional and International Shorebird Monitoring (PRISM)

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## Introduction

Migratory shorebirds are some of the most mobile animals on the planet. Their dynamic annual cycles have presented a challenge for monitoring populations and evaluating changes in population levels. In conjunction with the development of the Canadian and U.S. Shorebird Conservation Plans (Donaldson *et al.* 2000, Brown *et al*. 2001), the Program for Regional and International Shorebird Monitoring (PRISM) was established to address the monitoring needs of shorebirds (Bart *et al*. 2002). The current goals of PRISM are to: 1) identify species at risk, 2) determine causes of population changes, and 3) guide (and evaluate) effective shorebird management and conservation actions. Specific objectives are to: 1) estimate distribution, abundance, and habitat relationships of North American-breeding shorebirds throughout their annual cycle; 2) quantify changes and trends in distribution, abundance, and habitat relationships of North American-breeding shorebirds throughout their annual cycle; and 3) integrate shorebird monitoring data into a process of iterative learning and adaptive management (PRISM 2012). To achieve these goals and objectives, a four-part approach was initially recommended to include surveys in arctic and boreal breeding areas, north-temperate breeding areas, north-temperate nonbreeding areas and neotropical and south-temperate nonbreeding areas. Appendix 1 lists the families and species of shorebirds occurring regularly in the Western Hemisphere. A standardized approach to breeding surveys in arctic Canada and Alaska is now well established (see Bart and Johnston 2012), and species- or region-specific surveys have been conducted for some temperate breeding species (e.g., Stanley and Skagen 2007, Jones *et al*. 2008, Lyons *et al*. 2012, Thomas *et al*. 2012). The extent of the nonbreeding range of shorebirds in the Western Hemisphere challenges the development of broad-scale, standardized approaches, although efforts have been made at regional scales (e.g., Reiter *et al*. 2011, Ayala-Pérez *et al*. 2013, Senner and Angulo 2014).

There are several existing and emerging multinational monitoring programs for nonbreeding shorebirds and other waterbirds in the Western Hemisphere, such as the Neotropical Waterbird Census, International Shorebird Survey, Caribbean Waterbird Census, Migratory Shorebird Project, and Central American Waterbird Census. These existing monitoring programs vary somewhat in objectives, protocol, timing, geographic extent and focal species but frequently rely on the same organizations and volunteers to complete field surveys and provide some common data types (see Appendix 2 and 3 for program details and their websites). The ability to leverage these programs to maximize the value of data gathered into the future is necessary to inform the conservation and management of shorebirds, and other waterbirds, and requires open dialogue and cooperation among many partners who already rely on limited funding to sustain these important sources of information.

The development of the Atlantic Flyway Shorebird Business Plan (2015) and the Pacific Americas Shorebird Conservation Strategy (Senner *et al*. 2016) provide a flyway-scale context for prioritizing conservation needs and actions. Tracking short- and long-term benefits of implemented conservation and management actions across the flyways will require a coordinated and systematic approach to monitoring and evaluation. Aggregating site-based conservation achievements across flyway and hemispheric scales to assess effects on populations and determine large-scale, population-level conservation success requires some level of standardization and collaboration. To ensure long-term, sustainable monitoring and evaluation efforts for shorebirds, methods need to be readily understandable, relatively easy to apply and cost-effective. Within the USA, the U.S. Fish and Wildlife Service (USFWS) has supported development of standardized protocols for implementation throughout the National Wildlife Refuge System (see https://www.fws.gov/Refuges NaturalResourcePC/index.html), with the purpose of achieving more consistent and accessible data for making natural resource management decisions.

Implementation of effective shorebird monitoring can also make a valuable contribution to evaluating the progress toward achieving global biodiversity targets for conservation and sustainable development. Nearly all of the countries within the Western Hemisphere have made commitments to meet global targets, such as the Aichi Biodiversity Targets of the Convention on Biological Diversity (https://www.cbd.int/sp/targets/), the updated Sustainable Development Goals of United Nations (http://www.un.org/sustainabledevelopment/sustainable-development-goals/) and objectives of other multilateral environmental agreements. The Biodiversity Indicators Partnership developed measurable indicators of changes in biodiversity status (http://www.bipindicators.net/globalindicators), which include those based on population trends, the extent of protection and effective management of critical habitats.

In February 2016, leaders of many of the multinational nonbreeding shorebird, and other waterbird, monitoring programs active in the Western Hemisphere met in Panama City, Panama. The intent of the two-day workshop was to align strategies among monitoring programs in the Western Hemisphere to maximize the value of collected data for informing conservation of shorebirds (and other waterbirds). This workshop was a critical step in generating shared objectives for sustainable integration of data to inform shorebird conservation at a scale that is meaningful for many of the wide-ranging shorebird migrants. Participants highlighted the need for critical evaluation of the timing of surveys, field methods and implications for analyses to achieve objectives and to link databases across existing programs. To build on the Panama workshop, a two-day workshop was held in March 2017 in Lakewood, Colorado, USA, to 1) agree on key components of survey design, field methods, and data management that would enable existing programs to contribute to a common goal; 2) serve as a foundation for expanded collaboration among monitoring programs; and 3) establish standards for developing monitoring projects that can be integrated into a larger framework.

## Purpose, Goal and Objectives

The purpose of this document is to provide a unified set of standards to design and implement nonbreeding shorebird monitoring programs and projects throughout the Western Hemisphere. Although the focus is on programs developed in the Western Hemisphere, ideas presented here will be applicable to nonbreeding shorebird surveys at any location. We acknowledge the history, individuality and integrity of long-standing programs, but also accept the need to improve consistency and rigor to maximize the value of shorebird monitoring efforts throughout the hemisphere.

If followed, the overall goal of these standards is to increase the utility of shorebird monitoring data to inform conservation and management decisions. The standards address monitoring of all migrant and resident shorebirds occurring in the Western Hemisphere during their non-breeding period, with the perspective of providing inference across the entire nonbreeding range of a shorebird species or population. Thoughtful design may produce results that are useful for addressing shorebird conservation and management decisions at multiple scales. Application of these standards will help achieve the PRISM objectives of: 1) estimation of abundance and distribution and changes in abundance and distribution (trends); 2) determination of habitat relationships and any changes in the relationships; and 3) identification of key drivers of patterns and changes in abundance, distribution, and habitat relationships. To produce data that allows for rigorous analyses of shorebird patterns and trends at large spatial scales, implementation of consistent and standardized methods at the field level is critical. The standards presented here focus on monitoring elements of survey sampling design, field methods and program administration. We see the standards as a living document and plan to develop supplements that provide detailed discussions of analytical approaches and data management, for example. These supplements may also include specific actions needed to improve aspects of current programs. This document represents the views of the workshop participants and other contributors. Ideas presented here align with those recommended by the US-NABCI Monitoring Subcommittee (2007), and the general structure follows that of the USFWS National Wildlife Refuge System's Standard Operating Procedures of the Survey Protocol Handbook (USFWS 2013).

