A MONITORING PLAN FOR WINTERING SHOREBIRDS

IN COASTAL CALIFORNIA AND NORTHERN BAJA CALIFORNIA, MEXICO

Version 1.0

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TABLE OF CONTENTS

REVISION HISTORY LOG

Although consistency of sampling design and survey methodology is an important component to all long-term monitoring programs, this plan should be modified as needed to meet the monitoring objectives. All changes to the monitoring plan should be detailed in this "Revision History Log".

Prev. Version #	**Revision Date**	**Author(s) (of changes)**	**Changes Made**	**Reason for Change**	**New Version #**

Executive Summary

Coastal California and northern Baja California, Mexico, which together encompass all of the coastal regions of the California Landscape Conservation Cooperative, provide habitat for large populations of migrating and wintering shorebirds in the Pacific Flyway. Consequently, there is a need to better understand spatial and temporal trends in shorebird populations in these coastal regions both to inform local habitat management and conservation actions and to contribute to a broader understanding of shorebirds in the Pacific Flyway. Currently there is no coordinated annual effort to monitor shorebirds along this important coastal corridor. We propose a statistically robust, logistically feasible, long-term monitoring program for wintering shorebirds in coastal California and northern Baja to track spatial and temporal population trends resulting from changing climate and habitat conditions. Specifically, we recommend a sampling design and survey protocol for wintering shorebirds in coastal wetland habitat and provide the data storage and analytical framework for population and trend estimates to be made annually as new data come in through the online data portal in the California Avian Data Center. We also recommend a series of needed pilot studies, including evaluating methods for estimating error rates in shorebird counts, determining the appropriate scale for measuring habitat, and tracking habitat change. These data will also contribute to the broader Pacific Flyway Shorebird Survey, a multi-partner, multi-scale monitoring program to quantify spatial and temporal trends and habitat associations of Pacific Flyway shorebirds. Evaluating annual shorebird monitoring data from coastal California and northern Baja in the context of broader changes in shorebird populations will provide a multi-scale assessment of the impact of local management actions on Pacific Flyway shorebird populations.

Background

Coastal California and northern Baja California, Mexico, which together encompass all of the coastal regions of the California Landscape Conservation Cooperative (CA LCC; www.calcc.org), provide habitat for large populations of migrating and wintering shorebirds in the Pacific Flyway (Page et al. 1999). There are four estuary sites within this region that are designated of high importance to shorebirds by the Western Hemisphere Shorebird Reserve Network (www.whsrn.org; Table 1). Broad-scale environmental factors likely affecting shorebird habitats throughout the Pacific Flyway include urbanization, extreme weather and climate variation, agricultural runoff, wetland restoration and management, and sea-level rise (Galbraith et al. 2002). Consequently, there is a need to better understand spatial and temporal trends in shorebird populations in the coastal regions of California and northern Baja both to inform local habitat management and conservation actions, and to contribute to a broader understanding of shorebirds in the Pacific Flyway. Currently there is no coordinated annual effort to monitor shorebirds along this important coastal corridor. Designing an efficient and robust annual shorebird monitoring program for the coastal regions of California and northern Baja is an essential step towards the long-term conservation and management of shorebirds in the Western Hemisphere.

The influence of habitat changes on shorebird populations is not well understood. Furthermore, due to the ability of shorebirds to change their distribution rapidly in response to changing habitat conditions (Warnock et al. 1995), the influence of local habitat management or change on local shorebird abundance as a result can only be fully understood in the context of population changes at broader spatial scales. Currently, regular monitoring of shorebirds along the coast primarily focuses on individual sites (e.g., Tomales Bay, Bolinas Lagoon, Morro Bay), although one large-scale effort evaluated shorebird populations throughout the Pacific Coast in the early 1990s (Page et al. 1999). Despite the value of these studies to inform our understanding of shorebird ecology and status, they are too short in temporal duration or too localized in their spatial extent to provide a rigorous assessment of temporal and spatial trends for the broader region of interest. There is an increasing awareness that long-term, multi-spatial-scale monitoring programs are needed to inform habitat management and adaptation strategies to mitigate the effects of climate change (Conroy et al. 2011). Still, these programs must be cost effective to be sustainable over the time frame required to evaluate trends.

We propose a statistically robust, logistically feasible, long-term monitoring program for wintering shorebirds in coastal California and northern Baja to track spatial and temporal population trends resulting from changing climate and habitat conditions. Specifically, we recommend a sampling design and survey protocol for wintering shorebirds in coastal wetland habitat and provide the data storage and analytical framework for population and trend estimates to be made annually as new data are entered through the online data portal in the California Avian Data Center (CADC). We also recommend a series of needed pilot studies, including evaluating methods for estimating error rates in shorebird counts, determining the appropriate scale for measuring habitat, and tracking habitat change and developing habitat association models. These survey data will also contribute to the broader Pacific Flyway Shorebird Survey (PFSS; www.prbo.org/pfss), a multi-partner, multi-scale monitoring program to quantify spatial and temporal trends and habitat associations of Pacific Flyway shorebirds.

POPULATIONS BEING MONITORED

This monitoring plan targets all wetland-dependent shorebird species (Order: Charadriformes; Families: Charadridae, Scolopacidae, Recurvirostridae, Haematopodidae) that regularly occur along the coast of California and northern Baja. Although some shorebird species occur in coastal regions at all times of their annual cycle (breeding, migration, and wintering), this monitoring plan focuses on the populations of wintering shorebird species. We do this for several reasons. First, winter (November–February) and migration (July–October, April) are the periods with the greatest abundance of shorebirds in coastal California and Mexico (Page et al. 1999). Breeding shorebirds typically occur in low abundance and consist of few species in this region. Second, although migration surveys are common in regions with no wintering birds (e.g., International Shorebird Survey) they require multiple surveys each year to capture the variability in the timing of migration and subsequently pulses in shorebird abundance. This high level of variability makes estimates of trends and habitat associations very uncertain (Bart et al. 2007). Lastly, winter is the longest period of consistent use by shorebirds in this coastal region and thus a time when management actions may be most effective. Previous comprehensive surveys of the California coast identified 43 species of shorebirds in winter, and 20 of these occurred regularly in wetland habitats (Table 1; Page et al. 1999). Currently this monitoring design is not intended to track wintering use of rocky-intertidal, beach, or upland habitats. Hence, some species may not have their populations fully sampled (see Frame Bias below), thus limiting what can be inferred from data collected as part of this plan for these species (Table 1).

MONITORING OBJECTIVES

We designed this shorebird monitoring plan for coastal California and northern Baja to:

1. Estimate trends in wintering shorebird populations so that a 50% decline over 20 years can be detected.
2. Identify changes in the distribution of shorebird species within key areas.
3. Quantify habitat associations of shorebirds and the effect of habitat management actions at multiple spatial scales.
4. Estimate the winter population size of shorebirds with a coefficient of variation < 20%.

STUDY AREA

This stretch of more than 1,500 km of coastline, from the Oregon-California border south to Bahia San Quintín in northern Baja (Fig. 1), provides shallow-water wetland, rocky-intertidal, and beach habitat for over 500,000 shorebirds, representing more than 40 species, during winter (November–

March). The sites with highest abundance of shorebirds within this region are associated with large bays and estuaries that are characterized by extensive areas of inter-tidal mudflats and human-made salt ponds (Page et al. 1999). Recent analysis of the Page et al. (1999) data suggests that >70% of variation in counts of total shorebirds among sites along the California coast can be explained by the amount of these two cover types (PRBO, unpublished data).

SAMPLING FRAME AND DESIGN

Programs for long-term monitoring of shorebirds over a large landscape with potentially high spatial and temporal heterogeneity in habitats require sampling designs that are logistically feasible and minimize bias and variance in estimates of population size or population change (Bart and Ralph 2005, Braun 2005). It is also important to be able to link a broad-scale monitoring program with local management actions in a way that can inform conservation and management decisions over time (Lyons et al. 2006, Conroy et al. 2011). To estimate population trends, habitat associations, and population sizes of wintering shorebirds in coastal California and northern Baja, requires accounting for a high aggregation of species and habitat, multiple habitat types, and movement of birds among habitat patches. Each of these conditions has implications for identifying the sampling frame (i.e., the area over which to draw samples), as well as for applying standard survey techniques and sampling designs developed for breeding bird surveys (e.g., breeding birds are often territorial and thus evenly dispersed making random sampling more effective).

We defined the general sampling frame of potential shorebird habitat for wetland-dependent shorebirds (Fig. 1) to be the 38 coastal sites between the California-Oregon border and Bahia San Quintín in northern Baja that collectively encompassed 100% of the tidal flat and salt pond habitat in this region (Table 2; see Page et. al 1999, Stralberg et al. 2011). Although a complete count of all birds from a region or population of interest is desirable, such comprehensive data are often too time intensive to collect, and may be unnecessary to inform management decisions. Alternatively, both spatial and temporal sampling can be used to estimate the population within a selected region over time (Thompson et al. 1998). To optimize sampling design, the spatial distribution, scale, and temporal frequency of sampling must be considered relative to the monitoring objectives, ecology of the species, and logistical constraints (e.g., property access, funding; Reynolds et al. 2011).

Within the defined sampling frame, we followed a multi-stage panel sampling design (Cochran 1977). We removed sites that did not hold at least 1,000 total shorebirds on any single early winter survey (see Table 1). This remaining 18 sites, that collectively held over 99% of all shorebirds counted on historic surveys of the original 38 sites, encompassed >90% of the tidal flat and salt pond habitat in the region. Within each site, we defined sampling units based on habitat and logistical constraints. We attempted to make each sampling unit a homogenous cover type. At some sites with ongoing survey efforts, sampling units often include a mix of cover types. We are working with these legacy monitoring programs to divide existing sampling units to better represent homogenous cover types.

We determined the effort needed to cover all sampling units within a site, and whether we needed to sample from the population of sampling units that make up the site instead of completing a comprehensive count of the entire site. At nearly all sites, comprehensive surveys of all sampling units are possible either because they are small or they are part of legacy monitoring programs that already cover the whole site. Currently at two major sites, San Francisco Bay and San Diego Bay, sampling is being applied to estimate population size and track trends. These are large sites with over 300 sampling units defined at each for previous comprehensive counts. Within each site we attempt to survey enough sampling units to have the same level of precision for trend and population change estimates that the overall plan seeks to achieve (see Monitoring Objectives above). Following a simulation analysis of historic data from San Francisco Bay (Reiter et al. 2011) and San Diego Bay (see Appendix I for site descriptions and survey designs), we used Generalized Random Tesselation Stratified (GRTS) sampling (Stevens and Olsen 2004) and the "spsurvey" package in R v.10.1 (© The R Foundation for Statistical

Computing) to select ~30% of the sampling units from each of these large sites. Based on the sampling units selected, we determined that our sampling design captures ~50%–60% of the total shorebirds observed during previous comprehensive surveys within each site. Had our designs been in place during previous surveys, population estimates would have had a coefficient of variation of ~20%.

To achieve this precision, we weighted the selection of sampling units within each site by the natural logarithm of the total shorebirds counted in the sampling unit during the comprehensive surveys, 2006–2008, in San Francisco Bay (Wood et al. 2010) and 2006 and 2009 in San Diego Bay. Stratifying based on historical data of where the birds are typically found is accomplished by this approach and is common in ecology (Krebs 1999). Also, several studies have documented site fidelity of shorebirds in San Francisco Bay (Warnock and Takekawa 1996) and other coastal estuarine systems (Colwell et al. 2003, Conklin and Colwell 2007, Peters and Otis 2007). High consistency of site use should reduce the year-to-year variance in the data and subsequently improve estimates of population change; however, spatial shifts in the distribution of birds can occur over-time (Wood et al. 2010). When considering highly aggregated species, such as shorebirds, weighting heavily towards areas of historic abundance is beneficial in reducing sampling variance but can yield biased trend estimates if there is a shift in the distribution of birds. Simulation results suggested that our stratified weighting strategy, using the natural logarithm weighting structure, would produce the most accurate results with limited bias; the non-transformed weighting structure resulted in high bias in trend estimates. The GRTS sampling algorithm also allows flexibility in the sampling design as it provides a framework for selecting additional samples, which could be used to replace survey locations if accessibility becomes restricted or to add additional sample locations in the future.

The same sampling units within each site will be surveyed annually within the survey period of 15 November–15 December. We identify this survey period because by mid-November the majority of shorebird migration is complete and surveys can likely be completed before winter storms, which can influence the distribution of shorebirds along the coast (Warnock et al. 1995). Consequently, at a broad scale, and even within sites, the total coastal population appears to be largely closed (no births, and little immigration or emigration), except for mortality within sites.

This panel design can effectively detect population trend while also quantifying the effect of habitat change or management actions at a location over time (Duncan and Kalton 1987). We also increase survey efficiency through a decline in logistical support (e.g., orientation, maps, access), since the same sites are visited every year. This design has been used effectively in other large-scale monitoring programs (e.g., Breeding Bird Survey). A potential limitation of this design is temporal correlation among repeated visits to the same site over-time (i.e. repeated observations of the same sampling unit are not necessarily independent), which can reduce the efficiency of trend estimation models. However, under the assumption that the sampling units represent a random or at least representative sample of the population, data from panel designs can be combined with hierarchical models to obtain robust inference across the population of interest (Gelman and Hill 2007). Consequently, it is critical to define the sampling frame correctly and select a random sample of the population of sampling units.

Lastly, some of the 20 sites (collectively holding <1% of the total coastal wintering population) that were not included in this initial monitoring plan already have existing monitoring programs (Table 1). We will work to incorporate these existing efforts from small sites, which occur largely in southern California, into the broader monitoring framework.

SURVEY PROTOCOL

Coastal Area Search

Wetlands can only be surveyed for shorebirds from their edge without disturbing and dispersing the birds. Because most wintering shorebirds are not highly territorial, they will likely not return to a location when disturbed until that disturbance is gone. Consequently, all shorebird surveys are conducted from the edge of the habitat on either roads or trails that define a standard route around the sampling unit. Based on pilot surveys, we recommend conducting surveys <200m from birds, when possible, to improve count accuracy (PRBO Conservation Science, unpublished data). Our data suggest that between 150 and 200 meters there can be a decline in the probability of detecting certain species in interior rice fields. Further evaluation is needed to determine the optimal distance for survey in coastal systems. See Appendix II for additional details of the "Coastal Wetland Area Search Protocol".

