U.S. Fish and Wildlife Service
U.S. Department of the Interior
National Wildlife Refuge System
Point Blue Conservation Science

# Site-specific Protocol for Monitoring Marsh Birds

*Don Edwards San Francisco Bay and*
*San Pablo Bay National Wildlife Refuges*

Survey ID Numbers: FF08RSFB00-003 and FF08RSNP00-008

**Comment [BG1]:** Would be useful to have a figure showing the Estuary, TRMP recovery unit boundaries, and refuge boundaries

**Comment [BG2]:** Ensure consistent font throughout

**Version 0.1 [DRAFT 17 JUNE 2016]** **June 2016**

Incorporated edits: JE, TR,

**ON THE COVER**
Sunrise at La Riviere Marsh, Fremont, California.
Photograph by: Orien Richmond.

# NWRS Survey Protocol Signature Page

**Protocol Title:** Site-specific Protocol for Monitoring Marsh Birds: Don Edwards San Francisco Bay and San Pablo Bay National Wildlife Refuges
**Version[1] :** 0.1

| **Station Name:** | **Authors and Affiliations** |
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**Approvals**

| **Action** | **Signature/Name** | **Date** |
|---|---|---|
| **Survey Coordinator[2] Submitted by:** | Joy Albertson, San Francisco Bay Complex Supervisory Biologist | |
| **Zone I&M[3] or equivalent Approval:** | Orien Richmond, I&M Wildlife Biologist | |
| **Regional I&M[4] Approval:** | Karen Laing, Region 8 I&M Coordinator | |

| **Version[1]** | **Date** | **Author** | **Change Made** | **Reason for Change** |
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[1] Version is a decimal number with the number left of decimal place indicating the number of times this protocol has been approved (e.g., first approved version is 1.0.; prior to first approval all versions are 0.*x*; after first approval, all minor changes are indicated as version 1. *x* until the second approval and signature, which establishes version 2.0, and so on).
[2] Signature of station representative designated lead in development of a site-specific survey protocol.
[3] Signature signifies approval of a site-specific survey protocol.
[4] Signature by Regional I&M Coordinator signifies approval of a site-specific protocol.

## Survey Protocol Summary

This site-specific survey protocol provides standardized methods for monitoring marsh birds and was designed for use by the U.S. Fish and Wildlife Service (USFWS) on two national wildlife refuges (NWRs) in the San Francisco Bay Estuary (Estuary): Don Edwards San Francisco Bay NWR (DESFB) and San Pablo Bay NWR (SPB). Use of standardized, statistically-based protocols provides increased confidence in data integrity, facilitates data sharing at local, regional and national levels and improves our ability to detect true population trends over time. The two refuges and other partners in the Estuary have previously used different methods to monitor marsh birds, thus this protocol provides an opportunity for increased standardization of the bay-wide monitoring program and, more importantly, improved accuracy and precision of marsh bird trends. This site-specific protocol is compatible with the draft National Protocol Framework for the Inventory and Monitoring of Secretive Marsh Birds (Conway 2015). The survey method consists of 10-minute point count surveys that are repeated three times during the survey season at each survey station. The survey methods incorporate a five minute passive listening period followed by call playback for two species of conservation concern, the federally listed California Ridgway's rail (*Rallus obsoletus obsoletus*; formerly California clapper rail) and state-listed California black rail (*Laterallus jamaicensis coturniculus*). The protocol facilitates the estimation of detection probability, which is a critical component for monitoring secretive marsh birds who , which have low detectability. Compatibility of different, standardized approaches is discussed. The protocol includes a probabilistic sampling design, a data management procedure and data analysis techniques. The sampling design incorporates stratification with respect to marsh characteristics and is intended to support both refuge-specific objectives and regional-scale objectives, including monitoring progress towards recovery objectives for California Ridgway's rail from the USFWS Tidal Marsh Recovery Plan (U.S. Fish & Wildlife Service 2013).

**Comment [BG3]:** I believe it was just finalized – signature

**Comment [JW4]:** done

**Suggested citation:**

Wood, J.K., Nur, N., Salas, L. and O.M.W. Richmond. 2016. Site-specific Protocol for Monitoring Marsh Birds: Don Edwards San Francisco Bay and San Pablo Bay National Wildlife Refuges. Prepared for the U.S. Fish and Wildlife Service, Pacific Southwest Region Refuge Inventory and Monitoring Program. Point Blue Conservation Science. Petaluma, CA.

This protocol is available from ServCat XXXXXXX

**Comment [BG5]:** Do we want to add data.gov?

## Acknowledgments

The authors thank the staff of the San Francisco Bay National Wildlife Refuge Complex, including Anne Morkill, Joy Albertson, Meg Marriott, Rachel Tertes, Chris Barr, and Don Brubaker, and Point Blue staff Megan Elrod and Michael Fitzgibbon for valuable insights, review and contributions to this protocol document. Thanks to all of our conservation partners who contributed feedback, ideas and critical review (Jen McBroom and Toby Rohmer, Invasive Spartina Project; Steve Bobzien and Doug Bell, East Bay Regional Parks District; Courtney Conway, University of Idaho; Colin Grant, Katherine Sun, Kim Turner and Kim Squires, U.S. Fish and Wildlife Service Ecological Services Branch; Giselle Block, U.S. Fish and Wildlife Service Refuge Inventory and Monitoring Program; Karen Taylor and Sarah Estrella, California Department of Fish and Wildlife; Cory Overton and Michael Casazza, U.S. Geological Survey). Thanks to Sharon Dulava, USFWS, and Megan Elrod, Point Blue, for enduring many hours in cold muddy environments and collecting the data that informed this protocol.

## Contents

## List of Figures and Tables



**Comment [BG6]:** Figure and Fig? Separate list of figures and tables

# Narrative

### Element 1: Introduction

#### *Background*

Don Edwards San Francisco Bay National Wildlife Refuge (hereafter 'DESFB') and San Pablo Bay National Wildlife Refuge (hereafter 'SPB') are part of the San Francisco Bay National Wildlife Refuge Complex and are located within the larger San Francisco Bay Estuary (hereafter 'Estuary'), on the central California coast. The Estuary contains the largest expanses of tidal marsh on the West Coast and provides essential migrating and wintering habitat for hundreds of thousands of waterbirds and shorebirds and breeding habitat for a variety of waterbirds and marsh birds, including secretive marsh birds, such as the federally endangered California Ridgway's rail (*Rallus obsoletus obsoletus*, formerly California clapper rail, hereafter CA Ridgway's Rail) and state threatened California black rail (*Laterallus jamaicensis coturniculus*) (U.S. Fish and Wildlife Service 2011, 2012).

**Comment [BG7]:** Is this true – maybe just in CA?

**Comment [JW8]:** It's true. excludesAK which isn't considered West Coast.

**Comment [BG9]:** West coast of what? North America? California?

**Comment [JW10]:** done

Human activities have negatively altered and dramatically reduced the tidal marsh ecosystem throughout the Estuary. Tidal marshes are estimated to have covered approximately 190,000 acres in the 19th century before substantial impacts from European settlers began around the Gold Rush (Goals Project 1999, 2015). Approximately 80% of the Estuary's tidal marsh was subsequently converted to agricultural fields, pasture, salt production ponds, duck clubs and urban and commercial development (U.S. Fish & Wildlife Service 2013). Habitat loss, habitat degradation (from fragmentation, sedimentation, contaminants, subsidence, invasive species, human disturbance and other factors), predation, and overharvesting have been recognized as significant threats to marsh bird populations in the Estuary (Schwarzbach et al. 2006, Takekawa et al. 2006, 2012, Ackerman et al. 2012, U.S. Fish & Wildlife Service 2013). Potential future losses of tidal marsh due to sea level rise are an additional long-term threat (Stralberg et al. 2011, Thorne et al. 2012, Overton et al. 2015).

