Integrating Avian Datasets for Management, Modeling, and Visualization

Task 3 Final Report

Historical Waterbird Numbers

10 February 2014

FINAL

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Contract # 2009-0214

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Introduction

We present baseline population estimates for shorebirds, waterfowl, and other waterbirds derived from published and unpublished data and summaries. We also review, summarize and synthesize the results of studies (both published and unpublished) to describe baseline populations for selected species or groups of species. To describe baseline estimates, we present the results from some studies "as is" and have performed secondary analyses on summary data from other studies.

In addition to developing baseline numbers, we provide an annotated bibliography of published and unpublished sources. The informative annotated bibliography summarizes the scope of the study area, study period and study species, and summarizes the methods used, main findings and recommendations of each reference. We discuss in more depth the results of a few key studies that are particularly relevant to understanding historic waterbird numbers in the South Bay.

For determining site-specific baseline numbers, an example of how to use the Integrated South Bay Avian Database (ISBA-DB) is provided. ISBA-DB allows the user to define the time period, season, bird species or species group, tide level, and site(s) that represent the desired baseline conditions and query data from multiple organizations to determine the baseline number of individuals.

Because estimates of population size are sensitive to area, it is important to be explicit about the area being considered. Some datasets are more appropriate for estimating population size over large areas (e.g., South Bay) and others are more appropriate for site-specific assessments. Following discussions with SBSPRP staff, we developed an approach to describing baseline waterbird numbers based on three spatial tiers.

- Level 1- South Bay (area south of San Mateo Bridge)
- Level 2- Complex (collection of sites or ponds)
- Level 3- Individual site or pond

We acknowledge the need for information at even larger spatial scales to put in perspective changes occurring within the South Bay. However, it is not the goal of this report to describe baseline avian conditions at these larger scales. For each level 1-3, we present baseline numbers by species (or by species groups), and by season when applicable and feasible.

We rated the quality of the various baseline estimates on a 0-5 scale depending on the number of years of data used, whether the data contained repeated counts, and if models were used, how well those models performed. Combined, these criteria give the reader an at-a-glance idea of the confidence of the estimate. In most cases, ratings were calculated for each species or species group and season combination. In cases without secondary analysis, one rating was calculated for all the estimates from a particular dataset.

The baseline estimates in this report represent a first step toward setting goals and targets for the SBSPRP and most importantly, designing a monitoring program to measure change and progress toward those goals. The true number of individuals present in an area can be very different from the number observed and reported due to imperfect detection and other sources of error. Therefore, to measure the change from any particular baseline condition, the field and analysis methods used to develop the baseline estimate should be replicated as closely as possible when assessing post-baseline conditions. In other words the baseline estimates are very sensitive to the methods used to calculate them. We present these baseline estimates with the assumption that they will be used to compare with later years using similar methods or if this isn't feasible, that data from future conditions will be analyzed and presented with special attention to these issues.

Methods

Baseline estimates presented in the report come from multiple sources (published and unpublished data and study results) with some estimates presented as they appear in the original publication and others the result of secondary analyses conducted as part of this report. The baseline estimates in this report are all presented as number of individuals. As such, it is important to define the area encompassed by the estimate and the sampling effort. The baseline estimates described in this report were categorized into three hierarchical levels from South Bay wide to site-specific as follows:

- Level 1 - South Bay. The survey area or estimate covered the entire area south of the San Mateo Bridge.
- Level 2 - Complex. The survey area or estimate covered a FWS Refuge Complex, CDFW Ecological Reserve or a particular collection of sites.
- Level 3 - Site. The survey area or estimate was restricted to a particular site.

South Bay Baseline- Level 1

Wintering and migrating shorebirds- We present total counts of wintering and migrating shorebirds from the San Francisco Bay Shorebird Census (Stenzel et al. 2002) for the South Bay in spring, fall and winter. The winter surveys were conducted annually from 1990 to 1992 during the month of November. The fall surveys were conducted annually from 1988 to 1990 between mid-August and mid-September. The spring surveys were conducted annually from 1988 to 1993 in late April.

To determine the wintering shorebirds baseline, total counts for 22 shorebird species were averaged for the South Bay, south of the Dumbarton Bridge. For the migrating shorebirds baseline, the spring and fall South Bay totals were only available for three species groups (small shorebirds, medium shorebirds and phalaropes; see appendix B for species group composition). Stenzel et al. (2002) and Page et al. (1999) describe the methods used to collect field data which, for the wintering shorebirds, involved over a hundred coordinated observers conducting comprehensive census counts during high tide on a single day in November that covered the entire South Bay area including salt ponds, levees, and other known shorebird roosting areas. The fall (August-September) and spring (April) census data were also collected on a single day each year but were conducted during rising tides from mudflat tracts lining the edge of the Bay. Birds were counted on and flying over the mudflats as they were displaced by the rising tide. No secondary analysis was conducted on the San Francisco Bay Shorebird Census data.

Breeding waterbirds- To determine the baseline for five breeding waterbird species, two sources were used. For Black-necked Stilt and American Avocet, we relied on numbers from Rintoul et al. (2003) and for Forster's Tern, Caspian Tern, and California Gull we relied on data from Strong et al. (2004). Surveys for Black-necked Stilt and American Avocet were conducted throughout the entire South Bay with the aim of counting all birds in the area during the breeding season and assuming all individuals were potentially breeding. Because the Rintoul et al. census for stilts and avocets was only conducted once in one year, no secondary analysis was feasible.

For Forster's Tern, Caspian Tern and California Gull, a secondary analysis was conducted to determine baseline numbers using a snapshot of the most current 5-year period, 1999-2003. This approach was preferred over using the entire time period because the survey effort and colony site fidelity for some species was inconsistent in the early years and furthermore, a more comprehensive and complex modeling approach would be required to address the non-linear trends. The baseline was determined by fitting a hurdle model (Zuur et al. 2009) to account for the high number of zeroes in the dataset. The hurdle model assumes all zeroes in the data are correct (i.e., not the product of imperfect detection which is more common in surveys of birds that are difficult to detect) and applies a binomial probability prior to fitting a model for the count process. This binomial probability is the probability of the species being present and detected. That is, the count process' model is fitted to the data conditional on the species having been detected. For the count process of the hurdle model, we fitted a generalized linear model with negative binomial error distribution to the total counts for South Bay (i.e., using a negative binomial link function); the negative binomial link adds a degree of freedom in the estimation of the error parameter of the model, thus being able to account for over-dispersion in the count process. The model used Year and Year^2 (i.e., a quadratic function of Year) as predictors of total abundance for each species. That is, once the model fit was obtained, it was used to predict abundance and standard error of the prediction. The reported estimates are the mean predicted abundance and confidence intervals from the fitted model.

Strong et al. (2004) described the field methods in detail which involved volunteers and biologists conducting colony counts during the breeding season. The secondary analyses relied on the annual total colony counts (total number of breeding individuals) for Forster's Tern, Caspian Tern, and California Gull (Appendices 1-3 in Strong et al. 2004).

Waterfowl- The South Bay estimates of migrating and wintering waterfowl relied on monthly and semi-monthly aerial surveys of open bay and bayland habitats from 1988-90 as summarized by Accurso (1992). Because this dataset contained excess zeroes, we used an approach similar to that used for breeding waterbirds. The secondary analysis was conducted by fitting a generalized linear model with negative binomial error distribution when data contained no zeroes, or a hurdle model with negative binomial error distribution when they did. The generalized linear model used Month, Year, Location and the interaction of Year and Location, as it seems locations were used differently by waterfowl over time. The two locations were "open bay" and "baylands" which included salt ponds and tidal channels. The hurdle model, which assumes that zeroes are a temporal absence of birds during the survey, fits a mixture model with two sub-models to the data: a logistic regression for the presence/absence of waterfowl, and a generalized linear model for the abundance, conditional on the waterfowl being present. The generalized linear sub-model of the hurdle model is as previously described, while the logistic sub-model only considers Month and Location as predictors of presence. Once models were fit, we averaged fitted values and confidence intervals across the three years of data and across location (to combine open bay and baylands) to obtain an estimate for each month surveyed.

Complex-level Baseline- Level 2

Waterbirds- To characterize baseline numbers of waterbirds using SBSPRP land we used results from the Habitat Conversion Model (HCM; Stralberg et al. 2006) which was based on avian surveys conducted during a six-year period (1999-2004) at a subset of sites including ponds and tidal marshes within the South Bay. Pond characteristics (salinity, depth, size, etc.) were used to develop habitat relationship models for 29 focal species and seasons, and a model-averaging approach was used to predict densities to all sites including sites without bird survey data but for which there was physical information such as pond depth and salinity. The total number of individuals for each focal species was calculated for each complex based on the predicted densities. We present these model-derived predictions as-is and note that the values are conditional on birds being present at the site).

Site-specific Baseline- Level 3

Waterbirds- For site or multi-site baseline estimates, we rely on monthly pond and marsh surveys conducted by Point Blue Conservation Science (formerly PRBO), USGS, and SFBBO where each organization surveyed a different set of ponds and years. This dataset can be queried using the Integrated South Bay Avian Database (ISBA-DB) to obtain raw counts, or mean (geometric) numbers of birds over a specified time period (from 1990 to 2010), for selected species, and for selected sites. The geometric mean is provided instead of the arithmetic mean because it is less sensitive to the extreme values common in the monthly waterbird and shorebird surveys.

Baseline Estimate Reliability Rating

The baseline estimates presented in this report rely on data that have been collected using different field methods over different spatial and temporal scales. This heterogeneity of survey protocols implies different degrees of accuracy and precision from each estimate solely due to sampling error: different observer skills, different detection methods, different survey effort, etc. The various survey methods also require different analysis tools, which further complicates the task of developing a metric of reliability of estimates, because each method partitions the variance in the data differently. For example, measures of the amount of explained variance of regression models, like the R-squared metric, are not available to mixture models such as hurdle or zero-inflation models. Nevertheless, to help the SBSPRP managers understand the limitations of the estimates, we attempt to provide a metric of reliability that is informative about the intrinsic quality of the numbers we present.

The rating emphasizes objective features about the estimate and its provenance: survey design, survey effort, statistical model fit, model accuracy, and model over-dispersion (i.e., the statistical model's variance component being larger than expected). The ratings range from 0 (poorest quality estimate) to 5 (highest quality). The ratings do not attempt to describe the quality of the original data, other works' summaries, or prior analysis results that the baseline estimates were derived from, since they were likely fulfilling objectives other than those described in this report. The ratings are solely for the purpose of describing the utility of those data, summaries, and results in their capacity to inform baseline estimates for the SBSPRP, including estimates from analyses conducted for the purpose of this report.