Site Conditions

Controlling for sampling variability can increase the efficiency of trend analyses, the precision of population estimates, and the accuracy of model inference, particularly in observational studies. To control for sampling variation, as well as to evaluate factors influencing the use of specific locations by shorebirds, we ask observers to collect several pieces of data ("Site Conditions"), in addition to shorebird observations, at each sampling unit. We recommend that all sampling units within the same site be surveyed on the same day and during the same tidal window. The tidal conditions are standardized at each site and the same conditions are used annually. Generally, we recommend conducting surveys in tidally influenced landscapes during a rising neap tide close to high tide. This assures that birds that may be far out on a tidal flat during low tide are pushed close enough to shore so that they can be readily identified and counted accurately, but also occur prior to birds leaving to roost. Also because it is a neap tide, the water will rise slowly providing more time to complete surveys and limiting bird movement compared with a spring tide.

Although we have found the above recommendations useful, we recognize that there are cases where ecological and logistical limitations may reduce the effectiveness of this strategy and other alternatives may be preferable. For example, observations indicate that the hour before and after a high, low-tide is most effective for surveys in Bodega Harbor. In San Francisco Bay, high-tide roost surveys have proved more effective than tidal flat surveys, as the former require fewer observers and are easier to reschedule if winter rains restrict access to salt pond levees on a scheduled survey date. Given this variability in constraints across sites, we ask that each site establish a standardized tidal condition and subsequently a standardized survey window during which to conduct its surveys. These conditions should remain the same through time for each site, and we recommend that all surveys be conducted during a two- to three-hour window when dealing with tidal conditions.

To account for additional sampling variation, we record data on weather condition variables during the survey. Also, in many wetland habitats, the actual area surveyed without visual obstruction, a necessary condition for unbiased wintering shorebird counts, is often much less than the specified area of the sampling unit and may change over time (e.g., changes in vegetation amount and height). We record the percentage of the survey area that was able to be surveyed to account for these changes. Currently, we do not specify the temporal duration of the survey, which, similar to area surveyed, may be correlated with the number of birds observed on surveys. Although there is no maximum time limit for counting birds, once all birds in the sampling unit are recorded, the count is considered complete and no additional birds are recorded for that sampling unit. We will record the start and end time of each count to evaluate the need to control for variation in survey duration, as data are collected over the first couple of years of this program.

To account for differences in shorebird counts likely driven by ecological mechanisms (i.e. process variance), we will collect data on the habitat conditions (e.g., percent of area flooded, vegetation height, habitat type) at each sampling unit. These data may prove valuable for understanding processes driving the spatial and temporal trends in wintering shorebird populations. See Appendix II for more details on Site Conditions.

DATA CENTRALIZATION

All data collected as part of winter shorebird monitoring in coastal California and northern Baja will be entered into the California Avian Data Center (CADC; www.prbo.org/cadc). CADC is a secure, well-tested platform for managing, analyzing, and visualizing avian monitoring data. It is also a node of the Avian Knowledge Network (www.avianknowledge.net), which represents several interconnected bird data repositories (e.g., eBird). Data will be entered into CADC through an online data entry portal developed for shorebird surveys and specifically the broader Pacific Flyway Shorebird Survey (PFSS; www.prbo.org/pfss/; see Appendix II for the “Data Entry” protocol). This portal allows for rapid collection of data from field surveys. It is particularly efficient for integrating data collected by many different observers across multiple monitoring programs. For existing monitoring programs that may have their own database management system, we will construct queries to efficiently incorporate their survey data into the PFSS.

Data Analysis

It is important to use data collected as part of this monitoring plan annually to inform trend models, habitat association models, management decisions, and the public about shorebird population changes over time. The value of this monitoring program should be measured in terms of shorebird conservation and management actions that result from the information gained. Data produced by this monitoring strategy will be used for multiple purposes.

Basic Summaries

As part of this monitoring program, we have developed an open-source interactive data summary tool (http://data.prbo.org/apps/pfss/index.php?page=explore-project-results). This tool uses shorebird data stored in CADC to produce simple summaries at user-defined spatial scales from the individual sampling unit to the entire state of California and northern Baja. These interactive tools also allow annual data from the coastal sites to be compared to PFSS monitoring data collected from throughout California and, eventually, the entire Pacific Flyway.

Trend Estimation and Habitat Associations

To achieve two primary objectives of this monitoring plan, we will estimate shorebird population trends and habitat associations, for as many species as possible, using hierarchical mixed-models (Gelman and Hill 2007). Initially, we will fit simple models to the data using three covariates: (1) year – a continuous variable standardized to 2010 = year 1; (2) site; and (3) acres of the dominant cover type (>40% cover). We will also consider an interaction term between site and year and habitat and year in our models to evaluate whether trends are different among sites or cover types over time. Because there may be correlation among observations close together in space or time, we will consider random effects and correlation structures in our models (Gelman and Hill 2007). The general hierarchical model form is as follows:

Where is the count in sampling unit *i* at site *j* in year *k*; is the offset term to standardize effort among sampling units (e.g., area, survey effort); is the set of fixed-effect parameters evaluated in the model; and is the set of random effects and correlation structures in the model.

As part of the model development, we will be able to evaluate sources of sampling variation in the data using covariates recorded as part of our survey protocol (e.g., proportion of survey area visible, duration of survey). A common source of modeled variation is the difference in the area surveyed among sampling units. This variation is often corrected for in count data by using density (count divided by area surveyed). An offset term can be included in models to account for differences in sampling effort (Kery 2010). This simple approach, similar to the case for density, assumes that the offset term and the count are linearly correlated. Complex, although flexible, non-linear models can also be used to further account for effort variation (Link et al. 2006). Although incorporating some of these covariates can control for sources of variation, if they vary significantly they can confound analysis and inference, and may be better accounted for with a revised sampling design and protocol. We will control significant sources of variation through changes to the protocol and sampling unit boundaries.

Because data will be collected annually, we will use a Bayesian approach to model trend and habitat relationships through time. This will allow for our estimates of trend to be updated annually in a rigorous fashion while accounting for existing information from previous years' model analyses and parameter estimates (Williams et al. 2002). The hierarchical models developed above can also be used to quantify habitat associations of shorebirds and potentially the impact of management actions. This will require an initial study to develop the habitat models, as well as, regular tracking of shorebird habitat and management actions in coastal sampling units.

To fit models in a Bayesian framework, a simulation algorithm called Markov-Chain Monte Carlo (MCMC) is used to sample from probability distributions. During each iteration of the simulation, derived parameters, such as density or trend, can be calculated and results in a distribution of these derived parameters. This distribution of the derived parameter values provides the basis for rigorous estimates of variance to define the 95% credible interval of the estimates (Kery 2010).

Population Estimation

Some sites are sampled (e.g., San Francisco and San Diego bays) and consequently the population at those sites are estimates with some specified error for a given point in time. However, counts at other sites are comprehensive, which do not have spatial sampling variance. Lastly, at least 1% of the statewide population is not even counted. Consequently, we cannot simply sum the counts from all sites to generate an initial estimate of population size for California and northern Baja. We need to account for uncertainty from estimates from sampled sites and incomplete spatial coverage in our overall population estimates. To do this, each year we will estimate the population size and variance of all shorebirds, as well as for individual species, in coastal California and northern Baja using a Monte

Carlo algorithm (Manly 2007). In each of 10,000 iterations of the algorithm, we will generate a population estimate using this equation:

Where is the sum of, *i*, randomly chosen variables defined by the estimated population total at a sampled site, *i*, and the 95% confidence interval of this estimate. A new random value for each S_i will be selected in each iteration of the algorithm. Subsequently, the sum of these values will be different in each iteration of the algorithm accounting for uncertainty in our population estimates at the site level as the result of sampling. is the sum of all sites that are covered comprehensively; this value is the same in each iteration of the algorithm. Lastly, is a random value representing the proportion of the total population we estimate that we are counting through our survey of 18 sites. Based on data from Page et al. (1999), we estimate that P_T with be within the interval [0.975 – 0.995]. This correction accounts for the ~1% of the population not surveyed by this monitoring plan. This value (P_T) will be calculated for each species individually as well. The output of this algorithm will be 10,000 estimates of the coastal shorebird population ( ). The mean of the 10,000 iterations of this algorithm will be our population estimate for a specific year, and we will use the 250th and 9750th ranked values as the 95% confidence interval of our estimate.

We will also evaluate model-based estimates of the total population to account for non-surveyed sites based on habitat characteristics (e.g., acres of tidal flat). These model-based estimates will use a simple extrapolation of the density estimates derived from hierarchical models. We will estimate the population size by habitat as a derived parameter from each iteration of the MCMC model-fitting process (Link and Barker 2010). These derived population estimates will be calculated as the density in each habitat times the total area of that habitat available on the landscape. The variance estimate (95% credible interval) for the shorebird population estimate is calculated using the percentile method within each habitat and the derived population estimate from each iteration of the MCMC algorithm (Link and Barker 2010). A complete population estimate can be derived simultaneously using the sum of the individual habitat estimates. Again the 95% credible interval will be estimated. This approach to estimating populations allows variance components to be determined for derived parameters in each level of the hierarchy and allows local changes or habitat-specific changes to be evaluated in the context of the entire population (Kery 2010).

In both approaches, the fraction of the habitat or the population surveyed (P_T), and consequently the inclusion probabilities, can change if the amount of habitat within a region changes over time. Accounting for changes in the fraction of the habitat or the shorebird population surveyed is important to achieve unbiased estimates of population size and trend. Tracking large shifts in shorebird or shorebird habitat distribution from surveyed to non-surveyed sites in coastal California and northern Baja over time is needed to maximize the accuracy of the population estimates from data collected with these surveys.

Potential Biases

Sampling Bias

Variation in the sampling units or probability of detection among habitats, when not accounted for, may cause significant biases in analyses. Currently, we control for these biases using several variables (see "Site Conditions" above). Regardless, an approach to fully account for probability of detection and counting error is needed (see "Future Needs and Pilot Studies" below).

Frame Bias

Although our proposed monitoring plan provides a rigorous approach for long-term monitoring of wintering shorebirds in coastal California and northern Baja, we recommend continued assessments of its functionality and rigor over time to guard against selection and frame bias (Thompson 2002). The high degree of spatial aggregation in shorebirds can lead to biased trend estimates if there is a shift in distribution of shorebirds from surveyed to non-surveyed sites. There is also the potential for new habitat to become available outside of the area covered by the current sampling frame. This potential shift in the habitat distribution may be increasingly relevant in light of rapid environmental change, continued tidal marsh restoration activities, and sea-level rise. Consequently, our inference about shorebird populations along the coast would be biased ("frame bias"). We believe our careful evaluation of the sampling frame and subsequent sampling design should prevent this bias from being significant; our design captures 99% of the population of shorebirds in this region and the majority of shorebird habitat. However, within sampled sites like San Francisco Bay we also need to protect against this bias (see Reiter et al. 2011).

We recommend a comprehensive evaluation of the distribution of tidal flats and salt ponds, as well as the distribution and abundance of shorebirds every 10 years to guard against frame bias. Then, if necessary, we will make corrections in the sampling design or (P_T) to account for observed changes in population and trend estimates.

Survey Coordination, Logistics, and Sustainability

The survey of all sampling units in the coastal California and northern Baja region should be completed each year within the PFSS survey window of 15 November to 15 December. To successfully survey at all sampling units within this time period, a large number of trained observers are needed. Surveys will be conducted by both professional and volunteer biologists ("citizen scientists"). Training sessions will be held annually to familiarize new observers with survey protocols, data recording, species identification, methods of estimating shorebird numbers, and data entry through CADC. These training resources can also be located on the "Resources" page at www.prbo.org/pfss (also see Appendix II). We are also partnering with existing monitoring programs to link their data collection efforts with the broader PFSS network (Table 1). PRBO will take the lead role in the coordination of this annual survey in coastal California and northern Baja, as well as in the broader PFSS region. However, efficient survey coordination and widespread data collection will continue to require close partnerships with multiple state and federal agencies, NGOs, and universities.

The sustainability of a long-term monitoring program will also depend on maintaining active engagement by survey participants. We have developed the PFSS webpage (http://www.prbo.org/pfss), which provides a centralized location to engage citizen scientists and information about shorebirds and the PFSS (e.g., survey protocols, training materials). It also includes access to self-defined data summaries at multiple spatial scales, which are available as soon as data have been entered into CADC and have gone through quality control and assessment. We also use survey monkey (http://www.surveymonkey.com/) to elicit feedback from citizen scientists and partners about their experience with the PFSS. We believe these social networking tools will increase citizen scientist retention and generate enthusiasm and support for shorebird monitoring and conservation.

FUTURE NEEDS AND PILOT STUDIES

Although this monitoring plan describes a robust approach to tracking abundance and trends of wintering shorebirds in coastal California and northern Baja, there is still additional work to be completed to control for the potential biases listed above.

Habitat Tracking and Bird-Habitat Models (Frame Bias)

Throughout the coast, changes to the landscape can affect the distribution and availability of shorebird habitat, which, if unaccounted for, can result in biased estimates of population size and trends of shorebirds (see “Frame bias” above). Habitat composition in this region will likely be most affected by restoration of wetlands and riparian systems and climate change, primarily through sea-level rise (Galbraith et al. 2002). Although our monitoring protocol entails recording simple habitat metrics at sampling units surveyed annually, changes at non-surveyed sites go undetected. To track potential changes in shorebird habitat regionally, we need a consistent way of tracking habitat, or distinct changes in habitat, at least every 10 years (preferably more frequently). Currently, there is not a framework to regularly track habitat in this region, although the ability to do so efficiently (e.g., remote sensing; Wiens et al. 2009) is increasingly available and would benefit long-term monitoring of many ecosystems in coastal regions.

