The San Francisco Bay Joint Venture Monitoring & Evaluation Plan

MEASURING CONSERVATION DELIVERY EFFECTIVENESS IN AN EVOLVING LANDSCAPE

Phase I - Section IV: Shorebirds and Waterbirds

Developed by the San Francisco Bay Joint Venture Science Subcommittee

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San Francisco Bay Joint Venture (SFBJV)
735 B Center Boulevard
Fairfax, CA 94930
(415) 259-0334
http://www.sfbayjv.org
http://www.yourwetlands.org

The SFBJV Science Coordinator designed and compiled the information presented in this document section. She accepts the responsibility of accurately reflecting the information provided by all participants.

Please direct correspondence to: Christina Sloop, Ph.D.
SFBJV Science Coordinator
707-334-3174
csloop@sfbayjv.org

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IV. Status & Trends - Shorebirds & Waterbirds

Located on the Pacific Flyway, the San Francisco Bay (SFB) Estuary is a vital breeding, stopover and wintering area for a variety of wetland birds. Besides Alaskan coastal wetlands, the SFB hosts the highest proportions of total wintering and migrating shorebirds on the US Pacific Coast (Page et al 1999, Stenzel et al 2002, Kushlan et al 2002). The San Francisco Bay Joint Venture (SFBJV) region wetland and shoreline habitats are thus critical for shorebird, and important to other waterbird (including herons, rails, terns, gulls, and other wetland dependent birds (hereafter "waterbird") conservation. However, habitat loss and degradation top the list of the most likely causes of recent shorebird and waterbird population declines in North America. Moreover, the impacts of climate change are projected to add even more challenges for these wetland-dependent bird groups

The Southern Pacific Shorebird Conservation Plan (Hickey et al 2003), and the North American Waterbird Conservation Plan (NAWCP, Kushlan et al 2002) outline that monitoring shorebird and waterbird populations and habitats regionally and across the continent is required to determine conservation status, detect population trends, assess health of habitats, and indicate whether environmental changes and management prescriptions are affecting these birds. Both plans advocate partnerships in which participants work together to obtain the information necessary for shorebird and waterbird conservation. The goals for such monitoring partnerships include promotion of centralized data storage and management, generating standardized survey methods, establishing statistically valid and logistically feasible sampling schemes tied to hypotheses, building standardized models for analyses of data, and identifying and filling gaps in existing continental shorebird and waterbird monitoring programs.

The recently implemented Pacific Flyway Shorebird Survey, a broad-scale coordinated monitoring program for shorebirds and waterbirds in the Pacific Flyway, increases our ability to effectively evaluate habitat availability and function and manage populations (PFSS 2011). This provides a clear strategy to track population trends and to ultimately evaluate their response to changing habitat and environmental conditions at the landscape scale. Little information exists to date to link regional trends or habitat associations of most shorebird and waterbird populations to ongoing SFBJV restoration and enhancement efforts. Therefore, we need to link project-scale investigations throughout the SFBJV region with assessments of the entire Pacific Flyway. Broad scale and project-based surveys need to be conducted in such a manner that the contributions of SFBJV actions to regional shorebird and waterbird populations can be accurately evaluated. This will help to effectively set priorities for conservation, evaluate restoration effectiveness, and determine successful management techniques to ameliorate forecasted impacts from e.g., land use change and climate change.

This Monitoring & Evaluation Plan (M&E Plan) offers a critical opportunity for the SFBJV to coordinate local habitat conservation and bird monitoring partnerships, and simultaneously contribute to meeting the goals of regional and national shorebird conservation plans, and to national and international programs such

as the Waterbird Monitoring Partnership of the Waterbird Conservation for the Americas initiative (WMP), the Western Hemisphere Shorebird Reserve Network **(**WHSRN) and the Program for Regional and International Shorebird Monitoring (PRISM). The SFBJV will accomplish this by coordinating SFBJV partners in a multi-scale program to assess baseline estimates of local, regional and flyway-scale shorebird and waterbird population sizes, to detect population trends, and to monitor bird numbers at important stopover locations in the region. It will be important to integrate and build on existing and past efforts and to establish long-term monitoring schemes for shorebird and waterbird populations, especially for species of conservation concern.

The SFB is a designated site of hemispheric importance for shorebirds and annually supports over one million shorebirds (Page et al. 1999, Stenzel et al. 2002). It provides one of the most important staging and wintering areas on the Pacific Flyway for both wintering and migratory shorebirds (Page et al. 1999, Morrison 2001). However, habitats sustaining shorebirds and waterbirds are changing in the SFB estuary, as for example the ongoing conversion of thousands of acres of former salt ponds to a mix of managed ponds and tidal wetlands (Stralberg et al. 2006). Monitoring wintering, migrating, and breeding shorebird and waterbird relative abundance, density and distribution at project sites and throughout the estuary is crucial to assessing successes and impacts of these restoration activities on bird populations, and to inform restoration and conservation activities in an ongoing adaptive management context.

The monitoring of breeding shorebird and waterbird populations has been identified as a priority in the SFB area (PRBO 2004), and includes monitoring annual numbers, reproductive success, and survival of Western Snowy Plover, Black-necked Stilt, American Avocet, Forster's & Caspian Tern, and other species. The target list includes particularly those species dependent on habitat types that face the most imminent threats, or require long-term management such as maintenance of breeding islands within salt and managed ponds.