Results and Discussion

South Bay Baseline- Level 1

Wintering and Migrating Shorebirds- The most comprehensive surveys of wintering and migrating shorebirds in San Francisco Bay spanned the years 1989 to 1993 and 2006 to 2008 and were conducted as part of the San Francisco Bay Shorebird Census (Stenzel et al. 2002, Wood et al. 2010). The earlier set of surveys described by Stenzel et al. (2002) provides the most comprehensive estimates of shorebird numbers for the entire South Bay. Although the surveys took place about 13 years before the Initial Stewardship Plan (ISP) was implemented, these data likely provide the best baseline estimate of the total number of shorebirds wintering in the South Bay. However, because the surveys were not repeated within each year and because only three to five years of data are available, the variation associated with the survey method is unknown and the variation in annual totals is high. The overall reliability rating for estimating baseline abundances for this dataset is zero because of the lack of repeated counts necessary for quantifying the variation. The estimates should be used with caution.

The total number of wintering shorebirds in the South Bay was 203,000 in the early period (Table 1) and 18% lower in 2006-08 based on surveys using the same methods (Wood et al. 2010), but this change may be attributable to normal variability. Four species' populations in the South Bay did change significantly between the two time periods: the federally threatened Western Snowy Plover decreased by 49 individuals (50% decline), Dunlin decreased by 20,000 (37% decline) and the Long-billed Curlew and Least Sandpiper increased by 1,000 (316% increase) and 12,000 individuals (152% increase), respectively.

Table 1. Mean and confidence interval (lower-upper) of annual South Bay total counts for 22 species of wintering shorebirds from San Francisco Bay Shorebird Census (1990-1992) with baseline estimate reliability rating. Mean and SE rounded to 3 significant figures.

Common Name	**Mean**	**Confidence Interval**	**Reliability Rating**
Black-bellied Plover	8,260	6,410-10,110	0
Snowy Plover	99	52-146	0
Semipalmated Plover	715	0-1,497	0
Killdeer	80	21-139	0
Black Oystercatcher	0	0-0	0
Black-necked Stilt	4,190	2,646-5,734	0
American Avocet	12,800	11,355-14,245	0
Spotted Sandpiper	1	0-3	0
Greater Yellowlegs	199	152-246	0
Willet	11,300	8,321-14,279	0
Lesser Yellowlegs	34	7-61	0
Whimbrel	27	15-39	0
Long-billed Curlew	357	259-455	0
Marbled Godwit	9,660	8,517-10,803	0
Ruddy Turnstone	16	0-38	0
Black Turnstone	7	0-15	0
Red Knot	749	0-1,843	0
Sanderling	22	12-32	0
Western Sandpiper	82,300	66,679-97,921	0
Least Sandpiper	7,650	2,005-13,295	0
Dunlin	53,700	46,801-60,599	0
Total Calidris spp.	144,000	119,696-168,304	0
dowitcher spp.	10,500	7,972-13,028	0
other species	14	0-38	0
Total	**203,000**	183,400-222,600	**0**

The mean number of medium and small shorebirds during spring migration (457,600) was about double that of fall migration (226,000) for the years 1988 to 1990 (Table 2). Because only three surveys were used (surveys were conducted annually and not replicated within a year) the baseline estimate reliability rating is zero and the numbers should be interpreted with caution.

Table 2. Mean and lower and upper confidence intervals (CI) of annual South Bay total counts for phalaropes and medium and small shorebird species during spring (1988-92) and fall (1988-90) from San Francisco Bay Shorebird Census. Mean and CI rounded to 3 significant figures. See Appendix B for composition of species groups.

Species group	Spring mean	CI (lower-upper)	Fall mean	CI (lower-upper)	Reliability Rating
medium shorebird	22,500	15,100-30,000	53,900	44,300-63,500	0
small shorebird	432,000	337,500-526,500	156,000	138,700-173,300	0
phalarope	3,100	500-5,700	16,100	9,400-22,800	0

Breeding Waterbirds- Baseline estimates for breeding Waterbirds are derived from multiple sources. For Forster's Tern, Caspian Tern, and California Gull, colony counts reported by Strong et al. (2004) were used to develop baseline estimates of the South Bay breeding population (Table 3). For Black-necked Stilt and American Avocet, South Bay census counts from Rintoul et al. (2003) are presented.

Table 3. Baseline number and upper and lower confidence intervals (CI) of breeding individuals predicted for all South Bay colonies for the period 1993-2003. Model predictions used annual colony counts from 1982-2003 (Strong et al. 2003).

Species	Mean	Lower CI	Upper CI	Reliability Rating
Caspian Tern	203	130	317	2
Forster's Tern	1,908	1,477	2,466	2
California Gull	18,592	14,648	23,598	2

Rintoul et al. (2003) conducted comprehensive South Bay surveys on 9,613 ha of salt ponds including all SBSPRP ponds and a portion of privately owned salt ponds (excluding Mowry ponds north of Mowry Slough, portions of Middle and Outer Bair Island, and portions of the Redwood salt ponds). A map of the area surveyed is provided in Appendix C. Rintoul et al. (2003) also surveyed 4,068 ha of tidal/diked marshes, 575 ha of other diked wetlands, and approximately 4,039 ha of tidal flats for Black-necked Stilts and American Avocets in May 2001 (Table 4).

Table 4. Total number of Black-necked Stilts and American Avocets in the South Bay in 2001 during the breeding season.

Species	Total Individuals	Reliability Rating
Black-necked Stilt	1,184	0
American Avocet	2,765	0

Although only 270 stilts and 880 avocets were confirmed to be breeding, given the time of year, the rest were likely breeding. The surveys by Rintoul et al. (2003) represent the best estimate for the breeding population of Black-necked Stilts and American Avocets as no other comprehensive South Bay shorebird surveys were conducted in May and June when the majority of birds are breeding. Ackerman et al. (2011) could not estimate the number of colonial breeding birds in the entire South Bay because the monitoring effort varied with year. Instead, they report nest abundance for specific ponds that were monitored. These abundances are available on the ISBA-DB website for Black-necked Stilt (http://data.prbo.org/apps/isbadb/index.php?page=black-necked-stilt), American Avocet (http://data.prbo.org/apps/isbadb/index.php?page=american-avocet), and Forster's Tern (http://data.prbo.org/apps/isbadb/index.php?page=forster-s-tern).

Waterfowl- baseline estimates from baywide surveys summarized by Accurso (1992) are presented for the month of January (Table 5) to coincide with recent midwinter aerial surveys which were only conducted in January. Because the historic surveys spanned a portion of fall migration, winter and a portion of spring migration, we present baseline estimates and probability of presence for each month in Appendix D. This way, contemporary surveys from any of the months (October through April) can be compared to the baseline estimates. These estimates combine total individuals from baylands (e.g., salt pond and salt marsh) and open bay habitats in the South Bay.

Table 5. Predicted mean number of individuals and lower and upper confidence intervals (CI) for January for 12 species and species groups in South Bay baylands and open bay habitats based on aerial surveys by Accurso (1992). Scaup=Greater and Lesser scaup, Scoter=all scoter species, Dabblers=all dabbling duck species, Divers=all diver species, waterfowl=all waterfowl species. See Appendix D for monthly predicted means and probability of presence.

Species or spp group	Mean	Lower CI	Upper CI	Reliability Rating
American Wigeon	7,939	2,795	22,546	2
Bufflehead	89	17	484	2
Canvasback	21	4	101	2
Gadwall	1,227	389	4,072	3
Mallard	209	116	387	2
Northern Pintail	50,528	10,298	249,706	3
Northern Shoveler	44,831	13,107	151,964	2
Ruddy Duck	8,650	3,286	22,262	3
Scaup spp.	1,336	488	3,982	2
Scoter spp.	409	167	1,084	4
Total dabblers	68,798	24,318	197,420	2
Total divers	8,649	4,138	17,939	4
Total waterfowl	40,942	20,845	80,108	4

Complex-level Baseline- Level 2

In many cases land stewardship and restoration planning decisions are made at scales that encompass multiple contiguous ponds and marshes that are operated together as a unit (e.g., a Refuge Complex or Ecological Reserve with multiple interconnected ponds, sloughs and marshes whose management is often coordinated). Historical surveys were not always designed with these same boundaries in mind. Often, a sample of sites within the complex is surveyed and the results are extrapolated to the larger area as was the case with the Habitat Conversion Model (HCM) study conducted for the SBSPRP (Stralberg et al. 2006). However, survey data from later years, 2003-2004, covered almost all ponds within the project and were used to inform the HCM. For this report, we present HCM results as baseline estimates for the complex level.

Waterbirds-

Because the analyses were not performed as part of this report, we cannot attribute a baseline estimate rating for each species-season. Instead, we characterize the overall dataset at a reliability rating of 3. The baseline estimates for 26 focal species are presented by season and by complex in Table 6.

Table 6. Baseline estimates (predicted abundance) and lower and upper confidence intervals (CI) by focal species, season and complex calculated from Stralberg et al. (2006) Habitat Conversion Model results based on monthly surveys from 1999 to 2004. W = winter (Nov-Feb), S = spring (Mar-May), F = fall (Aug-Oct). Overall baseline reliability estimate rating = 3.

