Columbia River Streaked Horned Lark Surveys and Monitoring

Final Report 2014


Photo: Port of Portland

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Introduction

The streaked horned lark (*Eremophila alpestris strigata*) is endemic to the Pacific Northwest, and is a subspecies of the wide-ranging horned lark. The species has been extirpated throughout much of its range, no longer occurring in British Columbia, north Puget Sound, or the Rogue River valley in Oregon. The lark was added to the United States Fish and Wildlife Service (USFWS) candidate list in 2002, and the subspecies was ultimately listed as Threatened in October 2013 (Determination of Endangered Status for the Taylor's Checkerspot Butterfly and Threatened Status for the Streaked Horned Lark, 2013). The streaked horned lark (hereafter, SHLA or lark) occurs as multiple subpopulations across its current range in western Washington and Oregon: (1) the Willamette Valley in Oregon, (2) the Puget lowlands in Washington, (3) the Washington coast, and (4) lower Columbia River deposition islands. Movement among subpopulations occurs infrequently, mostly by dispersing juveniles.

Within these subpopulations, larks are found on open landscapes in early-successional habitats with short, sparse vegetation, plenty of bare ground, and few trees or shrubs. In the Willamette Valley, larks are primarily found on agricultural lands (e.g., grass seed farms) and airports, while in the Puget lowlands larks occur on some native prairies and on a number of airports. Along the Washington coast, larks are found on foredunes with limited vegetation. In the lower Columbia River region, larks occupy deposition islands created from and used for the placement of dredged materials.

The Center for Natural Lands Management (CNLM) has been monitoring larks in the lower Columbia River since 2010. Within the Columbia River there are a series of islands created through periodic placement of dredged materials that provide suitable habitat for larks. However, deposition islands appear to be suitable for a limited period, apparently from 2-3 years after creation until 7-8 years after creation (Anderson 2013). Understanding lark distribution is key to minimizing impacts from deposition actions as well as maximizing the habitat creation benefits of dredged material placement. In addition, monitoring lark distribution and trends through time can help us understand how larks are responding to deposition actions.

In 2014, we continued ongoing efforts and initiated new components; overall, we focused on five objectives. The first objective was to determine occupancy at deposition islands that had never been previously surveyed for larks or sites where larks had not recently been detected. Because the proposed abundance monitoring protocol, drafted by WDFW (2012) relies on counts at occupied sites, periodic assessment of unsurveyed sites is important to determine if they should be included in the abundance monitoring network and to inform potential deposition actions at these sites.

The second and third objectives were related to abundance monitoring efforts that have been ongoing since 2010. Long-term monitoring of lark abundance is key to assess the species conservation status, evaluate management efforts, and measure long-term population trends. Objective Two (or 2) was to conduct a pilot study to estimate lark detectability. This new project was initiated because we know that lark surveys have imperfect detection and understanding detectability and how it varies is critical to evaluating long-term trends in abundance. For example, some birds are missed because they didn't sing or an observer may have been looking the other way when an individual made a movement in their territory. Estimating detectability is also critical for use by the Washington Department of Fish and Wildlife (WDFW) to get a more precise estimate of population trend. WDFW intends to use an N-mixture model approach (Royle et al. 2004) in which prior estimates of detection probability is critical for conducting this analysis. We estimated detectability using Distance sampling, which is a well-established method (Buckland et al. 2001). The third objective was to continue monitoring larks on occupied deposition sites using the WDFW lark monitoring protocol. We also evaluated patterns of lark abundance over time to describe notable patterns in abundance.

The fourth objective was to qualitatively assess habitat for larks at the sites visited in Objectives 1 and 3. These assessments can be used by managers to determine future management (e.g., deposition) considerations. Finally, we make recommendations about future monitoring.

Goal and Objectives

Our goal was to acquire and provide to the US Army Corps of Engineers (USACE) information regarding streaked horned lark occupancy, distribution, and use in 2014 at 24 dredged material deposition sites in the USACE disposal network (Appendix I).

Our objectives were to:

1) Assess lark occupancy at sites previously not surveyed.
2) Conduct a pilot study to estimate detection probability with distance sampling.
3) Estimate abundance and assess trends at known occupied sites.
4) Evaluate habitat for larks at the 24 sites that comprise the USACE network
5) Make recommendations for future monitoring.

Methods

Objective 1: Determine Occupancy

There is no established protocol to determine if a site is occupied by streaked horned larks. To address that information gap, CNLM coordinated with WDFW on an interim approach. On sites where occupation status was unknown, including sites that have never been surveyed or where larks have not been documented during previous surveys, area searches through all apparently suitable habitat within the USACE deposition boundaries were conducted three times throughout the lark breeding season, one each in May, June, and July. Area searches were conducted by experienced lark surveyors who walked slowly through all potentially suitable habitat looking and listening for streaked horned larks. Because not all areas of all sites contained potentially suitable habitat, not all areas of all sites were surveyed on visits two and three. At the first visit we qualitatively described habitat suitability and identified potentially suitable areas that were revisited on the subsequent two visits.

All larks detected and their behaviors were recorded. If larks were detected during the May visit, we considered the site occupied and surveyed the site with the abundance protocol. If larks were first detected at a site in June or July, we considered the site occupied but did not have adequate time to implement the abundance protocol on those sites in 2014.

Objective 2: Conduct a pilot study using distance sampling to estimate detection probability.

Study area, line transects, data preparation

Eight line transects were established on each of two deposition islands, Brown and Rice Islands, in the Columbia River (Figure 1). Transects were spaced 300 m apart and ranged in length from 100 m to 350 m. Transect #1 on Brown Island was removed due to human activity. Total length of all transects was 1500 m for Brown Island and 2650 m for Rice Island. With transect half-width at 150 m, the total area surveyed was total transect length multiplied by 300 m (2 time the transect half-width), resulting in total surveyed area equal to 45 and 79.5 ha for Brown and Rice Island, respectively. Transects on each island were surveyed three times: June 17, 19, and 24th. Both islands were surveyed by one observer in a single morning beginning at sunrise and finishing by 11:30. Each repeated survey was conducted by a different observer (i.e., there were three observers).

During the survey, the observer estimated the distance and the bearing of each individual bird from their location on the transect, thus observations were of single birds. Surveyors recorded how the individual was detected (aural or visual) and the sex and age of the individual. Surveyors also recorded flyovers.

Prior to Distance analysis, we removed all flyovers and individuals recorded as hatch-year birds. We transformed our field-recorded detection distances to perpendicular distance from the transect line. Then, we viewed histograms of perpendicular distances to evaluate patterns of detectability among groups (e.g., males detected aurally, females detected visually).

Distance analysis

Analyses were conducted in program Distance v.6.2 (Thomas et al. 2010). Following a review of histogram data and a discussion with WDFW about which data would be most helpful for their N-mixture abundance and trend analysis, we decided to estimate detectability for four discrete groups: 1) all detections, 2) males – visual detections, 3) males – aural detection, 4) females – all detections.

In Program Distance, we usually began the analysis by fitting two models (half-normal and hazard-rate functions, both with a cosine expansion) to the full data set to assess the need

Figure 1. Map of line transects placed on Brown Island (upper) and Rice Island (lower).

for truncating the data and to examine the detection function for signs of assumption violations. We followed recommendations by Buckland et al. (2001) for assessing model fit; in general we relied on quantile-quantile (Q-Q) plots and the Cramer Von Mises Goodness of Fit test with the cosine weighting function for assessing the fit of ungrouped data.

After making a decision on whether to truncate, we then fit a series of candidate models, consisting of the following key function/series expansions: half-normal/cosine, half-normal/hermit polynomial, hazard-rate/simple polynomial, and hazard-rate/cosine. For each analysis, we selected the best fitting model using Akaike's Information Criteria, as adjusted for small samples (AICc) and standardized Akaike weights (w). If more than one model received substantial support from the data (as judged by AICc and w), we assessed Q-Q plots and detection function shapes to recommend the most appropriate detection probability for that group.

In addition to estimates of the probability of detection, Program Distance generates density estimates. We used these density estimates and the estimate of the total area surveyed to estimate total abundance of larks on Brown and Rice Island for each of the four discrete groups. This allowed us to compare abundance estimates corrected for detectability with uncorrected estimates from the occupied site surveys in Objective 3.

Objective 3. Estimate lark abundance and assess trends.

In 2014, we conducted breeding season abundance surveys following WDFW's protocol (2012) for streaked horned larks on 10 deposition islands with known breeding individuals and on sites where larks were detected following May occupancy surveys. Surveys were conducted on line transects positioned 75 m inside the habitat boundary and spaced 150 m apart at each site. On most sites there were multiple line transects and in some situations multiple observers surveyed separate transects at the same time. Total transect length on sites varied from 615 m to 6600 m.

In 2014, the survey period was modified following direction from WDFW. Each site was surveyed $\geq$ 3 times in a 2-week window during the period from 21 May to 20 June. Previously, surveys were conducted 3 times, once each in May, June, and July. This modification was made to reduce the likelihood that surveyors encountered individuals that had moved between sites within the breeding season. Prior to surveys, observers received training on recognizing streaked horned larks and other focal species by song and call and differentiating larks by sex and age.

Surveys were typically conducted between the period from 30 minutes after sunrise to noon, as long as weather conditions were appropriate (e.g., wind < 20 mph and temperature $\leq$ 80° F). Observers walked the transect line at a moderate, synchronous (if > 1 observer) pace, stopping at mapped station locations every 150 m to look and listen for larks for approximately 30 seconds. While either walking or watching at the station, observers recorded all larks seen or heard < 75 m on either side of their line, including those flying overhead or in front of the observer. In general, observers only recorded larks detected behind them if they were certain that they had not been counted by another observer. To avoid double counting, adjacent observers communicated either during the survey by cell-phone or radio during the survey or via notes and discussion post-survey. When detecting an individual, observers also recorded the time, age and sex (if determined), initial position of bird (flight vs. ground), how it was detected (aural or visual) and other behaviors. The estimated location of each bird, whether heard or seen, was mapped in the field for subsequent entry into a GIS file. Other focal species were also tallied (e.g., crows, ravens, meadowlarks). See protocol for a detailed description of methodology (WDFW 2012). Data were entered into an excel spreadsheet developed by WDFW and all data were submitted to WDFW at the end of the data season following QA/QC measures.

We used the data collected from the surveys to estimate three measures of abundance: maximum abundance, average abundance and relative abundance for known occupied sites. Maximum abundance was the highest count from the three surveys. As per the USACE Biological Assessment and USFWS Biological Opinion, the number of breeding pairs on deposition islands was estimated by doubling the maximum number of males detected at any one survey visit. Average abundance of SHLA for each site was the mean number of adults counted over the three surveys, whereas relative abundance was the number of adults per 1 km of transect, averaged over the repeated visits. We estimated maximum, average, and relative abundance by site and by the region for total adults, male adults, and female adults in each year from 2010 to 2014. While maximum and average abundance estimates help us assess population size and which sites support the most birds and therefore may be of high management priority, relative abundance standardizes counts relative to effort (i.e., transect length), similar to a density estimate, which may be helpful in assessing high quality habitat.

All of these measures of abundance are considered an index to the true number of adults. That is they are proportional to true population size. However, this assumes that the probability of detection is constant over space and time, an assumption that is increasingly questioned. It is because of this concern that we initiated the pilot distance sampling project to estimate detectability, and why WDFW is using N-mixture models, which both estimates and corrects for detectability, to assess population trends.

Objective 4: Habitat Evaluations

There are two main conditions required for suitable streaked horned lark habitat: an open context and short, sparse vegetation with ample bare ground (for a more complete description of lark habitat see Pearson and Hopey 2005). We relied on expert opinion to assess habitat quality at sites surveyed and assigned each site into one of four general categories: suitable and occupied, apparently suitable, not yet suitable, and unsuitable (Table 1). Even on sites categorized as suitable (suitable and occupied; apparently suitable), suitable habitat was not distributed continuously on sites where it was detected. Rather, the short sparse habitat conditions selected by streaked horned larks are often distributed patchily throughout the sites.

Table 1. Habitat evaluation categories.