In response to the Estuary's loss and degradation of tidal marshes and declines in associated wildlife of conservation concern, state, federal and private organizations are currently engaged in the largest tidal marsh restoration effort on the west coast (Stallings 2003, Trulio et al. 2007, U.S. Fish and Wildlife Service 2011, 2012). In 2009, the Estuary was estimated to have about 45,000 acres of tidal marsh. Since 2009, an additional 6,300 acres have been reconnected to the tides. Over the next 20-30 years, an additional 24,000 acres of tidal marsh will likely be added as part of already funded or permitted restoration projects (Goals Project 2015, San Francisco Estuary Partnership 2015). Based on refuge estimates, DESFB will increase its extent of tidal marsh by approximately 4,560 acres and SPB will increase its extent of tidal marsh by approximately 740 acres by 2030.

Marsh bird populations are expected to increase as more tidal marsh habitat becomes available, thus monitoring changes in marsh bird populations can provide ~~documentation~~evidencedocumentation for restoration success or failure and, ultimately, inform how we can improve our restoration and other /management efforts. The recently completed Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (U.S. Fish & Wildlife Service 2013, hereafter "TMRP") established delisting criteria that included population objectives for CA Ridgway's rail by Recovery Unit (Table 1).

**Comment [BG11]:** The TRMP has 4 recovery units for CA Ridgway's rail. Is the protocol just focused on the two recovery units presented here (and in table 1) and does not include Suisun Bay Area and Central Coast recovery units? Need to make it clear in this protocol that the TRMP has 4 recovery units for CA Ridgway's rail but this protocol focuses on just two of them….if that is true.

**Comment [JW12]:** done

Table 1. Delisting criteria for California Ridgway's rail (formerly California clapper rail).

| Recovery Unit | Most Recent Population Estimate (adjusted from Liu et al. 2012) | Delisting Criteria (U.S. Fish & Wildlife Service 2013) | Average Annual Growth Rate Needed to Reach Delisting Criteria by 2063 |
|---|---|---|---|
| Central/South San Francisco Bay | 369 (range 305-456) | 3,180 | 4.3% |
| San Pablo Bay | 794 (range 649-970) | 2,080 | 1.9% |

DESFB is in the Central/South Bay Recovery Unit, and SPB is in the San Pablo Bay Recovery Unit. The goal is to reach the delisting criteria by the year 2063. The TMRP recommends annual

monitoring to assess progress toward recovery. However, neither the specifics of the survey methodology nor the monitoring design were described or outlined in the TMRP.

Marsh birds have been monitored on DESFB and SPB for decades using two main survey methods, airboat surveys and point count surveys. Point count surveys can either be passive or incorporate broadcast of marsh bird calls (referred to as "call-broadcast surveys," "playback surveys," or "call-count surveys"). High-tide winter airboat surveys have been conducted at selected marshes on DESFB by USFWS, California Department of Fish and Wildlife (CDFW) and East Bay Regional Parks District (EBRPD) since 1982. Airboat surveys are conditional on weather and tide conditions, thus in some years they cannot be conducted. Airboat surveys are typically conducted only once in a given location each year, thus estimates of detection probability are difficult to derive.

Passive and call-broadcast point count surveys for marsh birds have been conducted by USFWS at DESFB since 1989. Originally, the survey method consisted of multiple observers remaining stationary at a listening station for 2 hours in a marsh, at sunrise or sunset, and spaced between 150 and 200 meters apart. Rail calls, time, direction and distance were noted on a map, and a summary map was prepared to derive a raw count of total rails per marsh. Playback was sometimes used. This survey methodology, known as the "Type B" stationary survey, is still used at LaRiviere Marsh at DESFB. In the early 2000's, a new survey method was introduced at DESFB whereby observers conducted 10-minute point count surveys at multiple points (usually 6-8) spaced 200 m apart along transects. Three visits were typically conducted at each point in each year, and all surveys were conducted near sunrise or sunset. The first two visits were passive, and the third visit incorporated a 5-minute passive segment followed by a conditional 1-minute broadcast of CA Ridgway's rail calls if no CA Ridgway's rails had been previously detected at that point on the first two visits followed by a 4-minute passive segment (10 minutes total). This survey methodology, known as the "Type A" survey method, has been widely used at numerous marsh sites throughout the Estuary, starting in 2005 (Liu et al. 2012), though it had been used at a smaller number of sites before 2005. Starting in 2004, DESFB incorporated CA Ridgway's rail call broadcast on all three visits. This modified survey method is known as "Type C".

**Comment [BG13]:** Here you use the term 'listening station', later you use the term'points'. Are they the same thing?

**Comment [BG14]:** Per marsh? same applies throughout where number of points is mentioned

**Comment [JW15]:** done

**Comment [BG16]:** Long sentence. Consider breaking up.

**Comment [JW17]:** done

Point count surveys for marsh birds were conducted on portions of SPB in 1998 and 2001-2002. In 2004, a point count survey method very similar to "Type A" was initiated and has been in use since that time. The SPB survey method consists of 10-minute point count surveys at multiple points (usually 6-8) spaced 200 m apart along transects. Three visits are typically conducted at each point each year, and surveys are conducted near sunrise or sunset. The first two visits are passive, and the third visit incorporates an initial 5-minute passive segment followed by an unconditional 1-minute broadcast of CA Ridgway's rail calls followed by a 4-minute passive segment (10 minutes total). The call broadcast is employed regardless of detections that may have occurred on the previous two rounds. This is in contrast to the "Type A" survey method, in which the 3rd round call broadcast is conditional on not detecting CA Ridgway's rails at that point on the first two visits.

The lack of a comprehensive secretive marshbird? protocol for San Francisco ~~Bay~~Baythe Estuary resulted in multiple field methods being employed by USFWS and other agency and NGO

partners involved in monitoring CA Ridgway's rails. Biologists were not always able to compile and integrate data among partners and were not able to easily extract information on recovery status, population trends, or response to restoration and management. This arrangement did not meet the needs of managers seeking to identify and reduce threats to the CA Ridgway's rail. As a result, the idea of identifying and promoting an efficient field method for surveying secretive marsh birds that could be employed by all ~~partners~~partnersthroughout the Estuary was pursued.

Broadcasting marsh bird vocalizations has been shown to generally increase detection probability for most marsh bird species (Gibbs and Melvin 1993, Hinojosa-Huerta et al. 2002, Lor and Malecki 2002, Allen et al. 2004, Conway et al. 2005, Conway and Gibbs 2011). Surveys where call broadcast is used on every visit are recommended for multi-species marsh bird monitoring under the Standardized North American Marsh Bird Monitoring Protocol (Conway 2011). This protocol framework has been adopted by many federal, state and local organizations across the U.S. and provides the basis for this site-specific protocol for DESFB and SPB. One concern about adopting the North American Protocol among refuge staff and others conducting marsh bird monitoring is that call broadcast may cause harmful disturbance to marsh birds and may potentially increase mortality risk (e.g., call broadcast might cause a rail to leave protective vegetation cover putting them at greater risk of predation). Available data are mixed about the effects of call broadcast on marsh bird movements. Legare et al. (1999) found evidence of small scale movements in response to call broadcast for Black Rails (males moved an average of 9.5 m in 63% of trials; females moved an average of 4.9 m in 47% of trials). In contrast, Bui et al. (2015) found that CA Ridgway's Rail movements were not consistently influenced by call broadcast in San Francisco Bay. This concern has been addressed by adding specific provisions to the survey method to minimize the risk of predation.