Name	season	Complex	Predicted Abundance	Lower CI	Upper CI
American Avocet	W	Alviso	1,253	420	2,650
American White Pelican	W	Alviso	156	0	743
Black-bellied Plover	W	Alviso	149	0	727
Black-necked Stilt	W	Alviso	440	103	1,442
Canvasback	W	Alviso	4	0	520
Dunlin	W	Alviso	3,477	1,876	5,804
Eared Grebe	W	Alviso	1,052	312	2,222
Forster's Tern	W	Alviso	90	0	623
Gadwall	W	Alviso	21	0	547
Greater Yellowlegs	W	Alviso	0	0	0
Least Sandpiper	W	Alviso	1,024	210	2,211
Mallard	W	Alviso	44	4	592
Northern Harrier	W	Alviso	1	0	1
Northern Pintail	W	Alviso	61	8	591
Northern Shoveler	W	Alviso	520	36	1,548
Ruddy Duck	W	Alviso	501	28	1,196
Scaup species	W	Alviso	250	0	881
Semipalmated Plover	W	Alviso	216	13	802
Western Sandpiper	W	Alviso	3,294	1,798	5,476
Willet	W	Alviso	760	100	1,816
Dunlin	S	Alviso	7,779	4,487	13,624
Least Sandpiper	S	Alviso	952	305	2,134
Western Sandpiper	S	Alviso	15,812	8,995	29,109
Least Sandpiper	F	Alviso	1,129	95	3,254
Red-necked Phalarope	F	Alviso	629	86	1,601
Western Sandpiper	F	Alviso	4,306	2,139	8,822
Willet	F	Alviso	1,084	62	3,671
Wilson's Phalarope	F	Alviso	440	73	1,346
American Avocet	W	Eden Landing	399	80	1,035
American White Pelican	W	Eden Landing	102	0	481
Black-bellied Plover	W	Eden Landing	72	0	438
Black-necked Stilt	W	Eden Landing	106	0	695
Canvasback	W	Eden Landing	2	0	334
Dunlin	W	Eden Landing	1,438	683	2,487
Eared Grebe	W	Eden Landing	613	131	1,366
Forster's Tern	W	Eden Landing	70	0	416
Gadwall	W	Eden Landing	15	0	353
Least Sandpiper	W	Eden Landing	637	152	1,379
Mallard	W	Eden Landing	21	0	371

Name	season	Complex	Predicted Abundance	Lower CI	Upper CI
Northern Pintail	W	Eden Landing	29	0	362
Northern Shoveler	W	Eden Landing	338	2	978
Ruddy Duck	W	Eden Landing	303	14	749
Scaup species	W	Eden Landing	180	0	589
Semipalmated Plover	W	Eden Landing	71	0	408
Western Sandpiper	W	Eden Landing	1,337	627	2,312
Willet	W	Eden Landing	284	25	882
Dunlin	S	Eden Landing	1,625	906	2,989
Least Sandpiper	S	Eden Landing	236	43	741
Western Sandpiper	S	Eden Landing	3,178	1,815	5,654
Least Sandpiper	F	Eden Landing	484	2	1,654
Red-necked Phalarope	F	Eden Landing	464	158	1,083
Western Sandpiper	F	Eden Landing	883	371	2,415
Willet	F	Eden Landing	409	7	1,812
Wilson's Phalarope	F	Eden Landing	162	12	680
American Avocet	W	Ravenswood	304	110	618
American White Pelican	W	Ravenswood	41	0	170
Black-bellied Plover	W	Ravenswood	43	0	171
Black-necked Stilt	W	Ravenswood	50	0	252
Canvasback	W	Ravenswood	1	0	113
Dunlin	W	Ravenswood	817	446	1,322
Eared Grebe	W	Ravenswood	64	0	260
Forster's Tern	W	Ravenswood	22	0	138
Gadwall	W	Ravenswood	4	0	118
Least Sandpiper	W	Ravenswood	194	42	433
Mallard	W	Ravenswood	9	0	128
Northern Pintail	W	Ravenswood	14	0	129
Northern Shoveler	W	Ravenswood	106	0	318
Ruddy Duck	W	Ravenswood	123	3	278
Scaup species	W	Ravenswood	73	0	213
Semipalmated Plover	W	Ravenswood	54	0	185
Western Sandpiper	W	Ravenswood	831	467	1,323
Willet	W	Ravenswood	191	39	421
Dunlin	S	Ravenswood	1,407	795	2,291
Least Sandpiper	S	Ravenswood	186	17	467
Western Sandpiper	S	Ravenswood	2,692	1,544	4,460
Least Sandpiper	F	Ravenswood	232	9	660
Red-necked Phalarope	F	Ravenswood	148	25	344
Western Sandpiper	F	Ravenswood	928	337	1,921
Willet	F	Ravenswood	256	27	830
Wilson's Phalarope	F	Ravenswood	116	6	320

Site-specific Baseline- Level 3

The ISBA-DB website allows resource managers, planners, and researchers to estimate baseline numbers of waterbirds at a specific site (or collection of sites) using a user-defined range of dates. In this example, the baseline number of wintering small shorebirds is estimated for the Eden Landing pond E12. A step-by-step example follows with recommendations for further customizing or refining the queries.

Generating an ISBA-DB Summary Report

1. Enter www.prbo.org/isbadb into your web browser. The ISBA-DB homepage appears and offers several links for getting started.
2. Click the “Data- Query and download observation data” link.
3. Acknowledge the multi-partner ISBA-DB Data Sharing Agreement by clicking “I agree.”
4. Enter the email address you used to register with ISBA-DB then enter your password.
    a. If you have not registered, click to register and your request for access will be sent to the web host and the South Bay Salt Pond Restoration Project Lead Scientist for authorization.
5. On the Area Survey Data screen, follow the steps to query the desired results beginning by selecting the “Ponds” button and selecting “E12” pond in the Eden Landing Ecological Reserve.
6. Click on the “Guild(s)” button, hold the ctrl key and select medium shorebirds and small shorebirds, “MEDSHORE + SMSHORE.” Click the yellow question mark for information on guild composition.
7. Then define the range of years of observation data; for example select the desired start year, “2003,” and the desired end year, “2004.”
8. Select the start and end months of the desired survey data; for example, “January” to “February.”
9. Select tide level “High.”
10. Review your selections to confirm the query and click “Summary Report.” Depending on the number of records being queried, there may be a delay while ISBA-DB retrieves the records, performs the analysis, and generates the summary report. The example here should take less than 10 seconds.
11. Review the results of the ISBA-DB summary report.

Interpreting the Summary Report

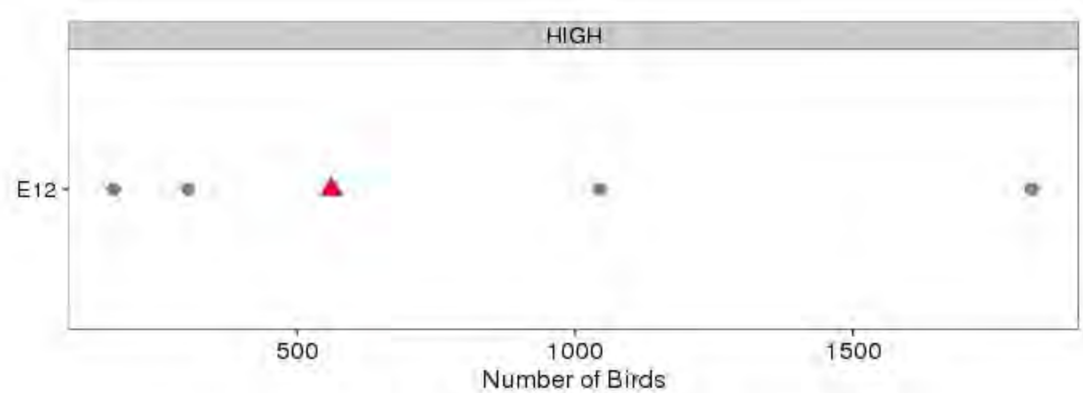
The ISBA-DB Summary Report includes the weighted geometric mean of number of individuals by tide height at time of survey at Pond E12 for small shorebirds (Table 7 and Figure 1) and monthly totals of waterbird use (Table 8). On the website, each table and figure can be downloaded as a csv, doc, html, or pdf file by clicking on the links above the table or figure. This allows tables and figures to be easily included in reports or presentations. Downloading csv files allows a user to aggregate tables, perform custom summaries or create custom figures in Excel or statistical software.

The geometric mean number of small and medium shorebirds at E12 prior to the ISP was 564.09 (Table 7 and Figure 7) with a range of 172 to 1,823 (Table 8). If a complex or reserve is selected, the geometric mean is weighted by the area of the ponds surveyed to account for variation in the sampling effort among years.

Table 7. Geometric mean number of small and medium shorebirds from ISBA-DB Summary Report for pond E12 in the Eden Landing Ecological Reserve, for January and February, 2001 through 2004 during high tide.

Location	Mean	Tide
E12	567.09	HIGH

Figure 1. The geometric mean for all small and medium shorebirds during January and February, 2003 and 2004. Shown below is the geometric mean (red triangle) and total counts for the sampling events (gray dots).



Also included in the report is species richness which is the total number of species observed in each pond/complex surveyed, for the user-selected taxa only and using only identified species (e.g., unknown Western/Least/Dunlin were not included). At E12 small and medium shorebird species richness varied from 3 to 8.

Table 8. Monthly totals of bird use by tide level at E12 for small and medium shorebirds during January and February, 2003-2004. Richness is the total number of species observed for the selected site and for the selected taxa. Total Count is the sum of all individuals across taxa. Area surveyed in hectares. Note: the ISBA-DB summary report includes additional columns not shown here (e.g., physical pond conditions). Area surveyed is in hectares.

Plot	Year Collected	Month Collected	Tide Level	Richness	MEDSHORE	SMSHORE	TotalCount	AreaSurveyed
E12	2003	1	HIGH	3	0	172	172	47.06
E12	2003	2	HIGH	7	742	304	1046	47.06
E12	2004	1	HIGH	4	25	281	306	47.06
E12	2004	2	HIGH	8	462	1361	1823	47.06

Recommendations

Assessing Change

Many of the baseline estimates provided in this report were taken directly from the results of published studies whose goals were different from that of describing baseline avian conditions for the SBSPRP. As such, the baseline estimates, and especially those with low ratings (0-2), should be interpreted with caution. We recommend using the baseline estimates within the context of how the data were collected. The actual number of birds present at a site or group of sites was likely different from what was reported on surveys because of imperfect detection and other sources of bias. For example, in the case of aerial-based surveys of waterfowl, the number of individuals is likely underrepresented. Most importantly, current and future numbers of birds should be compared to these baseline estimates by using field and analysis methods that best approximate those used in the past. The most valuable baseline estimates will be those that are derived from methods that are part of a long-term ongoing monitoring program designed in part to detect change over time.

Setting Targets

This report represents a first step toward setting targets for the SBSPRP and most importantly, designing a monitoring program to measure change and progress toward the targets. The results of surveys presented in this report were intended to represent minimum population sizes. Because most waterbirds are mobile, and habitat use varies, the baseline estimates, usually developed from surveys lasting from a few minutes to an hour, are effectively "snapshot" estimates of habitat use and are likely to underestimate bird use over the period of an entire day or season. This is in addition to the limitations of the surveys to assess true population densities. As such, we recommend using the baseline estimates along with information from carrying capacity modeling, as in Brand et al. (2012) and Rowan et al. (2011), to set population targets that consider potential habitat use by birds.

The historic waterbird survey results presented in this report and the custom-generated results from ISBA-DB can be used as baseline numbers for various bird species, in different seasons and for different areas of the South Bay. Following the guidance from the PMT, this report describes the baseline as bird use of an area prior to 2005 but because conservation actions during the ISP were not initiated at the same time, managers and decision-makers may choose to define baseline conditions differently for specific ponds or sites. In this case, we recommend using ISBA-DB which offers the flexibility and control to define the spatial and temporal extent of the survey data being queried for any given site. In addition to determining baselines and helping set conservation targets, ISBA-DB can provide the framework for ongoing avian data management and could be used to track bird response to restoration and wildlife-friendly management actions in real-time. Tracking bird response to restoration and management over time can only be achieved with continued monthly high-tide waterbird surveys.

