South Bay Salt Pond Restoration Project
Restoring the Wild Heart of the South Bay

Restoration Funding Application Cover Sheet

APPLICANT INFORMATION

Name of Organization(s) Requesting Funding: Nicole Athearn (U.C. Davis)

Mailing Address: P.O. Box 3371, Vallejo, CA 94590

Federal Employee Identification Number: ____________________

Principal Investigator: Nicole Athearn

Title: Graduate Student Institution: University of California, Davis

Telephone: 707-310-2518 Email address: nathearn@usgs.gov

Grant Administrator: ____________________

Telephone: __________ Email address: ____________________

PROJECT INFORMATION

RFP Study Topic # 6

Project Title Modeling Bird Abundance and Habitat Value in San Francisco Bay and the South Bay Salt Pond Restoration Project

Funding Request per year $ 12,264 Number of years: 2

Confirmed in-kind or matching contributions: $ 76,570

Source of in-kind or matching contributions: USGS

Purpose and Objectives: To develop a dynamic simulation model to estimate bird abundance in response to habitat conditions, which will be used to generate past bird abundances and future bird response to changing habitats as well as to help identify important gaps in our knowledge and understanding of San Francisco Bay waterbird ecology.

Proposed starting date: Sept 2009 Estimated completion date: June 2011

Signature : Nicole Athearn Date: 04 December 2008
Principal Investigator

Signature : ____________________ Date: ____________________
Grant Administrator

Modeling Bird Abundance and Habitat Value in San Francisco Bay and the South Bay Salt Pond Restoration Project

Nicole Athearn

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U.S. Geological Survey, San Francisco Bay Estuary Field Station, 505 Azuar Dr., Vallejo, CA 94592

ABSTRACT:
The restoration of former commercial salt evaporation ponds by the South Bay Salt Pond Restoration Project will reverse a severe decline in tidal salt marshes, but may reduce available habitat for waterbirds. Supporting similar numbers of waterbirds with fewer ponds will require adaptive management to react quickly when management actions trigger an unexpected drop in abundance of key waterbird species, but baseline numbers are needed to identify changes in waterbird abundance. I will develop a dynamic simulation model to estimate bird abundance in response to habitat conditions. Model parameters will be generated from existing bird-habitat relationship data as well as published data, and model relationships will be developed through consultation with published literature as well as San Francisco Bay bird biologists. Existing monitoring data provided by collaborators at USGS, PRBO Conservation Science, and SFBBO will be used to validate the model at three spatial scales: the project area, the South Bay subregion, and San Francisco Bay. I will use sensitivity analysis to assist in model validation and to identify potential data gaps. This model will be used to estimate baseline numbers as well as to predict changes in breeding and wintering waterbird abundance in response to changing conditions.

BACKGROUND AND JUSTIFICATION:
The South Bay Salt Pond Restoration Project (SBSPRP) plans to restore 50-90% of former commercial salt evaporation ponds to reverse a severe decline (>80%) in tidal salt marshes within the San Francisco Bay estuary (Goals Project 1999; Steere and Schaefer 2001; Siegel and Bachand 2002; Life Science 2003; EDAW et al. 2007). The intended result is a mosaic of wetland habitats that will support increased abundance and diversity of native species (EDAW et al. 2007), including migratory waterbirds that currently use salt ponds (Warnock et al. 2002; Takekawa et al. 2005, 2006a, 2006b, *in press*). Supporting similar numbers of waterbirds with fewer ponds will necessitate a comprehensive understanding of habitat needs for long-term planning, but it will also require attentive adaptive management to react quickly when management actions trigger an unexpected drop in abundance of key waterbird species.