The TMRP does not provide a specifics on a monitoring design for tidal marsh birds. Through a series of workshops, USFWS staff met with the authors to outline the needs and objectives that should inform a monitoring design focused primarily on CA Ridgway's rails. The desired monitoring program should be sensitive enough to: (1) quantify population trends at the refuge and regional level, both increasing and decreasing; (2) document responses in marsh bird populations with reference to tidal marsh restoration efforts at refuge and regional scales; (3) measure progress toward CA Ridgway's rail recovery objectives at refuge and regional scales; and (4) detect substantial short-term declines and increases (>40%) over short time spans (3-5 years) in CA Ridgway's rails at refuge and regional scales as an early warning system to refuge managers of imminent threats (e.g., introduction of a new predator or disease) or to indicate any other substantial changes of high concern. Given limited resources at both refuges, the desired monitoring program should also be maximally efficient so that it can be sustained through both bountiful and lean budget years. Smaller-scale site-specific management questions (e.g., effects of predator removal at specific management units) would require additional sampling that would not be considered by this protocol. However, the protocol is designed to facilitate addressing site- or management-specific questions by providing information on baseline and reference conditions. The Refuges and their partners have used different methods to monitor CA Ridgway's rails and other marsh birds which has made it more difficult to accurately estimate population sizes and trends across different spatial and temporal scales. Thus this protocol provides an opportunity for increased standardization for Estuary-wide marsh bird monitoring leading to more effective monitoring.

**Comment [BG18]:** But they were compiled and reported on, right. The issue is that the results may not have been reliable given the variation in methods. If this is true I think its worth mentioning here. Plus, the ability to assess 'recovery' was the limited.

**Comment [JW19]:** done

**Comment [JE20]:** I've often wondered how broadcast vocalizations of one species might influence behavior of other species. For example, I've had Ridgway's Rail respond to Black Rail broadcasts and visa versa, Sora respond to VIRA, etc.

**Comment [JW21]:** Yes, I'm sure they do! During our pilot protocol study I definitely noticed RIRA and BLRA responding to SORA broadcast.

**Comment [BG22]:** Where does the new protocol framework fit in here? -Conway 2016

**Comment [JW23]:** In the next sentence we say this it provides the basis for our protocol. Is that good enough?

**Comment [BG24]:** Do you mean Estuary here? If yes, state as such. What is the scope of the region? Same comment wherever the term 'region' or 'regional' is used.

**Comment [BG25]:** Is this statement necessary?

**Comment [BG26]:** Same comment as before

In addition to informing managers about the large-scale effects of tidal marsh restoration on marsh bird populations and tracking progress toward delisting objectives for CA Ridgway's rail, the monitoring data from this protocol can be used in conjunction with additional monitoring efforts to assess the effectiveness of ongoing or proposed management actions such as predator control, invasive plant removal, and marsh revegetation and enhancement. Marsh bird species can often serve as indicators for assessing the general health of wetland ecosystems, and their presence and abundance can be used as measures of the success of wetland restoration efforts (Lewis and Casagrande 1997). For example, marsh birds may be affected by accumulation of environmental contaminants in wetland substrates because they consume a wide variety of aquatic invertebrates (Klaas et al. 1980, Eddleman et al. 1988, Conway 1995, Schwarzbach et al. 2001, Takekawa et al. 2006, Tsao et al. 2008). Marsh birds are also affected by changes in wetland plant composition and invasion of wetlands by invasive plant species (Guntenspergen and Nordby 2006, Spautz et al. 2006, Overton et al. 2014).

The USFWS has a vested interest in marsh bird populations and their habitats because marsh birds are trust species, under the protection of the USFWS. The USFWS National Wildlife Refuge System (NWRS) of the USFWS has been a key partner in developing and promoting a standardized marsh bird protocol (Conway and Seamans 2016) because it contains the refuge system has a disproportionate amount of tidal and non-tidal wetlands within their boundaries, and marsh birds are often affected by the management actions typically employed by refuges. The Service has an additional interest in recovering federally listed threatened and endangered species (i.e., CA Ridgway's rail) and contributing to the recovery of other species of conservation concern, including the state threatened California black rail. Only CA Ridgway's rail and CA black rail These are the only two species whose vocalizations will be broadcast under this protocol. The highest-priority species for this protocol is the federally endangered CA Ridgway's rail, and the protocol was designed specifically for maximizing detection of this species.

**Comment [JE27]:** ??? Define

**Comment [LO28]:** Newly completed national marsh bird protocol.

**Comment [BG29]:** Relative to what? North American tidal marshlands? CA coast marshlands?

**Comment [BG30]:** Change? 'can be influenced by refuge management actions

In addition to CA Ridgway's rail and California black rail, five other secretive marsh bird species are considered focal species under this protocol including Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), yellow rail (*Coturnicops noveboracensis*), American bittern (*Botaurus lentiginosus*), and least bittern (*Ixobrychus exilis*). All detections for these species will be recorded. The USFWS has identified black rails, yellow rails, and American bitterns as *Birds of Conservation Concern* because they are relatively rare and basic information on status and trends is lacking in most areas (U.S. Fish and Wildlife Service 2008). The State of California identifies yellow rail and least bittern as Bird Species of Special Concern; in addition to identification of California black rail as state threatened. Any detections of these seven focal species will be recorded and entered into the database.

### *Objectives*

This protocol includes two types of objectives: management objectives and sampling objectives. *Management objectives* are statements detailing the resource outcomes a refuge plans to achieve (desired future conditions of a natural resource). Management objectives should be "SMART"

(Specific, Measureable, Achievable, Relevant and Time bound). *Sampling objectives* provide the specifics for measuring the resource or related indicator targeted in the management objectives and include what will be surveyed (resource or ecological indicator), the attribute actually measured or estimated (e.g., body size, cover, density), the desired accuracy of estimates, the magnitude of change one wants to detect, the chance of error you are willing to accept, and the power to detect a change of a specified magnitude (Nur et al. 1999). This information is necessary for guiding decisions about the sampling design. Guidance on how to develop ~~M~~management~~Management~~ and sampling objectives is are described in more detail in Elzinga et al. (2001, pages 247-270).

*Management Objectives*

The TMRP (U.S. Fish & Wildlife Service 2013) sets forth ~~explicit~~specificexplicit abundance objectives for CA Ridgway's rail (Table 2). The South Bay Salt Pond Adaptive Management Plan (Trulio et al. 2007) also contains explicit specific abundance or density objectives for CA Ridgway's rail based on objectives in the TMRP (Table 2). Likewise, the Refuges based their management objectives on the TMRP.

**Comment [BG31]:** Are you referring to CCP objectives here? If yes, make clear

Table 2. Management objectives and rationales for marsh birds that apply to Don Edwards San Francisco Bay and San Pablo Bay National Wildlife Refuges from available conservation plans.