Suitable and Occupied	The site meets the open landscape context requirement, contains patches of short, sparse vegetation with ample bare ground, and larks were detected at the site.
Potentially Suitable	The site likely meets the open landscape context requirement and contains patches of short, sparse vegetation with ample bare ground, but larks were not detected at the site.
Not Yet Suitable	The site likely meets the open landscape context requirement but does not contain adequate vegetation cover and is currently too bare to support streaked horned larks. It is assumed that with vegetative succession, the site would become suitable.
Unsuitable	The site may or may not meet the open landscape context requirement and vegetation conditions are too dense to support streaked horned larks.

Results

Objective 1. Occupancy

We visited 15 sites that had either not been surveyed for streaked horned larks or where larks had not recently been detected (Table 2). Of those sites, larks were detected during surveys at four sites: Dibblee Point, Lower Deer, Austin Point, and Gateway.

Table 2. Occupancy survey summary results.

Site Name	Survey Date	# Larks Detected	Survey Date	# Larks Detected	Survey Date	# Larks Detected
Benson Beach	5/21/14	0	6/19/14	0	7/11/14	0
West Sand	5/21/14	0	6/19/14	0	7/11/14	0
Skamokawa	5/29/14	0	6/19/14	0	7/9/14	0
Welch	5/29/14	0	6/19/14	0	7/9/14	0
James River	5/22/14	0	6/19/14	0	7/9/14	0
Hump	5/21/14	0	6/11/14	0	7/8/14	0
Lord	5/21/14	0	6/11/14	0	7/8/14	0
Dibblee Point	5/22/14	0	6/11/14	0	7/9/14	5[3,5]
Howard	5/22/14	0	6/11/14	0	7/8/14	0
Cottonwood	5/22/14	0	6/11/14	0	7/8/14	0
Lower Deer	5/21/14	2[1]	See abundance results			
Martin Bar (N & S)	5/23/14	0	6/17/14	0	7/10/14	0
Austin Point	5/23/14	0[2]	6/17/14	0	7/10/14	0
Gateway	5/23/14	0	6/17/14	3[3,4]	7/10/14	1
West Hayden Island	5/23/14	0	6/17/14	0	7/10/14	0

[1]Detection of male & female pair was made during May, leaving ample time to conduct 3 abundance visits within the revised survey protocol timing window.

[2]Male lark was detected during Austin Point survey, but was located outside site boundary and in the air only. He was conducting a flight display over the water just off the beach and the bird made a direct flight to Sand Island Marine Park.

[3]Because animals were not detected until mid-June or later, there was not time to conduct 3 abundance visits within the revised survey protocol timing window.

[4]Animals were detected in both sandy deposition area and surrounding agricultural fields. Initial detections were at site entry and in surrounding field. One of same individuals was observed conducting flight display over dredge deposition area.

[5]Detections were one adult male, one adult female, and three young of the year, suggesting that breeding occurred at the site in 2014.

Objective 2: Conduct a pilot study using distance sampling to estimate detection probability.

The total number of SHLA detections from distance sampling surveys on Brown and Rice Islands was 109, with more than half of the detections being visual (Table 3). Males were detected more often aurally whereas females were almost exclusively detected visually. Overall, males were detected twice as often as females (Table 3).

Table 3. Number of streaked horned lark detections by sex and detection type at three repeated distance surveys of line transects on Brown and Rice Island during the period 17-24 June 2014.

	Aural	Aural/Visual	Visual	Visual/Aural	Total
Male	39	2	25	1	67
Female	2		27		29
Unknown	4	1	8		13
Total	45	3	60	1	109

Following review and discussion with WDFW, we made several decisions on how detections were assigned to individual groups that we intended to analyze. First, for those detections where individuals were identified both aurally and visually, the detection was put into the category of the initial detection type; for example a male adult first detected visually and subsequently heard was placed in the visual detection group. Second, we placed detections of unknown sex into male and female sex categories in the following way. All visual detections of unknown sex, of which there were 8, were assigned as females. This was done because based on the analysis of the larger dataset by WDFW, visually detected adults of unknown sex were acting like females. There were also 5 aural detections of unknown sex. These were randomly assigned as males (2 detections) or females (3 detections). This changed sample sizes of groups to: adult males, visually detected = 26; adult males, aurally detected = 43; adult females, all detections = 40.

The pattern of perpendicular distances for all detections showed a gradually declining frequency of detection with distance, as is expected, with detectability declining farther from the transect (Figure 2). However, when detections were separated by sex and detection type, several patterns emerged. In general, all visual detections were relatively close to the transect with a strong spike close to the line (farthest distance 66 m, with one outlier at 129), whereas aural detections showed gradual declining frequency out to 200 m, although there was still a small to moderate spike near the line. The histogram for male detections showed a severe spike near the line (Figure 3), but histograms for visual and aural detections differed substantially (Figure 3). Visual detections were mostly close to the line and aural detections showed a gradual decline in frequency; both detection types still showed a strong spike close to the line. For female detections, the histogram looked similar to the histogram for male visual detections, which is not surprising since all but two detections were visual.

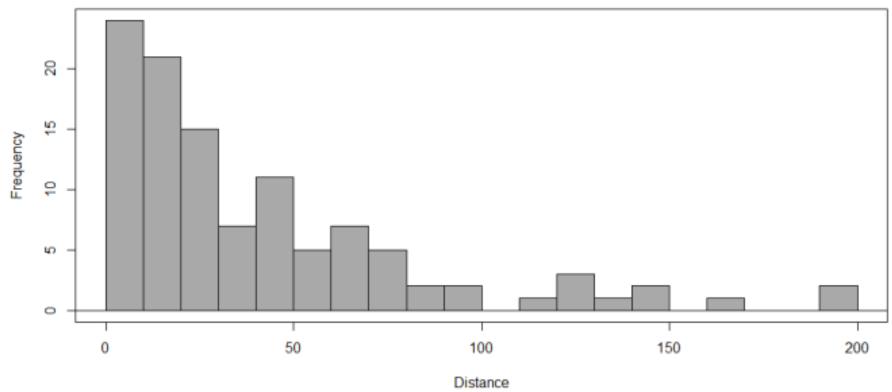


Figure 2. Histogram of SHLA detection distances (m; *n* = 109, adult males and females combined) from breeding season surveys conducted on Brown and Rice islands in 2014.

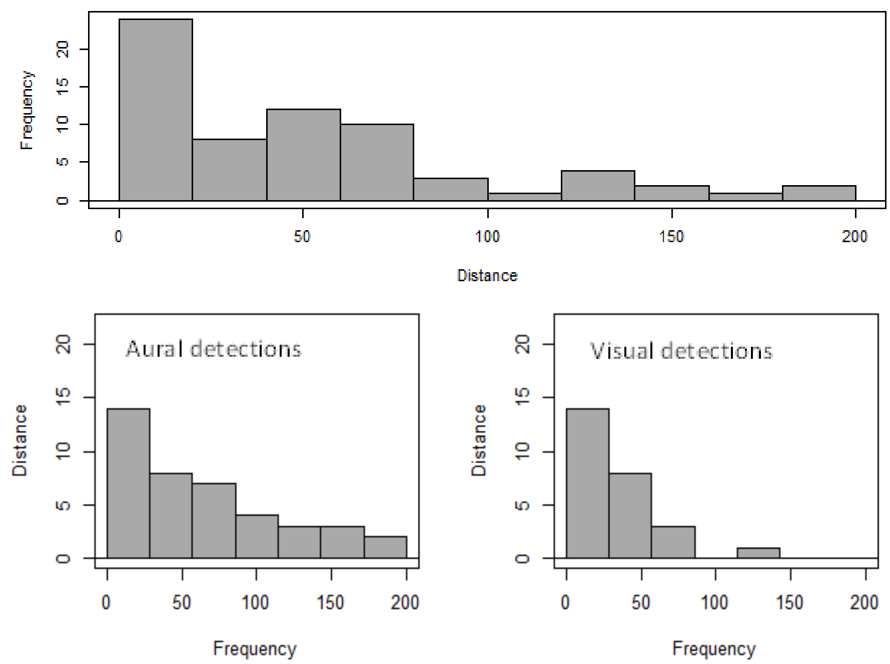


Figure 3. Histogram of adult male SHLA detection distances (m) (upper; *n* = 67), adult males detected aurally (lower left; *n* = 41), and adult males detected visually (lower right; n = 26) from breeding season surveys conducted on Brown and Rice island in 2014.

All Detections

There were a total of 109 SHLA detections and the histogram showed a gradually declining frequency of detection with distance as expected with detectability declining farther from the transect and no indication of evasive movement, but there were a series of outliers beyond 100 m (Figure 2). Preliminary model-building indicated decent fit with the entire data set and models did not require adjustments at farther distances (typically a common problem), although the model was clearly trying to fit the long tail of the data. Truncating by 10% maintained overall model fit and improved the shape of the detection function (evidence of a wider shoulder, which is desirable). Other truncation levels did not improve fit and we continued the analysis with the data set truncated at 10%. The top model was a hazard-rate key with no series expansion (Model 1), although one other model (Model 2: half-normal with cosine expansion) received nearly equal support (Table 4). The estimates of detection probability for these two models were very similar (range 0.41 to 0.43). 95% confidence intervals indicate that detection probability lies between 0.29 and 0.58. Overall, this suggests that surveys miss detecting some animals and that abundance may be underestimated across the study area. Density estimates ranged from 0.94 to 0.98 larks per hectare (Table 5).

Overall, we believe the detection probability estimate from the hazard rate model (Model 1 may be the most appropriate to use. Hazard-rate models are suggested for data that appear spiked, as seen in this dataset, because the model enforces the shape criterion, offers greater flexibility in fitting a spike, and gives a more realistic (larger) variance estimate (Buckland et al. 2001).

Table 4. Detection probability (95% confidence intervals) for discrete sex and vocalization types estimated in Program Distance using data collected from Brown and Rice Islands during the 2014 breeding season.

Sex	Detection Type	# detections	Model	Detection probability, p	p Lower 95% CI	p Upper 95% CI
Both	All	109	1	0.41	0.29	0.58
Both	All	109	2	0.43	0.34	0.54
Males	Aural	43	1	0.30	0.12	0.47
Males	Visual	26	1	0.39	0.26	0.60
Females	All	40	1	0.50	0.36	0.69

Table 5. Density estimates (number of larks/ha) and 95% confidence intervals for discrete sex and vocalization types generated in Program Distance using data collected from Brown and Rice Islands during the 2014 breeding season.

Sex	Density	Density L 95% CI	Density U 95% CI
Both	0.98	0.61	1.58
Both	0.94	0.62	1.40
Males	0.28	0.11	0.73
Males	0.21	0.10	0.41
Females	0.42	0.25	0.70

Males

There were a total of 67 male detections on the pilot study surveys and distance data shows a strong spike near zero and a bimodal pattern with another spike around 50 m (Figure 3). These patterns are typically difficult to model in Distance. In this case, they appear to be due to differences in detections from aurally vs. visually detected individuals (Figure 3).

Aural detections. We modeled 43 aural detection for males. The farthest detection distance was 200 m. Preliminary analysis showed modest fit only with the hazard-rate key for the full data set of male aural detections. Because of the small sample size of detections, we only evaluated the full data set in final analyses.

For the full dataset, the best model as evaluated by AIC_c was a hazard key with no series expansion. This model yielded a detection probability of 0.30 (Table 4; 95% CI = 0.12 – 0.74). Although other model received support (AIC_c <2.0 and w = 0.30), Q-Q plots showed poor model fit, especially near zero (Figure 4), and thus were not considered valuable. As noted earlier, hazard-rate models are suggested for data that appear spiked, such as found with the male detections. This model has shown good capability for fit a shoulder and providing good fit even with spiked data. The tradeoff is that the variance is quite large, which is also reflected in the density estimate. Estimated density for the best model was 0.28 (95% CI=0.11 – 0.73; Table 5).