General shorebird- and waterbird-focused monitoring needs in the SFBJV region include:

- Consistent long-term monitoring programs aimed at resident, wintering, and breeding shorebird and waterbird species in the region that are incorporated into an active integrated regional monitoring partnership;
- Standardized monitoring methods for the region, that can feed into national and international monitoring efforts;
- An effective and efficient empirical appraisal of impacts of projected environmental changes on shorebirds and waterbirds to be used in vulnerability and predictive modeling and to inform future adaptive management actions at local and regional scales;
- Assessment of net change in wetland habitat extent and condition to evaluate the continued impact of SFBJV conservation delivery activities in supporting shorebird and waterbird populations in the context of projected environmental and land use changes (SFBJV 2001, see M&E Plan Net Landscape Change section);
- Use and promotion of a regional online metadata central repository for monitoring results for the region that links to data portals such as

CADC (California Avian Data Center, see: www.prbo.org/cadc), and the aforementioned national and international databases;

- Maximized integration of SFBJV monitoring efforts with existing national and international networks such as WMP, WHSRN and PRISM (of which the Pacific Flyway Shorebird Survey (PFSS) is a component) at Pacific Flyway and continental scales.

General Shorebird & Waterbird Habitat Conservation and Management Goals:

- Maximize shorebird & waterbird habitat extent[1]
- Maximize conditions that contribute to shorebird & waterbird abundance and species richness, breeding success, and survival;
- Maximize shorebird & waterbird biodiversity;
- Minimize negative impacts from human disturbance;
- Minimize occurrence of invasive or nuisance species;
- Maximize adaptation/resilience to projected climate change impacts

At this time, this Plan section is not designed to present a detailed monitoring program with schedules and protocols, data management specifics, and other concrete details. Instead it is to establish an overall framework that will provide general guidance to SFBJV partners in the assessment of habitat extent, and the status and trends of shorebird and waterbird species as indicators of habitat condition, and the effects of SFBJV conservation, enhancement, or restoration implementation actions at the project, regional and Flyway scales. More details will be developed throughout phase II of the M&E planning process (see *Next Steps* section below).

This Shorebird & Waterbird Section Currently Provides:

- A set of prioritized monitoring and evaluation objectives addressing general questions of habitat quantity, SFBJV contribution, population abundance and species richness trends of shorebirds & waterbirds at the project and regional scales within the SFBJV region

- A suite of prioritized and general recommendations for further research needs, monitoring and evaluation metrics, protocols, and data repositories for integration with existing monitoring and evaluation programs, as relevant to various target shorebird & waterbird species.

- Information on key partners and existing monitoring programs to integrate with or compare to.

Focus Team Process & Participants

In a series of in-person meetings and phone conferences, the shorebird & waterbird focus team established focus-specific M&E and research objectives, relevant metrics, protocols, and data repositories, key partners, and existing programs for potential integration. All M&E Plan focus teams convened on May 26, 2011 for a daylong professionally facilitated workshop to vet and identify the top priorities of the identified monitoring, evaluation and research objectives. Focus team participants include:

Name	Affiliation
Ackerman, Josh	US Geologic Survey
Allen, Sarah*	National Park Service
Borgman, Kathi	Richardson Bay Audubon Center & Sanctuary
Brand, Arriana*	US Geologic Survey
Demers, Jill*	San Francisco Bay Bird Observatory
Doster, Rob	US Fish & Wildlife Service - Migratory Bird Program
Herzog, Mark	US Geologic Survey
Page, Gary*	PRBO Conservation Science
Richmond, Orien	US Fish & Wildlife Service - Refuges Inventory and Monitoring Program
Sloop, Christina	*Team Coordinator*, San Francisco Bay Joint Venture
Strong, Cheryl	US Fish & Wildlife Service – Don Edwards SFB NWR
Wilcox, Kerry*	Richardson Bay Audubon Center & Sanctuary
Wood, Julian	PRBO Conservation Science

*Participated in prioritization of objectives at May 2011 workshop.

Focal Habitats & Species

Shorebirds and other waterbirds found in the SFBJV region are defined by their respective taxonomic classification shown in Table 4.1. The classification directly conforms to that outlined in the North American Waterbird Conservation Plan (NAWCP, Kushlan et al. 2002), exclusive of some listed seabird families (including gulls and terns), and families with species not found in this area, and the Southern Pacific Shorebird Conservation Plan (Hickey et al 2003).

Table 4.1: Shorebird and waterbird taxonomic groups addressed in the M&E Plan.

Shorebirds	***Waterbirds***
Family Scolopacidae Snipe, sandpipers, phalaropes & allies	*Family Ardeidae* Egrets, herons, bitterns
Family Haematopodidae Oystercatchers	*Family Rallidae* Rails**, coots
Family Recurvirostridae Avocets, stilts	*Family Gaviidae* Loons
Family Charadriidae Plovers	*Family Podicipedidae* Grebes
	Family Phalacrocoracidae Cormorants
	Family Pelecanidae Pelicans
	Family Laridae Gulls, skimmers, terns**
	Family Alcidae[1] *Auks, puffins*

*** Also addressed in Special Status Species section of M&E Plan*

Focal wetland types outlined in the SFBJV Implementation Plan (2001) include: tidal flat, tidal marsh, lagoon, beach, production salt pond, managed pond, storage/treatment pond, diked wetland, agricultural bayland, moist grassland, vernal pool complex, lake, creek, and riparian zone.[2] Table 4.2 below outlines habitats used by shorebird and waterbird species throughout the SFBJV region.

Table 4.2: Habitat types utilized by shorebird & other waterbird species in the SFBVJ region.