| Conservation Plan | Management Objective | Rationale |
|---|---|---|
| DESFB CCP (U.S. Fish and Wildlife Service 2012) | Goal 1: Protect and contribute to the recovery of endangered, threatened, and other special status species on the Refuge by conservation and management of the habitats on which these species depend.<br><br>Objective 1.1. Conduct standardized monitoring efforts and research projects in coordination with other regional efforts for salt marsh harvest mouse and California clapper rail within five years. Improve high tide refugia for these species. | The California clapper rail and the salt marsh harvest mouse are two of the endangered species for which the Refuge was established. The Draft Tidal Marsh Recovery Plan (TMRP) identifies several actions needed to achieve recovery of the California clapper rail and salt marsh harvest mouse. Actions include evaluating and monitoring existing populations, protecting, managing, and restoring habitat, and conducting research necessary to promote recovery. Refuge management strategies will directly support the actions identified in the ~~Plan~~TMRPPlan. |
| SPB CCP (U.S. Fish and Wildlife Service 2011) | Goal 1: Support and contribute to the recovery and protection of threatened and endangered species and related ecosystems of the San Francisco Estuary.<br><br>Objective 1.1. Within five years of the Plan, develop and begin to implement an inventory and monitoring (I&M) program that addresses native and non-native species, habitats, and ecosystems of San Pablo Bay. | Federally listed threatened, endangered, and candidate species are trust responsibilities under the jurisdiction of the Service. Threatened and endangered species, as well as those proposed for Federal listing, are likely to become extinct due to environmental factors. Listed species known to occur on the Refuge, the California clapper rail and the salt marsh harvest mouse, are dependent on tidal wetlands. As much as 90 percent of wetlands around the San Francisco Bay have been lost to development (Goals Project 1999). The Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (Draft Tidal Marsh Recovery Plan) (USFWS 2009) identifies the need for monitoring to assess status, trends, habitat use, and threats to develop appropriate recovery actions. Refuge management strategies will support these objectives. Furthermore, understanding how listed species interact with their environment and other wildlife will support their recovery. |
| SPB CCP (U.S. Fish and Wildlife Service 2011) | Goal 1: (see above)<br><br>Objective 1.2 Within life of the Plan, evaluate population health, develop population goals, and identify and implement management actions that will preserve or enhance existing populations of priority species identified in the I&M program (see Objective 1.1). | The Draft Tidal Marsh Recovery Plan identifies several actions needed to achieve recovery of the California clapper rail and salt marsh harvest mouse. San Pablo Bay NWR Final Comprehensive Conservation Plan Actions include evaluating and monitoring existing populations, protecting, managing, and restoring habitat, and conducting research necessary to promote recovery. Refuge management strategies will directly support the actions identified in the Plan. |

| Conservation Plan | Management Objective | Rationale |
|---|---|---|
| South Bay Salt Pond Adaptive Management Plan (Trulio et al. 2007) | Clapper Rails: Project Objective 1A Restoration Target: Meet recovery plan criteria for clapper rail numbers (0.25 birds/ac over 10-year period) within the SBSP Restoration Project Area | Future actions are expected to open significant acreages of pond to tidal action in order to initiate development of significant areas of tidal habitat for California clapper rail and salt marsh harvest mouse and to allow large-scale testing of sediment dynamics and supply questions. One primary Project Objective is to provide adequate habitat to support pre-ISP numbers and diversity of waterbirds using the South Bay while increasing numbers of tidal marsh birds such as California clapper rails that have historically used the Bay. |
| Tidal Marsh Recovery Plan (U.S. Fish & Wildlife Service 2013) | Factor E/1. Downlist Criterion. To provide sufficient resilience to stochastic events, criteria under Factors A-C have been met and have resulted in at least the following average number of rails over a 10 year period, spread over a large geographic area:<br><br>Central/South SF Bay Recovery Unit: 1,060<br>San Pablo Bay Recovery Unit: 936<br><br>Note: Factors A-C relate to habitat, overutilization and predation/disease. | The average number of rails required for downlisting was calculated from the minimum required acreage (criteria A/1. A/2, and A/3), derived itself from a population viability analysis conducted for California clapper rail. For further information on this analysis, see Appendix F of the TMRP. The minimum acreage was multiplied by the rail density corresponding to the 60th percentile of observed winter populations for that particular region. Respectively, those are 0.15 bird/ac, 0.09 bird/ac, and 0.02 bird/ac for three recovery regions. Rather than specify a minimum number of rails that must be supported per marsh complex, it is assumed that a natural distribution over the entire recovery unit would result if the other minimum acreage protection and management criteria are met.<br><br>Surveys. Annual clapper rail monitoring should continue on Don Edwards San Francisco Bay National Wildlife Refuge, and expand to other Federal and State owned lands. Monitoring provides data that are useful both in the short-term for adaptive management of existing tidal marsh, and in the long-term to determine success of recovery efforts. Monitoring protocol should approximately follow current monitoring design used by PRBO Conservation Science in their estuary-wide surveys for long-term analysis purposes and should help to capture normal population fluctuations and to asses rail response to invasive Spartina control. As recovery efforts proceed, California clapper rail population distribution will expand. Intensive monitoring will be necessary to document the resulting range expansion. |

**Comment [BG33]:** Add parentheses with recovery region names for each of the birds/ac?

**Comment [BG32]:** How does 0.25 birds/acre (salt pond restoration) relate to criteria in TRMP rows below? the SBSP criteria refers to the TMRP but the criteria are represented differently.

| Conservation Plan | Management Objective | Rationale |
|---|---|---|
| Tidal Marsh Recovery Plan (U.S. Fish & Wildlife Service 2013) | Factor E/1. Delist Criterion. To provide sufficient resilience to stochastic events, criteria under Factors A-C have been met and have resulted in at least the following average number of rails over a 10 year period, spread over a large geographic area:<br><br>Central/South SF Bay Recovery Unit: 3,180<br>San Pablo Bay Recovery Unit: 2,080<br><br>Note: Factors A-C relate to habitat, overutilization and predation/disease. | The average number of rails required for delisting was calculated from the minimum required acreage above, derived itself from a population viability analysis conducted for California clapper rail. For further information on this analysis, see Appendix F. The minimum acreage was multiplied by the rail density corresponding to the 90th percentile of observed winter populations for that particular region. Those are 0.45 bird/ac and 0.20 bird/ac for Central/So SF Bay and San Pablo Bay, respectively. Species experts agreed on a realistic density of 0.04 bird/ac for the Suisun and Tomales Bay metapopulations. Rather than specify a minimum number of rails that must be supported per marsh complex, it is assumed that a natural distribution over the entire recovery unit would result if the other minimum acreage protection and management criteria are met. See information on Surveys above. |

The TMRP established population objectives for delisting for each recovery unit (Table 1) but did not step down these population objectives to smaller scales (e.g., to the Refuge scale, or to the subregion). The Refuge Comprehensive Conservation Plans (15-year management plans developed by each Refuge that set forth conservation goals and objectives for the Refuge management over that time period;;; hereafter "CCPs") similarly do not set forth explicit specific population targets for CA Ridgway's rail at the refuge scale. In the absence of explicit population targets at the refuge scale, the refuges have assumed tThethe following management objectives were developed by Refuge staff for the purpose of this protocol that support meeting the recovery objectives in the TMRP while recognizing management constraints and opportunities at each refuge:

(1) During the period 2017-2063, achieve an average annual rate of increase in the CA Ridgway's rail population at DESFB of at least 4.3% (2.3% during 2017-2032 and 5.5% during 2032-2063).
(2) During the period 2017-2063, achieve an average annual rate of increase in the CA Ridgway's rail population at SPB of at least 1.9%.

These objectives meet recovery objectives of the TMRP while recognizing management constraints and opportunities at each refuge.

*Rationale for thesurvey protocol targetthe stated targets: CA Ridgway's rail*

CA Ridgway's rail population size can be increased in two primary ways: (1) by increasing rail densities at existing marshes or (2) by establishing rail populations at newly restored marshes. Refuge management actions that can potentially increase rail densities at existing marshes include improvements to hydrology, restoration of upland-marsh transition zones, construction of marsh mounds, revegetation and predator control. Both refuges are restoring tidal marsh habitat by breaching levees surrounding salt production ponds, managed ponds and agricultural lands. Some breached ponds with high starting elevations are expected to provide new CA Ridgway's rail habitat within a relatively short time span through natural sediment deposition and growth of emergent plants, while others will require years or even decades of sediment deposition before they can support suitable emergent vegetation; artificial deposition of sediment can accelerate the process of marsh accretion (Williams and Orr 2002, Brand et al. 2012). Establishment of rail populations at newly restored marshes is assumed to occur via unassisted (natural) colonization. CA Ridgway's rail recolonization has been analyzed by Liu et al. (2012); recolonization occurs about 20 years after levee breaching on average in the Estuary..