To understand how changes to habitat availability will influence shorebirds, we need to develop shorebird-habitat association models. Typically, shorebird habitat management occurs within a wetland or wetland complex. The effectiveness of these localized (<1–2 km^2) management strategies in attracting shorebirds may vary due to changes in the availability of habitat over time in the surrounding landscape from restoration projects, development, or other forms of habitat conversion. For managers to make informed management decisions requires understanding how their local actions contribute to overall shorebird habitat in the broader landscape. Habitat association models that account for the effects of local and landscape-level habitat availability can provide guidance for wetland habitat managers about how to allocate resources to maintain current shorebird population objectives.

Probability of Detection (Sampling Bias)

Often not all birds occurring within a sampling unit are detected. The probability that a bird occurring within a sampling unit is detected is called the probability of detection (Thompson 2002). The probability of detection, which is often, incorrectly, assumed to be equal to 1 (i.e., all birds are detected), can be influenced by many factors, including habitat, distance from the observer to the bird, or the amount of habitat actually visible. Often the probability of detection is <1, and subsequently, population estimates will be negatively biased ("sampling bias") if probability of detection is not accounted for in analysis. Trend estimates are more robust to uncorrected counts as long as the probability of detection does not have a trend, i.e., the probability of detecting a bird in the sampling unit is constant overtime. Probability of detection can be particularly problematic when making comparisons of shorebird abundance among habitat types that have significant differences in probability of detection.

It is difficult to efficiently estimate the probability of detection of wintering shorebirds for two reasons. First, wintering shorebirds often occur in large groups clustered on the landscape. Estimating the size of these large groups is very challenging and includes error, the magnitude of which is unknown. Consequently, we do not know if we consistently under- (negative bias) or overestimate (positive bias) our counts. Estimating probability of detection when there is potentially high counting error and potential for overestimating numbers is a challenge.

Second, several commonly used approaches to estimating the probability of detection, including the double-observer (Nichols et al. 2000), the Royle count model (Royle 2004), double sampling (Bart and Earnst 2002), and distance sampling (Buckland et al. 1993), have assumptions (e.g., closure, uniquely identifying individuals) that cannot be met with wintering shorebirds or are logistically unfeasible to implement using citizen scientists. A modified version of the Royle count model, the "unreconciled double-observer method" (Riddle et al. 2010), may provide a rigorous approach to estimating probability of detection in a citizen scientist–driven project. Similar to the traditional double-observer approach, this method requires two observers counting independently at the same survey location, but does not require them to uniquely identify individual birds. Not having to "reconcile" individual birds among observers is valuable for surveys of large flocks. A better understanding of the magnitude of biases caused by probability of detection and flock estimation, which may be even more relevant in shorebird surveys in coastal wetland habitats, is needed to delineate effective strategies for correcting for these sources of bias.

Conclusion

Annual shorebird surveys in coastal California and northern Baja that generate estimates of population trends, distribution, and habitat associations at multiple spatial scales are needed to guide conservation and management of shorebirds in the face of a changing climate and habitat conversion. Linking observed changes in the distribution and abundance of wintering shorebirds to changes in habitat within the coastal region will also measure the impacts of local management actions. Evaluating annual shorebird monitoring data from coastal California and northern Baja in the context of broader changes in shorebird populations as part of the PFSS will provide a multi-scale assessment of the impact of local management actions on Pacific Flyway shorebird populations. This monitoring plan details an approach to provide this essential information for managers, decision-makers, and conservation practitioners.

Some aspects of this new monitoring strategy were launched in 2011, when more than 100 citizen scientists and professional biologists conducted surveys and entered their data through our new online data portal. In 2012, we will continue to implement the plan and expand to cover all 18 sites by 2013. We will use the first two years of data (2011 and 2012) to critically evaluate this monitoring plan and survey protocols and revise them as needed. All revisions to this plan or protocol (see Appendix II) will be tracked in the "Revision History" (see page iii).

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Table 1. Species likely to be observed regularly as part of this Coastal California and Northern Baja Monitoring Plan.

Common Name	Scientific Name
Black-bellied Plover	*Pluvialis squatarola*
Snowy Plover[1]	*Charadius alexandrinus*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer[1]	*Charadrius vociferus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Willet	*Tringa semipalmata*
Whimbrel	*Numenius phaeopus*
Long-billed Curlew	*Numenius americanus*
Marbled Godwit	*Limosa fedoa*
Ruddy Turnstone[1]	*Arenaria interpres*
Black Turnstone[1]	*Arenaria melanocephala*
Red Knot	*Calidris canutus*
Sanderling[1]	*Calidris alba*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Dunlin	*Calidris alpina*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*

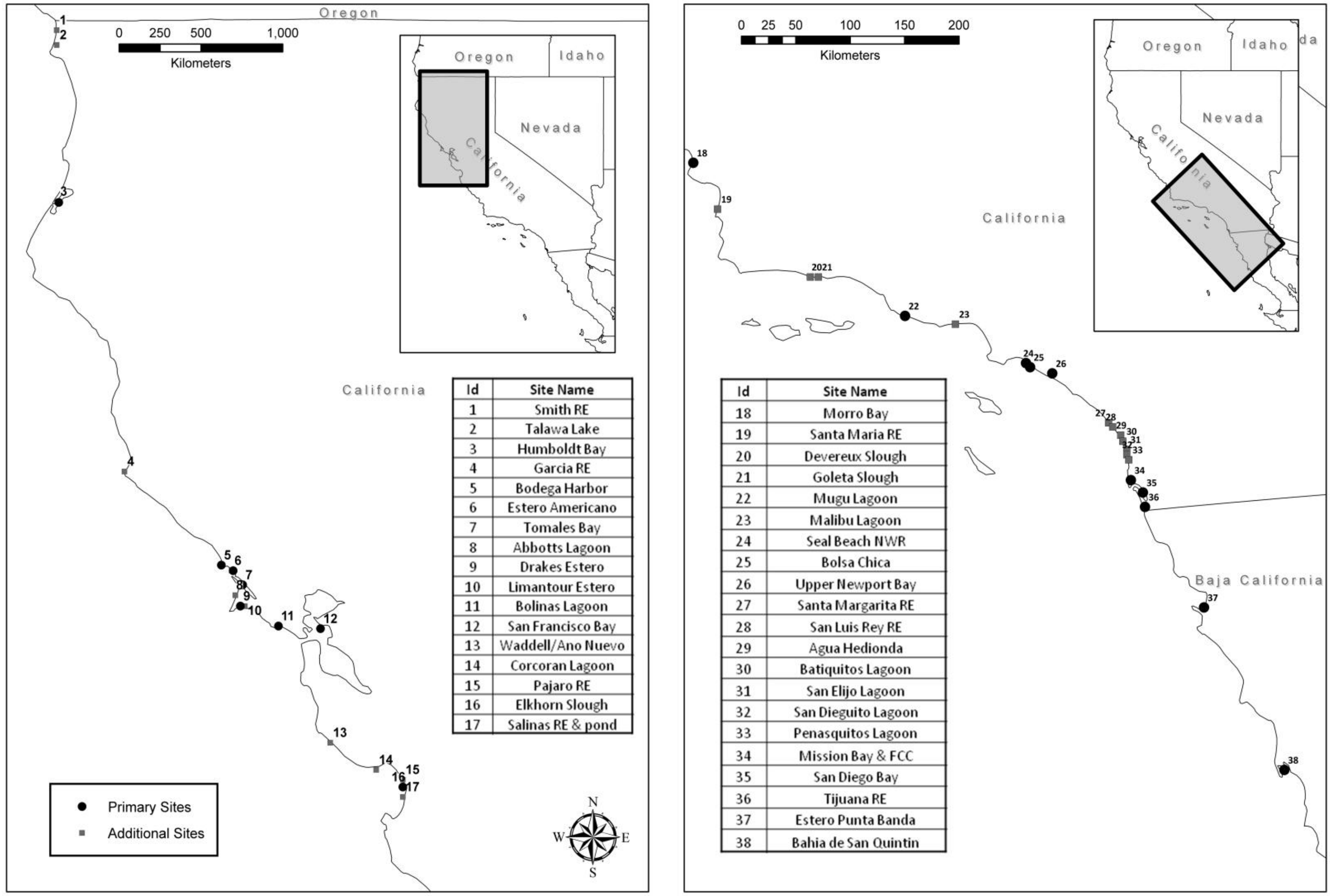
[1]Species with populations that will not be fully captured by the wetland sampling frame defined in this monitoring plan.

Table 2. Summary of shorebird abundance on early winter surveys at 38 coastal sites in coastal California and northern Baja (Page et al. 1999). CV = coefficient of variation among surveys.

Site	Maximum Count	Average Count	CV
San Francisco Bay[1,3]	357,754	341,902	0.05
Humboldt Bay[1]	79,353	60,222	0.29
Bahia San Quintín	27,291	25,652	0.06
Elkhorn Slough[1,3]	31,642	27,770	0.15
Tomales Bay[2]	33,425	20,155	0.31
Morro Bay	20,205	15,266	0.23
Drakes Esteros	18,001	14,538	0.20
Mugu Lagoon[3]	10,326	10,024	0.04
San Diego Bay[1]	11,144	9,793	0.10
Upper Newport Bay[3]	14,825	9,462	0.34
Bodega Harbor[3]	12,901	8,621	0.35
Bolinas Lagoon[3]	10,480	8,275	0.17
Bolsa Chica[3]	6,977	5,336	0.21
Seal Beach NWR[3]	5,550	4,757	0.25
Mission Bay & FCC	5,294	4,639	0.18
Estero Punta Banda	2,993	2,993	-
Estero Americano	1,797	1,567	0.21
Tijuana RE	1,837	1,149	0.58
Limantour Estero	1,514	814	1.22
Batiquitos Lagoon[3]	1,058	481	0.45
San Elijo Lagoon[3]	680	468	0.69
Santa Margarita RE	990	456	0.46
Santa Maria RE	422	422	1.00
Pajaro RE	750	360	0.48
Agua Hedionda[3]	387	354	0.91
Waddell-Año Nuevo	658	280	0.43
Malibu Lagoon	270	270	1.00
Garcia RE	411	261	0.63
Salinas RE & pond	368	240	0.65
San Dieguito Lagoon[3]	368	201	0.55
Penasquitos Lagoon	284	153	0.54
Abbotts Lagoon	181	124	0.68
Smith RE	178	121	0.68
Devereux Slough	227	109	0.48
Goleta Slough	153	94	0.61
San Luis Rey RE	78	78	1.00
Corcoran Lagoon	46	23	0.50
Lake Talawa	19	8	0.40

[1]Western Hemisphere Shorebird Reserve Network site (www.whsrn.org)
[2]J. Kelly et al., unpublished data; average count on Nov-Dec surveys 1990-1995
[3]Sites with existing monitoring programs

Figure 1. Coastal California and northern Baja survey region for shorebirds with all 38 potential survey locations indicated. Primary sites are the 18 sites selected for monitoring. The shaded area of the inset map shows the location of main map.



Id	Site Name
1	Smith RE
2	Talawa Lake
3	Humboldt Bay
4	Garcia RE
5	Bodega Harbor
6	Estero Americano
7	Tomales Bay
8	Abbotts Lagoon
9	Drakes Estero
10	Limantour Estero
11	Bolinas Lagoon
12	San Francisco Bay
13	Waddell/Ano Nuevo
14	Corcoran Lagoon
15	Pajaro RE
16	Elkhorn Slough
17	Salinas RE & pond

Id	Site Name
18	Morro Bay
19	Santa Maria RE
20	Devereux Slough
21	Goleta Slough
22	Mugu Lagoon
23	Malibu Lagoon
24	Seal Beach NWR
25	Bolsa Chica
26	Upper Newport Bay
27	Santa Margarita RE
28	San Luis Rey RE
29	Agua Hedionda
30	Batiquitos Lagoon
31	San Elijo Lagoon
32	San Dieguito Lagoon
33	Penasquitos Lagoon
34	Mission Bay & FCC
35	San Diego Bay
36	Tijuana RE
37	Estero Punta Banda
38	Bahia de San Quintin

Appendix I:

Site Descriptions

The following site descriptions for 18 primary survey sites in coastal California and northern Baja California, Mexico are adapted from Hickey et al. (2003) and listed from north to south. Special wetland designations are indicated for each site, when appropriate. See www.ramsar.org (Ramsar Convention) and www.whsrn.org (Western Hemisphere Shorebird Reserve Network) for detailed information about these designations.

1. Humboldt Bay

Wetland Description: Northern Humboldt Bay consists of marshes and mudflats with extensive eelgrass beds, wet pastures, and the estuary of the Mad River, which is separated from the ocean by extensive sand dunes. Arcata Marsh contains restored freshwater marsh habitat. Seven shellfish reserves are set aside for public clamming and oyster gathering. East bay marshlands were diked for railroad and highway construction. Humboldt Bay National Wildlife Refuge manages the southern Bay. A large marsh borders the southern bay; a vast system of tidal channels winds through wet pastures.

Shorebird Use: Depending on the season, 20,000 to 80,000 shorebirds reside in Humboldt Bay (Colwell 1994). The Western Hemisphere Shorebird Reserve Network (WHSRN) recognizes this large estuary as a site of International Importance for shorebirds. Tidal wetlands, especially the broad mudflats, support Dunlin, Long-billed Dowitchers, and Whimbrel (Colwell 1994).

Monitoring: Comprehensive surveys of the north and south portions of the bay have been conducted once a year, between 15 November and 15 December, since 2010 as part of the Pacific Flyway Shorebird Survey.

Survey Coordinator: Mark Colwell, Humboldt State University; Mark.Colwell@humboldt.edu

2. Bodega Harbor

Wetland Description: A long sandy spit separates the 850-acre estuary of Bodega Harbor from Bodega Bay. On the north side of the harbor, two marinas house a commercial fishing fleet. Access to the Spud Point Marina is by a deepwater channel that undergoes periodic dredging; dredge spoils have been stored in diked ponds on the east harbor. Salt marshes border the west and southeast of the harbor, and expansive mudflats extend to the channel on low tides. Substantial clam and bait harvesting occurs on the flats. A marine reserve protects mudflats on the southwest side of the harbor from exploitation and is a source for larval recruits to the rest of the harbor.