## Sampling Design

### *Spatial sampling frame*

Defining the spatial sampling frame (the region over which one wants to make inference) is an essential first step to survey design. Because implementation across the entire range of a species is daunting, defining the sampling frame by flyway or biogeographic population (see Andres *et al*. 2012) is a practical approach. Designs might also consider specific needs at an ecoregional scale; an ecoregion often shares similar threats and environmental conditions (Table 1). However, comprehensive and compatible flyway and regional program implementation is needed to provide information on all nonbreeding shorebirds across the entire Western Hemisphere. At any scale, proper delineation of the spatial sampling frame is important to ensure that inference is not confounded by frame bias (Bart *et al*. 2005b). The following maybe useful in defining the spatial sampling frame:

- Use range maps from sources such as NatureServe Explorer™ (http://explorer.natureserve.org/), Birdlife International's Data Zone (http://datazone.birdlife.org/species/search) or Wetlands International (http://test.wetlands.org/WPE6/) to find nonbreeding range information and define the appropriate spatial sampling frame.

*Spatial sample units*

Spatial sample units are discrete areas where observers count shorebirds and measure ancillary variables and are the basis for current shorebird monitoring programs. Spatially delineating sample units is critical for estimating density, comparing data among units of different sizes and across programs, and ensuring consistent spatial coverage through time. All existing programs should make explicit spatial delineation of sample units a priority. When delineating spatial sample units, consider the following guidelines:

- Use a GIS (e.g., ArcMap, Google Earth; see Bart *et al*. 2005a) and whenever possible use available GIS-based land cover data (e.g., Andres 1994, Penner *et al*. 2015) to define sample units.

- Delineate units so they can be surveyed in an appropriate amount of time (e.g., ≤ 2-3 hours, see *Survey effort* below). Although difficult to standardize sample unit size across large scales and management variability, it is desirable to minimize the variation in the size of sample units. When unit size is large, bias can be an issue due to land cover heterogeneity, reduced sampling effort and observer fatigue. Large units that take a long time to survey likely violate the idea of an instantaneous sample (see *Survey implementation*), particularly in tidally influenced areas where the amount of available habitat changes with time. Although analysis methods can help reduce these sources of bias, it is important to minimize sources of bias during survey design.

- Sample units should be as homogenous as possible in vegetation or land cover (e.g., tidal mudflat, salt pond or beach). This will help ensure that the probability of detection, given a bird is present, is similar across the entire unit and is as close to 1.0 as possible, and that density within sections of the sample unit is similar. Clearly, many existing programs have sample units that include several land cover or vegetation types. Some delineation of vegetation or land cover within large sample units could be useful in providing information on how birds are using the unit and make density data more easily comparable.

- Incorporate natural or human-made features in delineation of sample units if these features influence management of a particular unit (e.g., an impoundment in a managed wetland or a salt pond).

- Ensure consistent, long-term access and maximum visibility of the entire sample unit.

- If the spatial boundaries of an existing sample unit are changed, the name of the unit should change.

*Sample unit selection*

Ideally, select sample units from a frame of all possible units at the appropriate inferential scale. The overall goal of designed selection is to obtain a representative sample of the landscape within the sampling frame. Some type of randomization in the selection process is desirable to help guard against selection bias and allow for inferences to un-selected units (e.g., Brown *et al*. 2005). Sample units that are selected opportunistically or are thought to be representative can lead to biased estimates of shorebird abundance and density and do not allow for statistical inference to un-selected units.

Stratification is often an efficient way to partition the sampling effort, which can be based on environmental features or known/anticipated shorebird use. For example, Bart *et al*. (2005a) suggested allocating three tiers of effort based on 75%, 20% and 5% of shorebird use-days at a sampling site. Some designs can include a high-use stratum where all units (100%) are sampled (e.g., Andres *et al*. 2009).

Shorebird conservation actions are often focused at a particular site within a flyway. Accordingly, multistage stratified sampling can be used to allow for inference to a site. Sites within a flyway represent the primary stage and, because they can be quite large (e.g., Panama Bay), should be further divided into discrete sample units. Ideally, sites are randomly selected in some way (e.g., according to the criteria in the above paragraph), and then some type of randomization is used to select sample units within the sites. Consider the following guidelines when selecting samples:

- Randomly select sample units using software like R (e.g., *spsurvey* package) or even Microsoft Excel™.

- Determine the appropriate sample sizes for specific inferential scales and effect size of the parameter of interest. This may involve working with a statistician.

- Stratification of sampling across regions within the sampling frame with variable bird use will likely provide reasonable levels of precision when estimating population parameters and guard against bias if birds shift to lower-use areas over time. Some minimal selection in lower-use strata is needed to ensure the stratification is appropriate.

- Large-scale designs (flyway scale or larger) that want to make inference at multiple scales will likely require some type of multistage sampling to capture both within and among region and site variation

**Table 1.** Example of inferential spatial scales considered in the design and implementation of nonbreeding shorebird surveys. For small sites, the sample unit and site may be synonymous

| Scale | Example Distribution/Range |
|---|---|
| Global | Entire range of a shorebird species or population |
| Hemispheric | Western Hemisphere |
| Flyway | Pacific Americas Flyway |
| Regional | Southern Mesoamerican Pacific Mangroves |
| Cluster/Site | Gulf of Fonseca |
| Sample Unit | Plots surveyed within the Gulf of Fonseca |

*Response and explanatory variable definition*

All monitoring programs should measure a set of core response and explanatory variables to facilitate data sharing and analysis at large scales (Table 2). The primary response variable in the surveys discussed here is the number of shorebirds counted (abundance) by species or species group (Appendix 1). Shorebird-use days (Bart *et al*. 2005a) may be a value metric for evaluating use of a management unit or site and changes in the use, particularly at sites where multiple surveys are made across the season or year. The area of the sample unit is used to obtain an estimate of density (e.g., shorebirds/ha) either directly or via a model where the area surveyed is included as a covariate or offset term.

Measuring explanatory variables, in addition to counting shorebirds, is important for determining what may influence the count of shorebirds within the sample unit. Depending on the survey objectives, explanatory variables can be measured in the field, constrained by design considerations and observer training, measured remotely, or require a more intensive study effort (Table 3). With exception of the core variables, consider all other explanatory variables as either 1) supplemental (additional measures to meet defined objectives beyond those described above or are used to interpret large-scale results) or 2) incidental (additional information that may have value at some scale but is not used to meet specific objectives):

- Consider key supplemental variables, such as land cover condition, that could influence counts within sample units (e.g., percent flooded, vegetation height) that are not captured in the design (see *Sample unit selection*).

- Consider incidental observations that are of interest to research or conservation organizations and agencies, such as non-target birds or other animals within the sample unit or all target species or non-target species observed outside the sample unit.

- Keep the number of explanatory variables collected by field observers to the minimum required to meet specific objectives, while maximizing data quality and minimizing observer fatigue. Do not record supplemental and incidental variables if they interfere with the core variable data collection.