For DESFB, we assumed that CA Ridgway's rail population growth over the next 15 years would primarily come from tidal marsh restoration because resources for enhancements of existing marshes are expected to be minimal over this time frame, whereas tidal marsh acreage is projected to increase substantially via restoration. For setting the population target, we made the simplifying assumption that the population growth rate for rails would equal the projected rate of growth in habitat acreage—this assumes constant densities between existing and restored marshes. Based on refuge estimates, DESFB is projected to increase its tidal marsh acreage from 10,348 acres to 14,914 acres by 2032, representing a 2.3% annual growth rate in tidal marsh acreage. Note that a 4.3% average annual growth rate for the entire Central/South Bay Recovery Unit will be required to reach the TMRP delisting criteria by 2063 (U.S. Fish & Wildlife Service 2013). To make up for the lower growth rate over the next 15 years, we set a higher target (5.5%

**Comment [BG34]:** What is a subregion here – a portion of a recovery unit?

**Comment [BG35]:** But the SPB CCP called for developing them - see table 2. This work helps fulfill the CCP. I think this is worth mentioning here – meets SPB CCP objective 1.2

**Formatted:** Normal

**Comment [BG36]:** Add a little more detail on how these were developed?

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**Comment [BG37]:** Plural-'targets' but this section only talks about one target-CA Ridgway's rail. Is there more than one target? The management objectives target CA Ridgways rail but earlier in this document you mention that vocalizations of black rail will be played under this protocol. Assuming 'target' refers to species identified in management objectives.

**Comment [BG38]:** Add citations here pointing to literature substantiating that these actions can potentially increase rail densities – or is this just expert opinion?

**Comment [BG39]:** Clarify what 'high' means here

**Comment [JE40]:** Yes! In 2016 we documented unassisted colonization (by one pair) of the restored "pilot area" at Sonoma Baylands Wetlands 19 years after reintroduction of tidal influence.

**Comment [BG41]:** But varies by what factors – connectivity or distance to existing populations? Might be worth stating the variation around the average

**Comment [CTO42]:** Growth due to past restoration?

**Comment [CTO43]:** This seems to suggest that increasing marsh acreage will correspond to proportional (and immediate) change in rail populations. This is probably not the case as you indicated earlier, it takes 20 years on average to get dispersal into restored marshes. Or is this meant to indicate the increase in 20+ year marshland?

annual growth rate) for DESFB from 2032-2063. If other properties (not managed by USFWS) do not meet the target of 4.3% annual increase, then the recovery unit as a whole may not meet its goal, even though the Refuge may have met its stated goal.

For SPB, we assumed that population growth over the next 15 years would come from both enhancements to existing marshes and from tidal marsh restoration. SPB is currently incorporating habitat enhancements by improving hydrology and function to existing marshes. This includes creating high tide ~~refugia~~ refuge habitat (marsh mounds) and gradually sloping ~~transition zones at Sonoma Creek West, Dickson Ranch, Cullinan East~~ and ~~Cullinan West.~~re-vegetating transition zones at Sonoma Creek West, Dickson Ranch, Cullinan East and Cullinan West. SPB plans to enhance Strip Marsh West and Strip Marsh East within the next 15 years. The 440-acre Skaggs Island will be restored via levee breaching. Beneficial reuse of sediment and densely planted rhizomatous vegetation will help raise subsided areas to marsh plain elevation. Skaggs Island is not expected to provide any CA Ridgway's rail habitat by 2032. East Cullinan (approximately 300 acres) will be brought up to marsh plain and then breached within the next 5 years. The enhancements are expected to increase habitat quality for CA Ridgway's rail. SPB is projected to increase its tidal marsh acreage from 4,993 acres to 5,730 acres by 2032, representing a 0.9% annual growth rate in tidal marsh acreage. The SPB objective of 1.9% average annual growth includes growth from existing marsh enhancements and tidal marsh restoration. Note that if a 1.9% average annual growth rate is maintained on the refuge and throughout the San Pablo Bay Recovery Unit, this rate of change will result in reaching the TMRP delisting criteria for the recovery unit by 2063 (U.S. Fish & Wildlife Service 2013).

While there are no specific management objectives for the other marsh bird species in existing conservation plans, the refuges have assumed the following additional management objective:

(3) Maintain current levels of occupancy (proportion of occupied marshes) for Virginia rails and CA black rails on DESFB and SPB until 2032.

**Comment [BG44]:** Setting the refuge up for failure? Previously stated 2.3% based on increase in marsh acreage and jumped to more than double (5.5%). How does the refuge expect to meet this 5.5% beyond increasing marsh acreage? Maybe I'm missing something here.

**Comment [CTO45]:** What is the capacity of this methodology to assess the impact that local enhancement efforts have on abundance. I know that this is slightly beyond the scope of the problem you are working on. But as you point out enhancement is probably going to be limited in scope while BMP are developed. The extent to which they are implemented on the ground is a major factor influencing the ability to estimate their benefit as the numerical response of the rails. I ask because a sustained 5.5% increase in rail populations over 30 years results in a 5-fold increase in the population. If rails responded ONLY through increase habitat availability then the Central/South Bay would need more than 7 times the amount of tidal marsh that is currently has. Obviously, we need to find a way to put more birds onto the landscape beyond just increasing the size of the landscape. How will this monitoring strategy influence those sorts of decisions. I.e. what is the power to detect X amount of population growth that only occurs on x10 of the surveyed locations? (I think these sorts of actions will need their own monitoring, but I also think it is worth investigating what sort of potential we have if that monitoring isn't funded [since it often isn't])

**Comment [JE46]:** Are there examples of this? Some of the sites I'm familiar with are experiencing degradation through erosion or habitat alteration rather than enhancement. (e.g. Sonoma Creek, Gallinas Creek mid-reach; Corte Madera marsh, etc.)

**Comment [JW47]:** This only refers to FWS lands and I believe it would include activities such as t-zone restoration, and channel improvements (Sonoma Cr. Mouth), and lepidium control.

**Comment [BG48]:** This information would be better placed below the management objectives for CA Ridgway's rail. Seems out of place here.

## Element 2: Sampling Design

### *Objectives: Overview*

The protocol and associated monitoring framework is designed to (1) provide salient information on changes and variation in abundance of Ridgway's ~~rails~~rails~~s~~ over time and (2) provide a robust sampling framework for assessing Ridgway's rail response to large-scale conservation and management actions that can be expanded to include other partners operating on non-Refuge lands throughout the Estuary. More specifically, ~~t~~The~~the~~ survey method and design addresses multiple objectives. The first is to achieve sufficient precision to monitor changes in CA Ridgway's rail abundance such that progress towards the 50-year TMRP recovery criteria (USFWS 2013) can be assessed. However, the protocol is not limited to a pre-determined change in abundance or density. Rather, the sampling design allows a range of changes in density to be detected; target values will be subject to revision over time, and indeed trends over time are expected to change over the approximately 50-year TRMP time frame. Secondly, the protocol provides the ability to assess broad-scale response to tidal marsh restoration; local-scale management actions will likely require additional sampling that can build upon the effort described herein. Finally, the protocol provides the ability to detect short- and long-terms trends

of various magnitudes and annual changes in density that are of concern to the Refuge and other natural resource managers.

Whereas the absolute number of CA Ridgway's rails in a marsh, or in the Refuge Complex, or, ultimately, in the entire Estuary is, understandably, of high interest, it is important to acknowledge substantial limitations to estimating absolute abundance. Reliance on raw counts of individuals uncorrected for imperfect detection is inadequate because detection probability is much less than 100% and varies among surveys, thus confounding our ability to quantify differences in abundance among sites or changes in abundance over time. Instead, the approach implemented here is to quantify variation in absolute density (abundance relative to area), in a statistically justified and robust manner that can easily be replicated and can be conducted on an annual basis.