Visual detections. We modeled 26 visual detections for males, substantially lower than the recommended number of > 60 detections for adequate modeling. There was a single detection at 129 m, with all others less than 67 m. Preliminary analysis showed good fit for the full data set of male visual detections and was not improved by removing the outlier. The best model was a half-normal key with no series expansion with detection probability of 0.39 (95% CI = 0.26 – 0.60; Table 4). Additional models received some support; however, those models tried to overfit the tail and failed the shape criteria. The density estimate for the best model was 0.21 (95% CI = 0.10 – 0.41; Table 5).

Females

All Detections. There were a total of 29 female detections, 27 visual and 2 aural. To these detections, we added 8 visual detections of unknown sex because these seemed to act as females and 3 randomly selected aural detections of unknown sex (n = 40). Three models showed good fit, but we selected the hazard rate model because it had an especially good shape and provides the safest choice as the top model because the 95% confidence interval bounded the other two models. Detection probability for this model was 0.50 (95% CI = 0.36 - 0.69; Table 4) and density was 0.42 (95% CI = 0.25 – 0.70; Table 5).

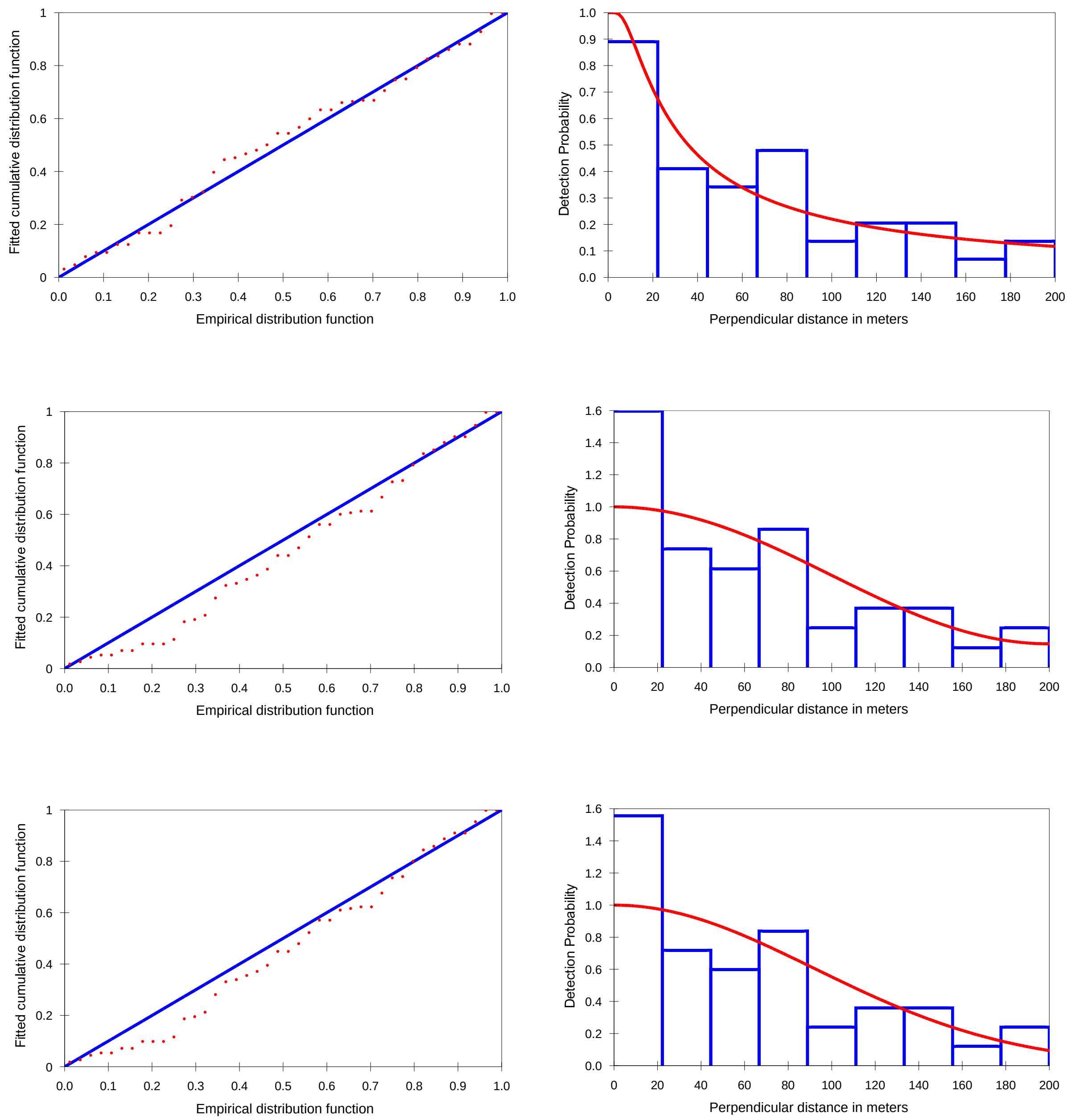


Figure 4. Q-Q (left) and detection probability (right) plots for top 3 detection function models (Model 1 = top, Model 2 = center, Model 3 = bottom) generated by Program Distance for data including all male SHLA observations detected aurally (no truncation).

Objective 3. Estimate streaked horned lark abundance in 2014

We conducted surveys on 10 deposition islands covering approximately 21 km of transects (Table 6). One site, Lower Deer Island, was added after larks were detected during the May presence/absence surveys. All deposition islands were surveyed three times. Rice Island had the largest number of larks detected, followed by Brown Island. These two islands also had the highest counts of adult males. Curiously, the total number of adults at all occupied islands was identical (68 individuals) at two separate visits and these counts were the same as the high counts of males. We suspect this supports the idea that the high count of males may be biased high relative to true abundance.

Table 6. Survey dates and total adults counted for repeated surveys of streaked horned larks during the 2014 breeding season at 10 placement sites in the Columbia River, WA.

		Visit 1		Visit 2		Visit 3	
Site	Transect length (m)	Date	Total Adults	Date	Total Adults	Date	Total Adults
Rice	6600	06/12/14	23	06/18/14	31	06/20/14	25
Miller Sands	3450	06/12/14	11	06/18/14	10	06/20/14	10
Pillar Rock	750	06/12/14	5	06/18/14	2	06/20/14	4
Tenasillahee	615	06/12/14	2	06/18/14	0	06/20/14	0
Brown	3720	06/12/14	12	06/18/14	31	06/20/14	14
Crims	1860	05/21/14	4	05/23/14	4	05/30/14	7
Northport	980	05/21/14	2	05/23/14	2	05/30/14	2
Sandy	810	05/21/14	7	05/23/14	14	06/02/14	5
Lower Deer	1425; 800	05/23/14	2	06/02/14	2	06/11/14	1
Sand	975	5/21/14	0	06/02/14	3	06/11/14	0
Total			**68**		**99**		**68**

Maximum, average, and relative abundance

The sum of the maximum counts of adults from surveys on occupied deposition sites in the Columbia River was 108, with maximum counts of male and females at 68 and 39, respectively (Table 7). Rice and Brown Islands had the highest maximum counts for adults, males and females, more than double the maximum counts of the next two closest ranked occupied sites - Miller Sands and Sandy Island.

Average abundance of adult larks mirrored maximum abundance. Average abundance was highest on Rice Island (26.3 individuals; Table 8), followed by Browns Island (19.0), Miller Sands (10.3), and Sandy Island (8.7).

We can see the effect of incorporating detectability to correct for imperfect detectability when estimating abundance in two ways. First, if we apply our detection probability estimate for all detections from Objective 2 ($p = 0.41$, 95% CI: 0.29 – 0.58) to our estimates of average abundance, we get the following corrected values for abundance at each site: Rice Island (64.1 individuals, range = 45.3 - 90.7), Brown (46.3 individuals, range = 32.8 –

Table 7. Maximum count of total adults, adult males, and adult females counted on repeated surveys at sites in Columbia River, WA from 2010 to 2014. NS=No Survey.

Total adults	**2010**	**2011**	**2012**	**2013**	**2014**
Brown_Island	29	21	23	36	31
Cottonwood_Island	0	NS	NS	NS	NS
Crims_Island	2	8	8	4	7
Dibblee_Point	NS	NS	NS	0	NS
Lower_Deer_Island	NS	NS	NS	NS	2
Miller_Sands	6	7	4	8	11
Pillar_Rock	5	5	3	3	5
Rice_Island	10	24	20	33	31
Sand_Island_MP	NS	NS	NS	NS	3
Sandy_Island	1	2	1	6	14
Skomakawa_Vista_Park	NS	NS	NS	0	NS
Northport	NS	NS	2	3	2
Tenasillahee_Island	4	2	2	NS	2
Wallace_Island	0	0	0	0	NS
Wasser_and_Winters	NS	NS	NS	2	NS
Welch_Island	3	0	0	0	NS
Adult Males	**2010**	**2011**	**2012**	**2013**	**2014**
Brown _Island	15	14	18	23	21
Cottonwood_Island	0	NS	NS	NS	NS
Crims_Island	0	7	4	2	5
Dibblee_Point	NS	NS	NS	0	NS
Lower_Deer_Island	NS	NS	NS	NS	1
Miller_Sands	3	4	2	5	8
Pillar_Rock	3	4	3	2	4
Rice_Island	6	22	14	23	18
Sand_Island_MP	NS	NS	NS	NS	2
Sandy_Island	1	1	1	4	6
Skomakawa_Vista_Park	NS	NS	NS	0	NS
Northport	NS	NS	1	3	2
Tenasillahee_Island	2	2	2	NS	1
Wallace_Island	0	0	0	0	NS
Wasser_and_Winters	NS	NS	NS	1	NS
Welch_Island	1	0	0	0	NS
Adult Females	**2010**	**2011**	**2012**	**2013**	**2014**
Brown_Island	4	4	5	9	10
Cottonwood_Island	0	NS	NS	NS	NS
Crims_Island	1	0	2	2	2
Dibblee_Point	NS	NS	NS	0	NS
Lower_Deer_Island	NS	NS	NS	NS	1
Miller_Sands	2	2	1	3	4
Pillar_Rock	2	1	1	1	2
Rice_Island	2	7	4	10	12
Sand_Island_MP	NS	NS	NS	NS	1
Sandy_Island	0	1	0	3	5
Skomakawa_Vista_Park	NS	NS	NS	0	NS
Northport	NS	NS	2	0	1
Tenasillahee_Island	2	0	0	NS	1
Wallace_Island	0	0	0	0	NS
Wasser_and_Winters	NS	NS	NS	1	NS
Welch_Island	2	0	0	0	NS

Table 8. Average number of total adults, adult males, and adult females counted on repeated surveys at sites in Columbia River, WA from 2010 to 2014. NS=No Survey.

Total adults	**2010**	**2011**	**2012**	**2013**	**2014**
Brown_Island	19.67	20.50	18.25	24.67	19.00
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	1.00	8.00	7.00	3.33	5.00
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	1.67
Miller_Sands	5.50	2.33	1.50	7.00	10.33
Pillar_Rock	3.33	2.67	1.25	3.00	3.67
Rice_Island	9.00	23.50	14.50	25.33	26.33
Sand_Island_MP	NS	NS	NS	NS	1.50
Sandy_Island	0.50	2.00	0.33	4.33	8.67
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	1.67	2.00	1.50
Tenasillahee_Island	2.33	0.67	0.67	NS	0.67
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	2.00	NS
Welch_Island	1.67	0.00	0.00	0.00	NS
Adult Males	**2010**	**2011**	**2012**	**2013**	**2014**
Brown _Island	10.00	13.50	13.00	17.00	12.33
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	0.00	7.00	3.67	2.00	3.00
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	1.00
Miller_Sands	2.50	1.33	1.00	4.00	6.67
Pillar_Rock	2.00	2.00	1.00	1.00	2.33
Rice_Island	5.50	18.00	11.25	16.67	14.67
Sand_Island_MP	NS	NS	NS	NS	1.00
Sandy_Island	0.50	1.00	0.33	3.00	4.33
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	0.67	2.00	1.00
Tenasillahee_Island	1.33	0.67	0.67	NS	0.33
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	1.00	NS
Welch_Island	0.67	0.00	0.00	0.00	NS
Adult Females	**2010**	**2011**	**2012**	**2013**	**2014**
Brown_Island	2.67	3.50	4.25	6.33	5.33
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	0.50	0.00	2.00	1.33	1.67
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	0.67
Miller_Sands	2.00	0.67	0.25	3.00	3.33
Pillar_Rock	1.00	0.67	0.25	0.50	1.33
Rice_Island	1.00	4.00	2.75	7.67	11.33
Sand_Island_MP	NS	NS	NS	NS	0.50
Sandy_Island	0.00	1.00	0.00	1.33	2.33
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	1.00	0.00	0.50
Tenasillahee_Island	0.67	0.00	0.00	NS	0.33
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	1.00	NS
Welch_Island	1.00	0.00	0.00	0.00	NS

65.5), Miller Sands (25.1 individuals, range = 17.8 – 35.5), Sandy Island (21.2 individuals, range = 15.0 – 30.0). As we note in the discussion, distance sampling only estimates one component of detectability, so these estimates are not to be taken as actual abundance estimates for those islands.