**Table 2.** Core variables required for all nonbreeding shorebird surveys. Individual programs will need to assign unique identifiers.

| |
|---|
| Uniquely-identified, spatially-delineated sample unit |
| Date |
| Local start time |
| Local end time |
| Observer identification and role (each primary counter or secondary) |
| Percent of sample unit visible |
| Shorebird species or species group |
| Count of shorebirds by species or species group |

**Table 3.** Supplemental measurements to control for variance and to assess influence of measurements and how to address these in nonbreeding shorebirds surveys. Training is required to conduct reliable surveys.

| Survey Element | How Supplemental Measure is Addressed | | | | |
|---|---|---|---|---|---|
| Measurement | Training | Design constraint | Measure in field | Measure remotely | Intensive study |
| Shorebirds | | | | | |
| Local shorebird knowledge | X | | | | |
| Plumage (age) | X | | | | |
| Size (for size groups) | X | | | | |
| Behavior | | | X | | X |
| Flock size | X | | | | |
| % flock visible | | | X | | |
| Banded/flagged individuals | X | | X | | |
| Dead or diseased individuals | | | X | | X |
| Observers | | | | | |
| Quality data collection | X | | | | |
| Optics | | X | | | |
| Habitat/Sample Unit Conditions | | | | | |
| % flooded | | | X | X | |
| % vegetated | | | X | X | |
| % bare | | | X | X | |
| Water depth | | | X | | |
| Saturation | | | | X | |
| Vegetation height | | | X | X | |
| Cover class | | | X | X | |
| Terrain | | X | | | |
| Wrack (beaches) | | | X | | |
| Food resources | | | | | X |
| Trash | | | X | X | |
| Abiotic Conditions | | | | | |
| % cloud cover | | | X | X | |
| Lighting (visibility) | | | X | | |
| Wind speed | | X | X | X | |
| Precipitation | | X | X | X | |
| Tide | | X | | X | |
| Disturbance | | | | | |
| Predators (native) | | | X | X | |
| Pets/livestock | | | X | | |
| Human activities | | | X | X | X |

*Survey frequency*

Local objectives and observer capacity are often the main determinants of survey frequency (frequency here defined as the number of surveys across a season or year). During the relative stationary period of the boreal winter (austral summer; December - February), a single count may provide a reasonable estimate of the nonbreeding population abundances and will likely provide a measure of change in populations through time. Simulation studies have suggested that even a single survey of shorebirds during the boreal winter can provide evidence of a temporal trend through time (Wood *et al*. 2010, Reiter and Nur 2015). For Austral migrants and some North America-breeding shorebirds that do not migrate north, a second stationary period south of the USA is June to July, when a single or a few surveys may be sufficient.

Greater survey frequency is required during migration periods to capture the full complement of passage shorebirds, reduce among-year variation in counts and provide information for a species across the entire migration window. In general, the year can be broken into two migration periods (August – November [southbound] and March – May [northbound]). Differences between length of stay and survey frequency can over- or under-estimate shorebird populations, which is also influenced by the methods used to summarize counts (e.g., counts are summed every 10 days when length of stay is actually 15 days). Ideally, the most intense effort during migration should match the average length of stay of the target shorebird population within the survey region or site. For example, if average length of stay is two days then ideally counts are conducted every two days. Despite the standardization of counts, it is essential to realize that changes in migration counts over time can be influenced by changes in length of stay rather than changes in numbers of birds at a site (e.g., Ydenberg *et al*. 2004). Decisions on survey frequency should consider the long-term ability to maintain observer effort and the following guidelines:

- A single survey during the boreal winter (austral summer) may be adequate but consider additional surveys to increase the precision of estimates or to address local objectives.

- For migration surveys, use local data on migration chronology to determine specific start and end dates for surveys. Ideally initiate surveys a week before first arrival and continue a week after the last departure. This buffer will allow for tracking of changes in chronology and, similar to spatial frame bias, can guard against temporal frame bias if timing changes. If local, detailed migration chronology data are not available, review eBird data pertinent to the survey area (http://www.eBird.org).

- Although daily surveys provide the best information on migration chronology and shorebird use, this intensity of effort is impractical in most cases. Therefore, incorporate one of three tiers of effort, unless length of stay is known, to sample shorebirds during migration periods; conduct surveys at 10-day intervals, 14-day intervals, or 21-day intervals (International Shorebird Survey, see https://www.manomet.org/program/shorebird-recovery/international-shorebird-survey-iss). These are suggestions, as stopover duration (length of stay) varies widely among species, sites or regions, and migration period. In all effort levels, conduct surveys with the same number of days between surveys during the entire migration survey period.

*Survey timing*

Tidal cycles complicate daily shorebird surveys in coastal areas, as birds often change behavior and habitat use between low and high tides. Tidal conditions, and consequently available habitat, should be similar for each survey. Choosing the right tide for a survey depends on sample unit or site-specific characteristics, such as accessibility, availability of shorebirds for sampling (i.e., occur in the unit during the tidal window), observer ability to discern species (birds are within ≤500 meters of the observer), and local conservation or management objectives (e.g., intertidal foraging habitat or high tide roosting habitat). Observers and coordinators should become familiar with the site and sample units to determine the most appropriate tidal window for a survey. It is much easier to target the same tidal conditions for nonbreeding surveys during the boreal winter, which may occur once or twice, than for migration surveys, which may occur far more frequently. Consider the following guidelines when selecting a tide level for surveys:

- Conduct pilot studies like those detailed by Colwell and Cooper (1993) to identify the best tide for the survey.

- Define tidal windows by the tide height rather than the tide cycle. For example, if you typically survey on a mid-rising tide of 2-3 meters, then conduct future surveys between 2-3 meters. Given natural fluctuations in tidal cycles, surveys may be closer to high tide or closer to low tide depending on the survey date. Remember that tide does not fall or rise evenly through the tidal cycle. Like frequency, consider the long-term ability to conduct the survey under the chosen tide conditions.

- Record the tide height during the survey. These data can often be enumerated following the survey using the start and end time of the survey and available software (e.g., Tides and Currents https://tidesandcurrents.noaa.gov/). Even if online data are available, use methods developed by the International Shorebird Survey and Migratory Shorebird Project (see Appendix 3) to record tidal conditions in the field. Beyond tides, lighting conditions at a specific site or sample unit may dictate the efficacy of morning or afternoon surveys. In coastal sites, conduct surveys simultaneously across the sample units at the site (e.g., all 120 units in San Francisco Bay) within a consistent tidal window to limit the influence of bird movement among sample units.

- If the effect of tide on shorebird use is of interest, conduct surveys of the same sample units at several different tide heights. If all programs record tide height when doing surveys across many sites and programs, then questions about variation in habitat use as a function of tide height could be evaluated at a large scale.

*Count duration*

The longer a survey of a sample unit takes the more birds the observer will usually record. Although maximum time limits are often set for many bird surveys, shorebird abundance can vary widely among sample units of the same size (e.g., 1 to 100,000 birds), which results in longer count durations where birds are more abundant. Although the duration of a count at each sample unit can vary, there are several important guidelines to consider:

- Spend a minimum amount of time to ensure a complete scan of the entire sample unit. For example, small, fixed-radius point counts in the Central Valley are conducted for at least two minutes to detect any birds present (Reiter *et al*. 2011).

- Because count duration can be long and birds may move in and out of the sample unit during that time, establish rules to control for changes in the number of birds counted over the course of the survey. In an ideal scenario, we would have perfect knowledge of the abundance and composition of shorebirds as soon as we arrive at a sample unit so that movement is not a factor. Therefore, survey the sample unit long enough to ensure good detection rates but quickly enough to limit shorebird movement.

- Use sample units that are consistent in size to limit the influence of area on survey duration (see *Spatial sample units* above).

- Record the start and end time for a survey of a sample unit to allow for evaluation of time of day, tide height and survey duration.