Bird abundance changes must be gauged according to a reference value, in this case the baseline bird abundance for the project ponds prior to SBSPRP management. USGS has conducted comprehensive monthly counts of SBSPRP ponds since 2003 (Takekawa et al. 2005, 2006b). However, three constraints prevent the use of the USGS dataset alone for providing baseline data for the project. First, San Francisco Bay is a dynamic, integrated mosaic of waterbird habitats. Birds regularly move among these areas for different purposes (foraging, roosting), and Bay habitats have been sampled disproportionately: SBSPRP ponds have been counted regularly, whereas other important waterbird sites such as the Coyote Creek Reach 1A waterbird pond and the Warm Springs lagoons have been counted rarely if at all. The second constraint on the use of long-term pond counts as baseline data is the high degree of pond complex-wide annual variability relative to the amount of data available, which may prevent statistical detection of numerical anomalies within a timeframe that is relevant for management response. The high annual variability may exist because most waterbird species are migratory, and their annual numbers may be impacted by factors external to San Francisco Bay. Finally, Bay habitats are continually changing, and the SBSPRP pond systems have been undergoing changes since the initiation of the Initial Stewardship Plan (ISP) in 2004. San Francisco Bay waterbirds respond quickly to changes in pond water depth and salinity (Athearn and Takekawa 2006, Athearn et al. *in press*b). Due to the dynamic nature of Bay habitats, it can be difficult to determine whether the cause of bird movement is a change in habitat quality at one or both sites, or simply a result of stochastic processes. Because of this, data from one site such as the SBSPRP salt ponds are not a reliable indicator of habitat quality or project success. It is instead necessary to examine larger spatial scales as well, including the entire San Francisco Bay and, because there is evidence that birds tend to remain in either the North or South Bay subregions (e.g., Hickey et al. 2007), the South Bay subregion as well.

The many potential confounding factors associated with bird habitat use throughout the Bay prohibit the use of monitoring data alone for understanding bird habitat response. It would be exceptionally costly and impractical to adequately survey every potential habitat within the Bay with sufficient frequency to attain an understanding of natural variability and stochastic processes. However, models can facilitate our understanding of systems when the data alone cannot, particularly when paired with a strong mechanistic understanding of the system (Table 1; Holling 1978). PRBO Conservation Science has completed a habitat conversion model (HCM) report (Stralberg et al. 2006), which focused on the response of waterbirds to habitat changes in the Bay. Although my modeling effort will have similar goals, my model approach differs in that it is a dynamic simulation model and will be more conceptually-driven than the HCM, which was primarily based on relationships derived from existing datasets. In this case, the experience and expertise of waterbird researchers from PRBO Conservation Science, SFBBO, and USGS will be combined with existing monitoring data from the salt ponds and other Bay habitats to generate causal models based on known relationships and parameters that have been derived from existing data and published literature. Restoration managers should benefit from both modeling efforts as well as what we may learn through their comparison.

I will use modeling to address three questions that have been posed by the current RFP (Priority Research Topic #6). I will develop a mechanistic simulation model of bird numbers based on habitat selection criteria. Because the numerical response will depend on habitat parameters, using values similar to past conditions will provide estimates of baseline data and will provide the current number of waterbirds using Bay habitats. By manipulating habitat parameters to simulated future conditions, I will explore changes in habitat value to waterbirds in response to changing conditions. Finally, I will use the model to explore potential data gaps through sensitivity analysis. This modeling effort will maximize the value of existing data while not relying exclusively on it; rather, I will combine published literature and SBSPRP data with the ecological expertise of San Francisco Bay bird biologists to generate a synergistic model to address critical project needs.

	Level of Mechanistic Understanding is Lower	**Level of Mechanistic Understanding is Higher**
Many Data Available	statistical and exploratory models	precise, well-understood models
Few Data Available	exploratory models	exploratory mechanistic models

Table 1. Potential results of modeling according to data availability and level of mechanistic understanding (after Holling 1978).

STUDY OBJECTIVES:

1. Develop dynamic simulation models of bird abundance based on habitat selection parameters for key bird species.
2. Generate baseline bird abundance ranges in the SBSPRP area, within the South Bay subregion, and within San Francisco Bay.
3. Evaluate waterbird response to habitat changes anticipated under the SBSPRP.
4. Identify habitats and ecological information areas where more data will be needed to assess future bird response to habitat changes.

