State of the Estuary Report 2015

Summary

WILDLIFE – Tidal Marsh Birds

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State of the Estuary 2015: Wildlife

Tidal Marsh Bird Population Indicator

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1. Brief description of indicator and benchmark

The Tidal Marsh Bird Population Indicator provides a measure of the breeding season population abundance of three tidal marsh-dependent bird species in the San Francisco Bay Estuary: the Black Rail (*Laterallus jamaicensis*), Song Sparrow (*Melospiza melodia*), and Common Yellowthroat (*Geothlypis trichas*). All three species are represented in the estuary by subspecies that display unique adaptations to tidal marsh habitat, but are, at the same time, of conservation concern (respectively: *L. j. coturniculus*; *M. m. pusillula*, *M. m. samuelis*, *M. m. maxillaris*; *G. t. sinuousa*). Standardized surveys of these species have been conducted in tidal marsh habitat since 1996, and from this an index of population density was constructed, combining results for the three species; the indicator was included in the 2011 State of the Estuary Report.

We evaluate the densities of the three species, comparing the most recent four years (2011-2014) with respect to the benchmark values. The benchmark for distinguishing Good from Fair is the 75th percentile of density as determined with reference to surveyed marshes during the benchmark period (1996-2008). The benchmark for distinguishing Poor from Fair is 25% reduction for the most recent 4 years, on average, when compared to the mean value during the benchmark period. The indicator and benchmark values all refer to results combined across the three species.

2. Indicator status and trend metrics

The mean value of the index over the last four years is 1.09 birds per hectare, below the criterion for Good (1.29 birds/ha) and above the criterion for Poor (0.77 birds/ha). Hence the status is Fair. In one of those four years, the density index was in the region demarcated "Good"; in the other three years, the annual density index was in the "Fair" region. This result, that three out of four years were in the "Fair" region, supports the overall score of "Fair" for this indicator.

The trend during the entire period of study, 1996 to 2014, is significantly positive (P = 0.002), increasing at 2.7% per year. Thus, progress is good, and gives indication of moving towards the desired goal.

3. Brief write-up of scientific interpretation

<u>What is the indicator?</u>

The indicator provides an index of population density of three tidal marsh-dependent species in the San Francisco Bay estuary during the breeding season. As part of Point Blue's tidal marsh bird monitoring project begun in 1996 (Nur et al. 1997, Spautz et al. 2006), standardized surveys are conducted every year for all bird species in tidal marsh habitat. Three species are included in this indicator, as they are valuable indicators of tidal marsh ecosystem condition. Each species is year-round resident and is represented by subspecies that are dependent on, or strongly associated with, tidal marsh habitat (Goals Project 2000). As part of the surveys, individuals are identified and enumerated within 50 m of an observer, surveys conducted at about ten survey stations per marsh. Ten marshes were regularly surveyed during the period 1996-2014 and included here. The indicator is based on the estimated value in each year for each species, statistically adjusted for variation in abundance among survey sites (not all sites are surveyed in each year), and then combined across all three species. We stress that it is an index of density but does not measure absolute density. Changes in the density index, we believe, reflect changes in the absolute density, which are translated into variation in underlying population abundance.

Why is it important?

San Francisco Estuary tidal marsh habitat has been dramatically altered in the past two centuries. Over 80% of the original tidal marsh habitat in the region has been lost due to creation of salt ponds, conversion to agricultural and industrial/urban use, and water diversion and management (Goals Project 1999). The reduction in area, fragmentation of remaining habitat, degradation in habitat quality, and spread of invasive species, have all contributed to reductions in the population size and viability of tidal marsh obligate species (Takekawa et al. 2012). For these reasons, many of the species that depend on tidal marsh habitat are currently listed as Federally- or State- threatened or endangered, such as the Black Rail, or are designated as California Species of Special Concern (Shuford & Gardali 2008). As a result of the significant loss of habitat quantity and quality, current management and restoration by agencies and non-governmental organizations has been directed at recovering depleted populations or ensuring their stability. The tidal marsh bird index provides a measure of current condition of three tidal marsh-dependent species, as well as providing insight into success at recovering or maintaining these threatened populations.

What is the benchmark? How was it selected?