Shorebird Habitats		
Foraging	**Roosting**	**Nesting & Chick-rearing**
Tidal flats Tidal marshes Production salt ponds Managed ponds Lagoons Diked wetlands Beaches	Tidal flats - at low tide Tidal marshes Production salt ponds[3] Managed ponds[3] Beaches	Tidal marshes Production salt ponds[3] Managed ponds[3] Coastal beaches Shallow inland wetlands
Waterbird Habitats		
Foraging	**Roosting**	**Nesting & Chick-rearing**
Sloughs Open Bays Production salt ponds Managed ponds Lagoons Estuaries	Production salt ponds Managed ponds Coastal beaches Estuaries Islands Bridges, power towers	Trees Production salt ponds[4] Managed ponds[4] Tidal marshes Freshwater marshes Coastal beaches Bridges

[1] Alcatraz and the Farallones are nesting areas for some Alcidae species.
[2] Habitat types are based on the Baylands Ecosystem Habitat Goals & associated SFEI EcoAtlas (Goals Project 1999).
[3] Levees & islands
[4] Levees & islands with nesting structures, such as old hunting blinds

Performance Targets

At this time, few specific conservation performance targets or population objectives have been set for most shorebirds and other waterbirds in the SFBJV region. The USFWS Recovery Plan for Western Snowy Plover provides population targets for SFB, and reproductive targets for the species throughout its Pacific coast range (U.S. Fish and Wildlife Service 2007). There are also targets outlined for California Clapper Rail and California Least Tern (U.S. Fish Wildlife Service 2009, U.S. Fish and Wildlife Service 1985)[5]. Also, some acreage goals of various habitat types needed to support shorebirds and waterbirds are outlined in the SFBJV Implementation Plan (2001). In addition, the South Bay Salt Pond restoration project (SBSPRP) and the North American Waterbird Conservation Plan and Regional Shorebird Conservation Plan contain general population goals for shorebirds and waterbirds as well as more specific goals for special status species (Hickey et al 2003, Kushlan et al 2002).

The role of population objectives in bird conservation is currently being discussed and debated in numerous venues (e.g., North American Waterfowl Management Plan (NAWMP) Committee 2004, Bart et al. 2005, NAWMP Science Support Team 2006). While setting population objectives can be challenging, members participating in these discussions suggest that setting population objectives can: 1) serve as the foundation for strategic conservation planning by establishing a biological target, 2) provide a performance metric for assessing conservation accomplishments, 3) operate as a communication and marketing tool to demonstrate the need for conservation, 4) guide what management prescriptions/conservation actions are put on the ground, and 5) provide a method to integrate and promote SFBJV goals with other agency/organization planning.

Consistent monitoring and evaluation programs are needed to inform the process of developing realistic population targets for conservation of shorebird and waterbird species at the various scales considered important for management, conservation, and restoration. Thus, population targets are likely to be a component of the upcoming update of the SFBJV Implementation Plan (2001).

Monitoring and Evaluation Objectives

The shorebird and waterbird focus group participants at a May 2011 objectives vetting and prioritization workshop felt that the "shorebird and waterbird" focus of this group was too broad, and provided the suggestion to separate out shorebirds altogether. In lieu of presenting two entirely separate sections for shorebirds and waterbirds at this time, we present more generalized objectives below, and indicate where appropriate, which of the two wetland bird groups an objective addresses.

[5] See more information on these species in the special status species section of this plan.

Priority M&E Objectives and Associated Metrics & Protocols

Summarized below are the three highest priority M&E objectives the shorebird & waterbird focus group identified at a May 2011 workshop, based on several criteria:

1) Ease of implementation
2) Long-term importance;
3) A natural "early" step;
4) Usefulness for managing or modeling;
5) Ability to help manage SFBJV "effectiveness"; and
6) Cost-effectiveness.

These criteria were assigned scores from 1-5 (lowest to highest value) by each participant. Final scores were averaged across participants and the top three priority objectives are listed here:

Priority M&E Objective 1[6]: *Habitat Quantity & SFBJV Contribution.* Every five years, evaluate the net change in the extent and distribution of shorebird and waterbird habitat types throughout the SFBJV region, and determine the relative contribution of SFBJV activities.

- *Metrics* & *Protocols:* See *Net Landscape Change* section of this plan.

Priority M&E Objective 2: *Species Composition & Wintering Population Trend Estimates; Project, Regional & Flyway Scale.* For the next 10-20 years, support, continue, integrate and expand as appropriate, ongoing (project-scale, e.g., pond surveys at species or guild level), and recently implemented Pacific Flyway Shorebird Survey (PFSS; regional & flyway scale) annual abundance surveys of wintering shorebirds.

- *Metrics*: Occupancy (presence/absence), density (birds/area), abundance, mapping of spatial distribution
- *Protocols:* PFSS and pond survey protocols (including distance sampling protocols, and abundance estimation).

Priority M&E Objective 3: *Breeding Bird Population Trends; Regional-Scale*. Continue and/or establish a 10-20 year breeding shorebird and waterbird monitoring program in the SFBJV region to assess the number and success of breeding birds per year.

- *Metrics*: Nest and breeding bird abundance
- *Protocols:* Nest monitoring, nest success, detection-adjusted abundance estimates. North American Marsh Bird Monitoring Protocols (Conway 2009) for secretive marsh birds.

[6] This objective links directly with prioritized objectives in the net landscape change section module.

Additional M&E Objectives

Here is a non-ranked listing of additional objectives for monitoring and evaluation of SFBJV program effectiveness, addressing remaining key questions for shorebird and waterbird status and habitat management at the project and regional scales within the SFBJV region.

POPULATION STATUS & TRENDS - SHOREBIRDS

- Species Distribution & Hot Spots; Project & Regional Scale – Sustain the annual PFSS winter shorebird survey for at least 20 years. For five consecutive years, map wintering shorebirds by habitat type and season at roosting and foraging sites throughout the SFB and entire SFBJV region to identify "hot spots" of distribution.

POPULATION STATUS & TRENDS - WATERBIRDS

- Species Composition & Population Trend Estimates; Project-Scale - Continue and expand existing programs to annually monitor waterbird abundance to determine status and trends at known rookeries, roosting sites, and foraging habitats throughout the SFBJV region for the next 10-20 years.

BREEDING STATUS & TRENDS – SHOREBIRDS & WATERBIRDS

- Major Breeding Sites; Project-Scale- Determine major shorebird and waterbird breeding sites throughout the SFBJV region and continue and expand regular annual census of breeding bird numbers.
- Monitor Nest Success – Assess annual nest success (at minimum) and juvenile survival (if feasible) of target shorebirds and waterbirds and evaluate at project and regional scales.

