State of the Estuary Report 2015

Summary

WILDLIFE – Shorebirds

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State of the Estuary 2015 - San Francisco Bay

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Wildlife: Birds:

Wintering Shorebird Abundance Indicator

1. Brief description of indicator and benchmark

Nine common wintering migratory shorebird species, representing three groups, based on body size (large, medium, and small) and breeding distribution, were selected to be indicators for intertidal mudflats, salt marshes, and saline ponds in the north, central, and south regions of the San Francisco Bay estuary. The indicator, birds detected per ha, is a measure of shorebird abundance during the winter. The benchmark for the wintering shorebird indicator was established as a 10% increase compared to the baseline value, which is the average abundance of each group in each bay region from early winter surveys conducted 2006-2008.

2. Indicator status and trend measurements

We determined whether the current status (2011-2013 average) of the indicator relative to the historical average (2006-2008), that is, the reference value, in each region of the estuary was Poor, Fair or Good, based on whether abundance had decreased, stayed the same, or increased between periods. Status of the indicator differed depending on the **guild** (size class) of shorebird. For **large shorebirds**, status was **Poor** in the central and south regions but **Fair** in the north, and thus they were scored **Poor** overall. **Medium shorebirds** were also **Poor** in the central and south regions, but **Fair** in the north, hence were scored **Poor** overall. **Small shorebirds** were scored **Fair** in each of the three regions and so were scored **Fair** over all. Since Fair and Poor were so evenly split, our overall assessment for shorebirds is "**Fair-to-Poor**".

Benchmark calculation and score assessment:
The benchmark (the break between Fair and Good) was defined as a 10% increase from the historic period (2006-2008) to the current (2011-2013), provided that the 95% confidence interval of the density estimate for the most recent 3 years did not overlap the reference value. Conversely, we defined the break between Fair and Poor to be a 10% decrease from the reference value as well as a 95% confidence interval of the current density estimate for the most recent 3 years that did not overlap the reference value. For each group the parameter estimate (determined in natural log units) was averaged across species in the group and then back-transformed to obtain a density value.

3. Brief write-up of scientific interpretation

The San Francisco Bay estuary is a site of hemispheric importance for non-breeding migratory shorebirds (Order: Charadriiformes; sub-order: Scolopaci, Charadrii) (Page et al. 1999, Stenzel et al. 2002). Over 1 million shorebirds use the intertidal mudflats, marshes, and saline ponds of the estuary each year (>300,000 birds in winter). The species of shorebirds using the estuary in the non-breeding season vary greatly in body size and abundance, as well as in their migratory pathways and the location of their breeding grounds. While some breed as close as San Francisco Bay and the Central Valley, others nest as far away as the tundra in northern Alaska. The importance of San Francisco Bay for non-breeding shorebird populations representing different species and different migratory traits makes shorebirds in the winter a good indicator of the condition of San Francisco Bay's intertidal wetlands and saline ponds.

Change in shorebird densities between the reference period 2006-2008 and the most recent years available, 2011-2013, were summarized as a Wildlife Indicator of the State of the Estuary for San Francisco Bay. The benchmark for shorebird density was established for each of three regions of the bay (North Bay, Central Bay, and South Bay) and three groupings of nine total shorebird species (based on body size and migratory pathways). The reference value used for comparison was the average density observed on early winter surveys from 2006 to 2008. The benchmark and score was then based on the magnitude of the difference in density relative to the reference value and the degree of certainty in density estimates. Shorebird species included were:

- American Avocet (*Recurvirostra americana*), Willet (*Tringa semipalmata*), and Marbled Godwit (*Limosa fedoa*) to represent **large-bodied,** generally **temperate breeding** birds;
- Black-bellied Plover (*Pluvialis squatorola*) and Short- and Long-billed dowitchers (*Lindronomous griseus*, *L. scolopaceus*) to represent **medium-bodied, mid- to high-latitude breeding** birds;
- Three species of the genus *Calidris* (Dunlin [*Calidris alpina*], Western Sandpiper [*C. mauri*], Least Sandpiper [*C. minutilla*]) to represent **small-bodied, high-latitude breeding** birds.