We expect increased density of tidal marsh breeding birds, reflecting population recovery and improvement in habitat quality (e.g., due to reduction of threats, maturation of restored habitat). The benchmark value for Good is the upper quartile value of population density observed for mature tidal marsh, combined across the three target species. The justification for using the upper quartile for the benchmark for Good is that it represents the median of the highest 50% with respect to density. The value determined for the baseline period, 1996 to 2008 was determined specifically with respect to the set of marshes that have been regularly surveyed during the entire period (1996 – 2014). The minimum value for Good was calculated to be an index value of 1.29 birds/ha.

For demarcating Poor vs Fair, we used a value that was 25% below the mean as determined for the benchmark period. Thus, if the mean index value for the most recent 4 years was below 0.77 birds/ha, the indicator was scored Poor. Given that the goal of tidal marsh management and restoration is to increase populations of tidal marsh dependent species, all three of which are either State-Threatened or California Species of Special Concern, we consider a 25% or greater decrease compared to the benchmark period to merit a score of Poor.

What is the status and trend for this indicator?

The three species Tidal Marsh Bird Population Index varied from 0.93 birds/ha to 1.32 birds/ha during the four years 2011 to 2014, with a mean value of 1.09 (Figure 1). Thus, the indicator was scored Fair. We note that three of the four years were in the region corresponding to Fair; one year (2012) was in the Good region.

The Tidal Marsh Bird Index demonstrated a significant, increasing trend over the entire time period (Figure 1), of 2.78% per year (S.E. = 0.73%; $P < 0.002$). An average annual growth rate of 2.78% over the course of 18 years (i.e., 1996-2014), translates into a total estimated increase of 64%. However, not all species exhibited increases over this period. Black Rail and Common Yellowthroat significantly increased over the entire period ($P = 0.012$ and $P = 0.016$, respectively). Song Sparrow exhibited a weak increase, but this was not significant. However, the overall increase in trend reflects an early increase (1996-2005) followed by no overall increase during the latter period (2005-2014), as demonstrated in Figure 1. The best estimate of the trend in the first 9 years is 5.1% per year, whereas in the last 9 years, the trend is indistinguishable from 0% change.

What does it mean? Why do we care?

The Tidal Marsh Bird Population Indicator provides an insight into two important aspects of the tidal marsh ecosystem. First, it reflects the condition of three species of conservation concern that depend on tidal marsh habitat, with respect to their population status and how that has changed since 1996. Second, the index also bears on the apparent efficacy of activities designed to stabilize or increase populations of these three species.

The 2015 Tidal Marsh Bird Population Indicator reflects, overall, a mixed picture. On the one hand, the current status is Fair; the benchmark value of Good has not yet been reached. While there is a general increase in density of the three-species-index since 1996, no clear increase is evident in the more recent years (2005 to 2014). Furthermore, only two out of the three species demonstrate an increase in density over the entire period, 1996 to 2014. That said, there is no evidence of a decline in density during the entire time period, nor a portion of the time series, nor do any of the three species demonstrate a decline. This is in contrast to findings for the Ridgway's Rail Population Indicator which has demonstrated a recent decline in the South Bay, from which the population has yet to recover. In contrast, the rebound observed for Ridgway's Rail in the North Bay since 2005 (the first year of the Ridgway's Rail Population Index), is consistent with the increase observed for Black Rails, which are almost entirely confined to the North Bay, for the period 2005-2014 as well as during the entire period (Evens and Nur 2000).

Our conclusion is that habitat suitability is currently sufficient to maintain populations at their current density, and possibly is sufficient to support increase in density, at least for rail species and for the Common Yellowthroat. Furthermore, an increase in density is expected to be manifest as young restored marshes become more mature, and thus increase in their ability to support growing populations of tidal marsh bird species. The prognosis for the near future is encourage.

4. Related Figures

Figure 1 displays results of the Indicator. The Technical Appendix includes index results by species as well.