HABITAT FUNCTION – SHOREBIRDS & WATERBIRDS

- Food Resources; Project-Scale - In locations determined as important for shorebirds and waterbirds throughout the SFBJV region, survey the availability of key food resources (e.g., fish, biofilm and benthic invertebrates, every 5 years, covering different regions of the Bay in each rotation).
- Environmental Context; Project- Scale – In locations determined as important for shorebirds and waterbirds throughout the SFBJV region, regularly map and evaluate the environmental context such as availability of foraging sites (e.g., mudflats critical for shorebirds), upland refugia, shelter and roosting sites, threats (e.g., distance to highways, power lines, development, disturbance from trails and boats, etc.), and predator distribution and abundance (e.g., raptors, gulls, foxes, cats, etc).

ENVIRONMENTAL CHALLENGES – SHOREBIRDS & WATERBIRDS

- Contaminants; Project & Regional-Scale – Continue to monitor contaminant levels (Hg, Se) in biosentinel species in all locations determined as important for shorebirds and waterbirds throughout the SFBJV region.
- Climate and Landscape Change; Regional-Scale – Facilitate collaborations within and between disciplines that link shorebird and waterbird population data with habitat assessment data to promote larger-scale assessment of local changes across a broader climatic gradient.

- Human Disturbance; Project & Regional Scale. Annually (for first five years, then every three or five years) evaluate the levels of anthropogenic disturbance in high value areas for shorebirds and other waterbirds, where public access occurs; evaluate impacts to roosting & foraging from disturbance and frequency by watercraft, trail use, noise, etc.

Recommended Metrics

Monitoring metrics should ideally be derived from established population targets. Because there are currently no population targets for most shorebirds and waterbirds in the SFBJV area, broad metrics are recommended here. Ultimately, the metrics used should lead to refining the monitoring program in a way that clarifies: 1) habitat condition, 2) stability or sustainability of wetland systems and communities, 3) the health or fate of individual species, and 4) the effectiveness of SFBJV conservation delivery and management. The measurements proposed below head us in this direction, but by themselves will not provide enough information to draw precise conclusions, highlighting the need for further research and monitoring program development. Bibby et al. 2000 (Bird census techniques) provides some useful general descriptions of metrics (e.g., cost/benefit) and can help managers and researchers decide which of the recommended metrics to pursue within their resource contexts. Frequently updated GIS maps of all the key habitats in the SFBJV region will become available, and data on geographical distribution of populations, and important habitat features will be added as they become available.

POPULATION STATUS & TRENDS

- Shorebird and waterbird counts to estimate abundance – Count of the number of individuals per sample, unit time, or location. Methodology should be utilized consistently and should target specific species to account for detection ability. Count data can be used to assess trends that then can scale up or down. *Consideration: There may be significant differences between observers if they are not well trained and calibrated to one another*.
- Density estimations (birds/area) – Count of the number of individuals within a specific area (plot, pond, quadrat, etc.). This technique could be targeted for individual species or species groups. If the boundaries of a site are not well defined, it can be difficult to determine the precise area sampled. *Consideration: There may be significant differences between observers if they are not well trained and calibrated to one another*.
- Occupancy – Proportion of area occupied by target species. This is a cheaper and easier approach than estimating abundance, and there are lots of new models that account for detection probability. However, the method is likely insensitive for abundant species. It is most useful for regional or other large-scale analyses, and may not meet localized needs. *Note: Fewer differences between observers are expected, because only presence is recorded, not abundance or distance.*
- Distance sampling — Count of the number of individuals and estimate the distance to each individual from the observer. This technique allows for an estimate of detection probability, which can be used to correct the abundance estimate. *Consideration: There may be significant differences between observers if they are not well trained and calibrated to one another*.

REPRODUCTIVE SUCCESS

- Breeding abundance – Number of nest sites and nest density at project, regional, and flyway scales. Also, fecundity is an important component if population models are an objective.
- Nest success – Project site-specific (or SFB -wide) estimates of nest survival (probability of nest surviving from nest to hatch) per season implemented at all three spatial scales. If possible, egg survival would be a better measure. In general, survival at all stages – egg, hatchling, fledgling.
- Fledging rates, chick growth and survival (compared over time or sites) - this would likely involve a mark-recapture/re-sight study.
- Recruitment – Number of surviving fledglings per year (also allows you to obtain estimates of nest success).

HABITAT FUNCTION

- Spatial distribution of habitat features of interest - GIS analysis of high tide refugia, shelter, distance to given threats (highway, power lines etc), islands, etc. Assess these parameters at both project & regional scales.
- Habitat structural diversity & function - Examples: vegetation cover/biomass, plant species composition, water depth, salinity, food density, substrate, etc.
- Food resource abundance - Prey density, availability and capture rates, or capture rates only.
- Species abundance counts, diversity or density over time, since observed bird use could serve as a presumed response to habitat function/quality.
- Recruitment, including nest success, chick growth and survival rates stratified by habitat

ENVIRONMENTAL CHALLENGES

- Spatial distribution of threat - GIS layers of habitats reflecting projected climate change impacts, contaminants (if known) and invasive species layers as possible. This should be done at all three scales, ideally. Minimally at project and regional for climate change.
- Food source contaminant levels – Hg, Se, Cd, PCBs, PBDEs levels in fish & other sentinel species.
- Target organism contaminant levels - Hg, Se, Cd, PCBs, PBDEs levels in eggs, chicks & adults
- Chick growth rates – relative to measured contaminant levels.
- Predation by nuisance species - Disturbance type and frequency, associated loss, distance birds take flight due to disturbance, foraging behavior and body condition of disturbed birds
- Human disturbance - Disturbance type and frequency, distance birds take flight due to disturbance, foraging behavior and body condition of disturbed birds.