The approach detailed here centers on the quantitative estimation and statistical analysis of variation in **absolute density**, that is, the number of individuals inferred to be actually present per unit of area. The key underlying relationship is the following:

density (birds per ha) x area (number of ha surveyed) = abundance (number of birds within a survey area). ).

We focus on density in this protocol because this parameter explicitly takes into account the area being considered, both with regard to area sampled and with regard to area of inference. Another important strength to density estimation is that historic data are available that can be incorporated into an analysis. Thus, data collected and analyzed with respect to variation in density (either over time, or with regard to spatial variation) can provide a strong, quantitative basis for assessing progress in meeting conservation and management objectives. Density can readily be converted to abundance using data on habitat acreage to assess progress toward meeting abundance objectives, such as those laid out in the TMRP (USFWS 2013).

***Sampling objectives***

The sampling objectives for this protocol are:

(1) For each Refuge, achieve 80% statistical power to detect average increases in CA Ridgway's rail density of 1.9% to 4.3% per year over 20 years with a Type I error rate of 0.05.

(2) For each Refuge, achieve 80% statistical power to detect average declines of 3.4% and 5.0% per year in CA Ridgway's rail density per year over 20 years with a Type I error rate of 0.05.

(3) For each Refuge, achieve 80% statistical power to detect a 40% or more one-year increase or decrease in CA Ridgway's rail density compared to a suitable baseline period (e.g., 3+ years) with a Type I error rate of 0.05.

(4) Achieve sufficient precision to estimate trends in CA Ridgway's rail density differentiated with respect to age of marsh (< 50 years vs. ≥50 years) as well as with respect to habitat quality as it pertains to CA Ridgway's rail (high vs. low quality; see definition under "sample selection and size"). Trends are to be estimated at the refuge level; in addition, the sampling design can be scaled up to the regional level (corresponding with the recovery units in the TMRP), using this survey protocol as a framework.

**Comment [BG49]:** Survey sites rather than just surveys?

**Comment [CTO50]:** As written this seems to imply that absolute density is not subject to the same concerns about detection probability. There is definitely value in providing both absolute and relative (i.e. density) abundance measures for particular pieces of ground/boundries, etc. Site level estimates of abundance, even if they are "caveated" with assumptions are going to be very important for site specific management in the future. I recommend providing a mechanism where abundance is tracked along with density.

**Comment [JE51]:** This may be too fine a point, but should abundance indices be discussed (and included in analysis) as well? We understand that detection probability varies among surveys, but will some factors (marsh size, age, contiguity, etc.) be integrated into abundance calculations?

**Comment [JW52]:** Yes, we discuss the importance of including those factors in calculating density further down. Also, we tried to stick with using density as opposed to abundance since most of time the estimates are presented as number of birds per hectare/acre and not per site.

**Comment [BG53]:** Not sure if my suggested changes are helpful here

**Comment [CTO54]:** There are many reasons to look at density and abundance both. Population demographics are influenced by both numerical and relative (i.e. density) abundance. In theory, a territorial "high-r" prey species with a generalist predator community may be more affected by numerical abundance than by density. That is to say population change (trends) at low absolute abundance may be different than at high abundance independent of density. Furthermore, absolute population change across all regions may be greater for large populations with lower trends. Analyzing and presenting both to find what does and doesn't make sense seems prudent.

**Comment [CTO55]:** Back of the envelope calculation is that this represents a 45% to 132% total population gain. Possibly worth including

**Comment [CTO56]:** And this would be 50% to 35% . This are big numbers and we should know up front what sort of changes are being discussed.…now I see the numbers below. Those numbers seem pretty extreme to me.

*Rationale for sampling objectives*

**Estimation and detection of increasing density trend**

The magnitude of a trend, whether increasing or decreasing, is one of the key variables determining the ability to statistically detect a trend, and thus represents an important input value in our design (Nur et al. 1999). With regard to the detection of increasing trends, we considered trend values that correspond to the **long-term** annual population growth rates that would be required to reach CA Ridgway's rail delisting criteria by 2063 for each TMRP Recovery Unit (USFWS 2013). For the San Pablo recovery unit, the last population estimate was 794 birds in 2012 (Liu et al. 2012). To reach the TMRP delisting criterion of 2,080 birds by 2063, a constant annual growth rate of 1.9% would be required over the full time period. The corresponding trend to go from 369 birds in 2012 (Liu et al. 2012) to the delisting TMRP criterion of 3,180 birds for the Central and South Bay recovery unit is 4.3% per year. These rates represent initial "baseline" target values. This survey protocol addresses other target values that may be of equal or greater relevance with regard to management of CA Ridgway's rails. It is important that this protocol addresses a variety of trend values; one single value is not sufficient, since: a) target values are expected to change over time and b) the monitoring framework needs to address multiple objectives, including monitoring at local and regional scales. Therefore, we assessed the ability of each Refuge to detect both trends (1.9% and 4.3% per year).

Note, in particular, that the "baseline" target calculations cited above, assume a 50-year time frame for achieving implied increases in density, and furthermore assume that all parcels in a recovery unit, regardless of land ownership, will achieve the stated increases in density in order to meet the recovery unit delisting criteria. If increasing density over a shorter time period is desired (see below) or if Refuge-managed parcels desire to contribute a larger share to the goals for a Recovery Unit than is implied by the area of tidal marsh that they manage, then other target trends would be relevant. Hence, we have considered the ability to detect and quantify a range of trend values.

The interval of time over which refuge-specific trends will be assessed, both increasing and decreasing, is between 5 and 20 years. It is expected that the monitoring program, once implemented, would be in place for longer than 20 years, but the design has used 20 years as the maximum value to consider.

**Estimation and detection of decreasing density trends**

While the detection and quantification of decreasing trends is recognized as a priority, no specific values of trend magnitude were a priori identified. Here we consider two magnitudes: (1) a moderate decline of 3.4% per year which, if maintained, would result in a 30% decline after 10 years, a 40% decline after 15 years, and a 50% decline after 20 years, and (2) a more severe decline of 5.0% per year, which if maintained, would result in a 40% decline after 10 years, a 54% decline after 15 years, and, after 20 years, would result in a cumulative 64% decline.

**Detection of short-term change in density over time.**

We It is recognized that detection and estimation of short-term changes in density, as short as one year, are also of interest. Here we consider the ability to estimate and to detect a significant change after 1 year. More specifically, a step-change, either up or down. For example, Point Blue has reported a step change in the CA Ridgway's rail density in the South Bay commencing

in 2008, which has extended for several years (Liu et al. 2012). Furthermore, the 1-year change is evaluated relative to a baseline period: in this case, we have assumed a 3-year baseline period prior to the short-term increase or decrease.

**Assessment of spatial variation in density and trend.**
Detecting and estimating variation in density among marsh sites, such as e.g., comparing regions of the Estuary, or comparisons with regard to habitat quality or features, or with regard to age of a marsh (such as e.g., restored or older, mature marsh), represents another objective of the monitoring framework, which is critical in assessing the need for, and success in, implementing conservation actions. Thus, the collection and analysis of data must be highly comparable among different sites to allow for such assessment.

However, we note that assessment of spatial variation will be limited by the breadth and number of the sites being analyzed. Thus, some comparisons may not be possible unless one considers a large number of sites in addition to the Refuge. The monitoring framework has been developed to facilitate just such a comparison both with regard to comparing sites with respect to overall density and in relation to changes in density over time.