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Appendices

Appendix A- Annotated Bibliography of Historical Waterbird Numbers

This appendix is a selected list of sources (technical reports and published journal articles) relevant to determining baseline waterbird numbers in San Francisco Bay with an emphasis on the South San Francisco Bay. This annotated bibliography summarizes the scope of the study area, study period and study species, and summarizes the methods used, main findings and recommendations of each reference. The purpose of this annotated bibliography is to inform the reader about the relevance of the reference to his or her management questions. The summary information below includes text taken directly from the reference source as well as interpretation and paraphrasing of the main findings by the authors of this report in an effort to provide the most concise and useful information. The original source material should be always be used to make informed management decisions.

References

Accurso L.M. 1992. Distribution and abundance of wintering waterfowl on San Francisco Bay 1988-1990 (M.S. thesis). Humboldt State University, Arcata, CA.

Study Area: San Francisco, San Pablo, and Suisun bays
Study Period: Monthly and twice-monthly surveys in winter from 1987-1990
Study Species: all waterfowl in the SF Bay Estuary

Summary:
Peak waterfowl counts in December and January

Wintering population 45% scaup species, 20% scoter species, 13% Northern Shoveler, >7% Ruddy Duck, and <7% Canvasback.

Distribution maps of waterfowl use of SF Bay

Salt pond regions held 34% of the waterfowl on 23% of the surface area.

Ackerman, J. T., and M. P. Herzog. 2011. Waterbird Nest Monitoring Program in San Francisco Bay (2005-2010). Summary Report, U. S. Geological Survey, Western Ecological Research Center, Davis, CA. 21 pp.
http://www.southbayrestoration.org/documents/technical/Ackerman%20and%20Herzog%20Waterbird%20Nest%20Program%20OFR%202012.pdf

Study area: SBSPRP including land within DESFBNWR, Eden Landing Ecological Reserve, and land managed by Cargill Inc.
Study period: 2005 – 2010
Study species: Forester's Tern, American Avocet, Black-necked Stilt

Summary:
Found immediate response to management (nesting islands were created by lowering water levels in pond A12)- waterbirds increased nesting (from 0 to 500 attempts in 2008).

Because nest monitoring effort varied across years, it was not possible to estimate total abundance of nesting waterbirds. Variation was due to funding availability.

Nearly 11,000 nests monitored by USGS from 2005-2010. Forster's Tern and American Avocet abundance was variable at sites throughout the South Bay complex, while Black-necked Stilt were concentrated at New Chicago Marsh.

Nest success was highly variable and dependent on localized conditions for all 3 species.

Recommendations:
Continue the long-term annual waterbird nest monitoring program and increase communication between researchers and managers to facilitate adaptive management.

Design and implement a comprehensive breeding survey to estimate the total population sizes and nesting success of waterbirds in the South San Francisco Bay.

Manage ponds to create waterbird nesting habitat, but with caution because some sites have high levels of mercury contamination.

Maintain ponds A1 and A2W as managed salt ponds and bolster the nesting islands to halt erosion.   The ponds contained 21% of all monitored Forster's Tern nests in the South Bay.

Mitigate the loss of nesting habitat for approx. 300-400 American Avocet pairs, annually, in ponds A7 and A8 slated for tidal restoration.

Replicate New Chicago Marsh's muted tidal conditions to benefit nesting Black-necked Stilts.

Targeting individual California Gulls that specialize in preying upon waterbird eggs and chicks may be more effective than targeting all California Gulls at the waterbird nesting site.

Bollman, F.H., P.K. Thelin, and R.T. Forester. 1970. Bimonthly bird counts at selected observation points around San Francisco Bay, February 1964 to January 1966. Calif. Fish and Game 56:224-239.

Study Area: San Francisco and San Pablo Bay
Study Period: Twice monthly from 1964 - 1965
Study Species: all species in the SF Bay Estuary

Summary:
Established 13 census areas, conducted counts at 139 points, and 2 aerial survey areas in San Pablo Bay.

Census areas covered 14,350 acres of salt pond habitat, 67,955 acres open water, 44,690 acres of tidal flat, and 26,240 acres of marsh.

824,450 total birds were counted in salt ponds in 1964 with ducks (135,300) and shorebirds (629,200) found in the highest numbers.

1,050,185 total birds were counted in salt ponds in 1965 with duck numbers doubling from the previous year count to 328,800 and shorebird numbers decreasing to 562,950.

Tidal flats, followed by salt ponds, supported the greatest number of shorebirds in both years. For ducks, the greatest numbers were found in open water and salt ponds.

Study was primarily an inventory of bird numbers, and more in depth comparisons based on seasonality, habitat types, or site level productivity were not assessed with this count.

Brand, A.L., J.Y. Takekawa, J. Shinn, K. Miles, and S. Spring. 2012. Effects of wetland management on carrying capacity of duck and shorebird benthivores in a coastal estuary. Final data summary report to South Bay Salt Pond Restoration Project.

Study area: SBSPRP- 46 ponds included, 7 excluded
Study period: winter 2007-2010
Study species: Diving duck species (Scaup, Ruddy Duck, Canvasback, Bufflehead) and shorebird species (Western Sandpiper, Dunlin, Black-bellied Plover, American Avocet, Least Sandpiper, Willet, Marbled Godwit, and Black-necked Stilt)

Summary:
Carrying capacity (bird-days) defined as species energy requirements + prey energy available.

Because prey quality or shorebird foraging efficiency may be directly affected by a change in mud flat characteristics resulting from restoration, such effects should be identified before significant changes to mud flats occur.

Changes in mud flats may be subtle, and include increased slope, elevation, or channelization. Focused on shorebird/waterfowl species that depend on benthic inverts (Western Sandpiper, Dunlin).

An average of 35,000 and a peak of 45,000 diving ducks, and an average of 64,000 and a peak of 108,000 shorebirds used the study area at high tide through winter, with the greatest shorebird abundances in seasonal ponds and greatest diving duck abundances in circulation ponds.

Among 16 benthic invertebrate taxa, there were substantial differences in average abundance per sample among pond types.

Overall, the study area provided 102% of energy required for the diving duck guild across the study area at average abundance and 79% of the energy required at peak abundance. The study area provided only 52% of the energy required for small shorebirds and 29% of that needed at peak abundances.

High variability in results across sites was dependent upon pond types, inverts and bird species.

Demers, S. A., J. Y. Takekawa, J. T. Ackerman, N. Warnock, and N. D. Athearn. 2010. Space use and habitat selection of migrant and resident American Avocets in San Francisco Bay. The Condor Vol. 112(3).

Study Area: South Bay salt pond (pond A8) and adjacent Coyote Creek lagoon and tidal flat
Study Period: March and February 2005 and 2006
Study Species: American Avocets

Summary:
Habitat selection differed little between migrant and resident American Avocets, but capture site greatly influenced habitat selection.

Suggested that individuals have high wintering site fidelity, but the species is plastic in their space and habitat use, indicating an ability to adapt to habitat changes in the South Bay.

Hickey, C., N. Warnock, J.Y. Takekawa, and N.D. Athearn. 2007. Space use by Black-Necked Stilts *Himantopus mexicanus* in the San Francisco Bay Estuary. Ardea 95:275-288.

Study area: San Francisco Estuary
Study period: June – September 1999
Study species: Black-necked Stilts

Summary:
Marked 20 male and 13 female Black-necked Stilts with radio-transmitters in South Bay sites.

Cluster analysis showed overall space requirements were larger for stilts with multiple centers of activity. Birds with multiple centers of activity were often those that bred in vegetated marshes and moved into salt ponds when their nests failed or after chicks hatched.

Stilts in 3 of the 4 South Bay breeding areas heavily used salt ponds at Don Edwards San Francisco Bay National Wildlife Refuge. The 4 stilts captured in Ravenswood, stayed there less than 3 weeks after the beginning of their tracking periods; 3 of those stilts crossed to the Bay's east shore. Stilts captured in New Chicago Marsh moved into nearby salt ponds and stayed in the southern portion of the Bay for their entire tracking periods.

Home range size did not differ by subregion, despite the marked difference in the proportions of various wetland types between the North and South Bays. Differing home range sizes by capture site indicated that stilts responded to habitats on a finer scale. Site specific water level management most likely accounted for some of the bird's movements.

Recommendation:
Retain shallow, mid-salinity ponds particularly during breeding, to mitigate losses due to salt pond conversion to tidal marsh, based upon Black-necked Stilt needs for hypersaline habitat and associated brine flies and shrimp.

Rintoul, C., N. Warnock, G.W. Page, and J.T. Hanson. 2003. Breeding status and habitat use of Black-necked Stilts and American Avocets in South San Francisco Bay. Western Birds 34:2-14.

Study area: South SF Bay (south of San Mateo Bridge)
Study period: May 2001
Study species: Black-necked Stilts, American Avocets

Summary:
Comprehensive coverage in the South Bay counted 1,184 stilts and 2,765 avocets.

270 stilts and 880 avocets were confirmed to be breeding, the rest were likely breeding.

Surveyed 9,613 ha of salt ponds, 4,068 ha of tidal/diked marshes, 575 ha of other diked wetlands, and approximately 4,039 ha of tidal flats.

Salt ponds contained the highest numbers of both species, followed by marshes, other wetlands, and tidal mudflats.

Fewer than 20% of the stilts and avocets detected were found on levees, while the greatest concentrations were on islands within salt ponds. Suggested that human disturbance on levees was the contributing factor.

Rowan, A., I. Woo, J. Takekawa, J. Lovvorn, J. Davis. 2011. Effects of the South Bay Salt Pond Restoration Project (San Francisco Bay, California) on Mud Flats and their Carrying Capacity for Small Shorebirds. Final Technical Report to RLF. Available from: http://www.southbayrestoration.org/documents/technical/Rowan_CarryingCapacity2011.pdf

Study area: Dumbarton Shoals
Study period: 2009-2010
Species: Western Sandpiper, Dunlin

Summary:
Mudflat at carrying capacity for small shorebirds during spring migration.

Reducing mudflat foraging area by 1/3 reduced bird use days in all months (The effect on baywide numbers was not investigated.).

Recommendations:
Manage for shallow pond habitat during spring migration and winter to account for potential 30% decline in mudflat habitat over next 50 yrs.