Recommended Protocols

Here we present recommended protocols for use in the various monitoring contexts. Detailed recommendations on the standardized use of certain metrics in the local and regional context, and how they align with protocols nationally used, are not in the scope of this document, but should be discussed in more detailed in the next phases of this planning process. Generally, the standardized use of a suite of vetted protocols throughout the SFBJV region is recommended.

POPULATION STATUS & TRENDS

Most protocols for the survey types listed below are available here:
http://www.wrmp.org/docs/protocols/WetlandBirds.pdf

- Point count surveys – Used to obtain estimates of abundance and diversity for shorebirds and waterbirds (some shorebirds require specific timing of monitoring (e.g., phalaropes)).
- Area scans or searches – Used for estimates of abundance and diversity for shorebirds, in particular by the PFSS protocol for SFB.
- Distance sampling protocols – Used in density estimation corrected for detection probability.
- Aerial photographic surveys – Used for monitoring colonial species.
- Call count surveys – Used for surveys of secretive marsh bird, such as California Clapper Rail and other rails (Standardized North American Marsh Bird Monitoring Protocols (rails, green herons, etc); Clapper Rail Protocol for the San Francisco Estuary Large Scale Population Surveys)[7]

REPRODUCTIVE SUCCESS

- Mark recapture/resight – Used for estimating breeding population sizes, survival estimation and recruitment
- Nest monitoring – Used to obtain estimates of nesting success.
- Nest monitoring and banding hatchlings – Used in combination with mark and recapture to assess recruitment.

HABITAT FUNCTION

- Wetland habitat condition – Soon to be updated for use in wetlands: California Rapid Assessment Method (CRAM). Since diversity scores for poorly managed marshes are often higher because of exotic species than marshes in good condition, the current CRAM is not well suited for monitoring managed marshes. A University of California, Davis student is currently working on adapting CRAM for managed wetlands.
- Western Hemisphere Shorebird Research Network (WHSRN) – Site assessment tool
- Soil core counts – Method used to estimate spatial presence-only, abundance, density and biomass data of macroinvertebrates (Rowan et al 2011).
- Fish sampling – Sampling of fish abundance (e.g., otter trawls) in time and space.
- Bioflim - Biofilm has been recognized as major food source for estuarine birds (~50% of shorebird diet can come from biofillm; Kuwae 2010). USGS and NASA Ames researchers are looking at reflectance patterns to hopefully map biofilm areas using remote sensing in order to get a better sense of biofilm abundance and variation throughout the SFB estuary.

ENVIRONMENTAL CHALLENGES

Sentinel species sampling - South Baylands Mercury Project
Using DGTs to Assess Bioavailable Methylmercury - Diffusive Gradient Thinfilm (DGT).
Chick growth/survival – Assessment of chick growth and survival relative to contaminants and predators.

[7] Please note: The California clapper rail protocol is currently under revision.

Projected changes in habitat - GIS analysis using Bay Area Aquatic Resource Inventory and other models and tools.
Climate Change Vulnerability assessment tool for Shorebird Habitat (CC-VASH) – This is an innovative, Excel-based assessment and decision-making tool from the Western Hemispheric Research Reserve Network. http://www.whsrn.org/tools/climate-change-tool
Human Disturbance effects – Protocols were established by San Jose State University researchers on levee use, Avocet Research Associates, and USGS on impacts of ferries & boat on open water use of waterbirds.

Research & Information Needs

Team members prioritized research needs by filling out the ranking worksheet listing all vetted research needs. As with M&E objectives, rankings were based on the sum of the highest average scores of several criteria: 1) ease of implementation 2) long-term importance; 3) a natural "early" step; 4) usefulness for managing or modeling; 5) ability to help manage SFBJV "effectiveness"; and 6) cost-effectiveness. Shorebirds and waterbirds were ranked separately, and research priorities are presented for each group below:

Priority Research Needs - Shorebirds

Priority Research Objective 1:

- *Shorebird Regional Hot Spots; Regional Scale.* Determine shorebird hotspot characteristics (i.e. abiotic factors) and locations and the level of connectivity between habitat types (utilized for foraging, roosting, and nesting & chick rearing) situated in proximity to each other across the region.
- *Threats Assessment at Regional Hot Spots; Project & Regional Scale.* Identify major threats to shorebirds at identified hot spots by evaluating impact of highways, power lines, development, other human disturbance, and predator distribution & abundance (i.e. raptors, gulls, foxes, cats, raccoons, etc.) on adult, nest and brood survival.

Priority Research Objective 2: *Restoration Impact on Wetland Birds; Regional Scale.* Synthesize existing knowledge on wetland restoration efforts in the SFBJV region and evaluate how shorebird populations have been affected.

Priority Research Objective 3:

- *Landscape Change Impacts - Shorebird Vulnerability; Project & Regional Scale*. Implement landscape-scale models that incorporate habitat type and landscape covariates to predict avian response to changes in land use, climate change, and restoration and habitat evolution scenarios.
- *Landscape Change Impacts – Habitat Suitability; Regional Scale*. Model predicted changes in habitat suitability given scenarios of projected changes in land use, climate change, and restoration and habitat evolution. Utilize information gained to protect, restore, and enhance areas that will remain or likely become important bird areas in the future. This proactive priority will help prevent future losses.

Priority Research Needs – Waterbirds

Priority Research Objective 1:

- *Climate Change – Sea Level Rise (SLR) Impacts; Regional Scale.* Evaluate and model the changes in predation risk, habitat & food resource availability/accessibility, water level and tidal dynamics, and other projected impacts to waterbirds from sea level rise.
- *Climate Change – Effects of SLR on Ecotones; Project & Regional Scale*. Evaluate the effects of marsh ecotone restoration projects on birds that require high-tide refugia (e.g., rails).

Priority Research Objective 2:

- *Causes of Population Decline; Regional Scale*. Conduct a meta-analysis to determine what the potential causes of regionally declining waterbird populations are, and design coordinated studies to address the most likely threats.
- *SFBJV Contribution.* Evaluate the effects of land use changes due to SFBJV restoration and enhancement projects on waterbird nesting success and chick survival in the region.