### *Sampling units and sample frame*

*Two tier-approach*
The sampling design consists of two tiers, which differ with respect to spatial extent. Tier 1 consists of refuge properties, including all those that are managed by the two refuges and/or where they have management responsibility for CA Ridgway's rail. The objectives for this tier focus on detecting trends over time for each Refuge (**Sampling Objectives 1 and 2**, described above) and detecting short-term changes (**Sampling Objective 3**, above). Tier 2 is the Recovery Unit level (San Pablo Bay Recovery Unit and Central/South San Francisco Bay Recovery Unit). Tier 2 includes additional areas not owned or managed by the Service. An important objective of the proposed monitoring protocol/framework is to provide the ability to estimate trends separately for high quality marsh sites, which will also tend to be high density marsh sites (though not necessarily so), compared to low quality marsh sites. Here we refer to differences in habitat quality, which has been extensively analyzed by Point Blue (Liu et al. 2012). Estimation of habitat-specific trends fall under **Sampling Objective 4**. In addition, the sampling design provides the ability to track changes in density for young restored marshes (defined here as 50 years or younger; Liu et al. 2012) compared to older marshes (>50 years in age)(which includes older restored and mature sites). Because restoration of tidal marsh is a high management priority in the ~~San~~EstuarySan Francisco Bay region, for USFWS and others (agencies, NGOs, etc.), this is also a component of **Sampling Objective 4.** Thus, the ability to track changes separately for these two categories of marsh sites (high vs. low quality and old vs. young),), applies both at the Tier 1 level, as well as at the broader Tier 2 level.

Note that we make no assumption of whether trends in density would necessarily differ when comparing marshes with respect to habitat quality or age, nor do we make assumptions regarding the direction of any difference. Rather, the design allows separate estimates of trend for these two categories. To accomplish Sampling Objective 4, the design includes **stratification** with respect to habitat quality and marsh age, as described below.

**Comment [JE57]:** Probably too late to add this category, but wouldn't contiguity (with other occupied or high quality parcels) be an important variable?

**Comment [JW58]:** It's definitely an important variable. But remember that we used predicted rail density to define habitat quality and those model predictions *might* include variables associated with contiguity. I don't remember all the variables that were included in that model.

**Comment [BG59]:** Might be useful to put this information in a table format to make it easier to digest

There are undoubtedly additional comparisons among extant marshes that will be of interest to the refuges and others. Tier 2 includes a large number of marsh sites in addition to the Refuge sites that historically and/or currently are being monitored by partners. Application of this monitoring framework to the larger sample of sites will allow one to address a number of important questions regarding habitat features, significance of adjacent land use, tidal range, etc., as well as evaluate potential responses to management strategies or considerations.

***Sample selection and size***

The design is a stratified, hierarchical design; hierarchical in that survey locations are nested within marsh sites. To the extent possible, we use random choice of marsh sites, taking into account the stratification of sites, which is described below. An additional consideration is the availability of legacy (a.k.a. historical) data. Statistical analysis of change over time (whether or not in response to management actions or other known environmental drivers) will be much stronger when the same survey stations are monitored over time (as in longitudinal or "panel" studies). Optimizing the use of legacy marsh sites is thus an important consideration, and places a constraint on randomization. That said, new sites will be included as part of the sampling design described below.

*Stratification*

The design is stratified according to four criteria:

- First, by "bay region": identified here as North Bay vs. Central/South Bay. The two regional populations have been shown to behave differently and are faced with different threats and stressors (Liu et al. 2012). Each region as identified can also be aligned with a TMRP recovery unit. (San Pablo Bay, and Central/South San Francisco Bay, respectively). In addition, SPB is in the North Bay region and San Pablo Bay recovery unit; DESFB is in the Central/South Bay region and Central/South San Francisco Bay recovery unit.

- Second, for DESFB only, by "segment group," as identified in the TMRP (2013), for the Central/South San Francisco Bay recovery unit. DESFB spans the eastern, southern and western portions of the South San Francisco Bay. To ensure adequate representation across all areas of the South Bay, the sampling design includes representation from the following three segment groups: m and n, o and p, and q and r (see ~~Figs~~figuresFigs. 4-6). The design for SPB is not stratified by segment group.

- Third, by CA Ridgway's rail habitat quality, which has been modeled across the Estuary by Liu et al. (2012) using several physical explanatory variables such as channel density, tidal range, etc. Habitat quality is correlated with density of CA Ridgway's rail (Liu et al. 2012), but is defined independently of density. One advantage of using quality rather than density for stratification is that sites lacking previous surveys can still be classified with respect to "expected density" on the basis of habitat characteristics. We define the "high quality" category as the one corresponding to marshes in the top quartile of the quality measure. We define "low quality" as the marshes below the top quartile. To maximize the ability to detect change over time for these two categories, the sampling design consists of 1:1 ratio of high:low quality marshes. Thus marshes in the top quartile, as determined by habitat quality, will be over-sampled to a large extent. Refuge staff altered the habitat quality classification

based on local site knowledge for ~~LaRiviera~~LaRiviere~~aLaRiviera~~ Marsh, from “low” to “high.”

- Fourth, by marsh age class: marshes <50 years old vs. marshes ≥50 years old. On the basis of earlier analysis (Point Blue, unpublished), and given the distribution of marsh ages, we used 50 years as the cut-off in the classification. More specifically, 34.5% of marsh sites in the Tier 2 sampling frame are “young”. For the sampling design, the ratio of young:older marshes is 2 young marshes for every 3 “older” marshes. That is, we are slightly over-representing young marshes in the design, compared to their frequency in the data set. The “older” category is diverse, including centennial marshes, ancient marshes, and older restored marshes (though the latter category is not common), hence we have included more marsh sites in this category than “young”. Because of the limited number of sites that can logistically be included in Tier 1 monitoring, we restrict the stratification to only two levels. Preliminary analyses by Point Blue indicated that young marshes differed from mid-aged marshes more so than mid-aged marshes did from older marshes, with respect to presence and abundance of tidal marsh bird species (unpublished).

**Comment [BG60]:** Earlier stated as ≤50 and >50 (p.20). Which is correct?

An important feature of the sampling design is that it is flexible. This protocol identifies the minimum set of marsh sites where monitoring will be conducted in Tier 1 in 2017. However, additional sites are highly desired to improve statistical power, increase precision and address objectives in addition to Objectives 1 and 2. Such sites can be added, consistent with this protocol, whether in 2017 or in future years. Furthermore, the protocol is designed to be revisited every 5 years. The objective of the “revisit and revision” is to, first of all, reconsider the allocation of marsh sites due to changes in habitat quality and age of marsh sites already included, as well as inclusion of any marsh sites added since 2016. For example, a marsh that was previously low quality may transition to higher quality. Additionally, there may be marsh sites that are no longer suitable due to logistical considerations (such as changes in access, permitting, or safetyaccess has changed, permitting considerations have changed, there are safety concerns, etc.). Also, marshes that were less than 50 years old, will at some point be more than 50 years old. Another impetus for the revisit is to include marshes that at one point in time (e.g., in 2016) were not considered to consist of suitable habitat for Ridgway’s rails, but after 5, 10, or 15 years are considered to be suitable. The transition from unsuitable to suitable may reflect a change in tidal action (e.g., from muted to fully tidal) and/or a change in vegetation. For example, one such criterion established by the South Bay Salt Pond Restoration Project is attaining at least 40% vegetation cover (Trulio et al. 2007).

**Comment [JE61]:** Indeed!

***Statistical power analysis***

Given that the sampling objectives of this protocol are to be able to statistically detect and quantify declining and increasing trends (**Sampling Objectives 1 and 2**) as well as detect major short-term change (**Sampling Objective 3**), it was necessary to conduct a statistical power analysis. Nur et al. (1999) describe statistical power analysis for trends and other analyses with regard to the design of monitoring programs.