Shorebird Use: Mid-winter numbers vary from 2,000 to 12,000 shorebirds in winter. Large shorebirds are especially attracted to Bodega Harbor, and consistently high numbers of godwits, Willits, and dowitchers feed and roost within the harbor. Smaller shorebirds, such as Dunlin and Sanderlings, feed in the harbor at low tide and fly to beaches or northern Tomales Bay at high tide to take advantage of additional feeding opportunities.

Monitoring: Bodega Marine Lab (UC Davis) conducts quarterly surveys of 13 sampling units that make up the shorebird habitat in the harbor. These are essentially comprehensive counts, and the early winter survey occurs within the Pacific Flyway Shorebird Survey window of 15 November to 15 December. Surveys are conducted during a tidal window around a +1 foot low tide.

Survey Coordinator: Jackie Sones, Bodega Marine Lab, UC Davis; jlsones@ucdavis.edu

3. Estero Americano

Wetland Description: Estero Americano consists of approximately 400 acres of wetlands. A sand bar forms at the mouth of the estero, blocking tidal action. Heavy grazing by sheep on the surrounding hills has led to erosion of sediments into the estuary. A restoration and management plan has been implemented for an 86-acre preserve established by the Sonoma Land Trust at the mouth of the Estero. Three are small amounts of tidal flat as well.

Shorebird Use: Estero Americano has 1,000 to 3,000 shorebirds in fall and winter (Page et al. 1999). A small area of mudflats attracts migrating shorebirds.

Monitoring: No ongoing monitoring.

Survey Coordinator: TBD.

4. Tomales Bay

Wetland Description: This is an 8,658-acre coastal embayment with tidal mudflats, marsh, and rocky shoreline. Important tidal flats for shorebirds are at the north end off Lawson's Landing and the mouth of Walker Creek and at the very south end of the bay. The south portion of the bay has recently been restored to tidal action.

Shorebird Use: Tomales Bay holds 5,000 to 10,000 shorebirds in spring and fall and up to 20,000 in winter, thereby qualifying it as a potential WHSRN site of Regional Importance (Kelly 2001).

Monitoring: Regular monitoring conducted by Audubon Canyon Ranch (www.egret.org/) at 15 sampling units that, in aggregate, represent a comprehensive survey of Tomales Bay shorebirds. Surveys are conducted during a rising neap tide. Data from surveys conducted during the PFSS window are contributed to the program.

Survey Coordinator: Emiko Condeso, Audubon Canyon Ranch; emiko@egret.org

5. Drakes and Limantour Esteros

Wetland Description: These two esteros are best considered as a single wetland system because of their common entrance to the ocean and the regular interchange of shorebirds between them. The 1,816-acre Drakes Estero is managed partly for mariculture and the 481-acre Limantour Estero is an Ecological Reserve. The entire system has extensive tidal flats, and saltmarsh occurs in various arms of the esteros. Some ponds at Limantour have recently been restored to tidal action to allow stream access to spawning salmon. Coastal scrub habitat surrounds the estuary; grazing by dairy cows occurs within the watershed.

Shorebird Use: Each regularly holds thousands of shorebirds with combined totals sometimes reaching nearly 20,000 individuals in winter.

Monitoring: No ongoing monitoring.

Survey Coordinator: TBD.

6. Bolinas Lagoon

Wetland habitat description: Though not a true lagoon, as it is always open to tidal action, this 1,100-acre, very shallow estuary consists of extensive tidal mudflat and salt marsh. There is also agriculture in the surrounding landscape. Bolinas Lagoon is recognized as a Ramsar site of International Importance

Shorebird Use: Regularly holds 5,000 to 10,000 shorebirds; during spring migration, numbers have been known to swell to 35,000 (Shuford et al. 1989). Bolinas Lagoon would qualify as a WHSRN site of Regional Importance.

Monitoring: Six surveys are conducted each winter of 8 sampling units in Bolinas Lagoon. These surveys have been conducted for over 40 years and represent a comprehensive survey of Bolinas Lagoon. Surveys include all waterbirds not just shorebirds. The surveys conducted during the PFSS window of 15 November to 15 December will be contributed to the program.

Survey Coordinator: Lynne Stenzel, PRBO Conservation Science, lstenzel@prbo.org

7. San Francisco Bay

Wetland Description: The San Francisco Bay is the largest estuary on the west coast of North America. San Francisco Bay contains a variety of habitats, including tidal mudflats, diked and undiked seasonal wetlands, managed and unmanaged salt evaporation ponds, and tidal marshes that support a diverse bird community. In addition, shorebirds use other features such as islands, levees, rip-rap shoreline, piers and other structures for roosting. The San Francisco Bay Area is also highly urbanized with over 6 million people and has undergone many changes over the last 200 years. In the late 1800s and early 1900s, over 80% of the wetlands were diked, channelized, and/or filled for agriculture, grazing, urban infrastructure, and other uses. During the shorebird surveys in the early 1990s, many areas in both the north and south regions of the estuary were still used as commercial salt evaporation ponds or were agriculture fields. In the 14 years between 1992 and 2006, over 11,000 acres of bayland were created or restored to tidal action by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and numerous other agencies. These restoration activities continue and the South Bay Salt Pond Restoration Project (www.southbayrestoration.org/) is the largest tidal restoration in the western United States. They have also changed the water management regimes of the salt ponds to maximize bird use. However, sea-level rise is projected to further change the distribution and abundance of shorebird habitat in the San Francisco Bay Estuary (see http://data.prbo.org/apps/sfbslr/).

Shorebird Use: More than 1 million shorebirds occur annually in the San Francisco Bay estuary representing 38 species (Stenzel et al. 2002). Shorebirds are most numerous in San Francisco Bay during spring migration, with up to 932,000 counted. However, fall and early winter are also important, with over 300,000 birds, and late winter (January-February) can have 225,000 (Stenzel et al. 2002). The overall abundance of wintering shorebirds has remained stable in San Francisco Bay over the last 15 years, despite significant changes in habitat; however there have been shifts in the distribution of some species (Wood et al. 2010).

Monitoring: Comprehensive surveys of the bay have been conducted by PRBO and partners from 1990-1992 and 2006-2008 (see Stenzel et al. 2002 and Wood et al. 2010). In addition, localized surveys are being conducted regularly as part of studies by USGS and the San Francisco Bay Bird Observatory. Currently, PRBO is working with partners to survey >120 sampling units annually during the PFSS survey window. These set of randomly selected sites represents ~50 - 60% of the shorebird population in the Bay. These surveys have been conducted in 2010 and 2011. See Reiter et al. (2011) for a detailed description of the San Francisco Bay Monitoring Design.

Survey Coordinator: Dave Shuford; PRBO Conservation Science; dshuford@prbo.org

8. Elkhorn Slough

Wetland Description: Elkhorn Slough contains approximately 4,000 acres of tidal flat and associated wetlands. Tidal mudflat is the primary feeding area for most shorebirds. There are derelict salt ponds on the west end of Elkhorn slough. Tidally restricted mudflat occurs in North Marsh and Moro Cojo Slough. Culverts restrict tidal flow into Moro Cojo Slough, creating an area where water fluctuations are governed by rainfall and evaporation.

Shorebird Use: Nearly 32,000 birds have been recorded during comprehensive counts of Elkhorn Slough (Page et al. 1999) during winter. The slough is used as a high tide foraging and roosting area by many shorebirds. Marbled Godwit, Willet, Long-billed Curlew and Least Sandpiper use the extensive *Salicornia* marsh for foraging and roosting, particularly at high tide. Black-necked Stilt, American Avocet, and Killdeer forage on all tides in the slough; these species also breed on the slough's edge. At the upper end of Elkhorn Slough, Black-necked Stilts also nest in the diked Porter Marsh, which is cut off from tidal influence; tide gates prevent water from entering but not exiting into the main channel of Elkhorn Slough. North and Strawberry marshes are managed for flood and mosquito control but provide important foraging habitat for the American Avocet, Black-necked Stilt, and dowitchers. Strawberry Marsh also provides foraging habitat for the Red-necked Phalarope in fall. Salt ponds support nesting

Snowy Plovers, Black-necked Stilts, and American Avocets during summer and many other shorebirds at other seasons. Sand beach at the Elkhorn Slough mouth serves as foraging and roosting habitat for several shorebird species and nesting habitat for the Snowy Plover.

Monitoring: Quarterly surveys are conducted of 10 sampling units that represent a nearly comprehensive survey of the slough and adjacent wetlands. Survey data from the early winter survey are contributed to the PFSS database in CADC.

Survey Coordinator: Susie Fork; Elkhorn Slough Foundation; skfork@gmail.com

9. Morro Bay

Wetland Description: The 2,300 acre estuary of Morro Bay is designated a National and State Estuary and is a Globally Important Bird Area. Four miles long, the estuary is separated from the Pacific Ocean by a long sandy spit with a narrow opening. The estuary is managed for oyster harvesting, fishing, and hunting, and contains a marina. Mudflats, salt marsh, and patches of fresh water marsh exist in the eastern and southern reaches of the estuary. The town of Morro Bay borders the north end of the estuary.

Shorebird Use: 20,000 shorebirds in winter qualify this site as a potential WHSRN site of Regional Importance. Morro Bay supports tens of thousands of migrating and wintering shorebirds, including the Black-bellied Plover, Willet, Long-billed Curlew, Marbled Godwit, Sanderling, Western Sandpiper, and Least Sandpiper (PRBO unpubl. data). The Morro Bay sand spit is an important Snowy Plover nesting area.

Monitoring: Quarterly waterbird surveys are conducted at 15 sampling units which, in aggregate, represent a comprehensive count of shorebirds using this site. The early winter survey conducted in mid-November is now contributed to the PFSS database.

Survey Coordinator: Andrea Jones; Audubon California; ajones@audubon.org

10. Mugu Lagoon

Wetland Description: Mugu Lagoon is a 1,480 acre estuary within Mugu Naval Air Station weapons testing facility. The lagoon consists of tidal flats, salt pannes, tidal marsh, channels, creeks, and open water and is fed by Calleguas Creek. Surrounding the weapons facility are agricultural fields, open space, duck clubs, and Point Mugu State Park.

Shorebird Use: Holds up to 66,000 shorebirds during spring and over 10,000 in fall and winter (Page et al. 1999). Mugu Lagoon is a potential WHSRN site of Regional and possibly International Importance. The lagoon is used by tens of thousands of migrating and wintering shorebirds and modest numbers of nesting Snowy Plovers, Black-necked Stilts, and American Avocets.

Monitoring: Surveys for waterbirds have been conducted monthly at Mugu since 2001 within 17 sampling units which in aggregate represent a comprehensive survey of shorebirds in the site. Beginning in 2011 at least one survey from selected sampling units will be conducted within the PFSS survey window and these data contributed to the PFSS database.

Survey Coordinator: Martin Ruane; US Navy; martin.ruane@navy.mil

11. Seal Beach NWR

Wetland Description: The approximately 1,000 acre Seal Beach National Wildlife Refuge lies within the 508-ha Anaheim Bay wetland complex, which includes 230 acres of salt marsh, 59 acres of tidal flat, 114 acres of tidal channels and ponds, and 475 acres of human-created waterways and open water. Over 2,000 acres of surrounding agricultural land, mostly in row crops, buffer the wetlands on two sides from dense urban development and provide additional foraging habitat for wintering shorebirds. Anaheim Bay's wetlands have been reduced to about half their former extent during the past 150 years by diking and filling for agriculture and construction of a railway and interstate highway through the marsh, an ammunition depot with connecting harbor, a marine-oriented residential community, and an oil pumping facility.

Shorebird Use: Holds up to 5,500 shorebirds in winter; recognized as a wetland of International Importance by the Ramsar Convention Treaty. Thousands of shorebirds occur during migration and winter, feeding primarily on tidal flats; some rocky coast species forage on rock jetties. About a dozen Black-necked Stilts breed in the wetlands.

Monitoring: Monthly monitoring has been done at the Refuge within 9 sampling units that in aggregate represent a comprehensive survey of shorebird s at the site. Beginning in 2011 at least one survey will be conducted during the PFSS survey window and contributed to the PFSS database.

Survey Coordinator: Kirk Gilligan, US Fish and Wildlife Service, kgilligan@fws.gov

12. Bolsa Chica

Wetland Description: Although recently threatened with development, all 1300 acres of the Bolsa Chica wetlands are now in state ownership. The site was recently restored to tidal influence on about 700 acres, which created large tidal flats. The existing Bolsa Chica Ecological Reserve (330 acres) is managed by California Department of Fish and Game. It consists of open water, tidal marsh, sandy islands, and 79 acres of tidal flats. The remaining 1000 acres contain an operating oil field with extensive areas of seasonal ponds and non-tidal flats.

Shorebird Use: Holds up to 5,400 shorebirds in fall, 7,000 in winter, and 7,700 in spring. Bolsa Chica supports nesting Snowy Plovers, Black-necked Stilts, American Avocets, and thousands of migrating and wintering shorebirds.

Monitoring: New surveys recently initiated. PFSS will seek to partner with this new program to integrate their data.

Survey Coordinator: TBD

13. Upper Newport Bay

Wetland Description: Upper Newport Bay, fed by San Diego Creek and Delhi Channel, consists of nearly 1,400 acres of open water, salt marsh, freshwater marsh, and tidal mudflat. Upper Newport Bay was heavily used for salt extraction until the salt works were destroyed by San Diego Creek floodwaters. Marinas have been constructed near the mouth of the bay, and now the lower bay is used intensively for motor boating, camping, and kayaking. Habitat is a mix of marsh, mudflat, and open water for migrating and wintering shorebirds and other aquatic species. Managed marsh habitat exists at the very upper reaches of the Bay that make up San Joaquin Marsh.

Shorebird Use: Holds up to 14,800 shorebirds in winter; a potential WHSRN site of Regional Importance. Thousands of shorebirds forage on the mudflats much of the year. Willets, Long-billed Curlews, and Marbled Godwits also feed in the salt marsh. Many species forage in the freshwater San Joaquin marsh; Black-necked Stilt and American Avocet nest there.

Monitoring: Monthly surveys of Upper Newport Bay have been completed by volunteers since 2000 using 13 sampling units that in aggregate represent a comprehensive count of shorebirds in the Bay and San Joaquin Marsh. Beginning in 2011 at least one of their surveys will use the PFSS protocol, be completed during the PFSS survey window, and contributed to the PFSS database.