STUDY AREA:

Although the purpose of this study is to assess the effects of SBSPRP changes on waterbird abundance, the dynamic nature of San Francisco Bay wetland habitats necessitates examining bird habitat use on a larger scale. This study will focus on three spatial scales: the SBSPRP ponds, the South Bay subregion, and the entire San Francisco Bay.

APPROACH:

<u>Objective 1: Develop dynamic simulation model of bird abundance based on habitat selection parameters for key bird species.</u>

Model parameters will differ among species, and particularly among avian foraging guilds, due to disparate habitat needs. Models will initially be developed for individual species as representatives of foraging guilds because more reliable, less aggregated parameters may be available. The initial shorebird species will include a small shorebird, western sandpipers (*Calidris mauri*), which winter in San Francisco Bay, and a medium shorebird, American avocets (*Recurvirostra americana*). Avocets are year-round San Francisco Bay residents which also breed in the Bay; 38% of avocets in the South Bay subregion use salt pond islands for breeding (Ackerman et al. 2006). Duck species will include a diving duck, ruddy ducks (*Oxyura jamaicensis*) and a dabbling duck, northern shoveler (*Anas clypeata*). These species were selected due to their relative importance and abundance in salt pond habitats (Stralberg et al. 2006), and are most likely to be affected by pond conversion. Additionally, they were chosen to facilitate comparison of model results between this effort and Stralberg et al. (2006).

I will use STELLA 9.0.3 (isee systems, inc.; Hannon and Ruth 2001) to construct models following conceptual relationships and parameterization based on species ecology (e.g., Fig. 1; Gertseva et al. 2004; Boykin and McDaniel 2008) and through consultation with collaborating

PRBO Conservation Science, SFBBO, and USGS biologists to arrive at a consensus that the modeled relationships are consistent with ecological understanding. USGS has collected geomorphologic data in the South Bay subregion (Takekawa et al. 2005; Foxgrover et al. 2007; Athearn et al. *in press* a), as well as water quality data (Lionberger et al. 2004; Takekawa et al. 2005; 2006b) and prey densities (Takekawa et al. 2005). Additionally, we have established relationships between bird abundance and these external data (Athearn and Takekawa 2006; Takekawa et al. 2006a, *in press*) that will be used in addition to published literature to validate model parameters. STELLA models will be created to accommodate different types of responses (e.g., Fig. 1), such as abiotic (e.g., salinity, water depth, geomorphology, and landscape metrics) and biotic (response to other avian species present as well as prey abundance) modular compoments.

Models will be statistically validated using existing datasets from USGS, PRBO Conservation Science, and SFBBO from ponds and other Bay habitats that were not used in model construction. Model validation will be approached by comparing model output for specific surveyed areas to the survey data. It is not expected that model output should exactly match monitoring data as the data are imperfect indictors of habitat quality. However, model outputs for multiple simulations across multiple areas and spatial scales should display similar trends and should result in an acceptable statistical correlation, such as the modeling efficiency index, but a specific validation criterion will depend upon the type of relationship (i.e., linear or nonlinear). For example, if the monitoring data showed a continual downward trend over time, the model should also show this trend although the degree of decline and specific numbers will differ. Model corroboration is an evaluation of model realism and cannot be approached statistically, but through rigorous critical analysis of model relationships in relation to accompanying data. Because bird abundance outputs will depend on established conceptual relationships between birds and their habitats, the model will be tested by adjusting habitat parameters to match expected conditions at the time of the bird survey, a strategy which will be applied across different habitats for a given species. This will be an important model validation step to be applied to separate subcomponents at multiple scales, but after the model has been validated it will also be applied to entire regions comprising each scale of interest to generate predictions. In addition to applying realistic past and future habitat conditions, I will also consider more extreme hypothetical conditions to assess the model response to larger changes in the system.