We selected 2006-2008 for the reference period as it represents the state of shorebird populations just prior to a period of substantial change in wetlands in San Francisco Bay from large-scale restoration of saline ponds to tidal marshes. Within each year, we selected the early winter to measure the indicator as it is a time of stability in shorebird populations (no migration) resulting in relatively lower year to year variation in population counts. Furthermore early winter surveys of the same locations, completed annually in 2011 to 2013 as part of the Pacific Flyway Shorebird Survey (www.pointblue.org/pfss), provide an opportunity to measure change between the reference period and more recent surveys.

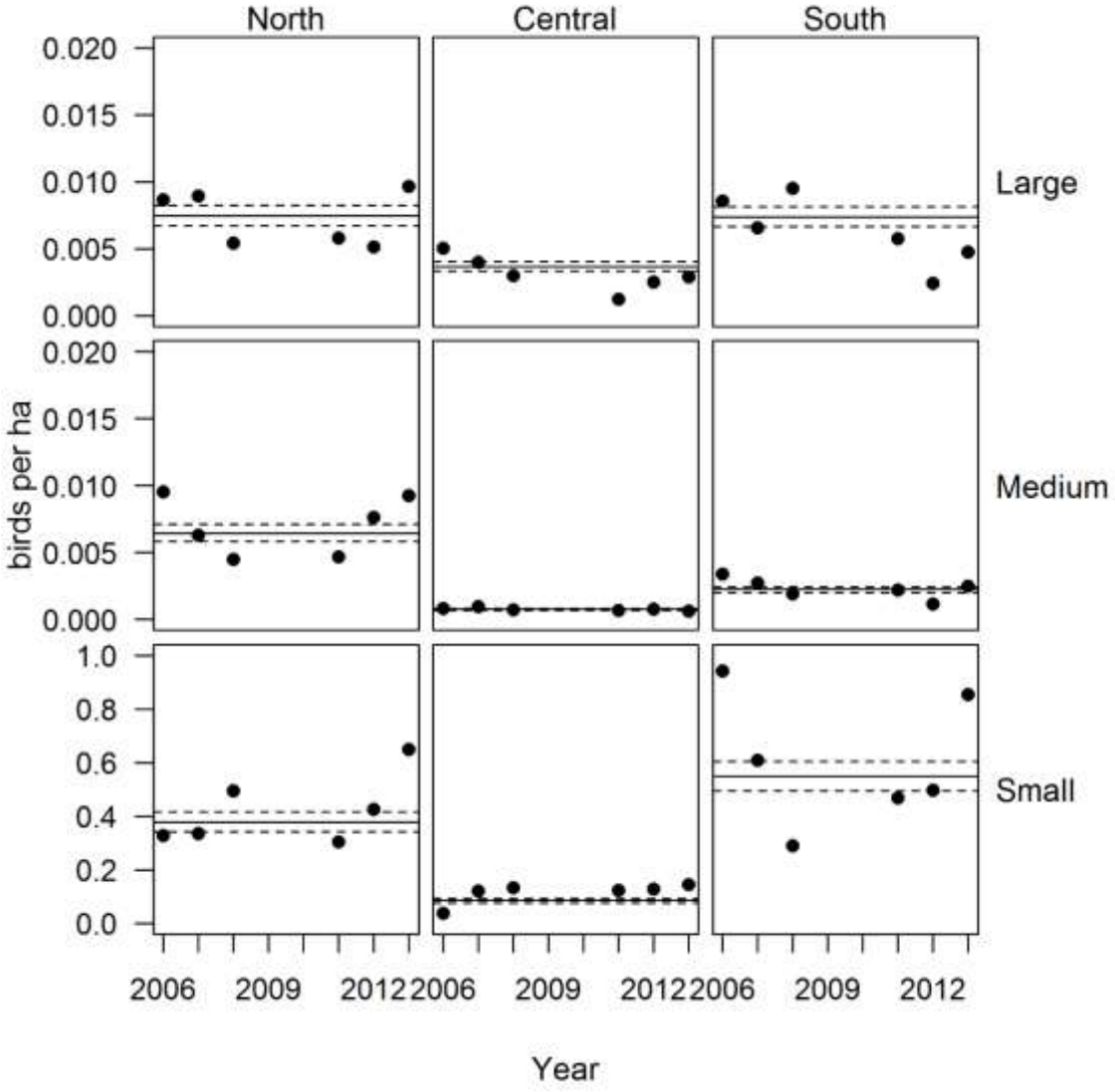
Overall, indicator densities of small shorebirds were the highest among the three shorebird size groups (small, medium, and large) (Fig. 1). Large and medium shorebirds had roughly equivalent densities in the north and central regions, but large shorebirds had higher densities than medium shorebirds in the south region. For all groups, indicator densities were higher in the north and south regions compared to the central region.