Survey Coordinator: Nancy Kenyon; Sea and Sage Audubon; nancykenyon@cox.net

14. Mission Bay/San Diego Flood Control Channel

Wetland Description: This 4,600 acre area was once a deep-water embayment. After the USACE diverted the San Diego River from San Diego Bay to Mission Bay, sediment began to rapidly fill False Bay (part of Mission Bay) making it very shallow by the turn of the century. Mission Bay was then dredged to create a park complex of islands and is now used primarily as a recreation area. Extensive tidal beaches now surround Mission Bay, and large expanses of mudflat occur at the edge of the Northern Wildlife Preserve, which includes the 16 acre Kendall Frost Marsh Reserve. This preserve and the 37 acre Famosa Slough contain the only remnants of native marsh. The San Diego Flood Control Channel is predominantly concrete but is open to tidal influence on the lower end near the ocean and contains some tidal mudflats. Due to their proximity, Mission Bay and the Flood Control Channel are considered one site in this monitoring plan.

Shorebird Use: Holds up to 5,000 to 6,000 shorebirds.

Monitoring: Pilot survey conducted in 2011. PRBO designing strategy for 2012

Survey Coordinator: Khara Strum; PRBO Conservation Science; kstrum@prbo.org

15. San Diego Bay

Wetland Description: San Diego Bay consists of 11,000 acres of sub-tidal and intertidal habitat and 1,400 acres of salt ponds. Less than half of the mud flats that surrounded the bay in 1850 remain (766 acres). After the San Diego River was diverted, the large marsh at the river delta was filled and developed by the City of San Diego. The bay has been dredged to fill tidelands, to widen beaches along Silver Strand, and to create military and domestic ports. The dredged area is much deeper and narrower than 150 years ago. Only the south bay contains significant areas of marsh, mudflat, and salt ponds (Marcus and Kondolf 1989).

Shorebird Use: Holds up to 18,000 shorebirds in fall, 11,000 in winter, and 13,000 in spring (Terp 1998, Page et al. 1999). It is also recognized as a WHSRN site of Regional Importance. Tidal mudflats are the main shorebird feeding area; the salt ponds provide additional feeding and roosting habitat (Terp 1998). Sweetwater Marsh consists of salt and brackish marsh, salt pannes, mudflats, fill, and upland and supports breeding Snowy Plovers and many species of migrating and wintering shorebirds (B. Collins pers. comm.).

Monitoring: Comprehensive surveys of San Diego Bay were conducted in 2006 and 2009 by Tierra Data under contract with the US Navy, the Port of San Diego, and the US Fish and Wildlife Service. Counts were conducted on >300 sampling units throughout the Bay (a comprehensive survey). In 2011, PRBO Conservation Science piloted a sampling design for San Diego Bay. Similar to San Francisco Bay (see Reiter et al. 2011), we selected a generalized random-tesselation stratified sample (GRTS) using the 2006 and 2009 species distribution data to guide the selection of sites. We selected ~30% of the sampling units (n = 100) weighting our selection of sampling units proportional to the natural log of shorebird abundance observed in previous surveys in those units. This strategy was shown to be successful in tracking population change with simulation analysis. Initial evaluation of this sampling strategy suggests that we can achieve population estimates for the Bay with coefficient of variation of <0.20. In fact, this strategy will still result in 50 - 60% of shorebirds being counted relative to 2006 and 2009 surveys. The GRTS sampling strategy also allows for additional sampling units to be added in the future if determined necessary.

Survey Coordinator: Khara Strum; PRBO Conservation Science; kstrum@prbo.org

16. Tijuana River Estuary

Wetland Description: Since 1852 the Tijuana River estuary has lost 80% of its tidal prism and 250 acres of the southern arm to sedimentation and agricultural reclamation. Apartments have been erected on most of the northern dunes. In 1983 the mouth closed and had to be dredged; now it is susceptible to periodic closure (Marcus and Kondolf 1989). Today the approximately 1320 acre Tijuana River estuary is included within NOAA’s 2,530 acre Tijuana River National Estuarine Research Reserve, which consists of tidally flushed wetland, riparian habitat, and upland.

Shorebird Use: Holds up to 1,000 to 2,000 shorebirds at all seasons except the summer breeding season. Besides supporting many migrating and wintering shorebirds, the Tijuana River estuary is a nesting area for the Snowy Plover, Black-necked Stilt, and American Avocet.

Monitoring: PRBO conducted a pilot survey in 2011 and is developing a specific design for 2012.

Survey Coordinator: Khara Strum; PRBO Conservation Science; kstrum@prbo.org

17. Estero de Punta Banda

Wetland Description: Located in Northwestern Baja California at the southwestern end of Bahia de Todos Santos, about 13 km south of the city of Ensenada. There are 4,050 acres of wetlands. In 2005 this site was designated as a Ramsar site.

Shorebird Use: During February 1991, 2,993 wintering shorebirds were estimated, although 4,000 Western Sandpipers were reported in October-November 1994. Marbled Godwit, Willet, and Long-billed Curlew accounted for 91% of the large shorebirds; Black-bellied Plover, dowitcher, and Greater Yellowleg accounted for 89% of the medium shorebirds; and Dunlin, Western Sandpiper, Sanderling, and Least Sandpiper accounted for 93% of the small shorebirds. Red Knots also occur regularly at this location. California Least Terns, Clapper Rails and Snowy Plovers nest in this wetland.

Monitoring: Pilot survey conducted by CICESE in December 2011. PRBO and CICESE developing specific design for 2012.

Survey Coordinator: Eduardo Palacios; Centro de Investigación Científica y de Educación Superior de Ensenada, B.C. (CICESE); epalacio@cicese.mx

18. Bahía San Quintín

Wetland Description: Bahía San Quintín is located on the Pacific coast of northwestern Baja California, about 300 km south of the Mexico-USA border, in the Municipality of Ensenada, Baja California, Mexico. It is the largest and the most important coastal wetland of the state of Baja California, the largest Mediterranean coastal wetlands in México and includes the most unaltered coastal salt marshes in the Californian region. It was recently designated as a Ramsar site. It covers more than 10,000 acres and is dominated by eelgrass (*Zostera marina*). Marine habitats also include salt marshes, channels, sand dunes, barrier beaches, and mudflats (40 % is exposed during low spring tides). The bay habitats are surrounded by coastal sage scrub mixed with desert scrub, and agricultural fields. Aquaculture of bivalve mollusks (especially Japanese oyster [*Crassostrea gigas*]) has been the main economic activity onsite since 1976. Other activities include: extraction of volcanic rock from the cinder cones; saltworks, sport, and artisanal fishing, and Black Brant hunting. These are allowed and regulated in the area. There is also intensive agriculture in the adjacent deltas and coastal plains.

Shorebird Use: A 1992 ground survey documented 31,925 migratory shorebirds for this wetland (Page et al. 1997). It is considered a key wetland for shorebirds in Mexico and it was designated as a WHSRN site of Regional Importance. Of the 31,925 migratory shorebirds 86% were in Bahía San Quintín, 4% in nearby salt ponds, and 11% at Laguna Figueroa. Marbled Godwits, Willets, and Long-billed Curlews made up 96% of the large species, dowitchers and Black-bellied Plovers 91% of medium species and Western Sandpipers and Dunlins 89% of small species. This site provides habitat for important breeding populations of several species or subspecies of birds that are threatened or endangered including Snowy Plover.

Monitoring: Two pilot surveys conducted by CICESE in December 2011 and January 2012. PRBO and CICESE developing specific design for December 2012.

Survey Coordinator: Eduardo Palacios; Centro de Investigación Científica y de Educación Superior de Ensenada, B.C. (CICESE); epalacio@cicese.mx

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APPENDIX II:

PROTOCOLS

Area Search Protocol for Surveying Shorebirds in Coastal Estuaries

***PLEASE READ:** The usefulness of data collected as part of these surveys requires that all observers closely follow the protocol outlined here. Please read the protocol and associated documents (area description(s), map(s), and data forms) thoroughly before conducting a survey. If you have any questions, please contact your site coordinator or Khara Strum (kstrum@prbo.org). Thank you in advance for your hard work and enthusiasm for birds.*

PURPOSE

These surveys are designed to obtain data on annual variation, long-term trends, and habitat associations of wintering shorebirds in coastal estuaries. These data will also be combined annually with shorebird survey data from across the Pacific Flyway to assess spatial and temporal patterns of shorebird abundance at a scale larger than individual coastal sites. The following protocol should be followed to allow for standardized data to be collected at all survey sites across the Pacific Flyway.

SURVEY DESIGN

These surveys consist of searching a set of pre-defined survey areas, preferably defined based on habitat, within an estuary for shorebirds and recording the abundance of each species. Surveys are conducted during tidal conditions that allow all species within the sampling unit to be identified to species (i.e., birds are not too far away to be accurately counted; preferably <200m) but BEFORE birds move to roosting locations. The optimal tidal conditions that satisfy these criteria may vary among estuaries, but each survey of the same estuary should occur during the SAME tidal conditions each year. Surveys will be conducted once annually during the survey window (November 15 – December 15) at optimal tidal conditions, and all surveys within the same estuary should be conducted during the same tidal window on the same day. For large estuaries, the exact timing of the survey at specific locations within the tidal window may vary. We recommend careful evaluation of the tidal conditions that will be optimal for conducting surveys before finalizing a protocol for long-term monitoring.

IMPORTANT THINGS TO REMEMBER

- **Plan Ahead:** Tidal estuary shorebird surveys should occur only within the time window where the tide is optimal and should be coordinated across the estuary. Because factors on the day of the count (e.g., wind, atmospheric pressure) may influence tidal height and timing, please try to be at your area slightly before the predicted start time to ensure adequate time to complete the survey.

- **Inclement Weather:** Surveys should not be conducted in weather with winds >24 mph (>5 on scale below), heavy fog (<200m visibility), or steady rain.

- **Observers:** Under most conditions, surveys should be conducted by one observer. Having multiple observers counting simultaneously may bias results. We recommend working in pairs where one person counts birds and a second person records data. In large areas or areas with large numbers of birds, additional observers should split the count effort to enable completion of the count in the allotted tidal window. The total number of observers (people counting) should be listed on the data sheet and entered into the California Avian Data Center (CADC).

- **Pre-survey scouting:** If possible, we urge you to visit your survey area prior to the day of the survey so you are certain how to easily access the area and the best strategy for covering the survey area.

- Please refer to accompanying datasheet along with this protocol.

SURVEY PROTOCOL AND DATA COLLECTION

Begin each count of a survey area by indicating the **Start Time** on the datasheet (24-hr clock; e.g. 3PM = 1500). Then move around, as needed, to count and identify to species all shorebirds using each survey area. For a bird to be considered "using" the survey area, it needs to be on the ground within the defined survey area for at least part of the time it takes to do the survey. Thus, birds that fly over the survey area but do not land in it should <u>NOT</u> be counted. For estuaries where only a sample of the estuary is counted, <u>count birds that enter or leave</u> the survey area during the count but try not to double count birds if they leave and then re-enter the survey area. For estuaries where the entire estuary is being surveyed simultaneously, efforts should be made to reconcile bird movements among the survey areas so that birds are not double counted. Also, record the number and species of <u>raptors</u> that are in, perched adjacent to, or soaring over the survey area.

Use the **Tally** column to keep track of the number of individuals of a given species as you move around the survey area. The total number of each species observed during the count of each survey area should be entered into the **Total** column, regardless of whether you track sub-tallies in the **tally** column for each species (see www.prbo.org/pfss for recording tips).

Once all birds in the survey area have been recorded, the count is considered complete. At that point, the **End Time** should be noted on the datasheet and thereafter <u>NO</u> additional birds should be recorded for that survey area.

<u>NOTE</u>: Site coordinators should match the number of observers with the size of the survey area and the expected number of birds in that area, so that the count can be completed within the optimal tidal window.

It usually will be possible to make exact counts of small groups of birds (<50 individuals), but estimation may be needed for larger flocks. However, it may not be possible to identify a few or, sometimes, even large numbers of shorebirds because of poor lighting, quick or distant views, similarity of species, or other factors. Try to count or estimate numbers by whatever technique works best as listed here in order of preference (also see tips on how to estimate flock size at www.prbo.org/pfss):

- Identify species and their abundance (i.e., 148 Western Sandpipers, 153 Dunlin, 308 Least Sandpipers)

- Estimate the proportion of species in flock and use the proportions and total flock size to calculate the total of each species (i.e., 600 birds: 25% Western, 25% Dunlin, 50% Least = 150 Western, 150 Dunlin, and 300 Least). **Note**: only do this calculation if you are confident the proportions are accurate. Please use a mixed-species code if necessary (see next bullet).

- Estimate size of flock and species present (i.e., 600 birds, composed of Western Sandpipers, Least Sandpipers and Dunlin in unknown proportions). Please see the species list at the end of the protocol for commonly recorded mixed-species flocks.

Following bird observations in each survey area, please fill out the remainder of the datasheet completely, including the **Date** (mm/dd/yyyy), **Observer(s)** who counted birds (full name[s]), and **Site Conditions** (see below). Data should be recorded on a separate datasheet for each unique **Survey Area,** which is assigned a specific ID code. Survey area ID codes are found on the survey area map.

Please fill out a datasheet and record weather and habitat conditions for each survey area using the following codes. Please fill out site condition data **<u>even if no birds were detected in the survey area</u>**. These data will help us determine the total effort expended during each survey and the conditions that influence bird use.