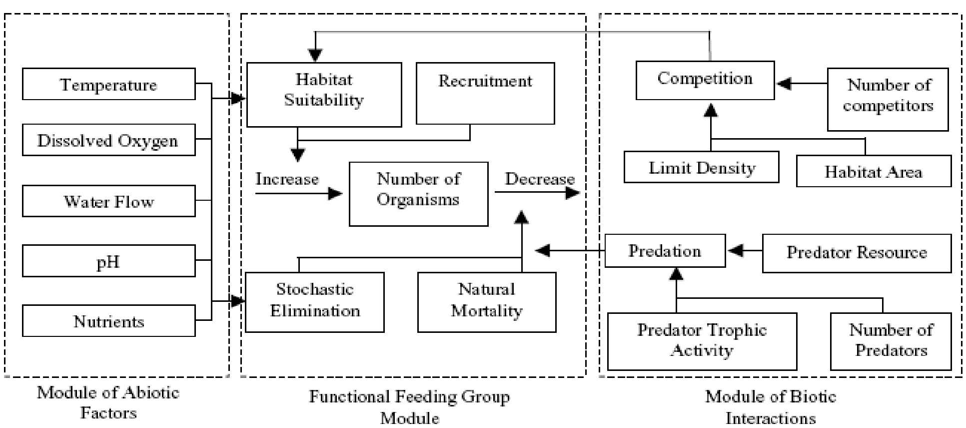

Figure 1. Example of conceptual modular model based on functional feeding groups of aquatic insects (Gertseva et al. 2004). Bird abundance in the habitat of interest would likewise be a function of combined abiotic and biotic response, though the specific parameters will differ.

Finally, I will compare the response of multiple species to the same habitat changes in order to assure the maintenance of expected inter-specific responses.

Objective 2: Generate baseline bird abundance ranges in the SBSPRP area, within the South Bay subregion, and within San Francisco Bay.
In order to expand the model beyond the SBSPRP ponds, it will be necessary to identify, quantify, and characterize potential San Francisco Bay waterbird habitats. I will use ArcGIS (ESRI, Redlands, CA) to extract spatially-based data and will conduct literature searches to obtain additional site information, which will be appropriately compiled at the South Bay subregion or San Francisco Bay scale. To generate past bird abundances, I will set the habitat parameters to approximate past conditions and generate a range of expected abundance values. Additionally, I will compare winter duck species output at the entire Bay scale to USFWS mid-winter waterfowl survey data.

Objective 3: Evaluate waterbird response to habitat changes anticipated under the SBSPRP.
Evaluations of bird response to hypothetical future conditions will be obtained by changing the habitat parameters of the pre-validated model to the expected future conditions. Stochastic variation will generate annual variability in numbers, and multiple iterations will provide a range of output values.

Objective 4: Identify areas where more bird habitat or monitoring data will be needed to assess future bird response to habitat changes.
Some parameters and relationships will inevitably be more clearly defined and better understood than others. The model will serve as a tool to examine to what extent the more poorly understood parameters or relationships are data gaps that need to be addressed. I will address the model parameters individually through sensitivity analysis, testing different hypothetical values of each parameter within a realistic range and examining the impact on the model output. If the parameter value can change considerably with little effect on the bird abundance output, then there is probably little value in refining the parameter's value. However, if small changes in a parameter result in large changes in bird abundance, then that parameter will be identified as one that the model is sensitive to and that it will be worthwhile to refine. Sensitivity analysis results will identify areas where we should increase our understanding, and also prioritize them by their relative impacts on model results.

DATA ARCHIVING:
The database developed during the course of this project will be made accessible through the SBSPRP website. Results will be presented spatially present to allow managers and policy makers to view seasonal mudflat habitats characterizations and analyses. During the project, data will be stored on a RAID network server at the U. S. Geological Survey, Western Ecological Research Center, San Francisco Estuary Field Station with secure backups onsite and offsite.