Second, we can also use the density estimates generated from our pilot Distance study to estimate abundance for the sites we surveyed (Table 9). Within the 45 and 80 ha survey areas on Rice and Brown Island, respectively, we estimate that lark abundance was 77.9 individuals (95% CI = 48.5 – 125.6) and 44.1 individuals (95% CI = 27.5 – 71.1). The maximum counts for total adults from the occupied surveys are lower than the abundance estimates from density, especially for Rice Island, but they are within the 95% confidence intervals. For males, the maximum count is nearly identical to the abundance estimate for Brown Island, but substantially lower than for the abundance estimate on Rice. Maximum females counts are substantially lower than abundance estimates from density.

Table 9. Maximum counts from repeated surveys and lark abundance (95% CI) estimated from density estimates in Program Distance on Brown and Rice deposition islands in the Columbia River, WA in 2014.

	Brown				Rice			
	Maximum count	Estimated abundance	L CL	U CL	Maximum count	Estimated abundance	L CL	U CL
Total adults	31	44.1	27.5	71.1	31	77.9	48.5	125.6
Males (aural)	21	12.6	5.0	32.9	18	22.3	8.7	58.0
Males (visual)		9.5	4.5	18.5		16.7	8.0	32.6
Female	10	18.9	11.3	31.5	12	33.4	19.9	55.7

In 2014, average relative abundance of total adult larks was highest on Sandy Island (10.7 individuals/km, followed by Brown Island (5.1 individuals/km), Pillar Rock (4.9 individuals/km), and Rice Island (4.0 individuals/km). Adult males and females followed the same rank for the top four sites, with male abundance higher than female abundance (Table 10).

Trend patterns of the three abundance measures during the period from 2010 to 2014 are nearly identical (Figure 5, 6, 7). All show a stable to slightly increasing trend.

Table 10. Lark relative abundance (individuals/1 km) for adults, adult males, and adult females from repeated surveys at sites in Columbia River, WA from 2010 to 2014. NS=No Survey.

Average number of adults/km	**2010**	**2011**	**2012**	**2013**	**2014**
Brown_Island	5.29	5.51	4.91	6.63	5.11
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	0.54	4.30	3.76	1.79	2.69
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	1.72
Miller_Sands	1.71	0.86	0.55	2.03	3.00
Pillar_Rock	3.03	2.42	1.14	4.00	4.89
Rice_Island	1.68	4.38	2.71	3.84	3.99
Sand_Island_MP	NS	NS	NS	NS	1.54
Sandy_Island	0.85	3.42	0.29	3.77	7.54
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	2.31	2.22	1.67
Tenasillahee_Island	3.46	0.99	0.99	NS	1.08
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	2.34	NS
Welch_Island	1.37	0.00	0.00	0.00	NS
Average number of adult males/km	**2010**	**2011**	**2012**	**2013**	**2014**
Brown _Island	2.69	3.63	3.49	4.57	3.32
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	0.00	3.76	1.97	1.08	1.61
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	1.07
Miller_Sands	0.78	0.49	0.37	1.16	1.93
Pillar_Rock	1.82	1.82	0.91	1.33	3.11
Rice_Island	1.03	3.36	2.10	2.53	2.22
Sand_Island_MP	NS	NS	NS	NS	1.03
Sandy_Island	0.85	1.71	0.29	2.61	3.77
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	0.93	2.22	1.11
Tenasillahee_Island	1.98	0.99	0.99	NS	0.54
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	1.17	NS
Welch_Island	0.55	0.00	0.00	0.00	NS
Average number of adult females/km	**2010**	**2011**	**2012**	**2013**	**2014**
Brown__Island	0.72	0.94	1.14	1.70	1.43
Cottonwood_Island	0.00	NS	NS	NS	NS
Crims_Island	0.27	0.00	1.08	0.72	0.90
Dibblee_Point	NS	NS	NS	0.00	NS
Lower_Deer_Island	NS	NS	NS	NS	0.65
Miller_Sands	0.62	0.25	0.09	0.87	0.97
Pillar_Rock	0.91	0.61	0.23	0.67	1.78
Rice_Island	0.19	0.75	0.51	1.16	1.72
Sand_Island_MP	NS	NS	NS	NS	0.51
Sandy_Island	0.00	1.71	0.00	1.16	2.03
Skomakawa_Vista_Park	NS	NS	NS	0.00	NS
Northport	NS	NS	1.39	0.00	0.56
Tenasillahee_Island	0.99	0.00	0.00	NS	0.54
Wallace_Island	0.00	0.00	0.00	0.00	NS
Wasser_and_Winters	NS	NS	NS	1.17	NS
Welch_Island	0.82	0.00	0.00	0.00	NS

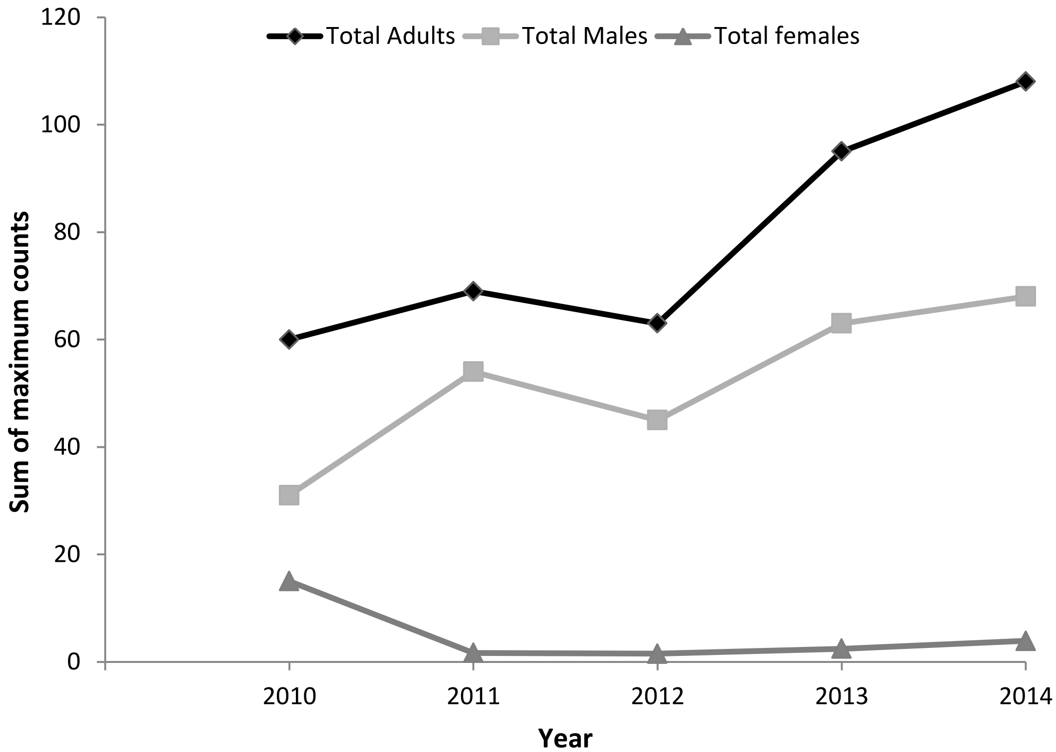
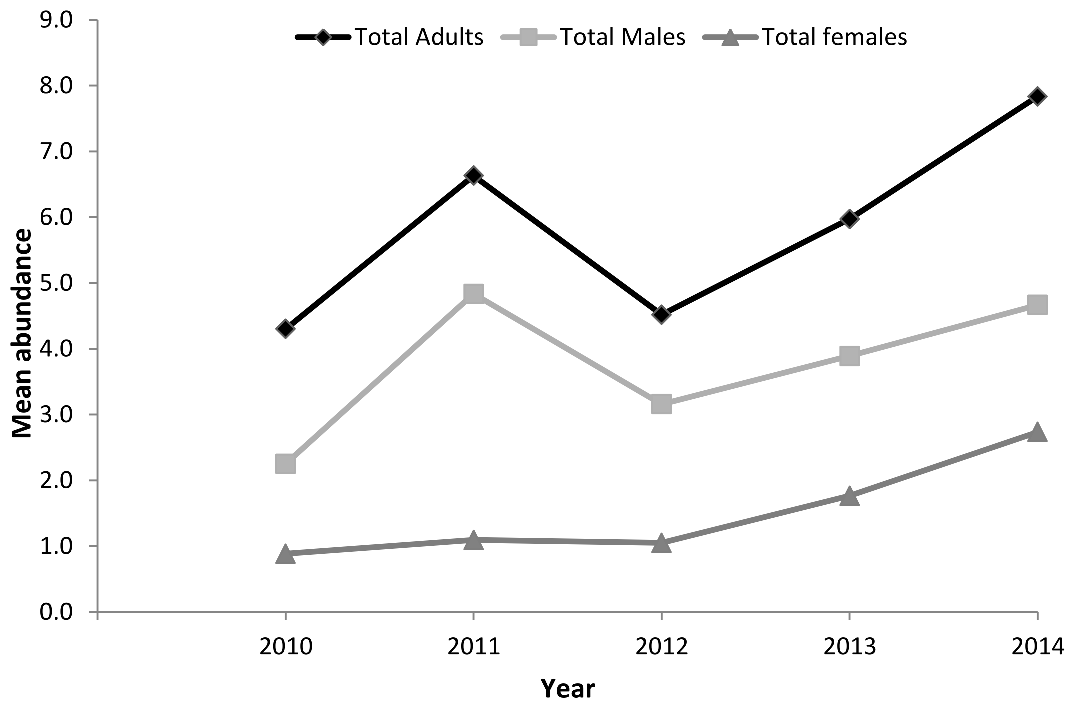


Figure 5. Sum of maximum counts of larks for adults, adult males, and adult females from repeated surveys at sites in Columbia River, WA from 2010 to 2014. Maximum counts of males is used as an estimate of pairs.



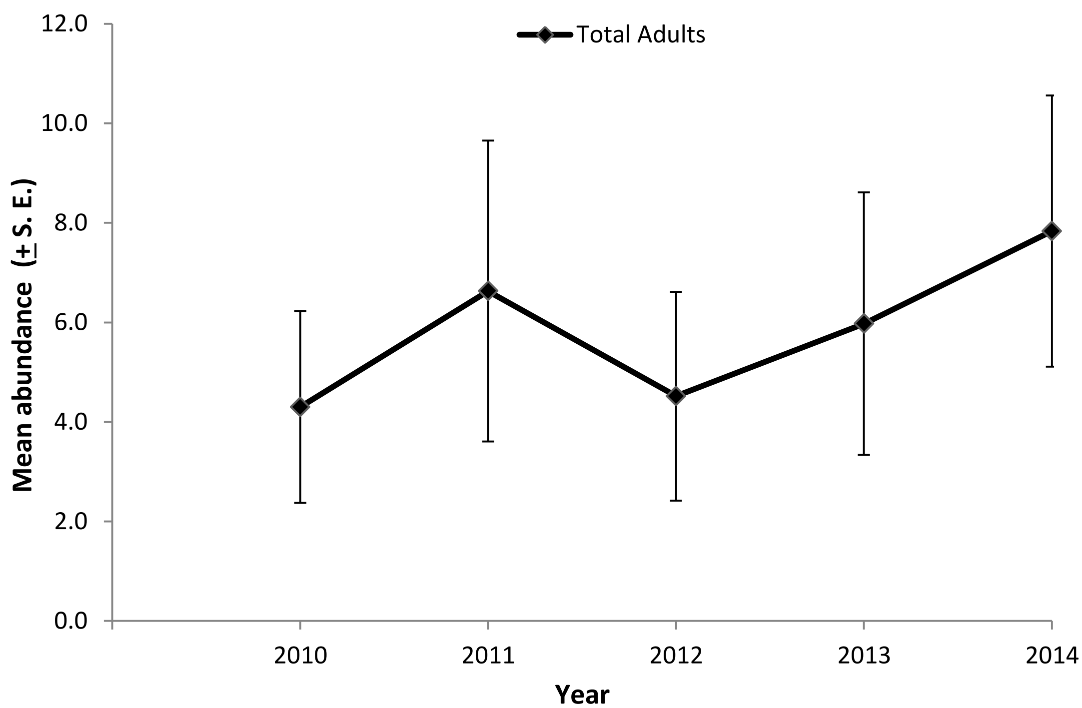


Figure 6. Mean lark abundance (number of larks/site) for adults, adult males, and adult females (upper) from repeated surveys at sites in Columbia River, WA from 2010 to 2014. The lower figure shows mean lark abundance for total adults with error bars as the standard error.