Large shorebirds were below the reference values across all regions (-20% in the north bay, -59% in central bay, and -52% in south bay). They were scored poor in the central and south regions as the 95% CI of density estimates did not include the reference value. The north region was considered fair because its 95% CI did include the reference value. The overall score for this group was poor. **Medium shorebirds** were below the reference values in both the central and south regions (-32% and -35%, respectively), but only 5% below the reference value in the north. This group received a status of poor in the south and central region but fair in the north as the 95% CI of the current density estimate overlapped the reference value in that region. Overall, we score the status of medium birds as poor. The average density of **small shorebirds** from 2011–2013 was 3%, 4% and 37% higher than the 2006–

2008 average in the south, north and central regions, respectively. However the 95% CI of current density estimates in all regions overlapped the reference values indicating a status of fair.

Non-breeding shorebird populations of different species and size groups are changing in different ways in abundance and perhaps in distribution within San Francisco Bay. Though some promising trends are evident, none of the three groups achieved the benchmark. Small shorebirds display variability but generally appear stable. Large and medium shorebirds are in decline across the estuary but particularly so in the central and south regions. There has been a large amount of change in wetlands in San Francisco Bay particularly in the south region. Whether declines in medium and large shorebirds in south region are related to these changes in wetlands requires additional research. Ongoing annual monitoring of randomly selected sites and periodic (every 5-8 years) bay-wide comprehensive surveys are needed to better understand the year-to-year variation in shorebirds and to establish whether the changes observed represent changes in wintering shorebird abundance or shifts in bird distribution since the 2006-2008 reference value was established.

Figure 1. Density (birds counted/ha) of large, medium, and small shorebirds within three regions of San Francisco Bay in early winter 2006-2013. The solid horizontal line represents the reference value set as the mean density of the 2006-2008 surveys. The dashed horizontal lines represent ±10% of the reference value. Densities >10% larger than the reference value were considered good and those >10% smaller were considered poor, provided that their respective 95% CIs (not shown) did not overlap the reference value; otherwise, they were considered fair. Densities within 10% of the reference value (between the dashed horizontal lines) were also considered fair.



State of the Estuary Report 2015

Technical Appendix

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Technical Appendix

State of the Estuary: Shorebird Population Indicator

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Background

The San Francisco Bay estuary is a site of hemispheric importance for non-breeding migratory shorebirds (Order: Charadriiformes; sub-order: Scolopaci, Charadrii) (Page et al. 1999, Stenzel et al. 2002). Over 1 million shorebirds use the intertidal mudflats, marshes and saline ponds of the Bay each year (>300,000 in winter). Non-breeding shorebirds species using San Francisco Bay vary greatly in body size and abundance, as well as in the location of their breeding grounds. Some breed as nearby as the Central Valley while other nest on the Arctic tundra in northern Alaska. Given the importance of San Francisco Bay for shorebirds, and that different shorebird species there use different migratory pathways and breeding grounds, make them a good indicator of the condition of San Francisco Bay's intertidal wetlands.

We summarized year-to-year variation in shorebird populations from surveys in early winter between 2006 and 2013 to develop an indicator of the State of the Estuary for shorebird abundance. Specifically we established a reference value based on the average density of shorebirds observed on surveys between 2006 and 2008 in three regions of the bay (north, central, and south) and for three groupings of shorebird species based on size and breeding distribution. We selected this time period (2006-2008) for the reference period as it represents the state of shorebird populations just prior to a period of change in wetlands in San Francisco Bay from large scale tidal marsh restoration. Within each year, we selected the early winter as it is a time a stability in shorebird populations (no migration) allowing for relatively lower year to year variation in counts compared to migration surveys. Furthermore annual surveys of the same locations were completed again from 2011 to 2013 and are ongoing as part of the Pacific Flyway Shorebird Survey (www.pointblue.org/pfss). The 2011-2013 surveys were compared to the 2006-2008 data to assess change in San Francisco Bay shorebird populations.