Priority Research Objective 3: *Regional Protocol Standardization and Alignment with National Protocols.* Evaluate and standardize local waterbird survey protocols currently used by various groups in the SFBJV region, and align procedures as much as possible with those outlined in available national or continental protocols.

Additional Research & Information Needs

Here we provide additional non-ranked recommendations for further research and information needs for shorebirds and waterbirds, as relevant to various target guilds or species, important to informing the long-term effectiveness of SFBJV habitat conservation delivery.

TARGET ORGANISM STATUS & TRENDS

- Connectivity; Flyway Scale - Evaluate and model the levels of connectivity of migrating shorebirds between Pacific coast, SFB and Central Valley populations over time. Evaluate the contribution of SFBJV projects to connectivity.

REPRODUCTIVE SUCCESS

- Target Species Annual Recruitment; Regional Scale - Assess the annual breeding success of target wetland bird species, such as Forster's Terns, Caspian Terns, American Avocets, Snowy Plovers, Black-necked Stilts, herons, egrets, and others, at several sites through the SFB;

- Limitations to Reproduction; Regional-Scale –Determine the major limiting factors to breeding success by monitoring direct and indirect causes of nest and chick mortality (e.g., CA gull, other predators) of target shorebird and waterbird species
- Nest Site Availability & Success Attributes Regional Scale – Annually determine the availability of shorebird & waterbird nesting sites at SFBJV project sites and assess data at the SFB regional scale. Assess nesting effort and nest success within different wetland habitat types and nesting substrates (island shape and size, levees, etc.).. Develop a list of successful breeding site attributes to determine and map 'high quality' sites and evaluate anthropogenic disturbance on nest site selection, reproductive success, and chick survival.
- Management Practices; Regional Scale – Identify a suite of management practices implemented throughout the SFBJV region and evaluate their benefit to breeding, wintering, and migrating shorebirds.

HABITAT FUNCTION

- Wetland Condition Indicators; Regional Scale - Improve models of heron and egret habitat sensitivity as potential biological indicators of wetland condition, and identify factors that can determine the linkage between colonies and surrounding habitat.
- Artificial Roosting and Nesting Habitat; Project Scale – Evaluate waterbird use and reproductive success on artificial floating islands; evaluate prospects for sea level rise mitigation (Clapper Rail USGS project).

ENVIRONMENTAL CHALLENGES

- Climate Change – Food Availability; Regional Scale - Implement intensive surveys of major food resources during key periods (shorebirds - wintering; waterbirds - breeding) to provide data on shorebird and waterbird food availability, to inform climate change analyses.
- Climate Change – Phenology; Regional-Scale - Implement frequent (daily or weekly) surveys during the migratory periods (fall arrivals and spring departures) to provide data on migratory shorebird and waterbird phenology, to inform climate change analyses. Investigate use of citizen science (e-Bird) to track arrival and departure dates of migratory species.
- Human Disturbance Impacts; Project & Regional Scale - Study and regularly evaluate the levels and impacts of anthropogenic disturbance in high value areas for shorebirds and waterbirds with public access. Expand current assessments of disturbance and other degrading impacts of human recreational activities on nesting, foraging, and roosting areas of target shorebirds and waterbirds.
- Contaminant Bioaccumulation; Project & Regional-Scale – Continue and expand long-term assessment of population level effects of major contaminants (Hg, Se, Cd) in bird biosentinel species (Forster's Tern, American Avocet, Black-necked Stilt), and develop thresholds for survival and reproductive success using eggs and radio-marked individuals.

Data Management

Collective standardized data sharing protocols should be developed for the SFBJV region and linked to existing relevant national databases. A useful way of collective data storing is to create a common metadata website that provides relevant information on the data, shows the spatial extent of the data on a map, includes a data format, provides for ease of transfer, and includes disclaimers about

data availability and allowed uses. This approach lets data owners decide whether to post entire datasets, or to just provide their metadata information and allow others to request a full dataset directly from the source. An existing portal for this proposed online forum is in development via the San Francisco Bay Conservation Commons (http://sfcommons.org/). This metadata approach still allows datasets to reside in different databases, and after standard data conventions are developed and followed, will enable easier transfer. Development of clear protocols on the rights and responsibilities of data sharing will facilitate this process of collaboration. Shorebird and waterbird population and habitat status monitoring data should be contributed directly to local repositories. These may be linked via metadata portals with other programs to enable larger-scale assessment of local changes across a broader climatic gradient.

Suggested data repositories for data submission and cross-linking are:

Bird Data

- California Avian Data Center and Avian Knowledge Network
- Migratory Bird Data Center,
- Integrated South Bay Avian Database (ISBA-DB) - in development for South Bay shorebird data and will be integrated into CADC
- National Wildlife Refuge Inventory & Monitoring program database - in development
- National Park Service I&M program database - online database in development
- ISS-eBird shorebird data repository - International Shorebird Survey (Manomet Center for Conservation Science)
- National Marshbird Database - This database is the result of a collaborative effort to enable efficient storage and sharing of marsh bird survey data collected under the National Marsh Bird Survey Program. The site provides data management capabilities for participants to manage their survey results & information.
- USGS database

Habitat Data

- SFBJV project database
- Wetland Tracker

Existing Monitoring Programs and Tools

POPULATION STATUS AND TRENDS

Ongoing South Bay and North Bay Salt Pond surveys – USGS (Vallejo) has been monitoring all ponds within the SBSPRP since 2003 and within the Napa-Sonoma Marshes Wildlife Area since 1999. USGS (Vallejo) is currently synthesizing these data and is working on models to assess population status, trends and habitat features related to high densities of target species. SFBBO has been monitoring active production salt ponds managed by Cargill and owned by the National Wildlife Refuge since 2005 using the same methodology as USGS. Continued surveys are critical to assessment of changes over time as former salt ponds within the SFB undergo restoration and management actions.