Stenzel, L.E. and G.W. Page. 1988. Results of the first comprehensive shorebird census of San Francisco and San Pablo bays. Wader Study Group Bulletin 54: 43-48.

Study area: San Francisco and San Pablo bays
Study period: April 1988
Species: Shorebirds

Summary:
First comprehensive Bay-wide shorebird survey.

70% of the shorebirds were found south of the San Mateo Bridge, largest number from San Mateo to Dumbarton Bridge east side of south Bay.

High-tide counts in salt ponds south of Dumbarton totaled over 296,000 small sandpipers with 240,000 counted in one salt pond alone.

Stenzel, L.E., C.M. Hickey, J.E. Kjelmyr and G.W. Page. 2002. Abundance and distribution of shorebirds in the San Francisco Bay area. Western Birds 33: 69-98.

Study area: San Francisco Estuary
Study period: 1988 – 1993
Species: Shorebirds

Summary:

Three fall counts between mid-August and mid-September 1988-1990, three "early winter" counts in early November I990-I992, a late winter count in late January to early February 1991, and six spring counts in late April 1988-1993.

Salt ponds accounted for most phalarope detections, 50% or more of Black-necked Stilt detections on four of five spring censuses, 35% of Snowy Plover and American Avocet detections during fall, and at least 40% of Snowy Plover and yellowlegs detections during spring.

Generally found higher proportion of stilts and avocets in salt ponds in fall than in spring, with yellowlegs showing the opposite pattern.

As an additional indicator of shorebird distribution within a season, biomass was estimated, and was highly correlated with the high density areas. Tidal flats on the east side of central San Francisco Bay and adjacent to the active salt ponds on the east and south shores of south San Francisco Bay had the highest shorebird densities and biomass.

Stralberg, D., D.L. Applegate, S.J. Phillips, M.P. Herzog, N. Nur and N. Warnock. 2008. Optimizing wetland restoration and management for avian communities using a mixed integer programming approach. Biological Conservation 142: 94–109.

Study area: South Bay salt ponds totaling 5471 ha
Study period: Monthly surveys were conducted from October 1999 to February 2000, September 2000 to April 2001, and November 2002 to January 2004
Study species: Tidal marsh and salt pond associated bird species

Summary:

Identified management strategies that simultaneously maximized abundances of marsh and pond-associated species.

Applied an integer programming approach to maximize avian abundance, comparing across two objectives, two models, and five species weightings.

Models showed that heterogeneous habitat configurations benefited more species.

Optimal mash area ranged from 9 to 60% of the SBSP study area. The range was dependent on the value or weighting assigned to each species, indicating the importance of selecting priority species for achieving desired conservation outcomes.

Recommendations:

Shallow managed ponds provided maximum benefits for the most species, but restoration of at least half the ponds to tidal marsh habitat was recommended when tidal-marsh-specialists and high conservation status species were prioritized.

Spatially, tidal marsh restoration and retention of high salinity ponds should be nearer the Bay while low salinity ponds should be maintained further inland.

Improve the model with additional variables (socio-economic costs and restoration constraints).

Strong, C.M., L.B. Spear, T.P. Ryan, and R.E. Dakin. 2004. Forster's Tern, Caspian Tern, and California Gull Colonies in San Francisco Bay: Habitat Use, Numbers and Trends, 1982-2003. Waterbirds 27:411-423.

Study Area: San Francisco Bay Estuary
Study species: Forster's Tern, Caspian Tern, and California Gull
Study period: 1982-2003

Summary:

Analyzed nesting colony census data from entire SF Bay Estuary and described nest sites.

Trends: CATE stable, FOTE decreased, CAGU increased.

Stressors: mammalian predation, human disturbance, and possibly annual variation in food availability

Recommendations:

Create sizeable tracts of islands specifically designed to provide nesting habitat for larids.

Replacement sites should be in place soon after the restoration has been implemented; i.e., well before scheduled completion.

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.

Study Area: South Bay salt ponds
Study species: all major bird guilds associated with salt ponds
Study period: October 2002- June 2005

Summary:

Provided baseline data for the SBSPRP by reporting a completed bathymetry and levee habitat map, characterized sediments, invertebrate composition and fishes for salinity reduction, monitored water quality concurrent with bird surveys, sampled discharge during desalination, assessed of hydrology and morphology of sloughs, characterized invertebrate and fish communities in sloughs for comparison, and assisted in development of LiDAR map

Ponds with lowest salinity (27-44 ppt) had greatest macroinvertebrate taxa richness.

Total bird numbers were positively related to fish abundance, but not to invertebrate abundance.

No relationships between avian foraging abundance (for any guild) and invertebrate or fish abundance were significant.

Bird guilds exhibit differing relationships with pond selection criteria, and multivariate analyses was performed for each guild separately, with seasonality of guild presence in the ponds as a contributing factor.

Shallow water and aquatic vegetation associated with non-high saline ponds provided optimal foraging conditions for dabbling and diving ducks.

Fish eaters were highly associated with ponds of lower salinity because their prey cannot tolerate high salinity (no greater than 80ppt). Herons and Forster's Terns showed similar relationships to salinity. Herons are associated with water depth as well, related to their foraging methods of wading in shallow water.

Small and medium shorebirds were highly associated with mean pond depth, requiring shallow ponds to forage in.

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: The International Journal of Waterbird Biology, Vol. 25, Special Publication 2: Managing Wetlands for Waterbirds: Integrated Approaches pp. 79-92.

Study area: 22 South Bay salt ponds
Study period: October 1999 to Feb 2000 and Sept. 2000- Feb. 2001
Study species: all salt pond associated waterbird species

Summary:

Birds were counted during the winter months of 1999-00 and 2000-01, on high and low tides.

Although salt ponds are non-tidal, ponds were surveyed twice in a day; once on a high tide greater than 1.2 m and once on a low tide less than 0.8 m. This was done because there is an exchange of some birds with the nearby bay, driven by the tidal cycle.

In 1999, 51 species of waterbirds totaling 136,900 birds were recorded on 54 high tide counts, and 44 species totaling 49,600 birds were recorded on 54 low tide counts.

In 2001, 69 species of waterbirds totaling 919,900 birds were recorded on 192 high tide counts, and 65 species totaling 283,700 birds were recorded on 161 low tide counts.

Dunlin and Western Sandpiper were the most abundant shorebird species (35% of all the birds counted) found in the salt ponds, followed by Willet, American Avocet, and Black-bellied Plover. Northern Shoveler accounted for 18% of all the ducks and grebes counted.

Effects included year (1999, 2000); month (September-February); area of pond (ha); tide (high and low); salinity (average salinity of pond, ppt) and pond. These were all significant indicators of bird use of the salt ponds, but with different effects for specific groupings of birds, based mainly on foraging methods.

Combining all waterbird species and controlling for various effects, the highest numbers of birds were in salinities of ~140 ppt and highest species diversity in salinities of ~126 ppt. This non-linear effect of salinity on numbers and diversity of waterbirds relates to prey diversity. But it is encouraged that various pond salinities are maintained to support diverse prey.

Annual bird use of salt ponds (calculated in bird days) numbered in the millions, supporting the existing designation of San Francisco Bay as a site of hemispheric importance to shorebirds

Recommendations:

To support maximum diversity of species, management needs to vary pond salinities and water depths, and maintaining islands for roosting.

Encouraged further study of the relationship between pond size to species numbers and diversity.

Warnock, N. and J.Y. Takekawa. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: Western Sandpipers in the San Francisco Bay estuary. Auk 112: 920-930.

Study area: San Francisco Estuary
Study period: winter and spring 1991- 1992
Study species: Western Sandpiper

Summary:
Investigated habitat preferences at two scales: proportions of habitat in home range with habitats available in the study area, and comparing proportions of radio locations in different habitats with their availability in the home range

Habitat preferences changed significantly depending on season and habitat availability, usually tidal influenced; preference also changed depending on how habitat availability was defined

Under all scales and scenarios salt ponds remained highly important for wintering Western Sandpiper.

Wood, J.K., G. Page, M. Reiter, L. Liu, C. Robinson-Nilsen. Abundance and Distribution of Wintering Shorebirds in San Francisco Bay, 1990-2008: Population Change and Informing Future Monitoring. 2010. PRBO Conservation Science Final Technical Report to Resources Legacy Fund, Sacramento, CA. 56 pp.

Study area: San Francisco Estuary
Study period: winter 2006-2008
Study species: All Shorebirds

Summary:
Stable or increasing populations for most species compared to equivalent surveys conducted from 1990 through 1992.

The number of individuals of 8 of 22 species increased throughout the Bay between the 1990-1992 and 2006-2008 survey periods with Willet and Least Sandpiper increasing by more than 4,000 individuals.

Dunlin and Snowy Plover decreased by 20,000 and 49 in the South Bay. Long-billed Curlew and Least Sandpiper increased by 1,000 and 12,000 birds.

Appendix B- Shorebird Codes

AOU Code	Spp. Group	Name	Species
BBPL	MEDI	Black-bellied Plover	*Pluvialis squatarola*
LEGP	MEDI	Lesser Golden-Plover	*Pluvialis dominica/fulva*
SNPL	SMAL	Snowy Plover	*Charadrius alexandrinus*
SEPL	SMAL	Semipalmated Plover	*Charadrius semipalmatus*
KILL	MEDI	Killdeer	*Charadrius vociferus*
BNST	MEDI	Black-necked Stilt	*Himantopus mexicanus*
AMAV	MEDI	American Avocet	*Recurvirostra americana*
GRYE	MEDI	Greater Yellowlegs	*Tringa melanoleuca*
LEYE	MEDI	Lesser Yellowlegs	*Tringa flavipes*
WILL	MEDI	Willet	*Catoptrophorus semipalmatus*
WATA	MEDI	Wandering Tattler	*Heteroscelus incanus*
SPSA	SMAL	Spotted Sandpiper	*Actitis macularius*
WHIM	MEDI	Whimbrel	*Numenius phaeopus*
LBCU	MEDI	Long-billed Curlew	*Numenius americanus*
MAGO	MEDI	Marbled Godwit	*Limosa fedoa*
RUTU	MEDI	Ruddy Turnstone	*Arenaria interpres*
BLTU	MEDI	Black Turnstone	*Arenaria melanocephala*
REKN	MEDI	Red Knot	*Calidris canutus*
SAND	SMAL	Sanderling	*Calidris alba*
SESA	SMAL	Semipalmated Sandpiper	*Calidris pusilla*
WESA	SMAL	Western Sandpiper	*Calidris mauri*
LESA	SMAL	Least Sandpiper	*Calidris minutilla*
BASA	SMAL	Baird's Sandpiper	*Calidris bairdii*
PESA	SMAL	Pectoral Sandpiper	*Calidris melanotos*
DUNL	SMAL	Dunlin	*Calidris alpina*
STSA	MEDI	Stilt Sandpiper	*Calidris himantopus*
RUFF	MEDI	Ruff	*Philomachus pugnax*
DOWI	SMAL	Short-billed Dowitcher	*Limnodromus griseus*
DOWI	SMAL	Long-billed Dowitcher	*Limnodromus scolopaceus*
COSN	MEDI	Common Snipe	*Gallinago gallinago*
WIPH	PHAL	Wilson's Phalarope	*Phalaropus tricolor*
RNPH	PHAL	Red-necked Phalarope	*Phalaropus lobatus*
REPH	PHAL	Red Phalarope	*Phalaropus fulicarius*

Appendix C- Breeding American Avocet and Black-necked Stilt Survey Map

Map of areas surveyed and not surveyed for breeding American Avocet and Black-necked Stilt in the South Bay from Rintoul et al. (2003).