We selected nine common shorebird species in San Francisco Bay representing three general groups based on body size and breeding distribution. First, we identified three species of large-bodied shorebirds (American Avocet [*Recurvirostra Americana];* Willet [*Tringa semipalmata*]; Marbled Godwit [*Limosa fedoa*]) that breed in California, the Great Basin and/or the Prairie Pothole region of the north-central United States and south-central Canada (Gratto-Trevor 2000, Lowther et al. 2001, Robinson et al. 1997). Second, we selected the Black-bellied Plover (*Pluvialis squatarola*) and Short- and Long-billed Dowitchers (*Limnodromus griseus*, *L. scolopaceus*) combined to represent medium-bodied shorebirds that breed in the mid- to high-latitudes in the arctic (Paulson 1995, Takekawa and Warnock 2000, Jehl et al. 2001). Lastly, three species of the genus *Calidris* (*C. alpina*, *C. mauri*, *C. minutilla*) were combined to represent small bodied shorebirds that are generally high-latitude arctic breeders (Warnock and Gill 1996, Nebel and Cooper 2008, Franks et al. 2014). These nine species composed 96% of the total shorebirds counted in baywide surveys from 2006-2008 (Wood et al. 2010). We selected relatively abundant species to ensure adequate sample sizes of detections. Further, by choosing these different groups of species as indicators, we are better poised to understand whether changes to shorebird populations reflect changes in the condition of intertidal wetlands in San Francisco Bay or are driven by changes on the breeding grounds or along migratory pathways. For example, if all migratory shorebird species show similar trends in abundance through time we are more likely to conclude this has

something to do with the condition of San Francisco Bay wetlands than if declines were observed in only birds that breed in the high arctic, which may suggest conditions on the breeding grounds or along the migratory pathway are changing.

Methods

We used November–December high-tide shorebird survey data from 114 randomly selected survey areas around San Francisco Bay (see Wood et al. 2010 and Reiter et al. 2011 for full description of the sampling design and survey methodology) from 2006-2008 and 2011-2013 to estimate the shorebird density (birds per ha) for each of the species in each of the three groups for each year. We established the reference value for each species as the average density across the 2006-2008 surveys and measured change by comparing to the 2011-2013 average density as an indicator of the State of the Estuary of intertidal wetlands, particularly tidal flats and saline ponds. We estimated densities and change of each species for each of three regions of San Francisco Bay (north, central, and south bay) as defined by Wood et al. (2010). We used generalized linear mixed models to estimate mean densities by year while accounting for overdispersion driven by autocorrelation associated with repeated surveys at specific survey areas and across years (Gelman and Hill 2007). We also fit a model that compared the 2006-2008 average density with the 2011-2013 average. We report the percent change between the modeled average density from these two three-year time periods and indicate whether this change was statistically significant for each species in each region. To account for survey areas that varied in size, we included the natural logarithm of the survey area size (ha) as an offset term in all models. We included a random effect of survey area to account for correlation among counts from the same location and a random effect for year to account for among year variation within the 3-year period.

For group density estimates by region (large-sized and medium-sized birds only) and time period (2006-2008 and 2011-2013), we calculated an average of the species-specific density estimates, as well as the average change comparing current and reference periods. For each group, the density parameter estimate (determined in natural log units) was averaged across species in the group and then back-transformed to get density. We estimated the 95% confidence interval (CI) of the group density estimates using a Monte Carlo simulation which randomly sampled the parameter estimates based on their mean and SE and calculated 10,000 estimates of the average. We applied the percentile method and used the 250th and 9750th sorted value to determine the 95% CI. Challenges with identifying Calidris shorebirds to species in the field and their tendency to occur in large roosting flocks (>5,000 - 10,000 individuals), resulted in many observations attributed to an unknown mix of Dunlin (*C. alpina*), Western Sandpiper (*C. mauri*) and Least Sandpiper (*C. minutilla*). We pooled these three species of Calidris spp., whether identified to species or in mixed flocks, into a single analysis.