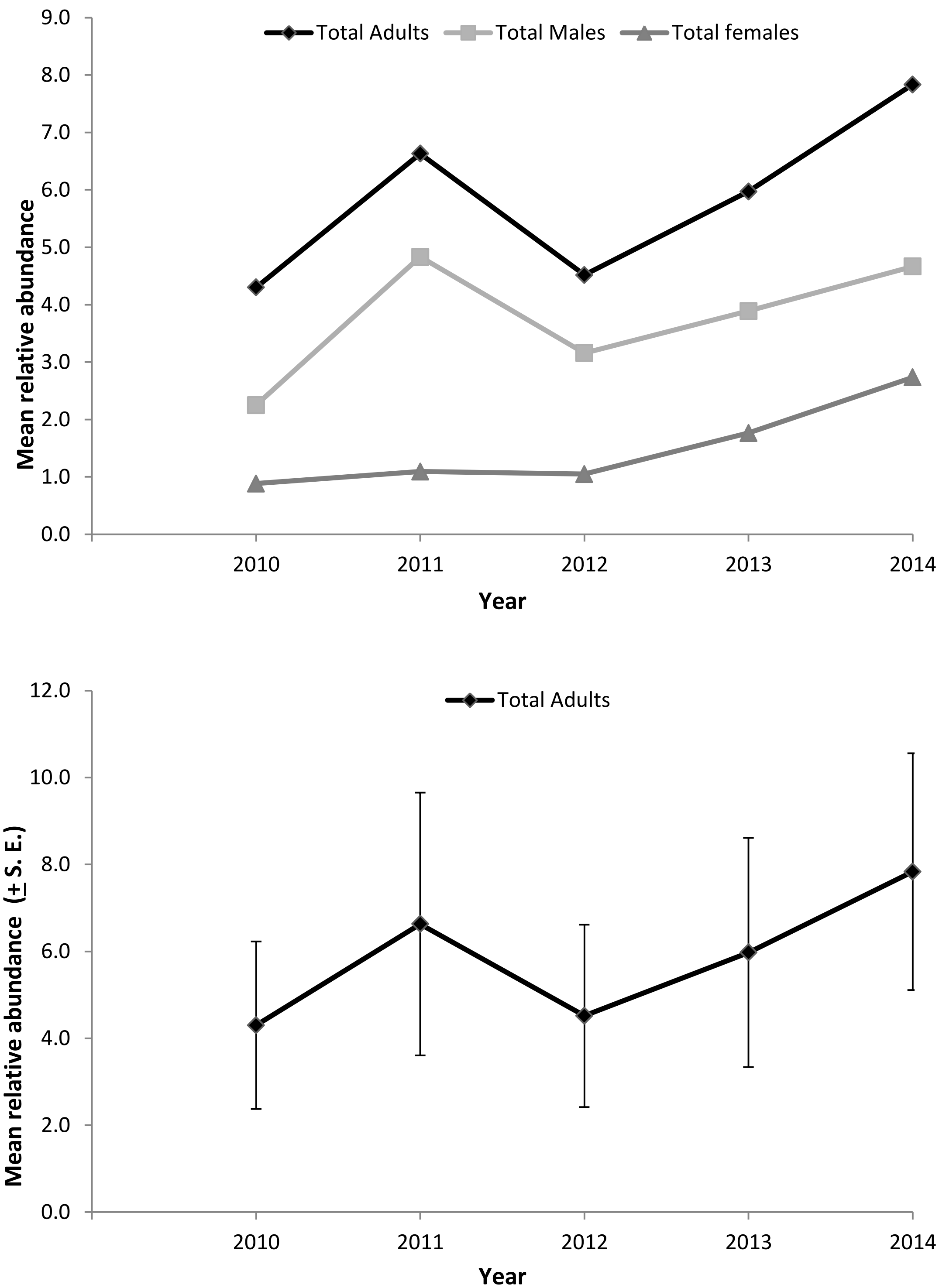


Figure 7. Mean lark relative abundance (individuals/1 km) for adults, adult males, and adult females (upper) from repeated surveys at sites in Columbia River, WA from 2010 to 2014. The lower figure shows mean relative abundance for total adults with error bars as the standard error.

Objective 4: Habitat Assessments

All occupied sites were considered suitable by the very nature of their occupation. Most unoccupied sites assessed we believe qualify as having adequate openness and landscape context to be considered potentially suitable for streaked horned lark habitat. However, many sites did not contain adequate short, sparse habitat situated within that open landscape context. Each site is described in more detail in the discussion below, Table 11 provides a summary of each site's assessed status, and images are contained in Appendix IV.

Table 11. Habitat suitability summary.

Site	Suitable and Occupied	Potentially Suitable	Not Yet Suitable	Unsuitable
Benson Beach				X
West Sand Island				X
Rice	X			
Miller Sands	X			
Pillar Rock	X			
Skamakowa			X	
Welch				X
Tenasillahee	X			
James River				X
Brown	X			
Crims	X			
Hump			X	
Lord				X
Dibblee	X			
Howard				X
Cottonwood				X
Northport	X			
Sandy	X			
Lower Deer	X			
Martin Bar		X		
Sand Island	X			
Austin Point			X	
Gateway	X			
West Hayden				X

Discussion

We gained substantial information about lark occupancy, abundance, and habitat use in the lower Columbia River in 2014. Area searches at sites with unknown occupation status helped us assess the range of habitat quality at deposition sites within the USACE network and expanded our understanding of how larks are using the lower Columbia River region in general. Survey results from occupied sites revealed the relative importance of individual sites, and estimates of SHLA abundance at the occupied sites indicated the population is relatively stable to slightly increasing. However, only a handful of sites supported more than 10 adults. Our pilot distance sampling showed that the probability of detection on the surveys was less than perfect, suggesting we are undercounting the number of larks on the sites. This is not unexpected. The detection estimates we calculated will be used in statistical models currently being created by WDFW to estimate abundance and trends in the Columbia River subpopulation and within Washington.

Occupancy

Of the fifteen sites that had either never been surveyed or where larks had not before been detected by CNLM, we documented new occurrences of streaked horned larks at four deposition sites within the USACE network. We believe that at a minimum these observations represent three new breeding sites: Dibblee Point, Lower Deer Island, and Gateway. We suggest these three sites be considered occupied and be added to abundance survey efforts in following years. Although we did detect a singing male conducting a flight display during the Austin Point survey, the individual was detected over the water and flew directly across the river to Sand Island Marine Park.

Detectability, abundance, and trends.

Monitoring for larks in the lower Columbia River is a critical component of range-wide population monitoring of the SHLA. These efforts are vital to evaluating the lark's conservation status and population trends, understanding the importance of the Columbia River subpopulation to long-term persistence of the subspecies, and quantifying the effects of recovery efforts and management, including the deposition of dredged material.

We found abundance estimates from occupied sites in 2014 were similar to those collected in previous years. In previous population summaries, the number of breeding pairs was estimated by doubling the number of the maximum number of males detected on repeated surveys. In 2014, the maximum count of males was 68, up from 63 males in 2013. Although there may be reasons to question the relationship between maximum number of detected males and the number of breeding pairs (i.e., population size), the consistent numbers between years suggest the population has not undergone a dramatic change in size. Previous estimates of breeding pairs suggested that approximately 120-140 adults (upwards of 60-70 breeding pairs) occur in the USACE Action Area (Altman 2011, Anderson 2013). However, the results from our pilot detectability study suggest that previous estimates may be underestimating population size.

Within the lower Columbia River, we found that the deposition islands supporting the most birds were Rice Island, Brown Island, Miller Sands, and Sandy Island. Unsurprisingly, several of these islands are the largest islands with the largest amount of habitat. The exception, however, is Sandy Island, a relatively small site compared to the other islands. The large number of birds found on Sandy Island is a recent phenomenon (2014 and 2013) and follows a deposition action in late 2011 that apparently created new habitat for the lark. Indeed, when looking at relative abundance, which can also be thought of as the encounter rate or density, the highest values in the network were found on Sandy. This indicates that even though the habitat patch is small, habitat quality appears high allowing the site to support a large density of birds. Our ability to chronicle this pattern over time, supports the concept that a management approach that creates new habitat through deposition at the same time that vegetation succession causes habitat to becomes unsuitable may be a long-term viable option for maintaining, or increasing, the size of the lark population in the lower Columbia River subpopulation.

We successfully completed our pilot detectability study and results confirmed that abundance surveys detect larks imperfectly, a common concern when monitoring birds (Farnsworth et al. 2002, Thompson 2002). We also found that detectability of larks on line transect varied dependent on sex and detection type, with males having lower detectability than females. At first glance, this result may seem surprising because males are more easily detected because they sing, and, indeed, many more males were detected than females. This outcome can be explained by considering the different components of detectability.

Detection probability for an individual bird is comprised of two independent processes (Stanislov et al. 2010). The first process can be thought of as "availability" (i.e., the probability a bird is available for detection; p_a). Birds make themselves available in a way that allows detection by an observer; for example, by singing or flying. Observers cannot detect a bird that remains hidden in the vegetation or does not sing. The second component of the detection process is "perceptibility" (i.e., the probability a bird is detected, conditional on the bird making itself available for detection; p_d). Observers may fail to detect birds even when they make themselves available, perhaps because it is too far away or the song is drowned out by vocalizations from closer, or louder, species. Overall detection probability, p, is the product of these two parameters, $p_a * p_d$.

In Distance sampling, only the second component, p_d, is estimated. So for lark males, who regularly sing, their availability, p_a, is likely very high, perhaps even close to 1.0, and therefore the estimate generated in Distance may be close to overall detectability. However, for females, who are quiet, cryptic, and often tending nests during surveys, p_a is likely very low. Although our estimate of detectability for females is higher than males, overall detectability is likely much lower because most females do not make themselves available for detection. Preliminary analyses by WDFW using N-mixture models, which estimates overall detectability, indicate that males have higher detectability than females (Scott Pearson, WDFW, Senior Research Scientist, pers. comm).

Although this pilot distance study greatly improves our understanding of detectability of larks, several limitations need to be noted. First, this pilot study was conducted on larger deposition islands with generally, open habitats with fairly homogenous vegetation cover across the survey area (i.e., less patchy). Detection probability may be different in other habitat types occupied by larks with different forms of vegetative cover, such as on native prairie or airfields. They may also differ on other deposition islands that are smaller or have greater vegetation patchiness. The degree to which detectability varies under these conditions remains unknown. It may be valuable to investigate detectability in other habitats. One first step could be using existing occupancy data where distances can be generated in a GIS environment from mapped detections; for example, at Joint Base Lewis-McChord (JBLM) in native prairie. Secondly, one of the biggest known factors that influences detectability is variation in observer's ability. Continued training and testing during the breeding season could be considered to ensure detectability is consistent among observers. Finally, our detectability estimates for individual sexes were generated with small number of detections. A general rule-of-thumb for appropriate sample sizes for distance modeling is 60-80 detections (Buckland et al. 2010). Most of our detectability estimates for discrete categories of sex and detection type were generated from smaller sample sizes than recommended.