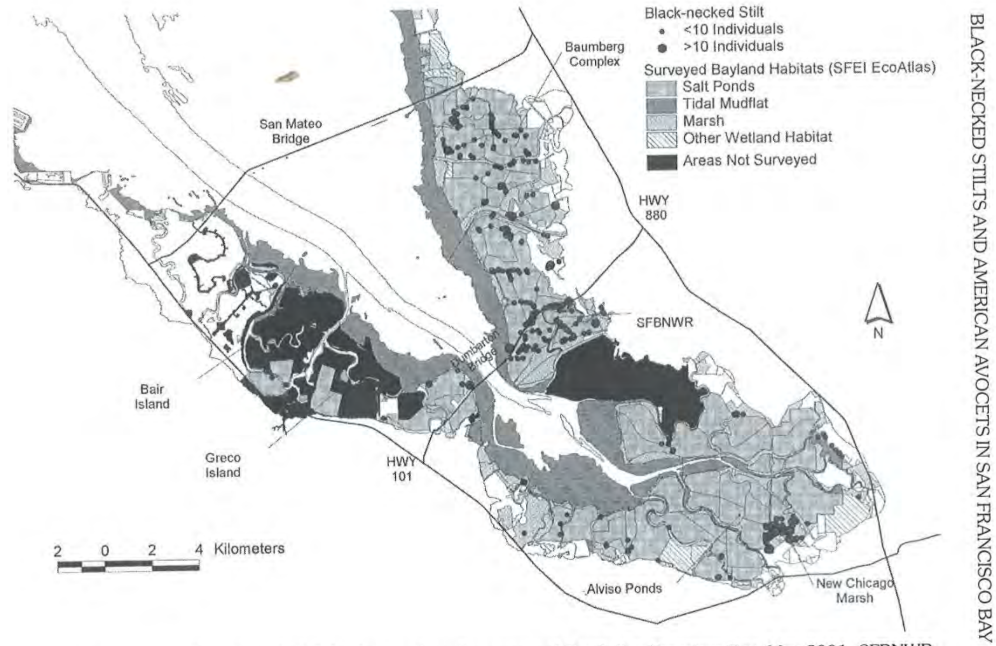

Figure 1. Locations of Black-necked Stilts during a breeding survey of South San Francisco Bay, May 2001. SFBNWR, Don Edwards San Francisco Bay National Wildlife Refuge.

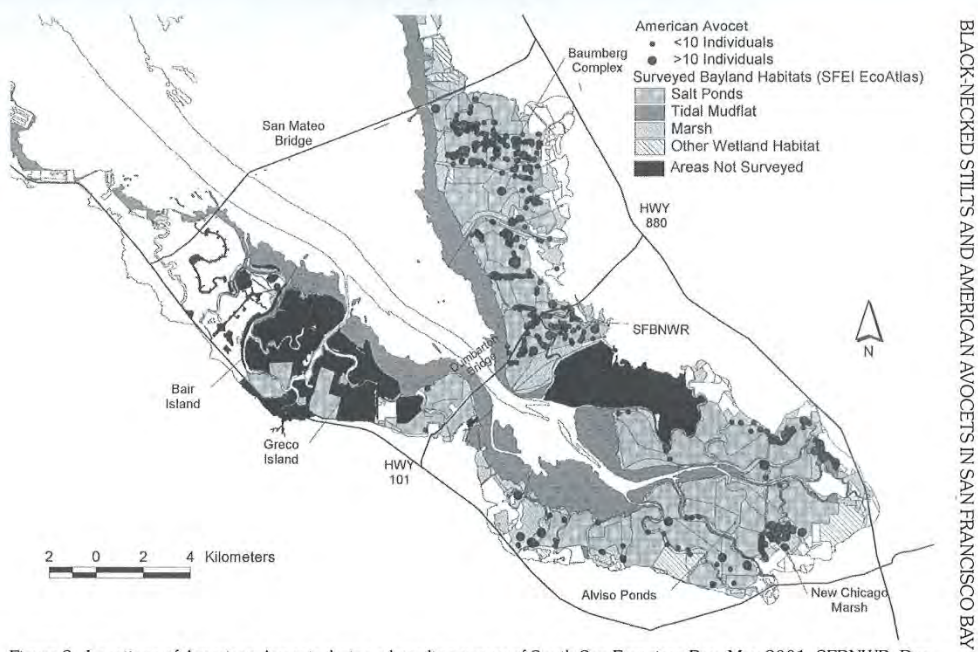

Figure 2. Locations of American Avocets during a breeding survey of South San Francisco Bay, May 2001. SFBNWR, Don Edwards San Francisco Bay National Wildlife Refuge.

Appendix D- Wintering Waterfowl Baseline

Predicted mean number and lower and upper confidence intervals (CI) of individuals for 14 species or species groups in South Bay bayland and open bay habitats based on aerial surveys (October to April, 1987-1989). Presence is the probability of encountering individuals within the survey area. Scaup=Greater and Lesser scaup, Scoter=all scoter species, Dabbler=all dabbling duck species, Diver=all diver species, waterfowl=all waterfowl species.

Species or spp group	Month	Mean	Lower CI	Upper CI	Presence	Rating
American Wigeon	OCT	3,133	1,086	9,119	0.50	2.1
American Wigeon	NOV	1,077	378	3,118	0.80	2.1
American Wigeon	DEC	1,177	393	3,588	0.90	2.1
American Wigeon	JAN	1,259	406	3,863	1.00	2.1
American Wigeon	FEB	355	175	740	0.90	2.1
American Wigeon	MAR	172	88	346	1.00	2.1
American Wigeon	APR	609	272	1,354	1.00	2.1
Bufflehead	OCT	743	214	2,661	0.43	2.1
Bufflehead	NOV	553	159	1,996	0.90	2.1
Bufflehead	DEC	140	39	535	1.00	2.1
Bufflehead	JAN	23	5	116	1.00	2.1
Bufflehead	FEB	325	139	800	1.00	2.1
Bufflehead	MAR	369	161	899	1.00	2.1
Bufflehead	APR	182	68	492	0.75	2.1
Canvasback	OCT	1,102	329	4,146	0.20	1.9
Canvasback	NOV	1,455	439	5,212	0.70	1.9
Canvasback	DEC	68	21	237	0.90	1.9
Canvasback	JAN	7	1	35	1.00	1.9
Canvasback	FEB	815	317	2,183	1.00	1.9
Canvasback	MAR	655	269	1,675	1.00	1.9
Canvasback	APR	762	276	2,128	1.00	1.9
Gadwall	OCT	187	49	755	0.50	2.5
Gadwall	NOV	242	61	1,038	0.50	2.5
Gadwall	DEC	206	50	910	0.50	2.5
Gadwall	JAN	196	47	879	0.70	2.5
Gadwall	FEB	155	53	472	0.70	2.5
Gadwall	MAR	87	30	256	0.70	2.5
Gadwall	APR	177	57	550	0.50	2.5
Mallard	OCT	28	13	60	0.50	2.4
Mallard	NOV	27	13	56	0.82	2.4
Mallard	DEC	16	8	34	0.50	2.4
Mallard	JAN	45	21	97	0.50	2.4
Mallard	FEB	33	19	60	0.50	2.4

Species or spp group	Month	Mean	Lower CI	Upper CI	Presence	Rating
Mallard	MAR	27	15	50	0.80	2.4
Mallard	APR	26	15	47	1.00	2.4
Northern Pintail	OCT	10,787	2,128	56,681	0.50	3.3
Northern Pintail	NOV	2,319	483	11,568	0.90	3.3
Northern Pintail	DEC	3,828	798	18,888	0.90	3.3
Northern Pintail	JAN	10,254	1,959	54,613	1.00	3.3
Northern Pintail	FEB	185	78	443	0.90	3.3
Northern Pintail	MAR	175	78	405	1.00	3.3
Northern Pintail	APR	497	176	1,405	0.50	3.3
Northern Shoveler	OCT	4,657	1,191	18,248	0.50	2.3
Northern Shoveler	NOV	1,378	351	5,539	0.80	2.3
Northern Shoveler	DEC	2,660	681	10,665	0.90	2.3
Northern Shoveler	JAN	2,275	565	9,110	0.90	2.3
Northern Shoveler	FEB	839	350	2,049	0.50	2.3
Northern Shoveler	MAR	956	386	2,368	0.70	2.3
Northern Shoveler	APR	1,056	385	2,902	0.75	2.3
Ruddy Duck	OCT	2,200	810	5,969	1.00	2.9
Ruddy Duck	NOV	1,654	605	4,481	1.00	2.9
Ruddy Duck	DEC	2,480	907	6,679	1.00	2.9
Ruddy Duck	JAN	1,318	482	3,565	1.00	2.9
Ruddy Duck	FEB	1,071	510	2,270	1.00	2.9
Ruddy Duck	MAR	963	458	2,029	1.00	2.9
Ruddy Duck	APR	1,217	540	2,752	1.00	2.9
Scaup spp.	OCT	4,552	1,610	13,481	0.80	2.2
Scaup spp.	NOV	4,976	1,705	15,229	0.90	2.2
Scaup spp.	DEC	3,254	1,086	10,203	1.00	2.2
Scaup spp.	JAN	329	115	1,004	1.00	2.2
Scaup spp.	FEB	8,741	3,409	23,865	1.00	2.2
Scaup spp.	MAR	3,414	1,385	8,820	1.00	2.2
Scaup spp.	APR	7,250	2,750	19,085	1.00	2.2
Scoter spp.	OCT	812	264	2,596	0.92	3.6
Scoter spp.	NOV	787	253	2,545	0.90	3.6
Scoter spp.	DEC	658	210	2,122	1.00	3.6
Scoter spp.	JAN	52	17	165	1.00	3.6
Scoter spp.	FEB	4,769	1,582	14,989	1.00	3.6
Scoter spp.	MAR	2,102	747	6,316	1.00	3.6
Scoter spp.	APR	379	141	1,041	1.00	3.6
Total dabblers	OCT	12,639	4,332	37,507	0.70	2.2
Total dabblers	NOV	3,372	1,192	10,054	1.00	2.2
Total dabblers	DEC	4,099	1,435	12,122	1.00	2.2
Total dabblers	JAN	5,149	1,713	15,811	1.00	2.2
Total dabblers	FEB	1,657	815	3,447	1.00	2.2
Total dabblers	MAR	1,614	795	3,366	1.00	2.2