*Bias and detectability*

The inability to detect birds that are present during a survey can lead to bias in counts and comparisons of bird use across habitats (Thompson 2002). Ideally, monitoring programs should incorporate some measure of detectability into survey procedures to adjust raw counts to reduce bias. The number of observers conducting counts within sample units can increase detectability of birds but in the process may introduce variability into the count data across many units if the number of observers varies across units. Distance estimation, which incorporates various covariates, is one possible method to reduce bias but may be difficult to measure with large, mixed-species flocks (Dias *et al*. 2014). Double-observer techniques can be used (e.g., Taylor and Pollard 2008) but require two observers. Double-sampling has proven successful for nonbreeding shorebirds (Farmer and Durbian 2006) but can be challenging when dealing with distant, large flocks on mudflats or other habitats that cannot be traversed. Ultimately, given these limitations across techniques, implementation of standardized detectability measures across the Western Hemisphere is likely infeasible, and methods may be difficult for volunteer observers to implement consistently. To limit the influence of detectability bias consider the following guidelines:

- Use a single, primary observer to conduct surveys, with a possible second observer to record data and identify significant changes in bird abundance and composition that may occur while the primary observer is making the count. In sample units with very large numbers of birds, an option is to split the count by shorebird species or size classes between two primary observers to complete the count as rapidly and accurately as possible. Since some surveys include multiple observers for a variety of reasons, record the number and names of the primary observers (those that counted the birds). Consider that multiple observers could be used to help estimate detectability.

- Constrain the maximum observable distance during surveys (between 300 and 500 meters) and couple with well-delineated sample units with good accessibility (see *Spatial sample units*).

- Record the percent of the sample unit that is observable during the survey to help minimize bias during analysis (Table 2).

- Consult with a statistician to develop methods for estimating detectability, particularly if addressing local objectives.

**Field Methods**

*Pre-survey planning*

Take the following steps prior to data collection in the field:

- Clearly delineate all sample units and produce associated maps using standardized geographic datum and coordinate measurements.

- Produce a written protocol with detailed instructions and data forms using core variables and any program-specific supplemental variables.

- Secure landowner permissions and access permits and address any safety concerns.

- Obtain required governmental permits for scientific investigations, if needed.

- Specify optic minimums (e.g., 10x40 binocular, 40x spotting scope).

- Identify the primary observer and ensure they have survey equipment (optics, GPS, maps, data forms).

- Train observers in bird identification, counting techniques and the survey protocol, either in-person or online, and review protocols annually.

- Assure that observers familiarize themselves with their assigned sample units.

*Survey implementation*

As above, observers need to be able to recognize the sample unit in the field. Observers should record all core variables and any supplemental variables identified by the specific program. Observers should also note any changes to the sample unit. The general implementation of a survey would include the following steps:

- Upon arriving at the sample unit, count all shorebirds as accurately and quickly as possible. As with most bird counts, we assume that an instantaneous measure or "snapshot" of the individuals present in the sample unit is being obtained (i.e., the population is closed). Thus, the count should reflect the number of shorebirds present in the sample unit upon first arrival at the unit and not include flyovers during the count period. A quick scan and estimate of the total number of shorebirds present is useful to track individuals that enter or leave the sample unit during the survey. Although the sample unit should be delineated to maximize visibility, the observer should record the proportion of the unit that is visible (Table 2).

- Identify all individual shorebirds to species when possible. In situations where species identification of the whole flock is not possible, identify a subsample of the flock and apply the proportion of each species in the subsample to the rest of the flock. In situations where a flock is at too great a distance to identify species, individuals can be assigned to size groups (see Appendix 1); for example: 1) small plovers (small *Charadrius* species); 2) yellowlegs (Greater or Lesser Yellowlegs), 3) peep (e.g., Baird's, Least, Semipalmated, Western, or White-rumped Sandpipers); 4) dowitcher (Long- or Short-billed Dowitchers); or 5) phalarope (Red, Red-necked, or Wilson's Phalaropes). Specific combinations of species within these and other groupings will vary relative to where the sample unit is located. Individual programs may develop their own unique groupings, though coordination across programs is preferred to limit the duplication of species groups stored in databases with different names. Recognize that data grouped in this manner will limit species-specific analyses.

- Record any supplemental variable measurements after counting shorebirds; however, some supplemental variables should be measured (e.g., disturbance variables) while counting shorebirds. Depending on the number of supplemental and incidental variables included in the protocol, several observers may be required.

*Post-survey processing and data management*

Data quality assurance and control are essential parts of any monitoring program, particularly those that rely on volunteers and relatively unexperienced observers. The following guidelines should be considered:

- Establish a data management plan, which includes defined procedures for data proofing, storage and management.

- Integrate observations into standardized online databases such as the Avian Knowledge Network (Appendix 3). Various data repositories, relative to geographic coverage and survey frequency of existing programs, are provided (Table 4). We dissuade the development of other databases and encourage increased collaboration among current programs to use these existing resources and to continue to find ways to increase the efficiency of linking data across these databases.

**Program Administration**

Program coordinators must accept responsibility for recruiting and retaining qualified observers; establishing and maintaining a digital data management system; playing a role in providing analytical support for the program, often in cooperation with program partners; and reporting and communicating results. Good program administration would including the following:

- Develop and periodically revise a manual that provides clear field protocols.

- To ensure high quality data collection, develop and implement training (either in-person or online). See examples of available training modules and field survey tips in Appendix 3.

- Implement good data management practices, including verification and editing of data, generation of metadata, ensuring data security and archiving data.

- Provide analytical support by harvesting remote supplemental explanatory variables (see Table 3), developing analytical methods specific to their program and providing post-survey adjustments to reduce measurement bias.

- Develop a specific dissemination plan along with a schedule for distribution of results to volunteers. Digital tool development and data display applications can enhance communication and minimize costs. In addition to program participants, routinely transmit results to appropriate land managers and other stakeholders.

### Large-scale Cooperation

Large-scale monitoring requires cooperation among many programs and partners, which is a challenge and requires clear communication and continuity. We encourage programs to communicate with each other and with PRISM representatives to ensure their data is connecting with others across flyways and the hemisphere over time. As originally envisioned, implementation of all components of PRISM will provide a comprehensive assessment of the status of Western Hemisphere shorebirds. To develop a comprehensive monitoring program, we offer the following suggestions to enable large-scale cooperation.

- Agreement on the structure of core variables (Table 2) will enhance cooperation among programs and assist in conducting large-scale analyses. Similarly, agreement on the measurement of core variables will alleviate the need to use multiple protocols and data management systems for counts conducted on the same sample units and will allow for the exploration of meta-analytical approaches for large-scale, population-level insights.

- Analytical tools should be freely shared among shorebird monitoring programs, as is the intent of the Avian Knowledge Network.

- Programs should work together to identify non-traditional stakeholders and determine appropriate monitoring outreach products for these groups.

- Continuity of operational and staff funding are essential to maintain and expand an effective shorebird monitoring program.

- Efficiency may be gained through increased coordination among programs and online data management and communications.

- Securing consistent funding for shorebird monitoring programs should be a priority of the bird conservation community, including the North American Bird Conservation Initiative.

- The PRISM Committee should maintain their role as a clearinghouse for bringing the various monitoring elements together to form a broad, and hopefully vivid, picture of shorebird status.