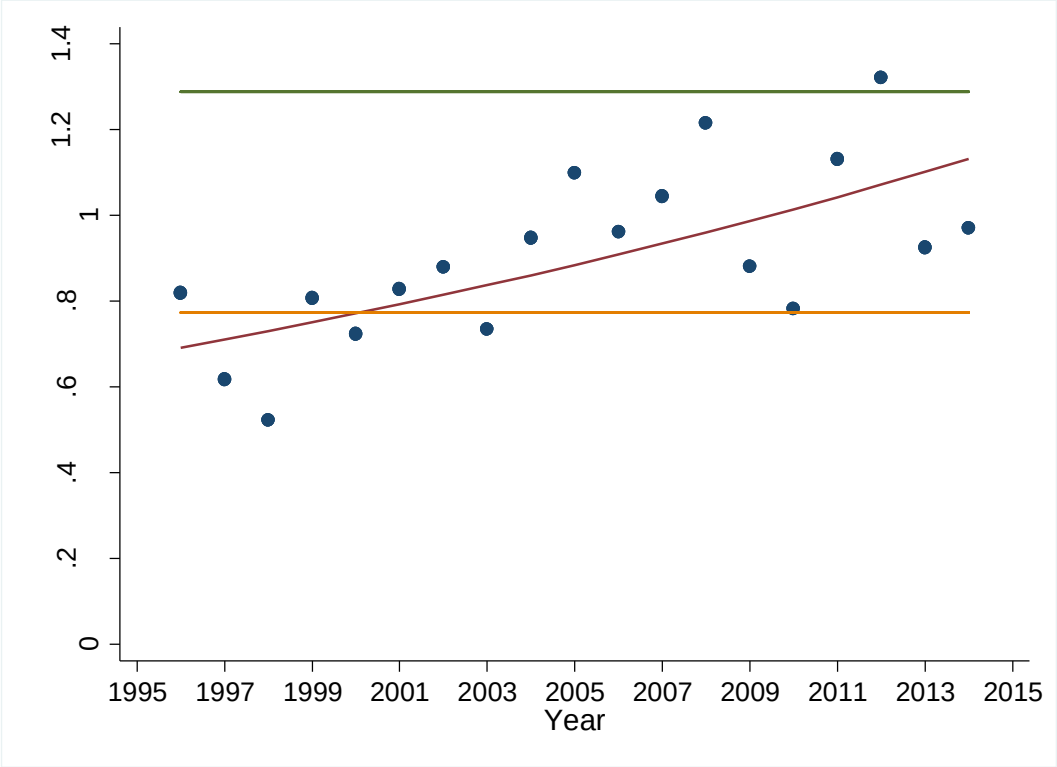

Figure 1. Density index values, combined over the 3 species, are displayed, as well as the line of best fit (shown in brown), a significantly increasing trend. All analyses were carried out on natural-log-transformed counts per unit area; results have been back-transformed for display purposes. Note that the regression line is calculated using the back-transformed values. Also shown are the criterion distinguishing Good from Fair (i.e., benchmark value), shown in olive green, and the criterion distinguishing Poor from Fair (i.e., scoring criterion for Poor), shown in orange. See text for further details.

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Technical Appendix

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5. Technical Appendix

Background and Rationale

Population abundance of tidal marsh-dependent species has been used as an indicator of population health of sensitive species and thus of the condition of tidal marsh ecosystem in the San Francisco Estuary, dating back to the State of the Estuary 2011 Report and earlier (e.g., Goals Project 2000). Density is a particularly suitable metric, because it tallies the number of individuals detected or estimated to be present in the survey area, in relation to the area surveyed. Because in this study the same sites are sampled repeatedly over time, the statistical analysis of change in the density over time is facilitated. Tidal marsh bird density has been evaluated at multiple tidal marsh sites every year since 1996 by Point Blue Conservation Science (Spautz et al. 2006).

The three species comprising the tidal marsh bird indicator are represented in the estuary by subspecies that display unique adaptations to tidal marsh habitat, but are, at the same time, of conservation concern, being either State-Threatened or California Species of Special Concern. A fourth species, the Ridgway's Rail, is tracked with its own indicator in the State of the Estuary Report because standardized results for this species are only available since 2005, whereas the three species used here have been monitored since 1996.

Benchmark

The benchmark value chosen is a density for tidal marsh birds that we consider to be a desirable target. The value chosen is the 75th percentile among all marsh sites studied during the period 1996-2008. The 75th percentile value corresponds to the median value for the upper half of all marsh sites surveyed during the reference period. We then used the most recent four years (2011-2014) to provide an assessment of current condition relative to the benchmark value.

The rationale for choosing a target density for the benchmark is that density of tidal marsh bird species reflects, in part, habitat suitability and may also reflect efficacy of management actions designed to support healthy tidal marsh populations. We therefore expect that improvements in habitat suitability, including maturation of newly restored tidal marsh habitat, should be reflected in an increase in the density of tidal marsh bird species.