Species-specific percent change from the reference value was estimated from the modeled change parameter (β) as:

$$(e^{\beta} - 1) * 100$$

The percentage change in the pooled current group average compared to the reference value was estimated as:

$$\frac{current\ value - reference\ value}{reference\ value} * 100$$

We evaluated the status of the indicator by establishing a benchmark value for each shorebird group, as determined for each region of the San Francisco Bay. The benchmark (i.e., the break between status of Fair and Good) was achieved with at least a 10% increase from the reference value (2006-2008) to the current value (2011-2013), provided that the 95% confidence interval of the density estimate for the current value did not overlap the reference value. Conversely, we considered an indicator status to be Poor when there has been at least a 10% decrease from the reference value, provided that the 95% confidence interval of the current value did not overlap the reference value.

Results

There has been variation and change in shorebird populations across San Francisco Bay since 2006-2008. Overall densities were highest for small shorebirds compared to large and medium shorebirds. Additionally all species groups experienced their highest densities in the north and south regions compared to the central bay.

North region: Large birds were scored as fair (though they exhibited -20% change) comparing current to the reference value in the north region. Species-specific changes from the reference value suggest the American Avocet (10%, $z = 0.57$, P = 0.57) and Willet (1%, $z = 0.02$, P = 0.90) were stable, whereas Marbled Godwit was pulling down the overall change with a significant decline (-38%, $z = -2.01$, P = 0.04) for the large shorebird group. Overall, medium shorebirds were scored as fair (-5%) in the north region. Dowitchers were increasing in the north region (55%, z = 1.02, P = 0.30), whereas Black-bellied Plovers were declining (-26%, $z = -1.15$, P = 0.25) though neither change was significant. Small shorebirds increased by 4% in the north region though the change was not statistically significant ($z = 0.63$, P = 0.53), so their status was considered fair.

Central region: Large shorebird density declined relative to the reference value in the central region (-59%). Significant declines of Willet in the central region (-68%, z = -2.62, P = 0.01) drove the negative trends observed in large birds, though American Avocet (-54%, z = -1.37, P = 0.17) and Marbled Godwit (-53%, z = -1.68, P = 0.09) experienced non-significant declines as well. For medium shorebirds, Dowitchers declined (-42%, z = -1.79, P = 0.07) while Black-bellied plover increased (16%, z = 0.55, P = 0.58) however overall change (-32%) indicated poor status. Small shorebirds increased, albeit non-significantly in the central region (37%; z = 1.21, P = 0.22).

South region: Large shorebirds declined in the south region (-52%), driven largely by a significant decline in Willet (-69%, z = -4.72, P <0.01). However, American Avocet (-17%, $z = -1.56$, P = 0.12) and Marbled Godwits also declined (-53%, $z = -1.48$, P = 0.40). Medium shorebirds were scored poor in the south region (-35% change compared to reference value). Both dowitchers (-27%, z = -1.12, P = 0.26) and Black-bellied Plover (-31%, z = -1.29, P = 0.20) declined though these changes were not statistically significant. Small shorebirds were relatively stable in south region compared to large and medium birds, with evidence of only a small, non-significant, change from the reference (6%; z = 0.67, P = 0.86).

Summary

Non-breeding shorebird populations of different species and size groups within San Francisco Bay are changing in different ways in abundance and perhaps in distribution. None of the shorebirds have achieved their benchmark. Overall, large and medium shorebirds declined across all bay regions and significantly so in the central and south regions. However, small shorebirds were stable across all regions compared to the reference period. Significant year to year variation in abundance for some species groups made estimates of change quite imprecise with only six years of data thus limiting inference. In many cases, observed changes exhibited large declines and increases in point estimates, but were not

statistically significant. Ongoing annual monitoring of randomly selected sites and periodic bay-wide comprehensive surveys are needed to better understand the year-to-year variation observed and whether the estimated trends are real.

Peer Review

This indicator was reviewed by shorebird ecologists at Point Blue including W. David Shuford and Gary Page.

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