**Table 4.** Geographic coverage of shorebird monitoring programs in the Western Hemisphere that cover more than one country and location of data. Contacts and websites are provided in Appendix 2.

| Geographic Area | Program | Survey Frequency | Data Storage |
|---|---|---|---|
| *South America* | | | |
| Entirety | Neotropical Waterbird Census | Twice yearly, February and July | Excel – Wetlands International |
| Atlantic Ocean countries | International Shorebird Survey | Every 10-14 days during migration to less often | eBird |
| Argentina, Uruguay, Brazil, Paraguay | Southern Cone Grassland Survey | Every 2–4 years, all coastal sites, January and February | Excel; eBird |
| Peru, Chile | Coastal Peru/Chile Shorebird Survey | Yearly, once January to mid-February to more than twice | eBird |
| Pacific countries | Migratory Shorebird Project | Yearly, once December to mid-February to more than twice | AKN node; California Avian Data Center |
| *Central America and Mexico* | | | |
| Central America | Central American Waterbird Census | Twice yearly, 15 January – 15 February and July | Excel – BirdLife eBird |
| Pacific Ocean countries | Migratory Shorebird Project | Yearly, once January to mid-February to more than twice | AKN node; California Avian Data Center |
| *Caribbean* | | | |
| Entirety | Caribbean Waterbird Census | Quarterly (all waterbirds) | eBird |
| Entirety | International Shorebird Survey | Every 10-14 days during migration to less often | eBird |
| *USA and Canada* | | | |
| Atlantic, Mississippi, Central Administrative Flyways | Atlantic Canada, Ontario, International Shorebird Surveys | Every 10-14 days during migration to less often | eBird; AKN node - NatureCounts |
| Pacific Administrative Flyway | Pacific Flyway Shorebird Survey | Yearly, once December to twice or more | AKN node; California Avian Data Center |

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## Appendices

Appendix 1. Size groupings of shorebirds occurring regularly in the Western Hemisphere, which include the following families: Burhinidae (Thick-knees, Stone-curlews), Charadriidae (Plovers), Chionidae (Sheathbills), Haematopodidae (Oystercatchers), Jacanidae (Jacanas), Pluvianellidae (Magellanic Plover), Recurvirostridae (Stilts, Avocets), Rostratulidae (Painted Snipes), Scolopacidae (Sandpipers, Snipes), and Thinocoridae (Seedsnipes). Based current taxonomy of the American Ornithological Society.

| ***Size Group*** | |
|---|---|
| **English Common Name** | **Scientific Name** |
| *Small shorebirds (20 – 85 grams)* | |
| Pied Lapwing | *Vanellus cayanus* |
| Lesser Sand-Plover | *Charadrius mongolus* |
| Collared Plover | *Charadrius collaris* |
| Puna Plover | *Charadrius alticola* |
| Snowy Plover | *Charadrius nivosus* |
| Wilson's Plover | *Charadrius wilsonia* |
| Common Ringed Plover | *Charadrius hiaticula* |
| Semipalmated Plover | *Charadrius semipalmatus* |
| Piping Plover | *Charadrius melodus* |
| Two-banded Plover | *Charadrius falklandicus* |
| Rufous-chested Dotterel | *Charadrius modestus* |
| Small Plover | *C. collaris/alticola/nivosus/semipalmatus/melodus* |
| Diademed Sandpiper-Plover | *Phegornis mitchellii* |
| Magellanic Plover | *Pluvianellus socialis* |
| Sharp-tailed Sandpiper | *Calidris acuminata* |
| Stilt Sandpiper | *Calidris himantopus* |
| Curlew Sandpiper | *Calidris ferruginea* |
| Long-toed Stint | *Calidris subminuta* |
| Red-necked Stint | *Calidris ruficollis* |
| Sanderling | *Calidris alba* |
| Dunlin | *Calidris alpina* |
| Rock Sandpiper | *Calidris ptilocnemis* |
| Purple Sandpiper | *Calidris maritima* |
| Baird's Sandpiper | *Calidris bairdii* |
| Little Stint | *Calidris minuta* |
| Least Sandpiper | *Calidris minutilla* |
| White-rumped Sandpiper | *Calidris fuscicollis* |
| Buff-breasted Sandpiper | *Calidris subruficollis* |
| Pectoral Sandpiper | *Calidris melanotos* |
| Semipalmated Sandpiper | *Calidris pusilla* |

| Size Group | |
| --- | --- |
| **English Common Name** | **Scientific Name** |
| Western Sandpiper | *Calidris mauri* |
| Peep | *C. bairdii/minutilla/fuscicolis/pusilla/mauri* |
| Terek Sandpiper | *Xenus cinereus* |
| Common Sandpiper | *Actitis hypoleucos* |
| Spotted Sandpiper | *Actitis macularius* |
| Solitary Sandpiper | *Tringa solitaria* |
| Lesser Yellowlegs | *Tringa flavipes* |
| Yellowlegs | *T. flavipes/melanoleuca* |
| Wood Sandpiper | *Tringa glareola* |
| Wilson's Phalarope | *Phalaropus tricolor* |
| Red-necked Phalarope | *Phalaropus lobatus* |
| Red Phalarope | *Phalaropus fulicarius* |
| Phalarope | *P. tricolor/lobatus/fulicarius* |
| Least Seedsnipe | *Thinocorus rumicivorus* |
| South American Painted-snipe | *Nycticryphes semicollaris* |
| *Medium shorebirds (95 – 205 grams)* | |
| Black-necked Stilt | *Himantopus mexicanus* |
| American Golden-Plover | *Pluvialis dominica* |
| Pacific Golden-Plover | *Pluvialis fulva* |
| Tawny-throated Dotterel | *Oreopholus ruficollis* |
| Killdeer | *Charadrius vociferous* |
| Mountain Plover | *Charadrius montanus* |
| Eurasian Dotterel | *Charadrius morinellus* |
| Northern Jacana | *Jacana spinose* |
| Wattled Jacana | *Jacana jacana* |
| Upland Sandpiper | *Bartramia longicauda* |
| Ruddy Turnstone | *Arenaria interpres* |
| Black Turnstone | *Arenaria melanocephala* |
| Red Knot | *Calidris canutus* |
| Surfbird | *Calidris virgate* |
| Ruff | *Calidris pugnax* |
| Short-billed Dowitcher | *Limnodromus griseus* |
| Long-billed Dowitcher | *Limnodromus scolopaceus* |
| Dowitcher | *L. griseus/scolopaceus* |
| American Woodcock | *Scolopax minor* |
| Common Snipe | *Gallinago gallinago* |
| Wilson's Snipe | *Gallinago delicata* |
| Imperial Snipe | *Gallinago imperialis* |
| Jameson's Snipe | *Gallinago jamesoni* |

| ***Size Group*** | |
|---|---|
| **English Common Name** | **Scientific Name** |
| Noble Snipe | *Gallinago nobilis* |
| South American Snipe | *Gallinago paraguaiae* |
| Puna Snipe | *Gallinago andina* |
| Gray-tailed Tattler | *Tringa brevipes* |
| Wandering Tattler | *Tringa incana* |
| Spotted Redshank | *Tringa erythropus* |
| Common Greenshank | *Tringa nebularia* |
| Greater Yellowlegs | *Tringa melanoleuca* |
| Gray-breasted Seedsnipe | *Thinocorus orbignyianus* |
| *Large shorebirds (210 – 405 grams)* | |
| Double-striped Thick-knee | *Burhinus bistriatus* |
| Peruvian Thick-knee | *Burhinus superciliaris* |
| American Avocet | *Recurvirostra americana* |
| Andean Avocet | *Recurvirostra andina* |
| Southern Lapwing | *Vanellus chilensis* |
| Andean Lapwing | *Vanellus resplendens* |
| Black-bellied Plover | *Pluvialis squatarola* |
| European Golden-Plover | *Pluvialis apricaria* |
| American Oystercatcher | *Haematopus palliates* |
| Black Oystercatcher | *Haematopus bachmani* |
| Blackish Oystercatcher | *Haematopus ater* |
| Magellanic Oystercatcher | *Haematopus leucopodus* |
| Snowy Sheathbill | *Chionis albus* |
| Long-billed Curlew | *Numenius americanus* |
| Far Eastern Curlew | *Numenius madagascariensis* |
| Bristle-thighed Curlew | *Numenius tahitiensis* |
| Whimbrel | *Numenius phaeopus* |
| Bar-tailed Godwit | *Limosa lapponica* |
| Black-tailed Godwit | *Limosa limosa* |
| Hudsonian Godwit | *Limosa haemastica* |
| Marbled Godwit | *Limosa fedoa* |
| Fuegian Snipe | *Gallinago stricklandii* |
| Giant Snipe | *Gallinago undulata* |
| Willet | *Tringa semipalmata* |
| Rufous-bellied Seedsnipe | *Attagis gayi* |
| White-bellied Seedsnipe | *Attagis malouinus* |

Appendix 2. Descriptions of multinational shorebird and waterbird monitoring programs in the Western Hemisphere.