Species or spp group	Month	Mean	Lower CI	Upper CI	Presence	Rating
Total dabblers	APR	1,947	854	4,389	1.00	2.2
Total divers	OCT	34,203	16,545	70,458	1.00	3.6
Total divers	NOV	18,282	8,772	37,711	1.00	3.6
Total divers	DEC	23,222	11,151	47,854	1.00	3.6
Total divers	JAN	4,267	2,053	8,809	1.00	3.6
Total divers	FEB	15,652	9,117	26,847	1.00	3.6
Total divers	MAR	14,764	8,561	25,372	1.00	3.6
Total divers	APR	17,951	9,929	32,481	1.00	3.6
Total waterfowl	OCT	56,314	28,431	110,741	1.00	3.7
Total waterfowl	NOV	27,725	13,956	55,189	1.00	3.7
Total waterfowl	DEC	51,234	25,665	101,517	1.00	3.7
Total waterfowl	JAN	18,742	9,413	37,148	1.00	3.7
Total waterfowl	FEB	25,011	15,036	41,663	1.00	3.7
Total waterfowl	MAR	24,127	14,460	39,937	1.00	3.7
Total waterfowl	APR	28,083	15,994	48,990	1.00	3.7

Integrating Avian Datasets for Management, Modeling, and Visualization

Task 4 Final Report

Data Needs and Gaps Assessment

June 6, 2014

FINAL

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Introduction

Herein we identify data gaps and research priorities which, if addressed, would significantly improve our knowledge about the baseline numbers of waterbirds using South Bay Salt Pond Restoration Project (SBSPRP) land prior to the Interim Stewardship Plan (ISP) as described in the Task 3 final report, "Historical Waterbird Numbers" (Wood et al. 2014). We also identify research and monitoring needs to help facilitate adaptive management. This document is organized into three sections: 1) baseline data gaps, 2) ongoing and new information needs, and 3) research priorities. The first section, baseline data gaps, focuses on what data are missing from the historical record that are needed to establish baseline bird numbers. These data gaps can be breaks in a continuum or the complete lack of information for the desired time period. The information needs described in this report are recommendations to help ensure that data will be available to assess changes in bird numbers relative to baseline or target numbers and relative to management actions. The research priorities identified herein focus on what is needed to fill the data and knowledge gaps. We also highlight the monitoring needs and research priorities identified in Tasks 2 and 3 (Ackerman et al. 2011, Brand et al. 2012) and related graduate project reports (Athearn et al. 2012 and Rowan et al. 2011). Some of the research priorities are multidisciplinary and fall outside the scope of the project reports. We discuss these research priorities as potential next steps to help address how the SBSPRP might fare under climate change if we continue to rely on the current restoration and management recommendations into the future. We discuss these research priorities within the context of building upon previous studies to help the SBSPRP answer their Key Uncertainties and promote adaptive management.

Baseline Data Gaps

In order to facilitate adaptive management, track changes in bird numbers as site conditions change over time, and make it easier for researchers to answer key uncertainties, baseline data on the condition of the system is required. The task of determining baseline bird population levels requires data from time periods prior to the conservation or management actions being assessed. Because the goals of some monitoring projects and programs were different from the current goals of the SBSRP, the data collected may be of limited use as baseline data. Fluctuating sampling effort due to funding or shifting priorities can also create gaps in a continuum or result in data that are less useful for determining baseline conditions. In many cases, researchers need to aggregate data across projects to close data gaps and this presents a potential barrier to developing baseline numbers. Often, data from different projects using compatible protocols cannot be easily integrated and analyzed because of inadequate metadata or disordered data curation. The ISBA-DB concept was designed to help solve this problem but is currently populated with only a few of the datasets that were originally identified as important datasets that could be used for data consolidation, baseline summaries, synthesis, and modeling (Appendix B). These potential barriers to developing baseline bird numbers are not data gaps in the traditional sense and are not covered in detail in this report.

Instead, we identify gaps in data, namely, gaps in a spatial or temporal data continuum that could reduce the accuracy of a baseline assessment.

The baseline bird population size estimates in the Task 3 final report, "Historical Waterbird Numbers," were developed for three spatial tiers (South Bay region, Complex-level, and site-level). The baseline data gaps below are presented for the same spatial tiers and for the same bird species and bird species groups as the Historic Waterbird Numbers report.

South Bay region

Breeding American Avocet and Black-necked Stilt- The surveys by Rintoul et al. (2003) represent the only dataset with total numbers of stilts and avocets during the breeding season for the entire South Bay but were only conducted during one season in 2001. Data from multiple years would be necessary to determine the accuracy of baseline estimates and to statistically compare that estimate with future population estimates.

Wintering and migrating shorebirds- only 3 years of non-repeated surveys (1990-1992) are available to describe wintering and migrating shorebird numbers for the entire South Bay. Sites were surveyed only once within each year and season making it difficult to quantify the variation associated with the estimate for a given year. Without information on the within-year variation associated with the estimate, determining the extent of change relative to the baseline is difficult. However, these surveys were considered censuses as all known shorebird roosting areas were counted during a 3-day period. As such, variability due to shorebird movements within the Bay was reduced. These results can and have been used to develop baselines but comparisons with future conditions should be made with caution and should consider not only the statistical significance of the population changes but also their magnitude.

Waterfowl- Aerial count data exists for the earlier years but can be difficult to interpret because of the difficulty in identifying individuals to species that are viewed at great distances. Site-specific data can be used to model population estimates for the entire South Bay baylands similar to the approach taken by Stralberg et al. (2006). However, the surveys by Stralberg et al. did not include the open Bay. The aerial count data used to establish baseline estimates were from both open bay and baylands (e.g., salt ponds and marshes).

Snowy Plover- South Bay population estimates from the 1970s and 1980s are scant for the Snowy Plover. Population estimates from annual breeding window surveys, beginning in 1999, represent the best available data for the South Bay.

Complex or site-level

Breeding waterbirds- Colony size and reproductive metrics are not available for all areas for all species. Data were collected at a subset of sites and years for Forster's Tern, Black-necked Stilt, American Avocet, and California Gull (Ackerman et al. 2011, Strong et al. 2004). The Ackerman study included sites in the Alviso Complex (ponds A2W, AB1, A7, A8, A16 and New Chicago Marsh). Data from Strong et al. (2004) encompassed a larger number of sites and is considered to have captured the majority of breeding California Gulls but is not comprehensive. The most notable data gaps for breeding waterbirds at the complex-level are for American Avocet and Black-necked Stilt (species not covered by Strong et al. 2004) from complexes not covered by Ackerman et al. (2011).

Migratory Shorebirds and other waterbirds- Surveys for shorebirds, waterfowl and other waterbirds (grebes and phalaropes) were conducted throughout the South Bay as part of the Salt Pond Habitat Conversion project (Stralberg et al. 2006). Monthly surveys were conducted beginning in October 1999 at a subset of sites and continued through the ISP with some notable gaps in the continuum. The most conspicuous data gaps include a six month gap from March through August 2000, and 17 months from May 2001 through October 2002. The surveys conducted by Point Blue during the early years (1999-2002) were only conducted at a subset of sites and within that subset of sites, data gaps (sites not surveyed in certain years) are identified in Appendix A. After October 2002 the USGS conducted waterbird surveys and increased the scope significantly to include all 53 ponds in the SBSPRP area. In addition, the data post-October 2002 were collected at a finer spatial resolution (using a 200 m grid) as opposed to the site-level data collected prior to May 2001. Despite these gaps and differences in number of sites surveyed, the survey protocols were comparable and reliable baseline estimates were developed using both datasets. The baseline estimates were presented in the Task 3 Historical Waterbird Numbers report (Wood et al. 2014). Future analyses should always carefully consider the differences in survey effort and protocol between these two datasets. .

Ongoing and New Information Needs

Successful adaptive management relies on ongoing monitoring to evaluate effects of management activities and to track progress towards stated goals. To address the key uncertainties identified by the SBSPRP and to track progress, continuing the salt pond monthly waterbird surveys and collecting physical data on pond conditions is essential. Because of the complexities involved in managing ponds to achieve desired conditions it may be difficult to capture such management activities in the Integrated South Bay Avian Database (ISBA-DB; Wood et al. 2013). Instead, the focus should be on monitoring the key physical conditions (e.g., salinity, water depth, and water cover) that affect bird species distribution and abundance and ensuring these data can be integrated with bird data for analysis. The monitoring design for the physical pond characteristics should be aligned spatially and temporally with bird monitoring to facilitate the analysis of bird response to changing conditions.

Because changes in bird numbers using SBSPRP lands may be driven by factors outside the project, there is a need to compare bird monitoring data to larger scales (e.g., the entire South Bay region, the entire San Francisco Bay Estuary and the Pacific Flyway). To achieve this, SBSPRP monitoring should be coordinated with larger-scale efforts which include the San Francisco Bay Joint Venture (SFBJV) Monitoring and Evaluation Plan Priority Objectives, the Pacific Flyway Shorebird Survey and the contributing San Francisco Bay Shorebird Survey. Furthermore, the SFBJV is embarking on a project to set quantitative avian objectives for the region to measure the success of conservation and management actions and to guide future activities. This process of establishing objectives should be coordinated with the SBSPRP and can serve as an opportunity to further refine the metrics and specific objectives of the project. Once the new objectives are described, the monitoring required to measure progress toward those objectives can be designed and implemented.