Pacific Flyway Shorebird Survey (PFSS) PRBO Conservation Science has recently launched a broad-scale monitoring partnership program to detect trends and quantify habitat relationships for Pacific Flyway winter shorebird populations. The PFSS has the primary goals of: (1) developing an efficient, sustainable yet statistically robust sampling design and monitoring protocol for the Pacific Flyway; (2) establishing a framework to capture, manage, share, and analyze these monitoring data; and (3) understanding critical associations between habitat management, habitat change, and spatial scale on the abundance of shorebirds in order to inform conservation and management actions. As new monitoring data become available annually through the PFSS and California Avian Data Center (CADC), an analytical framework will utilize it to iteratively evaluate competing hypotheses about shorebird habitat associations and the impact of habitat changes. This will provide ongoing evaluation of wintering shorebird trends and habitat to update management recommendations and inform conservation actions (e.g., tidal flat and roosting site needs in coastal estuaries) in response to current and future land-use and climate-related changes. This will facilitate future scenario planning at local, landscape, and eco-regional scales.

Annual SFB wide wintering shorebird roost counts – Led by PRBO Conservation Science Comprehensive SFB surveys were conducted for roosting shorebirds during November 1990-1992 and 2006-2008. Data were collected at >300 sampling units representing all shorebird habitat in the estuary. These data can be employed in conjunction with GIS habitat data to model factors influencing shorebird use and assess the scale at which habitat influences the abundance of roosting shorebirds in each sampling unit (characterized according to the dominant habitat type, and the proportion of tidal flat, salt pond, and tidal marsh habitat within 2, 5, and 10-km buffers around it). Spatial shifts in the distribution of shorebirds, and temporal distribution changes will be assessed.

Habitat association sampling - Seasonal surveys of South SFB mudflat shorebird abundance and behavior associated with distributions of benthic invertebrates has been collected by USGS (Vallejo). Initial work also includes characterization of biofilm. Baseline data have been collected, and should be followed by assessment of the habitat characteristics of mudflats for shorebirds, which can also be used in modeling scenarios of habitat changes and climate change.

Abundance surveys – focal species (CA Clapper Rail, Western Snowy Plover, etc. in the context of special status species assessments – for more details see section on special status species)

- *California Clapper*– Invasive Spartina Project CLRA monitoring in partnership with Don Edwards SFB NWR, East Bay Parks, USGS (Vallejo) and PRBO Conservation Science.
- *Western Snowy Plover winter and breeding window surveys: Snowy Plover* - monitoring by SFBBO in SFB and partially funded by Don Edwards SFB NWR. Similar surveys are conducted simultaneously by wildlife agencies, non-profits, and volunteers throughout the plover's US Pacific coast range

REPRODUCTIVE SUCCESS

Breeding surveys of SBSPRP focal species (Western Snowy Plover, Forster's Tern, American Avocet, Black-necked Stilt). There is currently no funded monitoring program for nesting birds. SFBBO (Snowy Plover) and USGS (Davis; all other species above) currently do this, but there is no assurance this work will go on after specific site-level research is completed. This should be a high priority for SFBJV and SBSPRP.

- *Forster's Tern, American Avocet, Black-necked Stilt nest monitoring* by USGS and SFBBO; currently funded by the South Bay Salt Pond Restoration Project. There are some concerns whether current methods adequately track trends in breeding numbers.
- *Forster's Tern, Caspian Tern, California Gull, herons and egrets* are monitored by a citizen science project conducted by SFBBO and Audubon Canyon Ranch (see Colonial Waterbird Monitoring below).
- *Snowy plover* - Monitored by SFBBO program that is partially funded by Don Edwards SFB NWR; includes nest success.

Colonial Waterbird Monitoring (e.g., egret & heron rookeries, cormorants, larids, shorebirds) - Long-term, during breeding season coordinated by SFBBO and Audubon Canyon Ranch. Fieldwork is mostly conducted by volunteers.

- SFBBO conducts one-time walk-throughs on all California Gull colonies annually. SFBBO also compiles annual numbers of breeding Forster's and Caspian terns and California Gulls from partners. SFBBO volunteers count at all South Bay tern colonies (from levees or other vantage points).
- SFBBO and Audubon Canyon Ranch coordinate volunteer monitoring of Snowy Egret, Great Egret, Great Blue Heron in the North Bay (ACR) and the South Bay (SFBBO). Audubon Canyon Ranch compiles data and plays a lead role in tracking heron and egret populations around the Bay Area.
- Studies are under way on impacts of trail use to shorebirds (and waterfowl), including nesting plovers in partnership with SFBBO, San Jose State University and the SBSPRP.

- PRBO conducts surveys of cormorants on Bay bridges. SFBBO volunteers count all cormorant rookeries in the South Bay and shared it with PRBO for their region-wide studies.

Bio-accumulation of contaminants - USGS (Davis) leads monitoring efforts of major contaminants (Hg, Se, Cd, PCBs, PBDEs) in biosentinel waterbird species & nesting success and chick survival of focal species (Forster's tern, American avocet, Black-necked stilt)

EXISTING INFORMATION & TOOLS

HABITAT FUNCTION

- Habitat association models (Stralberg et al 2006)- These habitat association models serve as the basis to provide management recommendations to wetland habitat managers about how to allocate resources to maintain shorebird population objectives. There is a current effort under way to develop an analytical framework to iteratively evaluate competing hypotheses about shorebird habitat associations and the impact of habitat changes as new monitoring data are available.
- Habitat association models - USGS (Vallejo) is currently working with SBSPRP salt pond monitoring data that they have collected from 2003 to present to develop habitat association models for shorebirds and waterbirds and assess the importance of habitat factors such as salinity and water depth, proximity to islands and levees, as well as landscape context to inform management priorities. USGS (Vallejo) is also seeking funding to implement a landscape-scale model that incorporates habitat type and context with shorebird and waterbird species density as function of distance from edges to project avian abundances as a function of restoration scenarios within the South Bay Salt Ponds using the Effective Area Model (Brand et al. 2006).
- Western Hemisphere Shorebird Reserve Network (WHSRN) site assessment tool. Information from existing surveys could be uploaded into WHSRN to develop a hemispheric scale of important shorebird sites to assist with prioritizing conservation.