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
|---|---|---|---|---|---|---|
| **Migratory Shorebird Project** | Spatial and temporal trends<br><br>Evaluate specific hypotheses about the factors influencing populations.<br><br>Use data for conservation prioritization and decision making.<br><br>Educating and connecting communities to support shorebirds and coastal wetland habitats. | **Sampling Frame:** Non- breeding range of *Calidris mauri* and *Calidris alpina pacifica*<br>**Design:** Multi-stage cluster sampling as well as opportunistic ("representative") surveys; cross-sectional design.<br><br>**Population:** Non-breeding shorebirds – 'wintering'; wetland dependent<br>**Frequency and timing**: 1 survey per year during December 1 – February 15<br><br>**Survey area definition:** Vary in size (1-100 hectares) but target specific habitats. Survey areas have specific spatial boundaries that do not change.<br>**Tide?** Standardized to be the same each year within sites but may vary across sites. Generally target foraging habitat. | **What is done?** Road transect with fixed radius point counts (interior) or area search (coastal).<br>**Which are birds counted?** All shorebirds within the survey area during the survey. Flyover shorebirds not counted. All raptors within, perched above or flying over are also counted.<br>**How long is survey?** Interior = >2 minutes; coastal/tidal = 2-3 hours within specified tidal window<br>**Are their constraints that limit when a survey can be conducted?** if winds >25 mph or raining Is anything else recorded besides birds? Weather, tide, habitat (cover type, %flooded, %dry, %vegetated) as well as disturbance (#dogs, #people, #flushes). | **Who does the surveys?** Volunteers and professional biologists. Training provided.<br><br>**How long have they been completed?** Annual survey since 2012.<br><br>**Funding?** Federal agencies (USFS International Programs, FWS), foundations (DLP), Volunteers very important<br><br>**Coordination?** Steering committee with regional leads then country leads and often local site coordinators<br><br>**Key partners in countries/across countries:** >50 organizational partners | **Where are the data stored?** California Avian Data Center which is node of Avian Knowledge Network. Individual projects for each country or region. Online data entry portal – English and Spanish. www.pointblue.org/cadc<br><br>**How can data be accessed?** Online data summary applications (www.prbo.org/pfss/data map; www.prbo.org/pfss/data map).<br>Raw data available upon request. | **How have the data been used?** Trend; Distribution models; Conservation prioritization Impacts of disturbance |

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
|---|---|---|---|---|---|---|
| **International Shorebird Survey (ISS)**<br><br>**Atlantic Canada Shorebird Survey (ACSS)**<br><br>**Ontario Shorebird Survey (OSS)** | Identify important stopovers and support their management and conservation<br><br>Enhance the knowledge of migration routes<br><br>Estimate population trends<br><br>Engage with citizen community to build conservation constituency | **Sampling Frame**: Sites used by shorebirds during migration **Design:** Opportunistic – most ISS. Stratified random plan ACSS, implemented in OSS. Atlantic ISS some sites.<br><br>**Population:** Shorebirds migrating<br><br>**Frequency and timing:** Annually, every 2 weeks - late July and late October, a smaller number for spring; ISS once every 10 day optimal, spring and fall; recommended dates vary with Latitude.<br><br>**Survey area definition:** Boundaries for sites defined by natural borders, birds outside that area should be noted as such. Randomly selected sites come with defined boundaries.<br><br>**Tide:** ACSS: Determine best time during tide cycle to survey, and always conduct surveys at that tide stage. ISS has had no tide recommendation; now 2 hr maximum on either side of high recommended. | **What is done on each survey?** Area search **Which birds are counted?** All shorebirds present **How long is survey?** Not defined- Suggest sites that take a reasonable amount of time (e.g. 1-2 hours) to survey. Tide dependent survey times for ISS. **Are their constraints that limit when a survey can be conducted?** OSS: no to light rain, less than 20km/h winds, and surveys same time of day for each visit. ISS: No weather restrictions. **Is anything else recorded besides birds?** ISS tides. Canada- Disturbances (and of effect on the survey), Weather (Temperature, Wind, Cloud Cover, Precipitation), Tide (ACSS), OSS: Habitat available to shorebirds, site description, size of survey area, raptors, plumage (OSS- optional) **Corrections for detectability?** No | **Who does the surveys?** Mainly volunteers. Training provided. Encourage maintenance of previously- surveyed sites and training with previous surveyor. **How long have they been completed?** Annually since 1974 **Funding?** Volunteers. ISS has some surveys conducted by state and Federal agency biologists. Survey coordination and analysis for ACSS. **Coordination:** Manomet, Environment and Climate Change Canada **Key partners in countries / across countries:** Birds Studies Canada, Environment Canada, Manomet, WHSRN, SAVE Brasil, DU, State agencies, US and Canadian Federal Agencies. | **Where are the data stored?** ACSS: AKN node ISS: eBird Portal eBird portal to linkCheck lists with survey data OSS: stored in Access database, csv files used for data analysis with software such as R. Quickbase database (in development for Manomet internal)<br><br>**How can data be accessed?** ACSS: Online data summary through AKN- Nature Counts: seasonal distribution, annual abundance graphs<br><br>OSS: Raw data available upon request.<br><br>ISS: eBird request | **How have the data been used?:** State of the Birds Reports<br><br>WHSRN site recognition and designation level setting<br><br>Conservation regulation development<br><br>State Wildlife Action Plans<br><br>Management priority setting<br><br>Atlantic Flyway Shorebird Initiative prioritization Academic Institution projects<br><br>Public outreach and education |