One of the biggest motivations for conducting the pilot Distance project was to provide preliminary detection probabilities to WDFW for their large-scale trend analysis for larks. This analysis will ultimately estimate abundance and evaluate trends for the three subpopulations in Washington: Columbia River, Coast, and south Puget Sound. WDFW is employing a hierarchical model (N-mixture) approach (Royle et al. 2004, Lyons et al. 2012). This modeling technique is able to jointly estimate overall detection probability (combined availability and perceptibility components) and abundance.

However, the strength of this technique is greatly improved with a prior, and independent, estimate of bird detectability. Results from the distance sampling project have been provided to WDFW, and the information has been extremely helpful to WDFW's efforts (Scott Pearson, WDFW, Senior Research Scientist, pers. comm.). This effort is expected to be completed in April 2015; when completed, those results will be provided to USACE.

Although, we did not perform a statistical trend analysis, so as not to duplicate WDFW's efforts, the patterns of abundance measures over time indicate the lark population in the lower Columbia River appears to be stable or perhaps slightly increasing. While not accounting for possible changes in detection probability among years, the patterns we observed appear similar to preliminary trend analyses by WDFW (S. Pearson, personal communication).

Larks on the River – Site by Site

Suitable Occupied Sites

All occupied sites, by the very nature of their occupation by streaked horned larks, indicate they meet the open landscape context requirement for streaked horned larks and contain some amount of short, sparse vegetation with ample bare ground. In some cases, there are extensive patches of suitable habitat covering much of the USACE deposition area and in other cases suitable patches were small and situated within a context of non-suitable habitat. At many sites 2014 observations provide strong evidence that larks are nesting on the sites (Table 12). Observations that indicate breeding include paired adults, singing territorial males, adults carrying food, females carrying nesting material, nests themselves, and young of the year. At sites where breeding evidence is limited to only territorial male behaviors by single individuals, further investigation *may be* warranted to determine with certainty if larks are holding territories and nesting on the ground within USACE deposition boundaries. Below, we provide a short summary regarding each occupied site's habitat status and lark use.

Table 12. 2014 Occupied site status and evidence of breeding.

2014 Occupied Sites	Paired adults and/or singing males	Food and/or nest material carries, nests	Young of year
Rice Island	X	X	X
Miller Sands	X	X	X
Pillar Rock	X		
Tenasillahee	X		
Brown Island	X		
Crims Island	X	X	X
Dibblee Point	X		X
Northport	X		
Sandy Island	X	X	
Lower Deer	X		
Sand Island	X		
Gateway	X		

Rice Island

This site continues to host a relatively large population of breeding streaked horned larks. The majority of larks detected and associated suitable habitat at Rice Island is situated on the western half of the site, although larks were detected throughout the main bowl of the site (Appendix II, Figure 1). Invasion of beach grass *(Ammophila spp)* has begun at this site (Appendix IV, Figure 1A), and although plants are currently relatively small and sparse, without intervention they will undoubtedly spread, thicken, and impact the suitability of the site. On the extreme downstream tip of the island, a gull colony occurs. While we did see a lark fly down to that area on one occasion, it seems unlikely they would be nesting there due to the thick vegetation and concentration of gulls. On the extreme upstream tip of the island, deposition in 2013 created very bare conditions, yet larks were detected during one survey visit. Larks were also detected, off survey effort, on the river side slope and we assume they are using this area in some capacity. Use in these areas is unclear. Breeding was confirmed at the site with multiple singing territorial males, observations of adults carrying food, young of the year, and a nest with nestlings was detected at the site (Appendix IV, Figure 1B)

Miller Sands
Lark distribution and lark habitat is situated above the scarp at Miller Sands in patches of short, sparse habitat interspersed within patches of non-habitat vegetation, such as thick moss or beach grass. The recent beach nourishment actions at this site have not yet grown into suitable habitat and we believe are currently too bare to support lark territories. It is unclear if the mounded sand left after the deposition action (Appendix IV, Figure 2) has created unsuitable conditions by breaking up the open context of the site. Conversely there are relatively large patches of thick moss, horsetail *(Equisetum spp)* and dense beach grass that make a large portion of the site unsuitable. Breeding was confirmed at the site with observations of multiple singing territorial males, accompanying females, adults carrying food, and young of the year.

Pillar Rock
Suitable habitat for larks is constrained to the upstream portion of the site, above the scarp, where there are several good-sized patches of short, sparse vegetation, with adequate bare ground (Appendix IV, Figure 3). However, this year we did detect a pair of larks foraging in an area of thick moss on the downstream end of the site. This observation was the first time we've seen larks using that portion of the site, which is comprised almost exclusively of thick moss and horsetail. We suspect use in that area is minimal. Breeding behavior was detected at the site with multiple singing territorial males accompanied by paired females.

Tenasillahee
Habitat on the upstream half of the site is quite bare as a result of recent deposition actions (Appendix IV, Figure 4A). Despite the small amount of vegetation, we did detect larks using that portion of the site. On the downstream portion of the site, vegetation had been cleared in preparation for deposition, leaving a considerable amount of bare sand mixed with vegetative debris (Appendix IV, Figure 4B). After the preparation, the sand was left in ruts in an attempt to discourage lark use. However, during one visit we did detect larks using that area of the site. Humans also use the site, and during the July visit, a fisherman was camping near the shore of the site between the recent deposition terrace and the area prepped for deposition. This is the same area where larks have been repeatedly detected in past years, and where suitable habitat conditions occur.

Brown Island
This site continues to host a relatively large population of streaked horned larks and contains several large patches of suitable habitat, primarily situated on the upstream half of the site (Appendix IV, Figure 5). The larks also use the southern edge of the upland and have been detected on the terraces down the slope to the river's edge. Human use is high at this site, with multiple fishermen present during all visits, dogs, a semi-permanent fishing camp on the beach, and this year even a volleyball net erected on the downstream end of the upland.

Crims Island
Crims Island continues to support a population of streaked horned larks and there is a relatively wide expanse of suitable habitat on the upstream end of the disposal site. Larks appear to be concentrated along the riverside edge of the upland and also use the terraced slope (Appendix IV, Figure 6). There is a considerable amount of Scotch broom *(Cytisus*

scoparius) invading the site, in places forming dense patches. The downstream end of the site appears unsuitable for larks.

Dibblee Point

This site is terraced, rocky, and contains a range of habitat conditions, some areas dominated by shrubs and small trees creating habitat too dense for larks (Appendix IV, Figure 7A). The upper terrace of the site does have the required landscape context and is dominated by short, sparse vegetation conditions with ample bare ground (Appendix IV, Figure 7B). Larks were not detected during the May or June visits to the site. However, we detected five lark individuals and evidence of breeding (male, female, and three young of the year as well as adults carrying food) during the July visit indicating that larks likely did use the site for breeding in 2014. These were the first observations of streaked horned larks at Dibblee Point, despite visits to the site in 2013.

Northport

As in past years, we did detected streaked horned larks using the Northport site and there continues to be a relatively small amount of suitable habitat at the site. The site appears to be maintained in suitable status by human use, likely all terrain vehicle use that disturbs the vegetation and creates bare ground. Most detections of larks at the site to date have been concentrated on the riverside middle terrace, the edge of the highest terrace, and the dirt road that divides the two (Appendix II, Figure 8). At no time have we detected larks using the main portion of the upper terrace and much of that area appears too dense to be suitable habitat patches. The upper area is also quite close to the tree edge, which may negatively influence its suitability for larks.

Sandy Island

The deposition that occurred in November 2011 has grown into very nice streaked horned lark habitat by summer 2014 (Appendix IV, Figure 8A). There were a large number of larks using the site this year, mostly grouped toward the upstream half of the site (Appendix IV, Figure 8B). There were singing territorial males, paired females and we also documented larks carrying food for young at this site, further evidence of breeding. We also documented lark movement between Sandy Island and its upriver neighbor, Lower Deer. Because observers were not monitoring Sandy and Lower Deer simultaneously, it is unknown if detections of individuals on these sites were double counted.

Lower Deer

The site meets the open landscape context required, but majority of this site is comprised of vegetation likely too thick to support streaked horned larks. However, the site does contain a small sliver of suitable short, sparse vegetation in the upland just above the beach and on the downstream end. These are the areas we detected one pair of larks (Appendix IV, Figure 9). There was evidence of breeding in the form of a singing male paired with a female. We also had multiple observations of larks moving between this site and neighboring sites, to and from Sandy Island, as well as across the river to the Port of Kalama. It is not clear at which site these individuals were nesting. Also important to note that the site was occupied by a small herd of cattle, approximately 25 head.

Sand Island Marine Park

The upstream tip of this site meets the open landscape context requirement and also contains patches of suitable habitat. There are also small, linear patches of suitable habitat patches adjacent the riparian zone along the linear length of the disposal area, but the adjacency to the trees may render this area unsuitable in regards to its landscape context (Appendix IV, Figure 10). Supporting this assumption is the fact that the upstream end is the area that larks were detected during the second visit on 2 June (Appendix II, Figure 9) and where larks have been detected in past years. Interestingly, on 23 May, while surveying the beach at Austin Point just across the river from Sand Island, a male was detected conducting a flight display and the observer watched the individual fly directly toward Sand Island. One can infer from this observation that larks may be using these sites in conjunction as one territory. Sand Island appears to receive a fairly high amount of human use. It is very close to both the Oregon and Washington mainland and has bathroom facilities and picnic tables. During our first visit on 21 May there were approximately 5 tents with people camping along the narrow portion of the island and people and dogs were on the island at both subsequent visits.

Gateway

The open landscape is interrupted on the river side by a line of tall trees. However, the site is surrounded by agricultural fields that provide a more open landscape. The area within the deposition boundary is primarily dominated by bare sand, although there were some areas where vegetation had begun growing creating small patches of short, sparse habitat (Appendix IV, Figure 11). We detected larks at this site on our second and third visits. The larks are likely also using the surrounding agricultural fields, as observations on both visits included larks moving to or from those areas.

Potentially Suitable Sites

Martin Bar

Of all sites surveyed, the only unoccupied site that fell into the potentially suitable category was Martin Bar South. This site appeared to have the open landscape context required, and while quite bare, it did have some short, sparse vegetation indicative of lark habitat (Appendix IV, Figure 12). However, we did not detect larks at the site during any of our three visits. Agricultural fields surrounded this site, which may also be attractive to streaked horned larks. The adjacent Martin Bar north site was not considered suitable. The open landscape context at the north unit was questionable and the vegetation on the ground was too thick with pasture grasses to support streaked horned larks. All portions of both sites were surveyed on all three visits.

Not Yet Suitable Sites

There were three sites we categorized as not yet suitable, indicating that the open landscape context is likely adequate, yet recent deposition or disturbances have created habitat conditions too bare for streaked horned larks. However, because there have been no studies that investigate minimum required site size and context, our assumptions of adequate open context are based solely on expert opinion. Minimum site size and configuration remains an important unanswered question in streaked horned lark ecology.

No larks were detected using these sites within the USACE deposition boundaries during any of our three visits to each site.

Skamokawa Vista Park

While small, this site likely has the open landscape context required; there are no visual barriers between the deposition area and the water. It remains to be seen if the small size and short distance to trees on the mainland may compromise its suitability. Currently, the very recent deposition area remains almost entirely bare sand and is likely too bare to attract streaked horned larks (Appendix IV, Figure 13). The entire area was surveyed on all three visits.

Hump Island

At the time of our visits, the majority of this site had been prepared for deposition although a smaller portion on the upstream end was not prepared and contained conditions too dense for larks, either shrubby with Scotch broom or a carpet of dense moss (Appendix IV, Figure 14A). In the preparation area, the vegetation was removed and the sand was arranged in trenches at three to six foot interval mostly perpendicular with the island (Appendix IV, Figure 14B). It is unclear if that sand arrangement was an effective dissuasion, as the site was unoccupied prior to site preparations and no larks were detected after site prep activities. The site likely has the open landscape context required, and as grasses and forbs become established it will likely become a site suitable for lark occupation. The entire bare area was surveyed on all three visits.