CLIMATE CHANGE[8]

- PRBO Sea Level Rise Decision-support tool
- WHSRN – Climate Change Vulnerability Assessment for Shorebird Habitat (CC-VASH): climate change assessment tool - The climate change tool on WHSRN may be a valuable tool to assess impacts of climate change. Shorebird monitoring protocols should all be consistent with PRISM to allow spatial and temporal comparisons of data sets.
- South SFB Shoals - using data collected by USGS (Vallejo) goal to model the effects of climate change on shorebird use of mudflats

[8] For more information on available and emerging climate change models, please review the climate change section of this Plan.

Key Partners

- Audubon Canyon Ranch - Audubon Canyon Ranch is annually monitoring heron and egret rookeries around the Bay Area as outlined above.
- Audubon California– Richardson Bay Audubon Center (RBAC) participates in Bay-wide shorebird surveys and helps organize volunteers to assess shorebird abundance. RBAC can integrate PRISM protocols into their current shorebird monitoring programs and contribute their data to a larger database to help address bigger questions.
- California Department of Fish and Game – DFG conducts marsh bird surveys at Suisun.
- East Bay Regional Parks District (EBRPD) – EBRPD conducts marsh bird surveys along East and Central SFB.
- Invasive Spartina Project – The Invasive *Spartina* Project manages annual monitoring of California Clapper Rails to assess potential impacts of invasive *Spartina* removal in tidal marshes throughout SFB.
- PRBO Conservation Science leads the implementation of the Pacific Flyway Shorebird Survey (PFSS) in partnership with a number of other agencies and organizations listed below. PRBO conducts annual shorebird roost counts around the Bay area. PRBO also conducts annual marsh bird surveys throughout the SFB.
- South Bay Salt Pond Restoration Project (SBSPRP) – SBSPRP is implementing large-scale restoration of tidal marsh and managed pond habitats throughout the South SFB. SBSPRP is subcontracting with other key partners listed here to conduct wetland bird surveys to evaluate restoration impact and evolution.
- SFBBO conducts long-term year-round shorebird and waterbird surveys of population abundance in the South Bay salt ponds, monitors waterbird breeding colonies, and leads the Western Snowy Plover population monitoring effort in SFB.
- US Fish & Wildlife Service (FWS) – National Wildlife Refuge (NWR) Inventory & Monitoring (I&M) Program – The FWS manages a lot of land in the SFBJV area, and so can contribute to monitoring. Programs of the FWS also span the Flyway, and so FWS can be a link to efforts at larger spatial scales. The SFB NWR Complex (as a partner in the SBSPRP) currently works with partners such as USGS and SFBBO to monitor shorebirds and waterbirds on ponds monthly, and in some areas for nesting birds. The FWS has launched an I&M program for refuges throughout the region.
- US Geological Survey (USGS) - The USGS Western Ecological Research Center (WERC) conducts long-term monthly shorebird and waterbird surveys of population abundance in North Bay and South Bay salt pond restoration sites. USGS WERC also conducts monthly mudflat surveys of shorebirds in the South Bay and participates in marsh bird surveys.

Next Steps - A Phased Approach

In this first planning phase, each M&E Plan focus section features priority objectives and references supporting information determined by the SFBJV science sub-committee. This information will be utilized in planning phase II to secure implementation funding for the outlined priority objectives, and as a basis for further Plan development to continue to refine and integrate the overall Plan objectives as our knowledgebase evolves. Phase III will evaluate and incorporate additional conservation goals and target performance objectives into an upcoming revision of the SFBJV Implementation Plan (originally released in 2001). We therefore consider the M&E Plan a "living document" that will change over time with continually refined and focused content. For more details on the planning phases, please refer to the Introduction & Overview section of this plan under *Planning Phases – A "Living Document."*

Future Challenges For Shorebird And Waterbird Related Monitoring And Research Include:

- Linking effects of conservation delivery actions to target organism status.
- Determining appropriate management strategies and desired outcomes relevant to target habitats.
- Refining monitoring objectives with focus on measuring conservation or management action impact or progress against specified outcomes.
- Developing suitable performance targets and management thresholds.
- Identifying and implementing appropriate metrics (e.g., vital rates) that are relevant to the SFBJV and larger landscape scales (e.g., flyways).
- Maximizing integration with other regional and national shorebird and waterbird conservation initiatives.

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The San Francisco Bay Joint Venture is a partnership of public agencies, environmental organizations, the business community, local governments, and landowners working cooperatively to protect, restore, increase, and enhance wetlands and riparian habitat in the San Francisco Bay Watersheds. We bring an ecosystem and collaborative approach to developing and promoting wetland and riparian habitat conservation throughout the Bay Area.

The Joint Venture Management Board

Nonprofit and Private Organizations

Bay Area Audubon Council
Bay Area Open Space Council
Bay Planning Coalition
Citizens Committee to Complete the Refuge
Ducks Unlimited
National Audubon Society
Pacific Gas & Electric Company
PRBO Conservation Science
Save the Bay
Sierra Club
The Bay Institute

Public Agencies

Bay Conservation and Development Commission
California State Coastal Conservancy
California Department of Fish and Game
California Resources Agency
Contra Costa Mosquito and Vector Control District
National Fish and Wildlife Foundation
NOAA National Marine Fisheries Service
Natural Resources Conservation Service
SF Bay Regional Water Quality Control Board
San Francisco Estuary Partnership
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
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San Francisco Bay Joint Venture
735 B Center Boulevard
Fairfax, CA 94930
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