WORK SCHEDULE:
Work will commence from final signature of the agreement for a period of two years with an annual report delivered at the end of year one and all other products (with the exception of workshops and updates) at the end of year two.

Work Element for Bird Abundance Model	Year 1				Year 2			
	1	2	3	4	1	2	3	4
Gather and integrate existing data	x	x	x					
Develop and verify bird abundance model			x	x	x	x	x	
Synthesize results for presentation						x	x	
Report writing				x			x	x
Report review				x			x	x

EXPECTED PRODUCTS:

My final products will be at least one manuscript that presents a set of dynamic bird abundance models for San Francisco Bay waterbirds, as well as a collaborative manuscript with PRBO Conservation Science comparing my results with those from Stralberg et al. (2006). I will provide annual and final reports with detailed information on progress. Additionally, I will present findings at meetings, science symposia, relevant workshops and Science Team updates. At least one scientific paper will be submitted to a peer-reviewed journal. Briefings will be provided upon request.

LITERATURE CITED:

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Takekawa, J. Y., A. K. Miles, D. H. Schoellhamer, B. Jaffe, N. D. Athearn, S. E. Spring, G. G. Shellenbarger, M. K. Saiki, F. Mejia, and M. A. Lionberger. 2005. South Bay Salt Ponds Restoration Project Short-term Data Needs, 2003-2005. Unpubl. Final Rep., U. S. Geological Survey, Vallejo, CA. 270 pp.

Takekawa, J.Y., A.K. Miles, D.H. Schoellhamer, N.D. Athearn, M.K. Saiki, W.D. Duffy, S. Kleinschmidt, G.G. Shellenbarger & C.A. Jannusch. 2006a. Trophic structure and avian communities across a salinity gradient in evaporation ponds of the San Francisco Bay estuary. Hydrobiologia 567:307–327.

Takekawa, J. Y., N. D. Athearn, B. J. Hattenbach, and A. K. Schultz. 2006b. Bird Monitoring for the South Bay Salt Pond Restoration Project. Unpubl. Final Prog. Rep., U. S. Geological Survey, Vallejo, CA. 74pp.

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Warnock, N., G. W. Page, T. D. Ruhlen, N. Nur, J. Y. Takekawa, and J. T. Hanson. 2002. Management and conservation of San Francisco Bay salt ponds: effects of pond salinity, area, tide, and season on Pacific Flyway waterbirds. Waterbirds 25:79-92.

QUALIFICATIONS:

Collaborators include Deborah Elliott-Fisk (U.C. Davis, graduate adviser); John Takekawa, Josh Ackerman, and Collin Eagles-Smith (USGS); Julian Wood, Mark Herzog, and Gary Page (PRBO Conservation Science); Jill Bluso Demers and Caitlin Robinson (SFBBO), and Aariel Rowan (San Francisco State University). Detailed qualifications information for these individuals follow in the fellowship application pages following this proposal (D. Elliott-Fisk) or are presented within the collaborative PRBO Conservation Science-led proposal to Objective 6.

NICOLE D. ATHEARN

U.S. Geological Survey, Biological Resources Discipline, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA, 707/562-2002, nathearn@usgs.gov

EDUCATION

Ph.D. Ecology. University of California, Davis (2011)

M.S. Wildlife Ecology; Certificate, Geographic Information Systems. Oklahoma State University, Stillwater (2002)

B.S. Wildlife, Fisheries, and Conservation Biology. University of California, Davis (1996).

RELEVANT EXPERIENCE TO THIS PROJECT

I am a biologist located at the USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, where I have led the Salt Pond Ecology program since 2002. In addition to a course on dynamic simulation modeling using STELLA (UC Davis PLS 121 in Fall 2007), I participated in a graduate continuation seminar during the Winter and Spring 2008 quarters. Additionally, I have taken coursework in spatial statistics and analysis as well as modeling seminars as evident on my transcripts and the full version of my CV. I am particularly interested in the integration of science and management, and the focus of my current work is to develop models and tools that can be used for the management of salt ponds as bird habitat. I am familiar with South Bay waterbirds and habitats as I have led the collection of monthly bird data and water quality data at all South Bay Salt Pond Restoration Project (SBSPRP) ponds since 2002.