Research Priorities

We highlight the key recommendations and research questions from the four studies that were conducted as part of the project, Integrating Avian Datasets for Management, Modeling and Visualization. Brand et al. (2012) identified the need to explore dietary flexibility in diving ducks. Of critical importance is whether dietary flexibility is sufficient to respond to changing pond conditions. Prey abundance correlates were also identified as a gap in our knowledge. It is important to determine what the sources of variation are in prey abundance among hyperhaline ponds, within ponds, and over time. Rowan et al. (2011) identified the need to include other variables in the carrying capacity modeling, including: risk of predation, weather, extreme tide events, availability of biofilm, and foraging and breeding conditions on other parts of the migration pathway. The authors also concluded that additional years of data were needed to reduce uncertainty attributable to normal stochasticity. Athearn et al. (2012) identified the need to measure bird response to changes in pond management underscoring the importance of continued surveys. Ackerman et al. (2011) recommended analyzing habitat features for associations with increased nest density, survival, and chick survival for colonial nesting birds in managed ponds. A key question that emerged was how island design and management could maximize reproduction and survival. In addition, information on the total South Bay population sizes for breeding waterbirds was identified as a critical gap.

The bioenergetics models from Brand et al. (2012) and Rowan et al. (2011) have led to a much deeper understanding of how current conditions within the ponds and mudflats of the project area can support the dietary needs of shorebirds and waterbirds. It is less understood how these conditions will be affected by landscape-level changes such as climate change, land use changes, and restoration. Managers and planners can anticipate and prepare for such changes by examining the potential effects of climate change on avian dietary needs. We recommend looking at a range of metabolic rates in relation to the range of temperature changes predicted by downscaled climate models, varying the availability of food resources including investigating the potential role of biofilm, and overall looking at changes in the amount of different types of habitat that may be available for shorebirds under a range of future conditions (e.g., changes in tidal flat, salt pond, and tidal marsh habitat). Varying the parameters of these mechanistic models can offer insights into the effects of climate change and provide managers with a robust framework for decision making (Veloz et al. 2013). Overall there should be an assessment of how restoration recommendations now, with our current understanding of the system, will fair under a set of plausible climate change scenarios. The results of such an exercise will help managers identify solutions that are robust to uncertainty. For example, mangers could explore optimal configurations of tidal marsh restoration and salt pond habitat that have a better chance of meeting stated goals given a set of plausible climate change scenarios.

To inform conservation planning and refine the adaptive management process we recommend analyses that link site characteristics measured by Brand et al. (2012) with the more spatially explicit coarse level recommendations (e.g., pond location, size, etc.) put forth by Stralberg et al. (2008). To identify an optimal pond restoration configuration, per Stralberg et al. (2008), using both levels of information could be of great value for planning. It would also be a useful exercise to explore the existing restoration scenarios using an updated optimization model to look at impacts to avian food resources using empirical data from Brand et al. (2012) on abundance and biomass of benthic invertebrate prey collected at the Alviso, Eden Landing, and Ravenswood complexes. Integrating these results and recommendations into the adaptive management framework would benefit the SBSPRP. In addition, quantifying ecosystem services (e.g., flood control, carbon sequestration) and benefits to non-avian taxa under different pond management and restoration scenarios would help identify those solutions that optimize most effectively across a range of criteria and for a range of future conditions.

To achieve this, we recommend using an optimization approach following an updated version of Stralberg et al. (2008) for example, and updating the baseline models through time using monitoring data from the ponds and emerging tidal marshes to assess how well restoration and management actions are achieving the desired goals. Resources for developing tidal marsh bird monitoring plans and protocols are available from the Integrated Regional Wetlands Monitoring project (http://www.irwm.org/). The results of such monitoring would reinforce beneficial practices, alert managers to failing ones, and generally provide science-based updates to the management plan. Thus, as the ponds are restored we can continue to learn whether the strategies that are being applied are truly optimal. It is also through this process that more refined population conservation targets can be defined.

The above research priorities have been broad-based but there is a need to conduct specific analyses for at-risk species such as the Western Snowy Plover. Given their small San Francisco Bay population size, specific habitat requirements and the threats to their habitat from salt pond conversion, the Western Snowy Plover requires special attention. In addition to ongoing population monitoring focused on determining population nest success, and population size and trends, we recommend a population viability analysis. Specifically, we propose assessing population viability under different SBSPRP management strategies using survey data collected by SFBBO and incorporating analysis limited resight records from within the Bay and extensive resight records from coastal populations to parameterize dispersal/movement rates and adult survival. In addition to the modeling work, this study would ideally include additional field studies and analysis aimed at clarifying chick and fledgling survival rates (which may require a telemetry component and additional resighting).

The research priorities for the South Bay discussed above should also be considered for the entire San Francisco Bay Estuary. There is a need to understand the impacts of changing resources in the South Bay on the demands for habitats in other areas of the Bay and to take into account habitat changes in other parts of the Bay (e.g., restoration and management of salt ponds in the Napa-Sonoma Marsh area). A Bay-wide bioenergetics model or conservation prioritization model would be useful for more broad scale conservation planning in the face of climate change.

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Appendix A. South San Francisco Bay salt ponds surveyed between October 1999 and January 2004 from Stralberg et al. (2006). Years surveyed indicated with a 1, data gaps indicated with a 0 (not surveyed).

Pond ID	Complex	1999/	2000/	2002/	2003/
A1	Alviso	0	0	1	1
A11	Alviso	0	1	1	1
A13	Alviso	0	0	1	1
A14	Alviso	0	1	1	1
A15	Alviso	0	0	1	1
A16	Alviso	0	1	1	1
A17	Alviso	0	0	1	1
A19	Alviso	0	0	0	1
A20	Alviso	0	0	1	1
A21	Alviso	0	0	1	1
A22	Alviso	0	0	1	1
A23	Alviso	0	0	1	1
A5	Alviso	0	0	1	1
AB1	Alviso	0	0	1	0
AB2	Alviso	0	0	0	1
B1	EdenLanding	0	0	1	0
B10	EdenLanding	0	1	1	1
B11	EdenLanding	0	1	1	1
B12	EdenLanding	0	0	1	0
B12/13	EdenLanding	0	1	0	0
B13	EdenLanding	0	0	1	0
B14	EdenLanding	0	1	1	1
B1C	EdenLanding	0	0	1	1
B2	EdenLanding	0	0	1	1
B2C	EdenLanding	0	0	1	1
B4	EdenLanding	0	0	1	1
B5	EdenLanding	0	0	1	1
B5C	EdenLanding	0	0	1	1
B6A	EdenLanding	0	1	1	1
B6B	EdenLanding	0	0	1	1
B6C	EdenLanding	0	0	1	1
B7	EdenLanding	0	0	1	1
B8A	EdenLanding	0	1	1	1
B9	EdenLanding	0	1	1	1
R2	Ravenswood	1	0	0	1
R3	Ravenswood	0	0	0	1
R5	Ravenswood	0	0	1	1
RSF2	Ravenswood	0	0	1	1
RSF2	Ravenswood	1	1	1	1

Appendix B. Inventory of important datasets that could be used for data consolidation, baseline summaries, synthesis, and modeling.

Survey Years	Data owner	Seasons	Bay Region	Habitat	Survey Type	Tides	ISBADB	Description of data
1999-2001	Point Blue	Year round	South Bay, San Pablo Bay	salt pond, marsh	area search	Low High	Yes	site-level waterbird counts, behavioral obs.
1986-1988; 2000-2002	Point Blue	late winter to breeding	South Bay, San Pablo Bay, Suisun Bay, Delta	tidal, muted marsh	call count	n/a	No	BLRA, vegetation
1988-1993	Point Blue	spring, fall	South Bay, San Pablo Bay	salt pond, tidal, restoration, muted	area survey	Low High	Yes	site-level shorebird counts
1996-2006	Point Blue	Breeding	San Pablo Bay, Suisun Bay	tidal, muted marsh	nest monitoring	all	No	BLRA nests, nest vegetation; nests/site/year
1999-2001	Point Blue	Year round	South Bay, San Pablo Bay	salt pond, marsh	area search	Low High	Yes	site-level waterbird counts, behavioral obs.
2001-2003	Point Blue	spring, fall, winter	San Pablo Bay	restoration marsh	area survey	Low High	No	site-level waterbird counts, behavioral observations
2003-2005	Point Blue	spring, fall, winter	South Bay, San Pablo Bay	tidal, restoration marsh	area survey	Low and High	No	site-level waterbird counts, behavioral observations, habitat associations
2005-present	Point Blue, SCC, SPBNWR	late winter to early breeding	South Bay, San Pablo Bay, Suisun Bay, Delta	Tidal marsh	call count	low	No	CLRA, BLRA, vegetation; point level counts
2006-Present	Point Blue	Fall	South Bay, San Pablo Bay	salt pond, tidal, restoration, muted	area survey	Low	No	SF Bay Shorebird Census. Single-day site-level shorebird counts

Appendix B. Continued

Survey Years	Data Owner	Seasons	Bay Region	Habitat	Survey Type	Tides	ISBADB	Description of data
2005-present	SFBBO	year round	South Bay: Coyote Hills and Mowry Salt Ponds	Salt Pond	area search	High	Yes	Site-level waterbird counts, behavioral obs. at 22 non-Project salt ponds in S Bay
1980-present	SFBBO	Breeding	San Francisco Bay	Salt Ponds, others	area search: colony walk-through	n/a	No	Breeding colonial waterbird counts (CAGU, CATE, FOTE, LETE, BNST, SNEG, GREG, GBHE, BCNH)
2003-present	SFBBO	year round	South Bay	Salt Ponds	area search	n/a	No	SNPL monthly surveys
2003-present	SFBBO	breeding	South Bay	Salt Ponds	area search	n/a	No	SNPL nest monitoring
2008-present	SFBBO	breeding	South Bay	Salt Ponds	area search	n/a	No	SNPL chick banding to determine chick fledging rates
2006-presnt	SFBBO	year round	South Bay	Salt Ponds	area search	n/a	No	Landfill surveys for gulls
2002-2010	USGS	Year round	South Bay	salt ponds	area search	Low High	Yes	Site-level waterbird counts, behavioral obs.
2010-present	USGS	Year round	South Bay	salt ponds	area search	Low High	No	Site-level waterbird counts, behavioral obs.
1999-present	USGS	Year round	San Pablo Bay	salt ponds	area search	Low High	No	site-level waterbird counts, behavioral obs, water quality and depth
2006-2006	USGS	winter	South Bay	mudflats	area search	Low	No	Site-level waterbird counts, behavioral obs, water quality and depth
1988-2008	USFWS	winter	San Francisco Bay	open water	area search	High	No	Mid-winter waterfowl survey, aerial waterbird counts
2005-2008	USGS	April-August	San Francisco Bay, especially South bay	salt pond, marsh	nest monitoring	n/a	Yes	Avocet, Stilts, Forster's Terns; nest success; abundance; hatching success; clutch size