Data Sources and Methods

Data for the indicator are from standardized, avian tidal marsh surveys conducted by Point Blue Conservation Science since 1996 (Nur et al. 1997, Spautz et al. 2006, Stralberg et al. 2010, Wood et al. 2012). Field methods for avian surveys in tidal marsh habitat are described in the above-listed references.

Briefly, multiple survey stations have been established within each marsh site surveyed. All individuals detected within 50 m of the observer are enumerated and identified to species. Two surveys are conducted per station during the course of the breeding season. The number of individuals detected per species is averaged over the two survey visits in each year. The analysis is then conducted at the individual survey station level or, instead, the number of individuals are averaged over all stations in a marsh and average density per marsh station per year is analyzed.

The latter approach is used here. Note that we divide the number of individuals detected by the area surveyed, thus yielding a density estimate.

We analyze each species separately, specifically the number of detections per unit area, natural-log transformed, for each marsh in each year. We statistically modeled the variation in density among years for all three species. Our models included "marsh site" as a main effect. That is, we estimated year to year change in tidal marsh bird density (fitting a model in which "year" was a categorical variable, or factor), while also statistically adjusting for marsh site, treated as a fixed effect. Adjusting for variation in density among marsh sites improves our ability to estimate the annual variation in density common to all sites. We used the `margins` command in STATA 13.1 (StataCorp.) to obtain the estimates of annual change in the density index, derived from the statistical model.

To obtain a three-species combined metric we first calculated the geometric mean of density across the three species, which is the back-transformed value with respect to the mean of the ln-transformed, model-derived values across the three species. We then multiplied the geometric mean by three to represent the total estimated number of individuals per hectare among the three focal species (Black Rail, Common Yellowthroat, and Song Sparrow).

Trends across the time period, 1996 to 2014, were calculated using the ln-transformed density values; we analyzed each species by itself, and also analyzed the combined (geometric-mean based) three-species metric, calculated as described above. The magnitude and statistical significance of the trend are reported with respect to the analysis of ln-transformed density values (see Table A1, below). However, for illustrative purposes, the trend line shown in Figure 1 is based on the geometric mean, three-species density index values, rather than the ln-transformed values. Thus, results displayed in Figure 1 are scaled in terms of birds/ha rather than in log units.

Assumptions and Uncertainties.

The two areas of greatest concern are: 1) We were not able to estimate detection probability independently of abundance. Hierarchical statistical models to separately estimate detection probability and abundance could not also incorporate marsh-specific variation in abundance. Hence we use the number of individuals detected as a proxy for abundance, and thus, density. Thus, we do not know if some of the annual variation in density is due to variation in detection probability. That said, we have no evidence that this is the case. 2) The sample of marshes systematically surveyed is small: 10 marshes were included in this analysis. We assume that the ten surveyed marshes are representative of the larger set of tidal marshes in the San Francisco Estuary, but that has not been confirmed. A greater sample size of marshes is needed, which requires sufficient funding to accomplish that objective.

Results

The three-species density index results are described above, section 3. Here we describe results for the individual species in more detail.

Species-specific trends are summarized in Table A1. Black Rail and Common Yellowthroat displayed significantly increasing tends in density, exceeding 3% per year for both species (P = 0.012, P = 0.016, respectively). The observed trend for Song Sparrows was positive but represented a very modest increase (1.1% per year), and was not statistically significant. However, the Common Yellowthroat trend exhibited significant down-turning (i.e., the quadratic coefficient was significantly negative, P = 0.021). Thus, the increasing trend has not continued in recent years.

Appendix, Table A1: San Francisco Estuary Tidal Marsh Bird Index
Trends 1996 to 2014 for three tidal marsh bird species
Estimated annual rates of change in the index and significance of the trend shown

	Trend Coefficient	S.E.	Annual Pct Change	P-value
Species				
Black Rail	0.0386	0.0137	3.94%	P = 0.012
Common Yellowthroat	0.0328	0.0123	3.33%	P = 0.016
Song Sparrow	0.0108	0.0078	1.09%	P = 0.18
Three Species, Combined Index	0.0274	0.0072	2.78%	P < 0.002

Peer-review and Acknowledgments

Methods for field collection and analysis used here have been published in several peer-reviewed scientific publications such as Spautz et al. (2006) and Wood et al. (2012). We thank many field staff for data collection over the years especially M. Elrod, L. Liu, and H. Spautz. Funding for analysis of the indicator presented here was provided by the Richard Grand Foundation. We thank the many agencies and land-owners for allowing access to tidal marsh study sites.

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