SITE CONDITIONS

WEATHER

<u>Wind speed (**Wind**):</u>

**Do not conduct surveys when wind speed is >24 mph (category 5 below).*

0 – *calm*: smoke rises vertically (<1 mph)

1 – *light air*: smoke drifts (1 – 3 mph)

2 – *light breeze:* felt on face, leaves rustle (4 – 7 mph)

3 – *gentle breeze*: leaves and small twigs in constant motion (8 – 12 mph)

4 – *moderate breeze*: dust, leaves, and loose paper rise up; small branches move (13 – 18 mph)

5 – *fresh breeze*: small trees sway (19 – 24 mph)
6 – *strong breeze*: large branches in motion (25 – 30 mph)

Cloud cover (**Cloud**):
**Indicate the percent of sky covered by clouds*
Enter numeric percentage (0 – 100)

Precipitation (**Precip**):
** Surveys should not be conducted in steady rain but if the survey is conducted despite some rain please record 3*
0 – none
1 – light intermittent; mist, sprinkle, drizzle
2 – fog
3 – steady rain

HABITAT
Cover Type (**Type**):
** Record the dominant cover type(s) in the survey area, i.e., any habitat that comprises at least 40% of the area. If no cover type is ≥40%, please describe the composition of cover types in detail in the notes section of the datasheet.*

1 – *Wetland*: open water with tules, cattails, and some grasses and sedges.
2 – *Rice:* flooded or dry field with clearly defined internal levees; if dry, the field may be tilled or have standing stubble.
3 – *Pasture*: predominantly grasses; if irrigated it will be green year round.
4 – *Hay*: various types of grass/herbs mowed and cured for fodder.
5 – *Irrigated Row Crop:* likely dirt field with raised beds or with standing stubble (e.g. corn, tomatoes, cotton)
6 – *Winter crop*: emergent green vegetation from tilled soil (e.g. winter wheat)
7 – *Freshwater Lake / Pond*: large body of freshwater including reservoirs
8 – *Evaporation Pond*: settling pond constructed to collect agricultural wastewater
9 – *Wastewater Pond*: pond associated with wastewater treatment facility
10 – *Orchard:* trees (e.g. almonds, apples etc.)
11 – *Forest*: extensive woody vegetation, non-agricultural (e.g. willows in riparian)
12 – *Developed*: houses, cemetery, parking lot, etc.
13 – *Salt pond:* impounded water without vegetation around an estuary
14 – *Tidal marsh:* tidally flooded marsh with vegetation
15 – *Tidal flat:* areas of exposed mud below high tide level with <5% vegetation cover
16 – *Beach*
17 – *Rocky shoreline*
18 – *Agriculture field* (non-orchard) includes categories 3, 4, 5 and 6 from above. Use this category only when unable to determine a more specific field type.

19 – *Open Bay*: open water within bay or estuary
20 – *Diked Salt Marsh:* muted or non-tidal salt marsh
21 – *Levee*
22 – *Islands*
99 – *Other*: describe in notes

Tidal Conditions (**Tide**)
**Each coastal estuary site should be surveyed under the same tidal conditions each year. However these may vary due to weather conditions. Please record you best assessment of the tidal conditions at your survey area.*

1 – high
2 – almost high, and rising
3 – almost high, and falling
4 – half tide, rising
5 – half tide falling
6 – almost low, rising
7 – almost low, falling
8 – low
9 – not observed, not applicable, or observations made during more than one of these periods.

Area Surveyed (**Visible Area**):
**Because wintering shorebirds can only be detected through visual observation, visual obstructions (e.g. levee, tall vegetation, distance) may limit your ability to survey some portions of the survey area from the survey location.*

Percent of the survey area you could see and subsequently count.
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

The following 3 variables (PercFlood, PercBare, PercVeg) should sum to no more than 100.

Percent of visible area with open standing water (**PercFlood**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Percent of visible area with bare ground (**PercBare**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Percent of visible area with vegetation (**PercVeg**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Vegetation Height (**VegHt**)
**Visual estimate of the average vegetation height in the visible survey area. If the survey area is flooded, estimate the height of the vegetation emerging from the water.*

0: Bare
1: 1 – 6 in.
2: >6 – 12 in.
3: >12 – 18 in.
4: >18 – 24 in.
5: >24 in.

WHAT TO TAKE IN THE FIELD:

Site Map(s)	Protocol
Datasheets	Permit (if applicable)
Species list	Pencils or Permanent Ink Pen (≥2; NO ballpoint pens)
Binoculars	Scope and tripod
Watch	Sunscreen
Water	Field guide
Clip Board	

DATA ENTRY
Data should be entered directly into CADC within a few days of the survey. If you have not registered for a CADC account please see http://www.prbo.org/pfss for instructions on how to register with CADC and enter data.

SHOREBIRD SPECIES IDENTIFICATION
View or download instructional shorebird identification materials at PRBO's website: http://www.prbo.org/pfss/.

TIPS FOR COUNTING SHOREBIRDS

This document includes information to help with identifying shorebirds, counting multi-species flocks, counting techniques, keeping track of where you are, and handling field difficulties. Because most non-breeding shorebirds occupy unvegetated or sparsely-vegetated habitat in which they can be easily observed, the accepted method of estimating their abundance in an area is to count them directly through visual observation. This requires that a person conducting an area survey (an observer) possess two important skills, in addition to being familiar with the survey protocol: (1) the ability to ***readily*** identify all species likely to occur in the area, and (2) the ability to count the number of each species present.

Identifying Shorebirds. Attending field trips led by experienced observers is a good way to learn shorebird identification; these are often offered by local Audubon, natural history societies, colleges, adult education programs, and PRBO Conservation Science (see http://data.prbo.org/partners/pfss/). Practicing on your own with one of the many good field guides available is essential to honing your skills. If you are a beginner, ultimately, you will need to go out with an experienced observer to validate your identification skills. Observers must develop a slightly different set of skills than casual bird watchers because they are counting all the birds in an area, not just those that are conveniently near or well lit for viewing. You may need to identify shorebirds that are in silhouette, shorebirds that are tightly packed in a roosting flock, or very large numbers of shorebirds in mixed flocks. You need to be able to identify them fairly rapidly, before they have a chance to move or fly; this is particularly an issue where raptors are active. Familiarity with the subtle differences in the shape, posture, behavior, and coloring between species is invaluable during a census.

Counting techniques. Direct counting is useful for low numbers of birds, and estimation is essential for large flocks. Some techniques involve a combination of counting and estimation. It is not unusual in the middle of a census to have shorebird flocks fly up, circle in the air, and land again; they may land where they previously arose, may land to join a nearby flock, or may leave the immediate area. Rising or falling tide levels, human disturbance, and raptors in the areas may cause this to happen multiple times during a census. In order to obtain counts before flock movement causes you to have to start counting over again, you need to balance the need for highly refined counts with the need to complete the count quickly.

For fewer than 50, or widely scattered, shorebirds you probably will count individual birds. This may not be the most accurate count method for large flocks because of flock movement. With larger flocks, you should start at one side of the flock and count 5, 10, 20, or 50 shorebirds at a time. Once you have a good idea of what, say, 20 birds look like in that flock, you can count the remainder of the flock in groups of 20 birds. For very large flocks, it may be necessary to count in much larger multiples. After you have conducted many surveys you will hone your ability to quickly estimate group sizes of birds.

However, it always is useful to count out bird groups in the beginning of each survey, as a defense against developing estimating biases.

Counting shorebirds in multi-species flocks. When beginning a survey of shorebirds at a site you must quickly decide whether to count all the birds together or scan the flock successively for each species present. With experience you will learn which method is most efficient for you, given the abundance, species composition, and dispersion of the shorebirds. Mixed species assemblages may be present as two or more species in relatively equal abundance, as predominantly one species with a few uncommon species, or some combination. We recommend having a recording assistant to whom you can enumerate the uncommon species as you maintain a running count of the most common species while you scan the flock. With experience, you may learn to count more than one species simultaneous as you are scanning or you may develop your own technique for handling multiple species counts.

Keeping track of where you are is essential when you are conducting a survey. Few areas can be covered from a single vantage point and you will have to move between points to count all birds. It often is difficult to relocate where you left off counting from a new vantage point, so think about all possible clues you will be able to use from your next location. Geographically distinct points in the wetland or background habitat (think about what it will look like from your next vantage point), a break in the flocks, or an individual of an uncommon species can be used to mark where you have left off counting. Move quickly to the next vantage point, locate where you left off, and begin counting.

Recording shorebird counts in the field involves counting multiple species, keeping track of where you are in the flock, and writing it all down. The way you keep your written field records will determine how difficult it is to tally a final count afterwards. On a separate handout (“PFSS_RecTips.pdf”), there are some tips on recording your data in the field. However, to minimize recording errors it is best if a second person can serve as the data recorded.

Some other techniques you may find useful:

- Obtaining an initial impression of the numbers of shorebirds you will be counting can be very useful if a survey is interrupted because the birds have flown out of easy viewing range. When you first arrive at a viewing location, make on-the-spot order of magnitude estimates of the numbers of at least the most abundant species.
- Order of magnitude estimates (OMEs) can be based on powers of ten, using arithmetic divisions of low, mid, or high ranges. With this method, if there were more than 9 but fewer than 100 shorebirds, you would estimate either low tens (10-39), mid-tens (40-69), or high tens (70-99); estimates are similar for low, mid, or high hundreds (100-399, 400-699, 700-999), thousands, and so on.
- If you are training or refreshing yourself in counting methods, you might make OMEs first, then count the birds you’ve spot estimated, to check and refine your estimating accuracy.

Tally your survey total for each species, on the day you conduct the survey. If there are any uncertainties or errors in what you wrote in the field, you will best be able to decipher or catch them when the survey is fresh in your mind. See “PFSS_DataEntry.pdf”.

TIPS FOR RECORDING COUNTS IN THE FIELD

Version 2 - September 22, 2010

Be sure that the way you record shorebird counts in the field doesn't confuse you when you tally the final counts afterwards. Here are some commonly used recording techniques that you can try to keep your notes readable when you are hurriedly trying to get it all down on paper.

For species that occur in large flocks, counts of birds are commonly recorded as numbers separated by a "+" or a "," or blank space:

225 + 48 + 677 + 32 OR 225, 48, 677, 32 OR 225 48 677 32

When you record this way, be sure that commas are distinguishable from "1"s, plus signs cannot be mistaken for numbers, and that blanks are wide enough to unambiguously separate numbers.

For species that are counted in smaller multiples, symbolic recording techniques may be helpful. Below are two that are commonly used. If, for some species, you use both numbers and symbols, physically separate them on the recording sheet.

❶ Most people are accustomed to crossed slashes for tallying in groups of 5, where:

1 = I 2 = II 3 = III 4 = IIII 5 = ~~IIII~~

You can take shortcuts with this method. For example, if you have already tallied two (II) and you next see three, you could simply cross the vertical slashes (~~II~~), knowing that every horizontal slash indicates 5, even if it crosses fewer than 4 verticals. We use the X (Roman numeral) symbol within this system to indicate 10, and C to indicate 100. ***Do not intersperse this symbolic method with regular numbers***, where eleven is indicated as 11 (use X I in tally form) or one hundred eleven as 111 (use C I in tally form).

❷ Ten birds also can be accumulated with a symbolic combination of dots and connecting lines. You keep adding them till you have an X inside a box. The first through the fourth birds are indicated by dots at the four corners of a square: 1 = . 2 = . . 3= : . 4 = ::

The next four birds are indicated by connecting the dots: 5= I : 6 = I I 7 = Π 8 = ☐

The ninth and tenth birds are added with the two diagonal slashes to create an X within the box (**%** and ☒).