Austin Point

This site likely has the open context required to support larks, but is comprised almost entirely of bare sand with very little, if any, vegetation making it too bare for larks (Appendix IV, Figure 15). The site is maintained in this bare sand status by the equipment training school that operates on the site. We did not walk through the active site because there were several large bulldozers and other equipment being operated by students. We did survey the edge of the upland on the river side as well as the lower beach area, even though it was not officially inside the network boundaries. Larks were not detected within the deposition boundary. However, we did observe a single singing male conduct a flight display just off the beach. This individual did not land at Austin Point. He flew across the river toward Sand Island.

Unsuitable Sites

Seven of the sites visited were categorized as unsuitable. In some cases, the open context requirement was likely adequate but the sites were dominated by trees, shrubs, or other dense vegetation rendering them unsuitable for streaked horned larks. No larks were detected at these sites during any of our three visits.

Benson Beach

We surveyed both the beach and the upland of this site for streaked horned larks. Even though we would not expect to see nesting on the beach itself, larks are known to forage in the rack and we wanted to ensure the greatest possibility of detection should they be present. The upland habitat within the deposition boundary absolutely had the landscape context required, but was dominated by beach grass ultimately rendering it unsuitable (Appendix IV, Figure 16). Although likelihood of occupation was low, all portions of the site were surveyed at all three visits.

West Sand Island

As at Benson Beach, we surveyed both the beach itself and the upland at West Sand Island on our first visit. The upland was determined to be entirely unsuitable, as trees, shrubs, and tall grasses fully cover the site (Appendix IV, Figure 17). Therefore, upon our return visits we only surveyed the beach area.

Welch Island

This site may not have met the open landscape context requirement as there are several large riparian trees interrupting the view between the deposition area and the open water of the river. Larks have been detected on the beach at Welch Island in the past (2012) but have never been detected in the upland, despite repeated surveys (Linders 2011, 2012) and apparently suitable habitat patches. In 2014, the upland habitat area at Welch is mostly unsuitable for larks, with multiple large patches of Scotch broom (Appendix IV, Figure 18). Although occupation was unlikely due to low potential of suitable habitat, we surveyed the entire site at all three visits and when the tide was low enough, we included the beach in our survey effort.

James River

This site may not have met the open landscape context requirement for larks as there is a tree line between the open deposition site and the river (Appendix IV, Figure 19). However, because minimum site size is unknown for the lark it could be potentially suitable for larks. It is likely that if the tree line were removed the site could provide the open context required possibly making the site suitable. There were patches of potentially suitable habitat within the deposition boundary. We surveyed all portions of the site at all three visits.

Lord Island

This site possibly met the open landscape context, although there is a line of trees that interrupted view shed on a portion of the site leaving approximately half of the site open to the river. The interior of the site was dominated with riparian trees and shrubs and several large patches of Scotch broom (Appendix IV, Figure 20). There were a few patches of short, sparse vegetation with ample bare ground, but because they were small, situated within the closed landscape context, and often surrounded by shrubs or close to a riparian edge we did not consider them suitable for streaked horned larks. We surveyed all portions of the site at all three visits.

Howard & Cottonwood

The majority of the site within deposition boundaries on Howard/Cottonwood is dominated by riparian trees, blackberry bramble *(Rubus spp)*, Scotch broom and other shrubs and is entirely unsuitable for streaked horned larks (Appendix IV, Figure 21A). There were some open grassy patches between the Howard and Cottonwood deposition areas that did meet the open context requirement, but even there we believe the grass was too dense and not enough bare ground was present (Appendix IV, Figure 21B). There was one small patch of potentially suitable habitat on the extreme upstream end of Cottonwood in a prior deposition area. On visits two and three we only surveyed the open grassy patches on the upstream portion of the Howard deposition area, the downstream portion of the Cottonwood deposition area, and the aforementioned patch on the upstream end of Cottonwood (Appendix III, Figure 9). All other areas were deemed entirely unsuitable and were not revisited after the first visit.

West Hayden Island

Portions of the site likely have the open landscape context required, particularly the portion adjacent the river (Appendix IV, Figure 22A). However, outside the dirt roads that occur at the site, there is little bare ground and vegetation is likely much too thick for streaked horned larks. In addition, multiple large shrubs and patches of riparian forest occur on the site (Appendix IV, Figure 22B). Despite the low likelihood of occupation, we surveyed all portions of the site at all three visits.

Recommendations

We recommend continuing the abundance monitoring of occupied sites, which have been ongoing since 2010, in order to assess abundance and trends of larks in the USACE network. Sites where larks were detected in 2014 on occupancy surveys: Dibblee Point, Lower Deer, and Gateway, should be incorporated into the list of currently monitored survey sites. We also believe occupancy surveys should be conducted at sites where habitat was evaluated as not yet suitable. We suggest that occupancy surveys are unnecessary at sites currently considered unsuitable (e.g., Benson Beach, West Sand Island) until management or other disturbance factors modifies habitat in a way that creates early-successional conditions that may be selected by streaked horned larks.

In previous survey efforts, the estimated number of breeding lark pairs has been indexed by the highest count of single males. We recommend not relying solely on counts of singing males as an index of breeding pairs. There are at least two concerns. First, singing rates by males are strongly affected by environmental and/or endogenous factors, which can in turn have a strong and variable effect on detection probability. Second, the number of males singing may not indicate the number of females engaged in breeding. Indeed, singing rates, and thus detectability, may be higher for unmated males, potentially biasing abundance estimates (Post 1974). Many of these males (i.e., "floaters") may not attempt breeding. The effect of these concerns is that the highest count of males may be biased high relative to true abundance. For most population statistics, the number of breeding females and not territorial males is the most relevant information in characterizing effective population sizes.

The upcoming results from WDFW's analysis may provide a long-term solution to this problem. Preliminary conversations with WDFW indicate their N-mixture analysis will provide estimates of abundance and trends for males and females. Those results will also include estimates of uncertainly (e.g., 95% confidence intervals, standard deviation), which will greatly improve the ability to assess population changes over time. One of the benefits of the N-mixture approach is that is uses information from across the survey area to generate detectability estimates. These analyses should be done annually for the Columbia River region by WDFW or CNLM. Additional benefits of the N-mixture approach is the ability to test whether abundance and detectability estimates vary with respect to region (deposition islands, native prairie) or other covariates, such as habitat or weather. For example, in preliminary analyses wind reduced detection of males in the Puget Sound region, but not in the Columbia River (Scott Pearson, WDFW, Senior Research Scientist, pers. comm).

We have made significant progress in understanding detectability rates of larks on abundance surveys through our Distance pilot project, and those estimates have greatly assisted WDFW in estimating abundance in the Columbia River and other regions across the lark's range in Washington. Those models will also provide estimates of overall detectability (P_a* P_d) and error terms for those parameters. However, these detectability estimates are modeled and have uncertainty around them, and thus true detection remains unknown. Detectability also likely varies spatially due to variety of factors; for example, density of birds. We suggest that an intensive effort to map and count territories and pairing rates on several deposition sites, perhaps at sites that vary in size and density of birds, would prove useful in increasing the confidence around these estimated parameters. Doing so, would help refine population estimates.

Finally, we believe our estimates of relative abundance offer the potential to better refine the relationship between habitat quality and abundance of larks. Better understanding this relationship could have important implications for advancing the "shifting habitat mosaic" management approach. Habitat quality is a potentially mappable parameter using GIS remote sensing, an effort being undertaken by USACE. Previous efforts have focused on using detection locations from abundance surveys to identify suitable habitat (Anderson 2013). However, this approach is imperfect in defining the relationship between where the birds were mapped and distribution of suitable habitat (see Anderson 2013). We suggest that this relationship might be improved by refining the precision of detection locations from abundance surveys, or even better, using nest locations or territory maps. More precise estimates of lark use locations could then be coupled with remote mapping of habitat characteristics with higher confidence.

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Appendix I. USACE Deposition Network

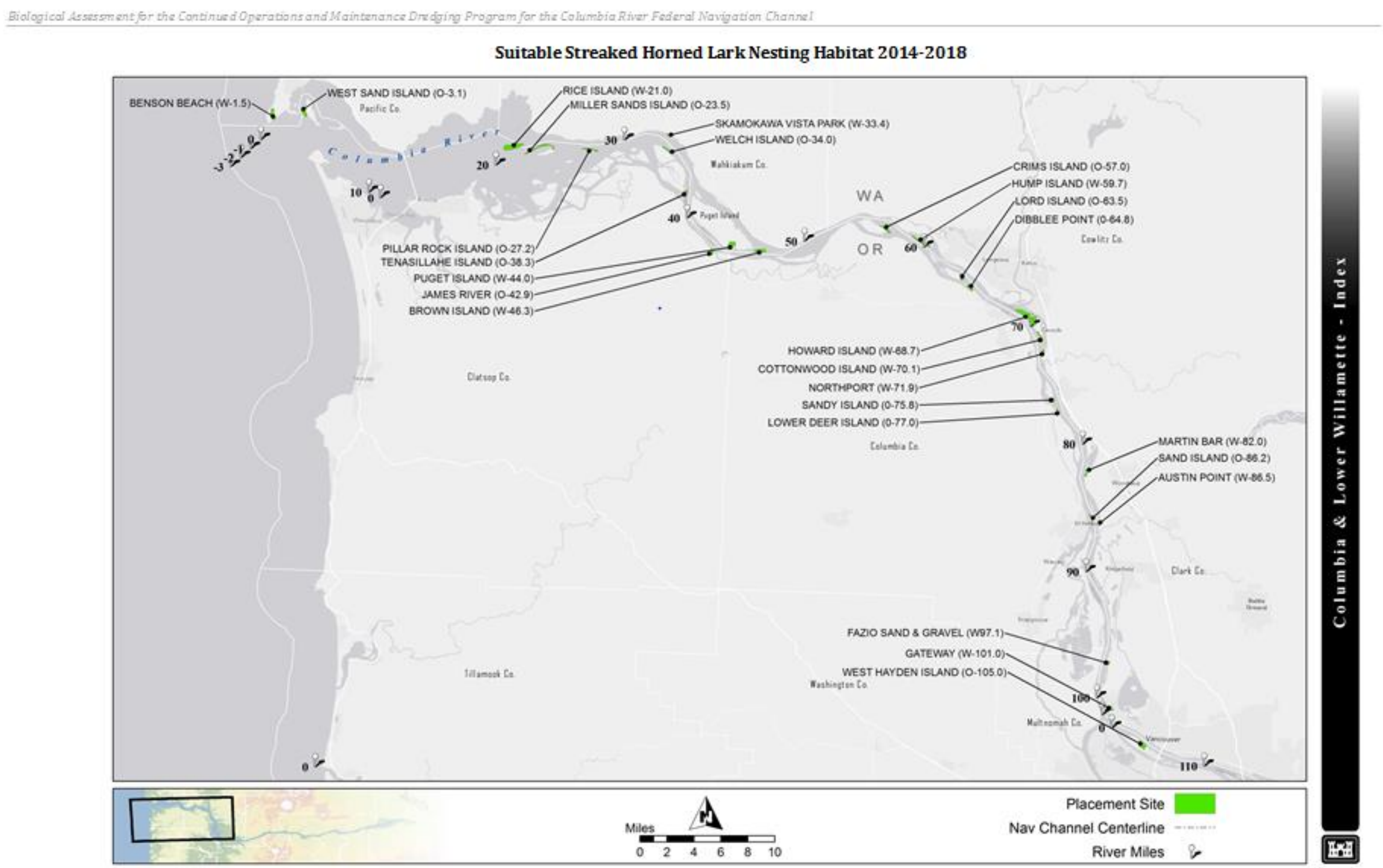


Figure 1. Suitable Streaked Horned Lark Nesting Habitat 2014-2018. *(note: Puget Island and Fazio Brothers are not included in CNLM survey scope)*

Appendix II. Lark Detection Locations

Appendix II - Figure 1. Rice. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 2. Miller Sands. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 3. Piller Rock. Streaked Horned Lark 2014 Abundance Surveys.