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
|---|---|---|---|---|---|---|
| **Integrated Waterbird Management and Monitoring (IWMM)** | Standardize waterbird counts and habitat monitoring in nonbreeding period<br><br>Rapidly assess local habitat conditions and quantify use of wetlands<br><br>Aggregate waterbirdand habitat data collected at the local scale for descriptive summary and/or analyses at larger scales.<br><br>Simultaneously track management actions in order to evaluate whether management objectives are being met at sites being managed.<br><br>Enhance ability to adaptively manage resources and adjust management actions as more information about waterbird responses to specific actions becomes available | **Sampling frame:** all nonbreeding waterbird wetlands<br><br>**Design:** any project can participate with the approved protocol (currently)<br><br>**Population:** nonbreeding waterbirds (waterfowl, shorebirds, and wading birds)<br><br>**Frequency and timing:** bird counts and unit conditions done weekly or bi-weekly during nonbreeding period; vegetation once a year<br><br>**Survey area definition:** delineated with specific observation points, visibility noted | **What is done on each survey:** waterbird counts and unit conditions<br><br>**Which birds are counted:** all waterbirds present<br><br>**How long is survey:** no limit; ideally all units on same day<br><br>**Constraints to when data collected:** hunting season, high tide, wind<br><br>**What else is recorded besides birds:** unit condition variables<br><br>**Corrections for detectability:** no | **Who does the surveys:** any qualified individual trained on protocol<br><br>**How long have they been completed:** since 2010 pilot season<br><br>**Funding:** based on refuge staff/ volunteers/temps<br><br>**Coordination:** IWMM staff<br><br>**Key partners:** NRPC of the USFWS refuge system administers program, but anyone can participate including state and federal partners | **Where are data stored?:** AKN node for IWMM specifically<br><br>**How can data be accessed?:** at http://data.pointblue.org/partners/iwmm/login/?returnUrl=%2Fpartners%2Fiwmm%2F | **How have the data been used?:**<br><br>Used to inform management decisions at the refuge and flyway scales.<br><br>Link abundance data to habitat condition to conduct scenario planning at refuge scale. |

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
|---|---|---|---|---|---|---|
| **Coastal Shorebird Survey (Peru/Chile)** | Create complete estimates for the Pacific coast of South America.<br><br>Identify important sites for shorebirds.<br><br>Develop a stable system to monitor the shorebird populations<br><br>Train volunteer observers | **Sampling Frame**: Perú and Chile<br><br>**Design**: Stratified random and representative design **Population**: Shorebirds-both Nearctic and Neotropical.<br><br>**Frequency and timing**: Every 2-4 years during the boreal winter.<br><br>**Survey area definition:** We delineate sites and habitats inside sites using satellite photos. The habitats are ground-truthed during the censuses and then confirmed using a classification process in ArcGIS.<br><br>**Tide?** ± 3 hours of the low tide | **What is done on each survey?** Each habitat has a different protocol and the objective is to have a detection of 100%<br><br>**Which birds are counted?** All those using the area.<br><br>**How long is survey?** The objective is 15 minutes per hectare.<br><br>**Are their constraints that limit when a survey can be conducted?** Tide<br><br>**Is anything else recorded besides birds? optional)** The size and extent of the census area<br><br>**Corrections for detectability?** Yes | **Who does the surveys?** Volunteers.<br><br>**How long have they been completed?** From 2010.<br><br>**Funding?** USFWS,<br><br>**Coordination:** National NGOs.<br><br>**Key partners in countries/across countries:** Corbidi in Perú; ROC in Chile; Cornell Lab of Ornithology in the USA. | **Where are the data stored?** eBird<br><br>**How can data be accessed?** Data is public and downloadable; there is a protocol in eBird, called the *Coastal Shorebird Survey*. | **How have the data been used?** Creation of new protected areas and publication of the *Atlas of Peru.* Example is the protection of the Virrila Estuary in Peru<br><br>Trend - Still, no decisions on the management of habitats<br><br>Virrila Estuary, Mangroves of San Pedro Conservation Plans |

| Program | Objectives | Design | Protocol | Implementation | Data Manage. | Data Application |
|---|---|---|---|---|---|---|
| **Neotropical Waterbird Census** | Identifying and monitoring sites that qualify as wetlands of international importance<br><br>Improving knowledge of little-known waterbird species<br><br>Providing the basis for estimates of waterbird populations<br><br>Monitoring changes in waterbird numbers<br><br>Increasing the awareness on the importance of waterbird and wetlands. | **Sampling Frame:** South America continent Design: Site-based counting scheme / opportunistic but also focused on key sites (WHSRN, Ramsar, IBAs)<br><br>**Population:** Waterbird populations (Nearctic and Neotropical) that distribute within South America<br><br>**Frequency and timing:** 2 surveys per year during February and July (Approx. between the day 5 and the day 20 each month)<br><br>**Survey area definition**: Survey areas vary in size and are defined by the volunteers. We stress the importance to count the same sites (same areas), in the same conditions and with the same method each year.<br><br>**Tide?** Not applicable (see above) | **What is done**: Variable depending on the site definition, including point counts, transects and area search.<br><br>**Which are birds counted?** All waterbirds within the survey area during the survey.<br><br>**How long is survey?** Not fixed. The time needed to count all waterbirds at the site<br><br>**Are their constraints that limit when a survey can be conducted?** This decision is in the volunteer hands<br><br>**Is anything else recorded besides birds?** We record data on the wetland type (*following Ramsar*), site characteristics and human activities, as well as about type of count, threats and weather. | **Who does the surveys?** Volunteers and park rangers, but also some professional biologists. Counting guidelines provided.<br><br>**How long have they been completed?** Annual survey since 1990, starting in southern South America with an increasing coverage to the north of the continent (nine countries participating in 1995).<br><br>**Funding?** Long term support from CWS. Other past supporters: USFWS, NFWF, DU, Bird Studies Canada, GAINS (WCS-USAID), Volunteers & NGOs. Coordination? Global coordination of IWC (WI Netherlands), Regional coordination of NWC (WI Argentina) and National Coordinators in each country<br><br>**Key partners?**: NGOs (BI partners, ROC, Averaves), universities and more than 50 small organizations. | **Where are the data stored?** Excel sheets. Global on- line database system under development by WI HQ.<br><br>Online site delimitation protocol under testing (Mark Drever / CWS). Shorebird data upload into eBirds under testing (Cynthia Pekarik/CWS)<br><br>**How can data be accessed?** Data summary products and NWC reports available at WI LAC Website (http://lac. wetlands.org). Raw data available upon request. | **How have the data been used?:** Distribution maps (South America) based on field data contributing to various Shorebird Conservation Plans *Upland Sandpiper Conservation Plan*<br><br>Creation of new protected areas and Ramsar Sites in Argentina, Chile, Ecuador, Uruguay.<br><br>Contributions to development of Red Books of threatened birds in Colombia and Uruguay.<br><br>Contributions to the National Shorebird Conservation Plans and other waterbird species management plans in Colombia and Brazil.<br><br>Designation of IBAs<br><br>Development of a database with records of migratory shorebirds in Paraguay. |

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
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| **Caribbean Waterbird Census** | Estimate density and abundance at a site - resident and/or migrant waterbirds<br><br>Measure changes in relative abundance from year to year to monitor trends<br><br>Measure changes in numbers and density over time in response to changes in the environment (e.g., management, site-based threats, climate change)<br><br>Assess effectiveness of management or conservation actions<br><br>Use results to justify conservation action (e.g. declaration of the site as a WHSRN site, Ramsar site, IBA or Protected Area) or potential for nature-based tourism | **Sampling Frame:** Varies, single site or set of sites or *most/all wetlands in a country*<br><br>**Design:** representative, opportunistic, stratified random<br><br>**Population:** Varies, migrant and resident waterbirds<br>Winter - 1 Regional Count (Jan. 14th – Feb. 3rd)<br>Spring – March-May (migration and peak breeding for some Cbn spp)<br>Summer – June-August (breeding and post- breeding for residents) Fall – September- November (migration) | **What is done?** Area search is a method that is very similar to birding – an observer moves through the habitat in a predefined area for a standard period and counts all the birds seen/heard Point count – the observer stands in a fixed location and counts all the bird seen/heard in a standard period of time.<br><br>Four levels of protocol. Increasing complexity to capture probability of detection. | **Who does the surveys?** Both volunteers and professional biologists (NGOs and government). Training in waterbird ID, census protocols provided.<br><br>**How long have they been completed?** Annual surveys since 2010.<br><br>**Funding:** WHMSI, USFWS, USFS, Environment Canada, local partners, volunteers<br>Coordination? BirdsCaribbean (Waterbird Working Group), country leads, and often local site coordinators/counters<br><br>**Key partners** in countries/ islands: >60 | **Data Entry and Storage**: eBird Caribbean portal online data entry – English, Spanish, and French.<br>How can data be accessed?<br>Counts can be viewed online (http://ebird.org/content/caribbean/); "hotspot" maps are available.<br>Raw data available upon request. | **How have the data been used?**<br><br>High counts for the region and for each country<br><br>Which sites have rare/ threatened species<br><br>Which sites have the highest species diversity |