CALIFORNIA AVIAN DATA CENTER

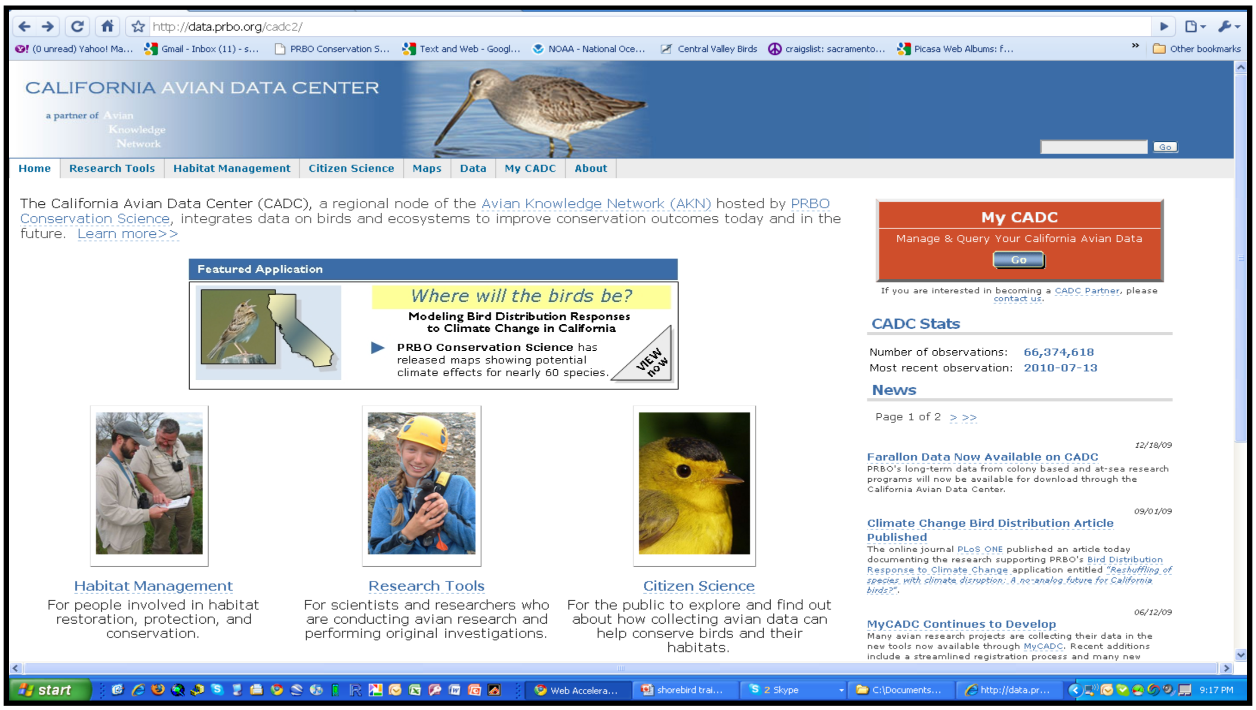
REGISTRATION & DATA ENTRY

October 1, 2010

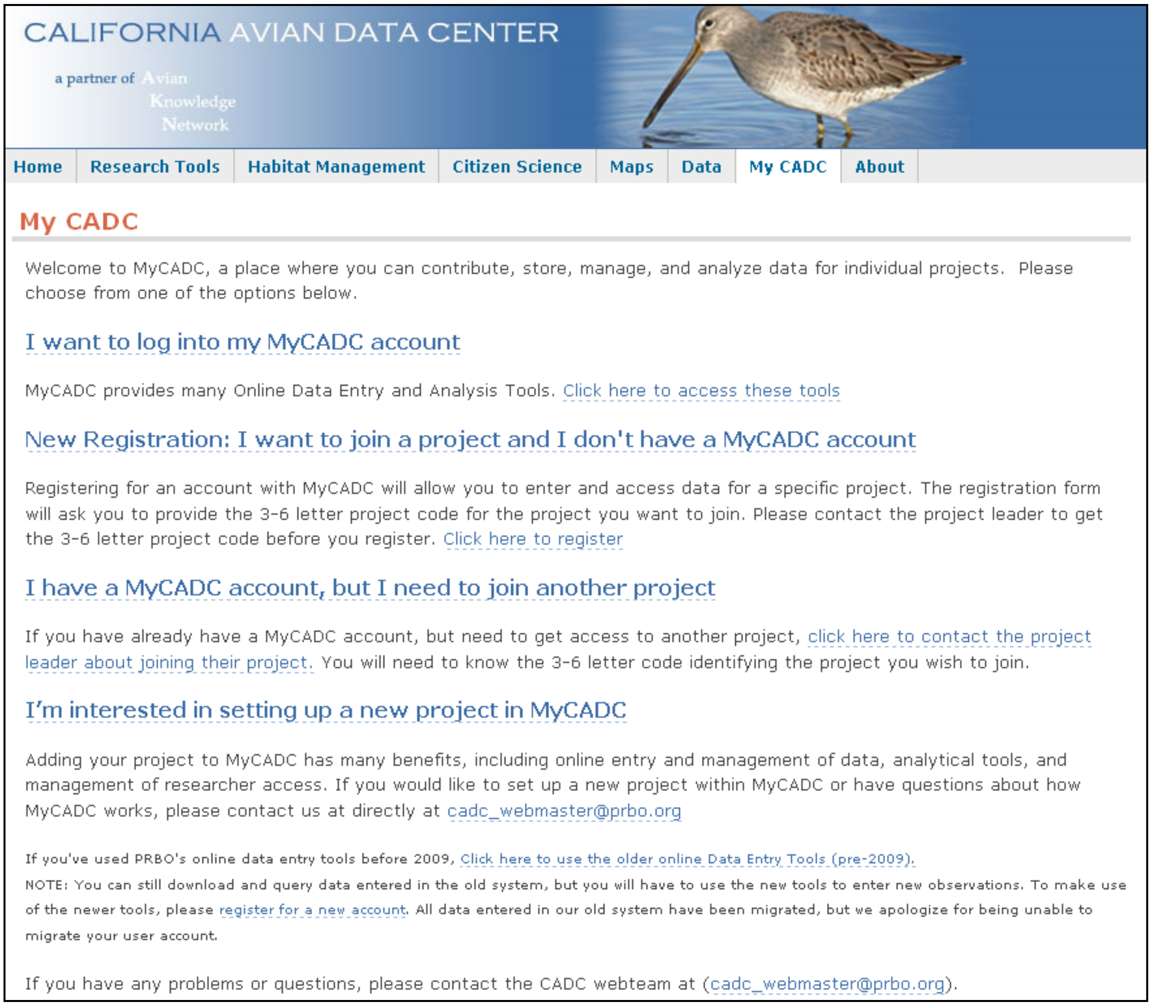
TO REGISTER

First time users must first register and create and user name and password.

1. Go to www.prbo.org/cadc
2. Click on the blue "**Go**" button in the red box in the upper right hand part of the page.



3. Select the appropriate selection on the next screen (below). Most will select "New Registration: I want…". However if you already have a MyCADC account you may join additional projects by selecting "I have a MyCADC account, but…".



4. Enter the information requested on the following page.

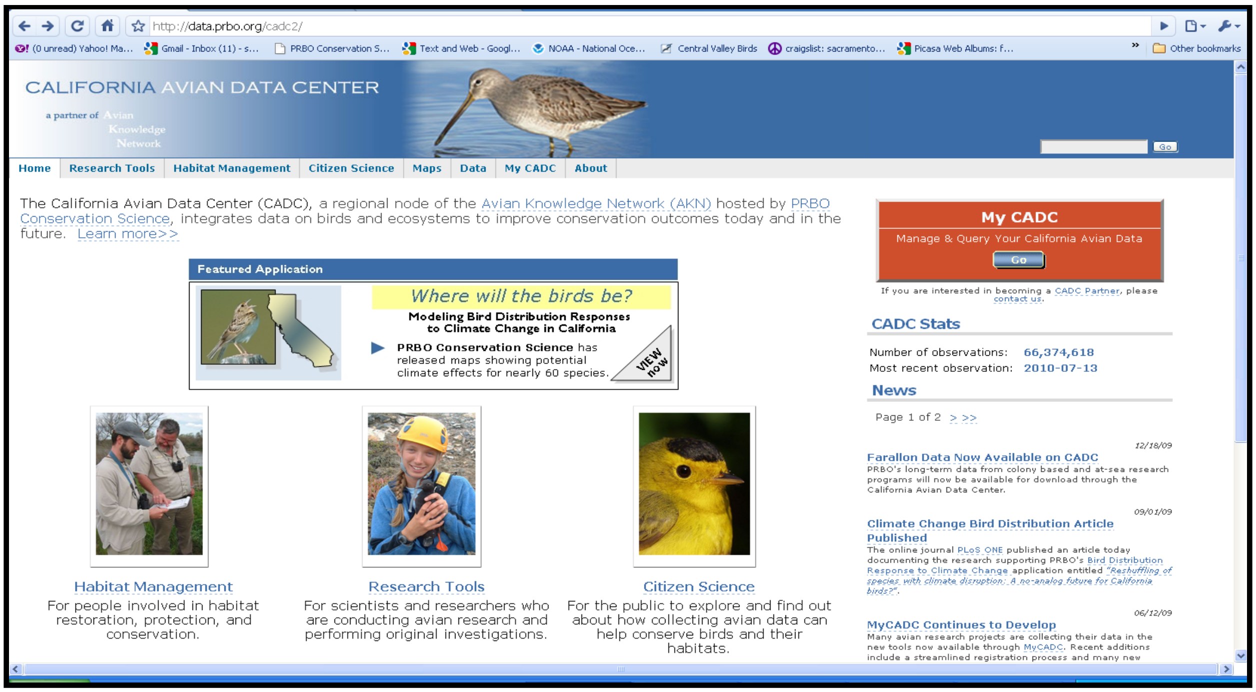
*****Note:*** In Step 5 of the registration process when asked "Please enter the project you would like to join", enter **(*Project code here*).**

After completing the registration page, an email from "no-reply@prbo.org" will be sent to the email account you entered. You will need to click the link provided in the email in order to complete your registration. The link will expire in 24 hours and you will have to re-register. If you do not receive your confirmation email promptly, check your junk or spam folder. After checking your spam folder, if you did not receive an email from no-reply@prbo.org please contact CADC help at "cadc_webmaster@prbo.org" with your name and email address used to register.

TO ENTER DATA:

A. Log-In

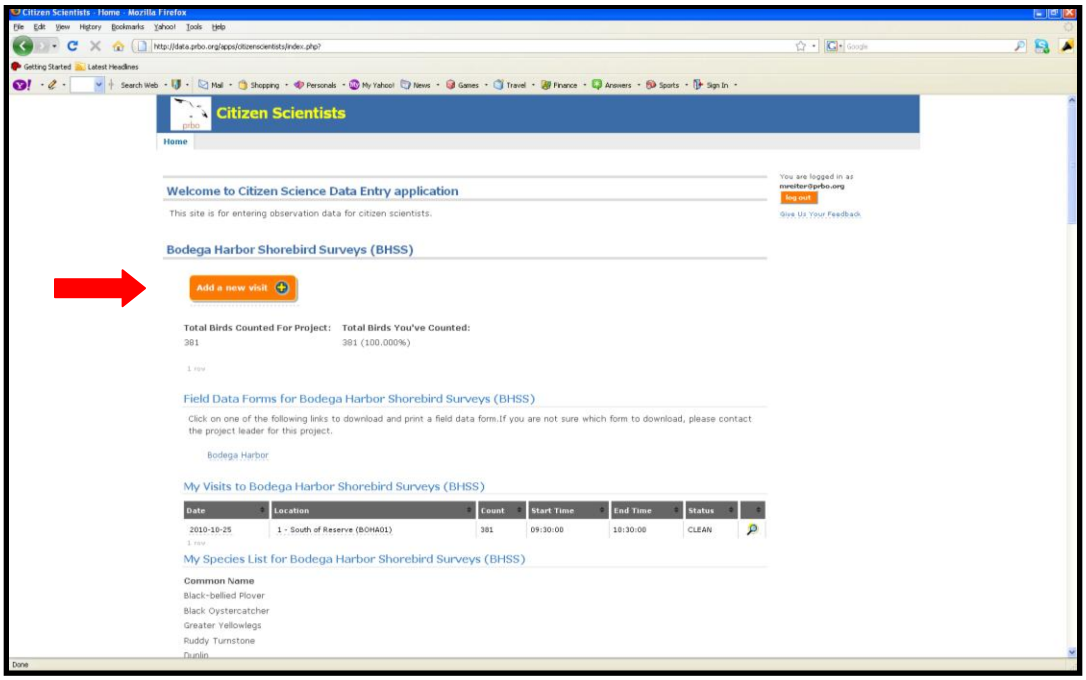
1. Go to www.prbo.org/cadc
2. Click on the blue "**Go**" button in the red box in the upper right hand part of the page (see below).



3. Next page, click on the link that says I want to log into MyCADC account
4. Next page, click on the link that says Citizen Scientists
5. Next page, enter email address and press enter
6. Next page, enter your password and press Log On

B. Select Project

Once you are logged-on, all the projects that you are associated with will show-up on the screen (see below.)



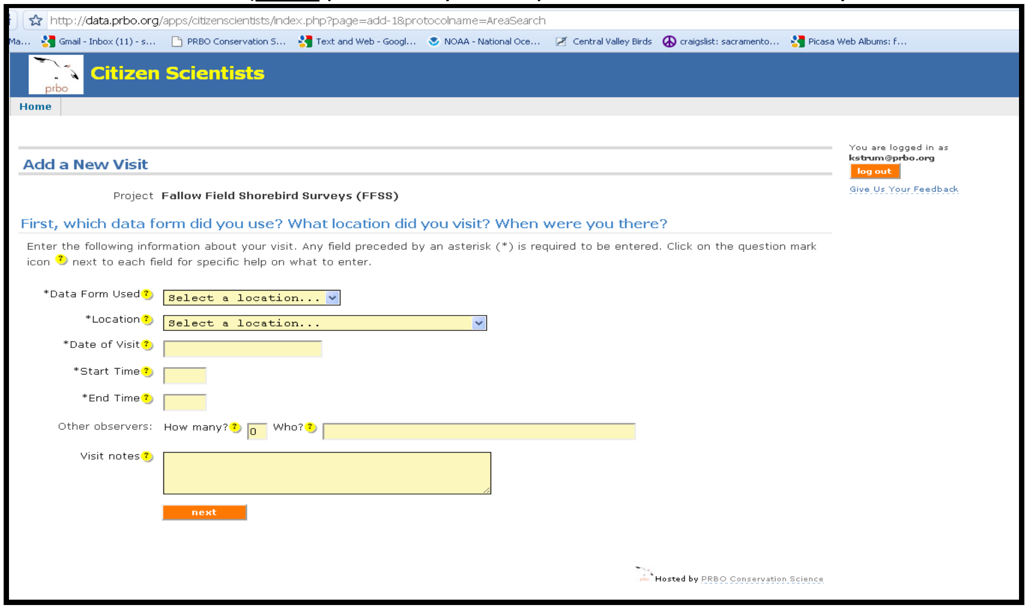
To enter new data click on the "**Add a new visit**" button (in orange above) that is associated with the project for which you want to enter data.

<u>Note:</u> Each survey point or survey area should be recorded on a separate data sheet and should be entered separately as a new visit.

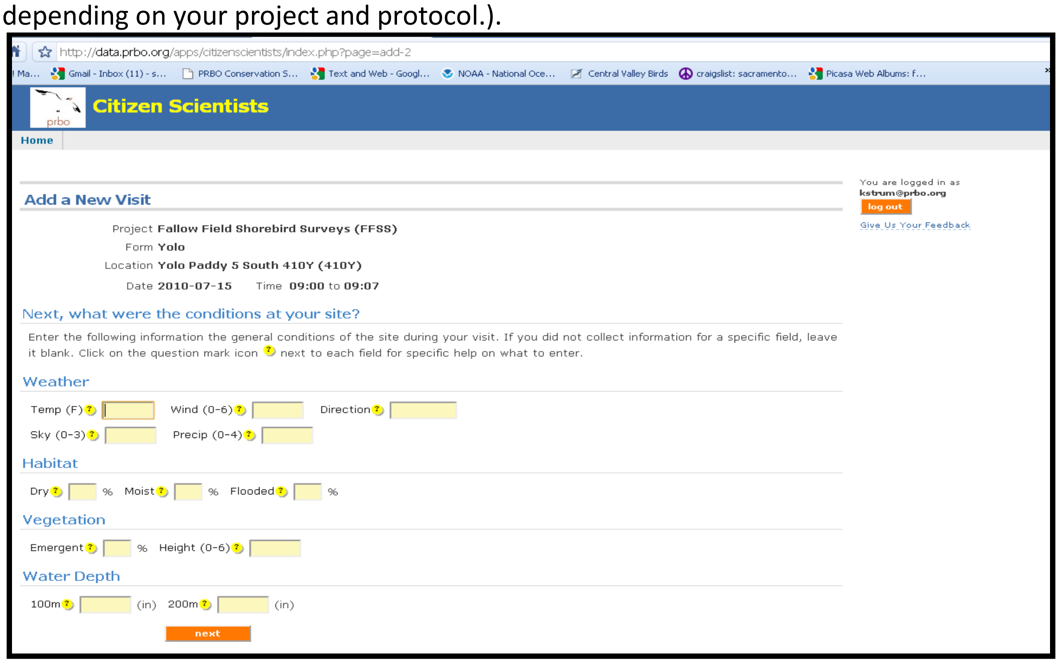
C. Enter Data

There are 3 data entry screens for getting PFSS data into CADC.