PROFESSIONAL EXPERIENCE

Wildlife Biologist, USGS, BRD, WERC, San Francisco Bay Estuary Field Station (7/02-present)

PUBLICATIONS: *I have authored 8 peer-reviewed journal papers, 10 technical reports, and 32 scientific presentations. Below is a selected list of relevant publications.*

Ackerman, JT, JY Takekawa, C Strong, **N Athearn**, and A Rex. 2006. California Gull distribution, abundance, and predation on waterbird eggs and chicks in South San Francisco Bay. Final Report, U. S. Geological Survey, Western Ecological Research Center, Davis and Vallejo, CA 61 pp.

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Takekawa, JY, **ND Athearn**, BJ Hattenbach, and AK Schultz. 2006. Bird Monitoring for the South Bay Salt Pond Restoration Project. Unpubl. Final Prog. Rep., U. S. Geological Survey, Vallejo, CA. 74pp.

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Takekawa, JY, AK Miles, DH Schoellhamer, **ND Athearn**, MK Saiki, WD Duffy, S Kleinschmidt, GG Shellenbarger, and CA Jannusch. 2006. Trophic structure and avian communities across a salinity gradient in evaporation ponds of the San Francisco Bay estuary. Hydrobiologia 567: 307-327.

Takekawa, JY, DT Melcer, **ND Athearn**, AK Miles, and DH Schoellhamer. 2009. Dietary Flexibility of Waterbirds across Salinity and Depth Gradients in Salt Ponds of San Francisco Bay. Hydrobiologia, in press.

Takekawa, J, I Woo, ND Athearn, S Demers, R Gardiner, W Perry, N Ganju, G Shellenbarger, and D Schoellhamer. Measuring sediment accretion in early tidal marsh restoration. Wetlands Ecology and Management, submitted.

BUDGET AND STAFF ALLOCATIONS:

Project Budget Worksheet

Timeframe: September 2009 - June 2011

Budget Categories	Total Project Budget		Total Grant Request		Total Proposed From Other Sources *(please specify the source, if known)*
	Year 1	**Year 2**	**Year 1**	**Year 2**	
Labor	$37,534	$39,036	$0	$0	$76,570 in kind contributed by USGS
Consultant fees/ Contractual Services	$0	$0	$0	$0	
Travel	$0	$0	$0	$0	
Project specific equipment, supplies/materials	$0	$0	$0	$0	
Overhead (not to exceed 10%)	$0	$0	$0	$0	
Other: ***UC Davis graduate student fees***	$11,680	$12,848	$11,680	$12,848	
TOTAL	$49,213	$51,884	**$11,680**	**$12,848**	$76,570 in kind contributed by USGS

POTENTIAL REVIEWERS:
Nils Warnock, Wildlife Health Center, University of California, Davis, CA 95616; tel: 530/752-5797; email: ndwarnock@ucdavis.edu
Gary Page, PRBO Conservation Science, 3820 Cypress Drive #11, Petaluma, CA 94954; tel: 707/781-2555; email: gpage@prbo.org
Cheryl Strong, San Francisco Bay National Wildlife Refuge Complex, 9500 Thornton Avenue, Newark, CA 94560; cell: 510-557-1271; email: Cheryl_Strong@fws.gov
Ted Foin, University of California, Davis, CA 95616; email: tcfoin@ucdavis.edu

NECESSARY PERMITS:
This proposal is based on existing data. No permits are needed for land access or bird handling because no new data will be collected.

ANIMAL CARE AND USE:
This proposal is based on existing data. No animals will be handled or disturbed.