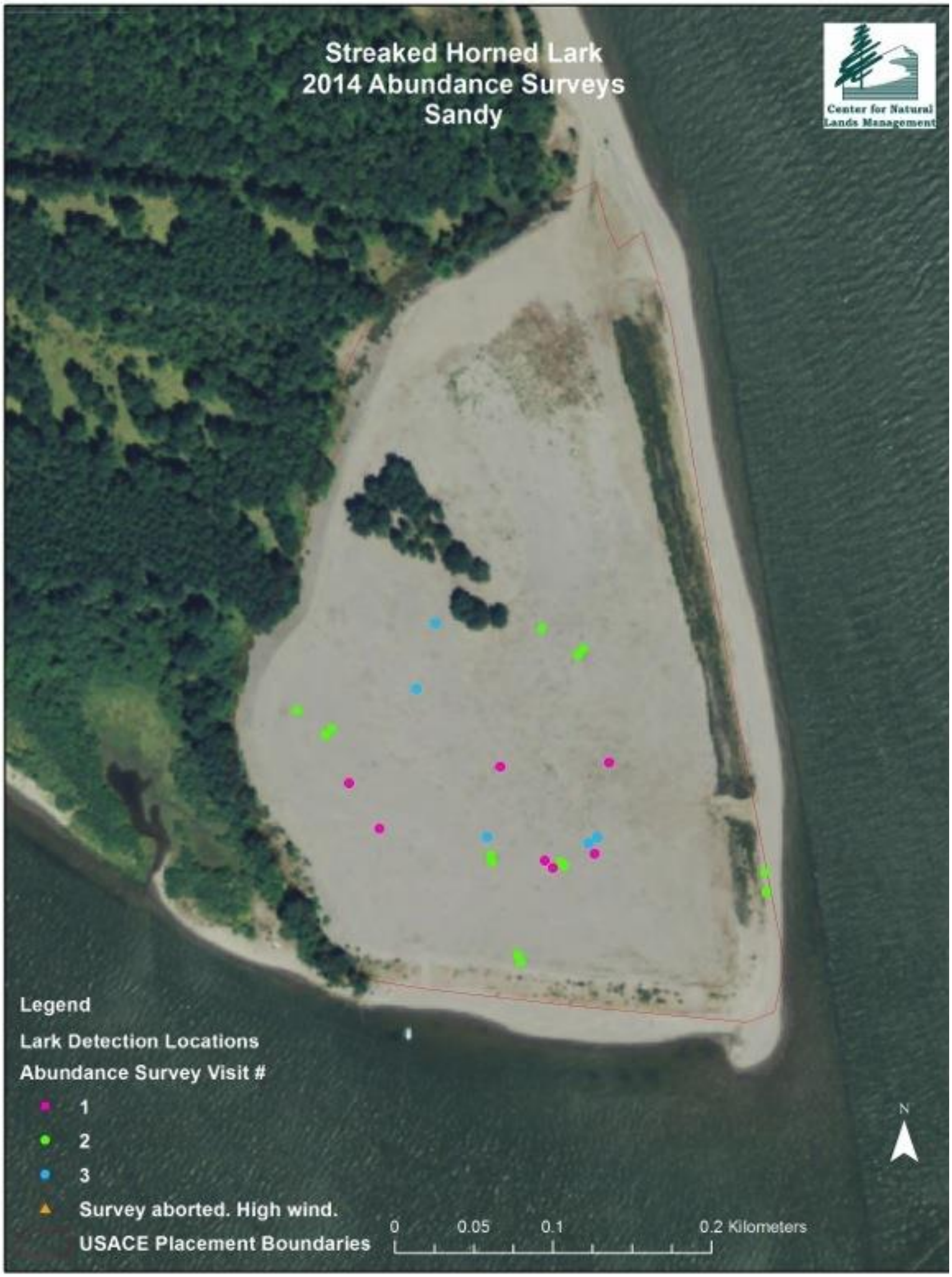
Appendix II - Figure 4. Tenasillahee. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 5. Brown. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 6. Crims. Streaked Horned Lark 2014 Abundance Surveys.

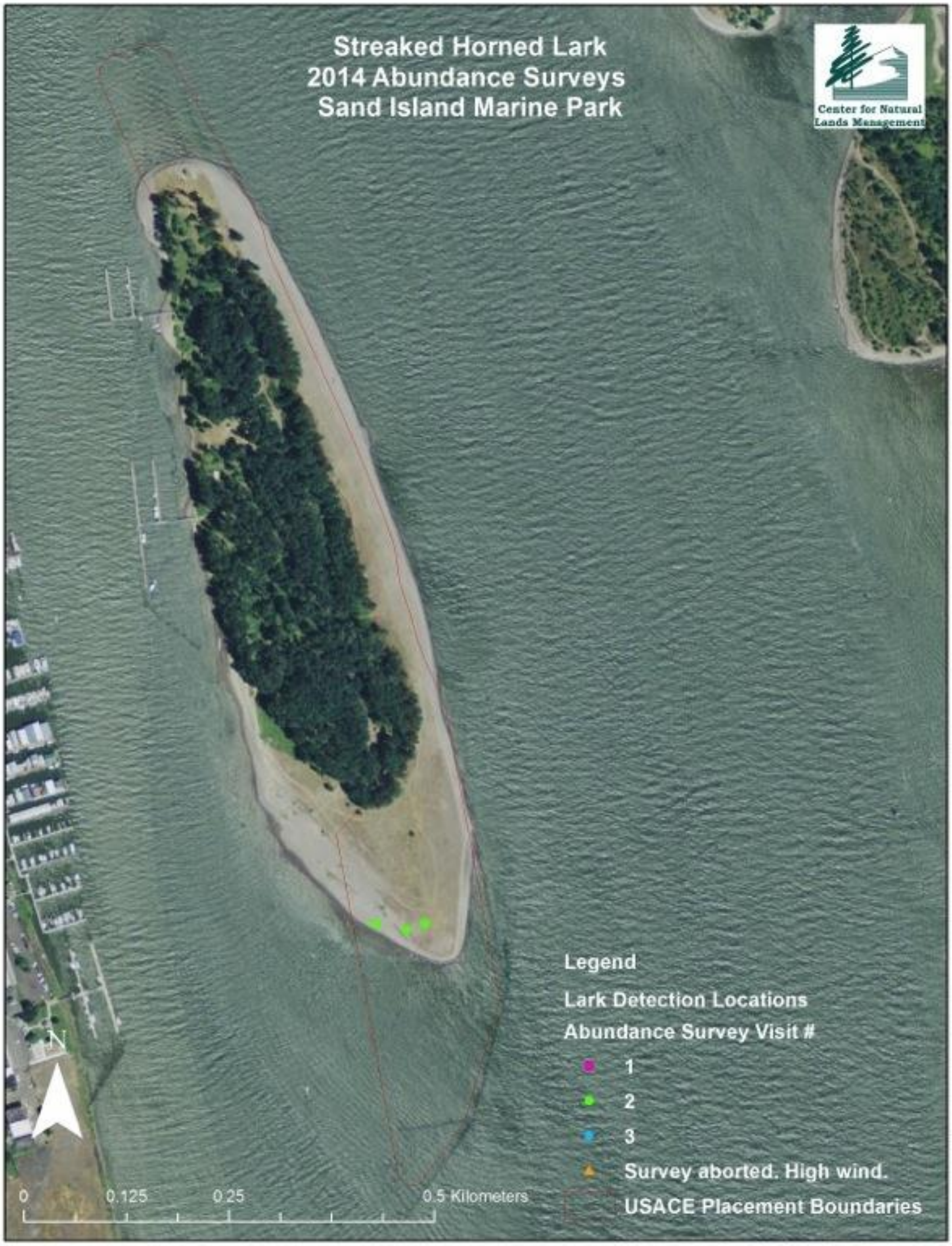
Appendix II - Figure 7. Dibble Point. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 8. Northport. Streaked Horned Lark 2014 Abundance Surveys.



Appendix II - Figure 9. Sandy. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 10. Lower Deer. Streaked Horned Lark 2014 Abundance Surveys.



Appendix II - Figure 11. Sand Island Marine Park. Streaked Horned Lark 2014 Abundance Surveys.

Appendix II - Figure 12. Austin Point. Streaked Horned Lark 2014 Occupancy Surveys.

Appendix II - Figure 13. Gateway. Streaked Horned Lark 2014 Occupancy Surveys.

Appendix III. Unoccupied Site Survey Routes

Appendix III - Figure 1. Benson Beach. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 1. Benson. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 2. Skamokowa. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 3. Welch. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 4. James. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 5. Hump. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III –Figure 6. Lord. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 7. Dibblee. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 9. Howard. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 9. Howard. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 11. Sand Island. Streaked Horned Lark 2014 Unoccupied Site

Appendix III - Figure 10. Lower Deer. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 10. Lower Deer. Streaked Horned Lark 2014 Unoccupied Site Survey Routes

Appendix III - Figure 12. Gateway. Streaked Horned Lark 2014 Unoccupied Site Survey

Appendix III - Figure 13. West Hayden. Streaked Horned Lark 2014 Unoccupied Site Survey

Appendix IV. Site Photos

Appendix IV. Figure 1. Unsuitable habitat in Benson Beach upland. 29 May 2014

Appendix IV. Figure 2. Unsuitable habitat at West Sand Island, upland. 29 May 2014

Appendix IV – Figure 3. Rice Island

3A. Rice Island 17 June 2014. Beach grass invasion.

3B. Rice Island nest and nestlings. 20 June 2014.


Appendix IV. Figure 4. Miller Sands 18 June 2014. Surveyors stand in mounded bare sand left after deposition action.


Appendix IV. Figure 5. Pillar Rock 12 June 2014. Patches of suitable habitat occur.

Appendix IV. Figure 6. Unsuitable habitat at Welch. 19 June 2014

Appendix IV. Figure 7. Potentially future suitable habitat at Skamakowa Vista Park. 29 May 2014.

Appendix IV – Figure 8. Tenasillahee Island.

8A. Tenasillahee 18 June 2014. Vegetation beginning to grow on bare sand.

8B. Tenasillahee 18 June 2014. Area prepared for deposition.

Appendix IV. Figure 9. Fort James. Potentially suitable habitat patches, yet perhaps not adequate openness. 22 May 2014.

Appendix IV. Figure 10. Suitable habitat at Brown Island. 12 June 2014.

Appendix IV. Figure 11. Suitable habitat at Crims Island. 30 May 2014.

Appendix IV. Figure 12. Lord island habitat. 21 May 2014

Appendix IV – Figure 13. Hump Island

13A. Unsuitable habitat at Hump island, upstream end. 11 June 2014.

13B. Hump Island. 21 May 2014. Area prepared for deposition, downstream end.

Appendix IV – Figure 14. Dibblee Point.

14A. Unsuitable habitat conditions at Dibblee Point. 22 May 2014.

14B. Suitable habitat conditions at Dibblee Point. 11 June 2014.

Appendix IV – Figure 15. Howard/Cottonwood

15A. Unsuitable habitat at Howard Island. 22 May 2014.

15B. Open context, yet dense vegetation between Howard and Cottonwood deposition boundaries. 22 May 2014 .

Appendix IV. Figure 16. Suitable habitat and vehicle tracks at Northport. 30 May 2014.

Appendix IV. Figure 17. Suitable habitat at Sandy Island. 21 May 2014.

Appendix IV. Figure 18. Lower Deer Island, Sandy Island in background. 21 May 2014.

Appendix IV. Figure 19. Lark detection location. Lower Deer Island. 21 May 2014.

Appendix IV. Figure 20. Potentially suitable habitat at Martin Bar south. 23 May 2014.

Appendix IV. Figure 21. Suitable habitat patches along narrow strip at Sand Island Marine Park. 11 June 2014.

Appendix IV. Figure 22. Bare sand at Austin Point. 23 May 2014.

Appendix IV. Figure 23. Suitable habitat at Gateway. 23 May 2014.

Appendix IV – Figure 24. West Hayden Island

24A. Open landscape context at West Hayden Island. 23 May 2014.

24B. Riparian trees at West Hayden. 23 May 2014.