1. “Where did you survey? When did you survey? Who did the survey?” screen. The fields on this screen should match the fields on your data form. After filling in the fields press “**next”** at the bottom of the screen (**<u>note:</u>** press the yellow question marks next to any field to obtain help).

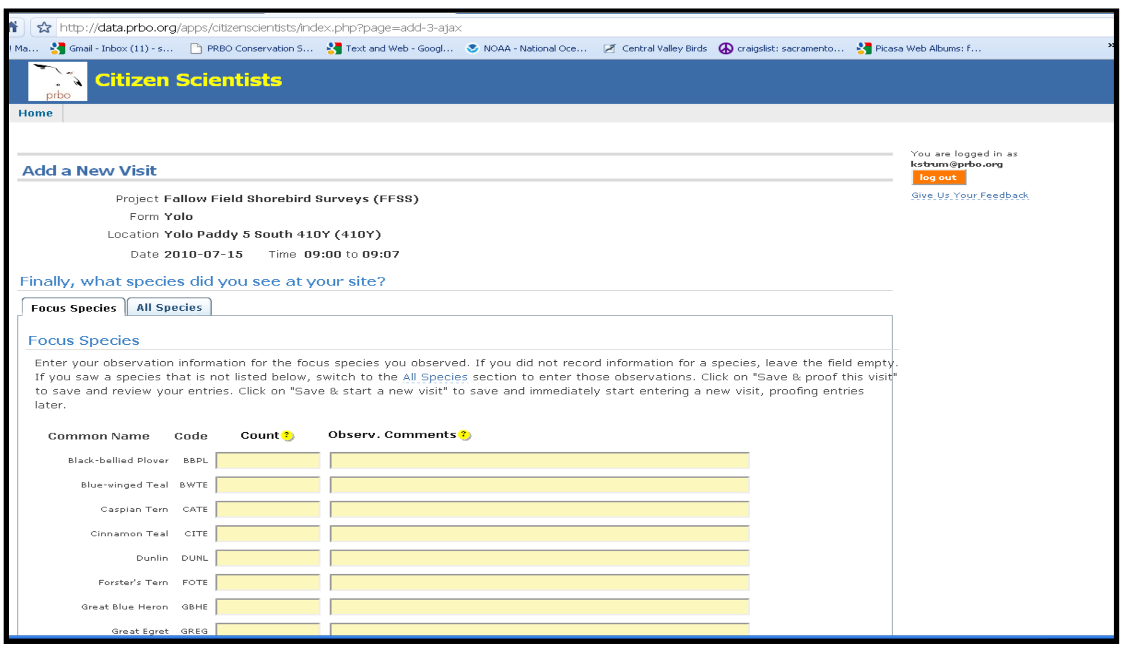


2. “What were the conditions at your site?” screen (below). The fields on this screen should match the fields on your data form and be described in the survey protocol. After filling in the fields press “**next”** at the bottom of the screen (**<u>note:</u>** fields may different than the example below depending on your project and protocol.).



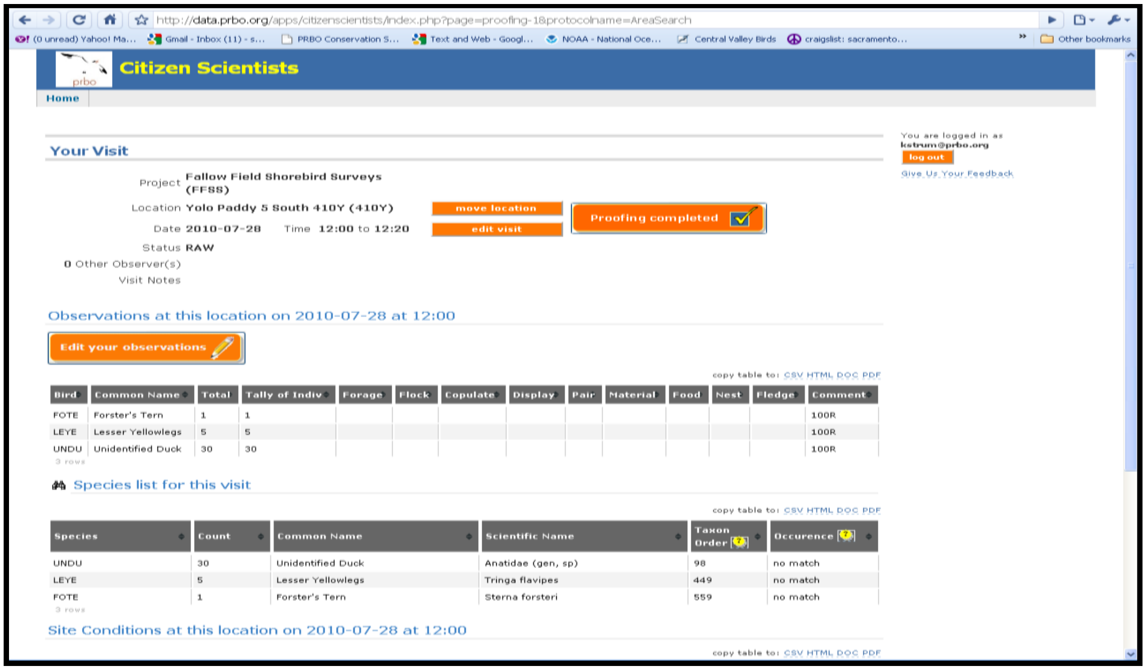
3. "Finally, what species did you see at your site?" screen (below).

a. The "**Focus Species**" table contains the large majority of species that you will see on your surveys.
b. Enter the "Count" for each species from your data sheet.
c. You do NOT need to enter "0" for species you did not see.
d. If you saw no birds at a survey site scroll to the bottom of the species table and press the orange "**No species observed Save & proof this visit**" button.
e. If a species does not appear in the Focus Species table, use the "**All Species**" tab to enter data for species not listed in the table.
    a. Enter the name of the species in the provided space.
    b. Select the correct four-letter code from those listed and that match those in "PFSS_SpeciesList.pdf"
    c. Enter the "Count" for each species
    d. Press "**next**" before moving on the next species OR before switching back to the "Focus Species" table
f. You can use the Focus Species and All Species tables interchangeably to enter data. However, please only enter data for species within the guilds listed in the project protocol and the project species list (i.e. do not enter gulls or terns.)
g. Once you have entered all the species detection data press "**Save and Proof this Visit**"

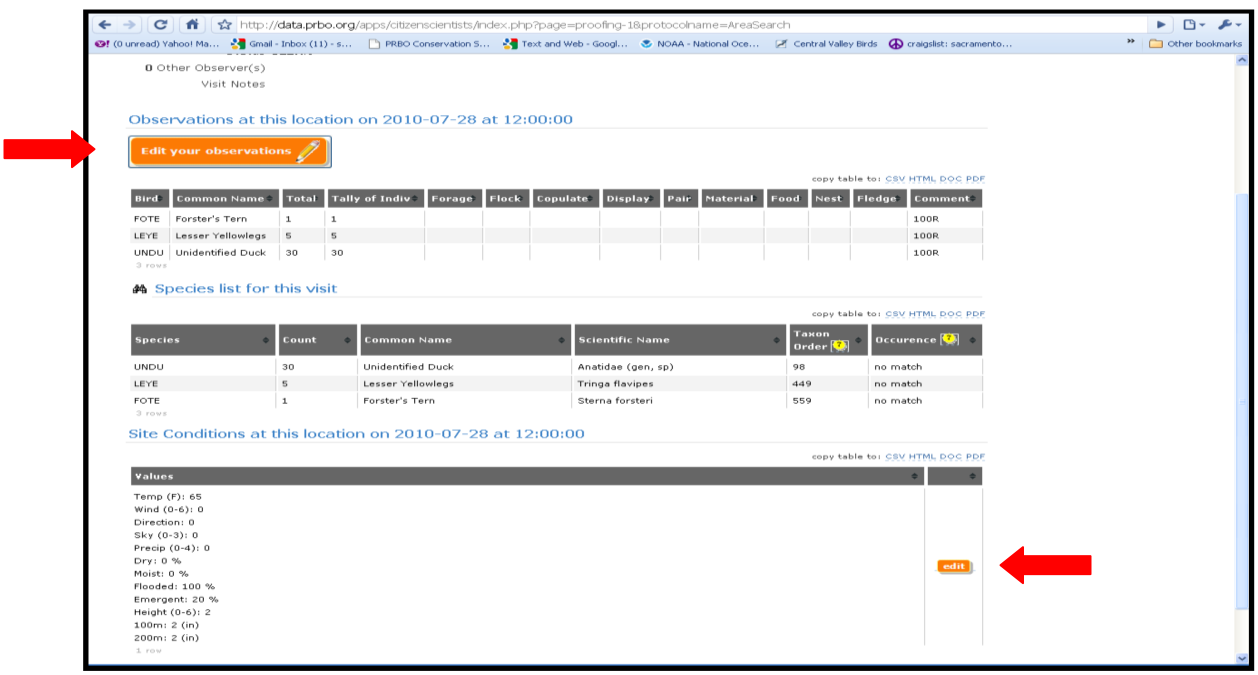


D. Proof Data

After clicking "**Save and Proof this Visit**" you should be taken to the following screen:



You must proof the data you entered in order for it to become part of the database. Look carefully through the data you entered and compare it to the data on your datsheet. If you note inconsistencies between your datasheet and what appers on the screen, follow the steps beginning with Step 1 below in the "Editing Data"section.



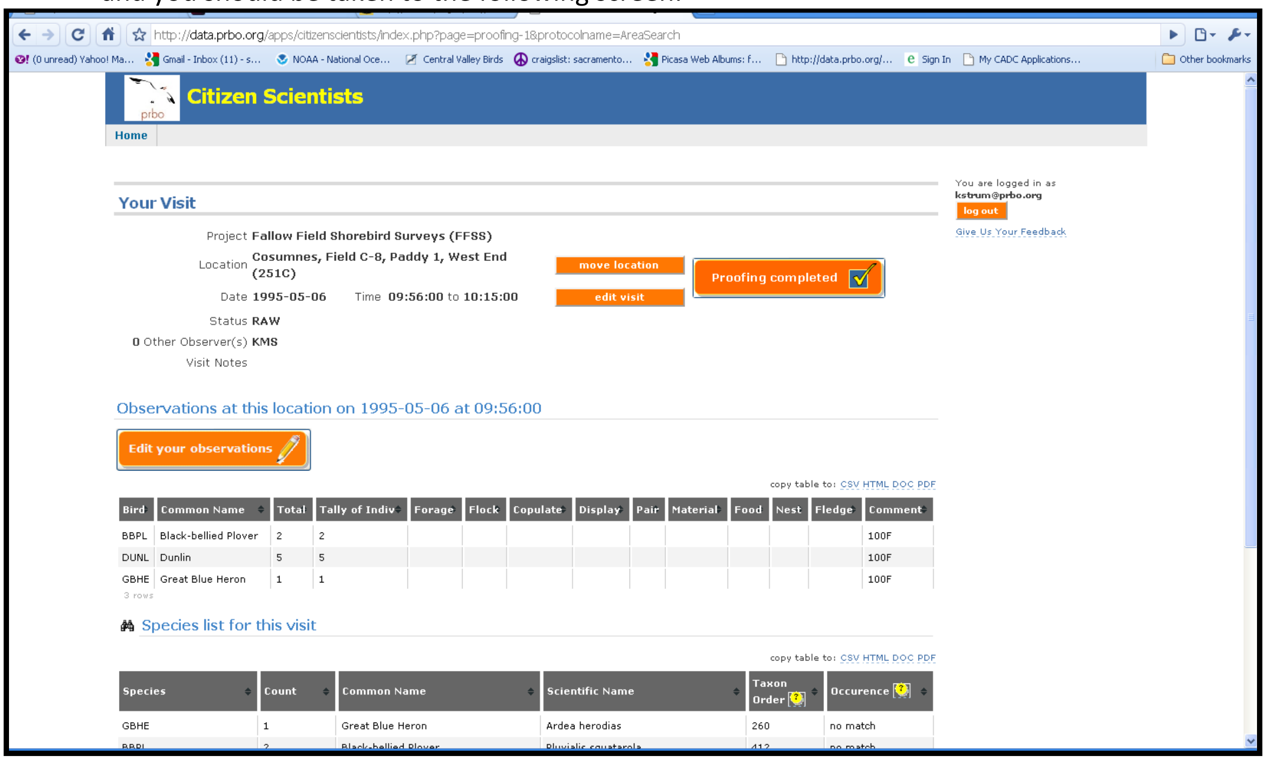
When you are finished proofing make sure to click on "**Proofing completed**" at the top of the page.

<u>Go back and follow each step to enter data for the rest of the survey points or areas.</u>

E. Edit Data

After you enter your data you may be asked to make corrections or you may realize you have entered something incorrectly. Each section of data (site condicitons, dectections, etc.) has a unique place for editing data.

1. To edit your data, log on into CADC (see **A. Log In** above).
2. Click the magnifying glass  next to the observation in the project that you would like to edit and you should be taken to the following screen:



3. To edit the ***Location*** click "**Move Location**". Choose the correct location for the observations and then click "**Move**".

4. To edit the ***Visit Information*** (Date, Start Time, End Time, Observers, Visit Notes) click "**Edit Visit**". <u>Make sure to click "**Save**" when you are finished editing your data.</u>

5. To edit your ***Observations*** (Species, Number, Comments, Add new species) click "**Edit your Observations**". On the following screen, click on the data to activate the table. If you want to add an additional species, enter data in a blank field and click "**Next**". <u>Make sure to click "**Save & Proof this Data**" when you are finished editing your data.</u>

6. To Edit ***Site Conditions*** (e.g. Weather) click "**Edit Site Conditions**". Make sure to click "**Save**" when you are finished editing your data.

7. Finally, when you are finished editing your data click "**Proofing Completed**"