| Program | Objectives | Design | Protocol | Implementation | Data Management | Data Application |
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| **Central American Waterbird Census** | Promote knowledge, appreciation and conservation of waterbirds in Central America.<br><br>Generate data as a basis for waterbird population estimates, trends and seasonal fluctuations of species.<br><br>Identify, monitor and promote sites that qualify as wetlands of importance to waterbirds at national, regional and international levels.<br><br>Provide information for decision makers. | **Sampling Frame:** Central America<br>**Design:** Standardized total counts at sites. Sites selected opportunistically.<br><br>**Population:** All waterbird species<br><br>**Frequency and timing:** Approx. 15 January – 15 February. Also limited effort in April, July and Oct/Nov.<br><br>**Survey area definition:** All types of wetlands, though must be clearly defined<br><br>**Tide:** No specific rules, other than to standardize tide level for repeat counts. | **What is done?** All waterbirds observed are counted from a specific spot or by walking through a site. Sites are completely or partly covered, depending on size; standardized between years.<br><br>A site form and count form are used.<br><br>Census is carried out once a year, but ideally twice a year<br><br>Only waterbirds are counted, however, volunteers do occasionally count other “wet birds” (kingfishers, raptors) | **Who does the surveys?** Volunteer based<br><br>**How long have they been completed?** Initiated in 2011 in response to lack of waterbird censuses in Central America<br><br>**Funding?** Funds to support census have been provided by CWS and USFWS<br><br>**Coordination?** National coordinators in each participating country and a regional coordinator (until recently, BirdLife International) | **Where are the data stored?** eBird (some)<br><br>Excel (BirdLife International)<br><br>**How can data be accessed?** Annual reports are prepared with a summary of the census results. Specific data not yet readily available, but stored on eBird and in an Excel file in the BirdLife Americas Secretariat. | **How have the data been used?**: *Results of the 2015 census*:<br>7 countries participated<br>100 volunteers<br>73 sites surveyed<br>102 waterbird species, including 65 Nearctic migrants<br>114,816 waterbirds counted |

| Program | Objectives | Design | Protocol | Implementation | Data Manage. | Data Application |
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| **Southern Cone Grassland Shorebird Survey** | Monitor key sites for the non-breeding concentrations of American Golden-Plover, Buff-breasted Sandpiper, and Pectoral Sandpiper previously identified in Argentina, Brazil and Uruguay<br><br>Identify areas of importance for the non-breeding distribution of Upland Sandpiper in Argentina, Uruguay and Brazil, and monitor migratory stopover sites of the species and other grassland plovers in Paraguay. | **Sampling Frame**: Natural grasslands of the Southern Cone, as described and mapped by the Grassland Alliance<br><br>**Design:** Repeated annual and opportunistic surveys<br><br>**Population:** non-breeding associated with grasslands<br><br>**Frequency and timing:** once a year, Nov-Feb<br><br>**Survey Area Definition:** Limits of the cattle ranch or lagoon area. The sampling areas are the same every year. | **What is done? Census t**ransects of 1,000 meters in length and variable width in optimal grassland habitat. Exploratory routes in cars, in areas distinct from the census; when shorebirds are observed, the number of individuals and exact location are recorded. In Asuncion Bay, total counts are made.<br><br>**Which birds are counted?** All of the focal species found on the transect; those in flight are not counted, but the note is made. Same for the auto routes.<br><br>**How long is survey?** The time needed to complete all transects at the site.<br><br>**Are their constraints that limit when a survey can be conducted?** Rain.<br><br>**Is anything else recorded besides birds?** Grassland characteristics. | **Who does the surveys?** Volunteers and biologists based on the protocol.<br><br>**How long have they been completed?** Routes since 2006, transects since 2008.<br><br>**Funding:** Regional at the Alliance level, national at the BirdLife partner level and local at the site level<br><br>**Coordination?** BirdLife partners in each country, protected areas. | **Where are the data stored?** eBird Excel<br><br>**How can data be accessed?** Requested to the coordinators. | **How have the data been used?** Identification of important sites for Buff-breasted Sandpipers and identification of sites with low counts. |

Appendix 3. Websites for monitoring programs described in Appendix 2 and other sources of training and field tips.

*Programs described in Appendix 2*

Atlantic Canada Shorebird Survey
https://www.bsc-eoc.org/birdmon/default/datasets.jsp?code=PRISM-ACSS

Avian Knowledge Network – http://www.avianknowledge.net/

Caribbean Waterbird Census
http://www.birdscaribbean.org/our-work/caribbean-waterbird-census-program/
http://ebird.org/content/caribbean/

Coastal Shorebird Survey (Peru/Chile)
http://www.minam.gob.pe/diversidadbiologica/wp-content/uploads/sites/21/2014/02/Atlas-de-las-Aves-Playeras-del-Perú-FINAL-WEB.compressed.pdf; http://ebird.org/content/peru/; http://ebird.org/content/chile/

Integrated Waterbird Management and Monitoring Program
http://iwmmprogram.org/

International Shorebird Survey
https://www.manomet.org/program/shorebird-recovery/international-shorebird-survey-iss

International Waterbird Census (Neotropical/Central American)
https://www.wetlands.org/our-approach/healthy-wetland-nature/international-waterbird-census/; https://lac.wetlands.org/

Migratory Shorebird Project/Pacific Flyway Shorebird Survey
http://www.migratoryshorebirdproject.org
http://www.pointblue.org/pfss

Ontario Shorebird Survey
https://www.birdscanada.org/birdmon/default/datasets.jsp?code=PRISM-OSS

PRISM (Program for Regional and International Shorebird Monitoring)
http://www.shorebirdplan.org/science/program-for-regional-and-international-shorebird-monitoring/

Southern Cone Alliance – http://www.alianzadelpastizal.org/en/institucional/ibas/

*Other Networks*

Florida Shorebird Alliance – http://www.flshorebirdalliance.org/

Gulf of Mexico Avian Monitoring Network – https:/gomamn.org/

*Training Resources*

Counting Shorebirds
http://www.migratoryshorebirdproject.org/uploads/documents/PFSS_shorebird-training-module_2012_counting.pdf

Estimating Flock Size and Composition
http://www.migratoryshorebirdproject.org/uploads/documents/Estimating_Shorebird_Flock_Size_&_Composition.pdf

Wildlife Counts – www.wildlifecounts.com

USFWS aerial survey training
www.fws.gov/waterfowlsurveys/forms/counting.jsp?menu=counting

Recording Shorebirds
http://www.migratoryshorebirdproject.org/uploads/documents/PFSS_RecTips_rev050214.pdf

Shorebird ID tips
http://www.migratoryshorebirdproject.org/uploads/documents/PFSS_shorebird%20ID%20slides.pdf