Statistical power to detect a trend depends on six parameters: (1) the sample size, or more generally the sampling effort in each unit of time (in this case, one year), (2) the number of years over which the trend is being assessed, (3) the magnitude of the trend for which power is being

calculated, (4) the variability of the data to be used in the analysis, (5) the specific statistical test to be used, and (6) the alpha level (i.e., the Type I error rate) used in the statistical test (Nur et al. 1999). The first two components may be thought of as reflecting sampling effort, but there will be a difference in statistical power between conducting 10 surveys per year over 5 years, assuming a trend of *t*% per year, and conducting 5 surveys per year over 10 years, assuming the same trend.

To provide a robust foundation for the sampling design provided here, we conducted a multi-faceted power analysis, using simulations based on the extensive data collected by Point Blue, USFWS, and partners (Liu et al. 2012). The focus is was on ~~the~~theon Tier 1 monitoring, but we also provide some consideration of a spatial frame greater than just the Refuges (such as , i.e., Tier 2).~~.~~

The following summarizes the power analysis conducted by L. Salas, N. Nur, J. Wood, and M. Elrod to support this protocol (unpublished; available from the authors). The statistical power analysis conducted comprised four components:

**Component 1.** We evaluated the statistical power to detect specified trends (both positive and negative) given the current survey effort. The current effort was set at 10 marsh transects at DESFB and 8 marsh transects at SPB, where a transect consists of 4 to 8 survey points surveyed by one observer in a single visit. Each marsh can be sampled with one or more transects. The positive trends in component 1 were the "baseline" trends cited above in Sampling Objective 1: 1.9% and 4.3%. These increases do not necessarily represent management objectives for the Refuge; rather they are long-term, broad-scale recovery-unit baseline values. For SPB, we considered both 1.9% and 4.3% increases as target values; the same held for DESFB. In this component, we considered both increases and decreases. Detection of decreasing trends was also an important sampling objective; here we considered 3.4% and 5.0% decreases per year (see Element 2: Sampling Objectives).

**Component 2**. We made the same assumptions of sampling effort for the two refuges as above, but we evaluated the statistical power to detect a one-time, one-year 40% change (up or down) with reference to a prior three years of "baseline" data.

**Component 3**. We determined how statistical power changed as the sample size increased from the current effort of 8 and 10 transects, up to 30 transects. The latter value corresponded in terms of sample size to a regional or sub-regional monitoring program, rather than to monitoring at a single refuge.

**Component 4**. We determined how statistical power changed in relation to the magnitude of the simulated trend (both positive and negative), given the current effort. Thus, this component addressed the question, "Given current level of effort, what trend magnitude can be detected with 80% power (as well as other levels of power)?"

**Comment [BG62]:** Use bullets similar to previous section. Consistent formatting?

**Comment [CTO63]:** How might this vary by estimated density. Trends will be much more variable at low density/abundance population size than at larger won't they?

To determine statistical power and other components associated with power (e.g., magnitude of trend that can be detected with adequate power), we conducted an extensive set of simulations. The procedure consisted of generating simulated samples of data for transects, each with a set number of points per transect, in this case, 6 points. To determine the appropriate magnitude of variance, we drew on our analysis from a large CA Ridgway's rail dataset, spanning the years 2010-2014, a total of 110 transects (see Liu et al. 2012).

The simulations varied with respect to the number of transects, the time span (from 5 to 20 years), the magnitude and direction of the trend being simulated, and the significance level (such as i.e., alpha = 0.10 or alpha = 0.05). These parameters were set according to the four components listed above. The simulated data were analyzed using standard statistical methods, resulting in a trend being detected, or not detected at the specified alpha level for each simulated dataset. This exercise, repeated a sufficient number of times, gives an estimate of the probability of detecting a significant trend under the set of conditions which apply, and with the specific statistical test (detection of trend vs one-time change in mean).

Each simulated dataset thus consisted of generating a sample of rail abundance estimates at each point in each transect each year, with respect to the trend specified and year span. Error in determining the density of rails is significantly influenced by the probability of detection, so it is important that the variance estimate at each point used in the simulation already incorporates this source of error. The rail density estimate at each point was sampled from a probability distribution, and its variance was the variance estimate obtained from our analyses of the 2010-2014 data set, applying imperfect detection models. The simulated data also needed to capture variation among transects. The variance components around the transect density was also estimated from the imperfect detection model. We stratified the imperfect detection model, to include independent estimates of the variance for a stratum of marsh quality (high/low), and these were incorporated in the simulated data too. Mean and variance values were obtained from analyses of high quality (defined as top quartile) and "lower" quality marshes (the lower 75 percentile).

Component 3 above requires varying the number of transects. We assumed a 1:1 ratio of high to low quality marshes, and simply increased the number of transects in increments of 5. For simulations with an odd number of transects, the extra transect was assigned to the high quality stratum and thus assigned the variance for that stratum.

Lastly, some of the above components required estimation of power to detect negative trends. As rail density decreases, so does the variance at points, transects and strata. This effect was corrected in the simulation through a simple linear trend in the variance estimate, with a 1% decrease in variance/year.

Results for Components 1-4 are summarized here by Component:

Component 1:

1) **10+ years needed for detecting selected trends** (Applies also to Components 3 and 4): For detection of trends, whether increasing or decreasing, whether 1.9% to 4.3%, statistical power is inadequate after 5 years; this result is not surprising (Nur et al. 1999). At least 10 years are required (and often more) for detection of specified trends with sufficient power, given the nature of the variability in the data and errors associated with estimating detection probability.
2) **Assuming a 4.3% increase:** 10 transects (current sample size at DESFB) is sufficient to achieve 80% power after 10 years, assuming alpha = 0.10 (Figure 1A). With alpha = 0.05, power is almost 75% for the same parameter values (10 years, 10 transects). With 8

transects (current sample size at SPB), power is substantially lower after 10 years, i.e., 62% and 54% respectively for alpha = 0.10 and 0.05, respectively, assuming a 4.3% increase per year. However, after 15 years, assuming 4.3% increase, power is very high (95% or greater), whether sample size is 8 or 10, and irrespective of whether alpha = 0.05 or 0.10.

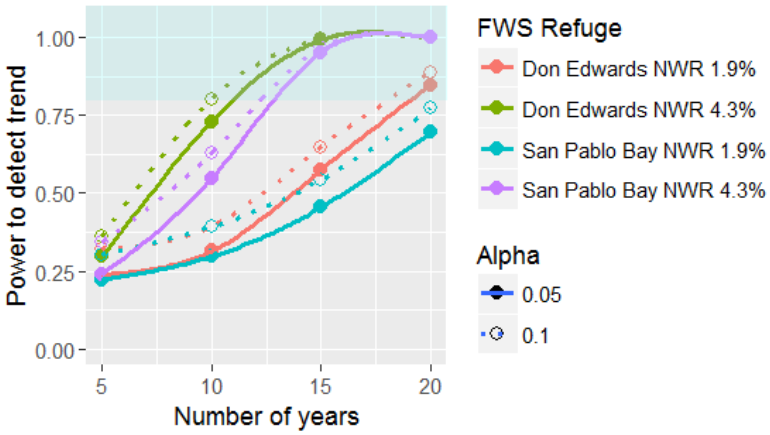



Figure 1A. Power to detect increasing trends of 1.9% and 4.3% per year given current sampling effort at DESFB (10 transects) and SPB (8 transects), over a span of 5, 10, 15, and 20 years, for Type 1 error rate of 0.05 and 0.10.

3) **Assuming a 1.9% increase**: power is very low after 10 years, under all conditions (Figure 1A). Even after 15 years, power is relatively low, ranging from 45% to 64%. **It will require 20 years to achieve at least 80% power**, and that is assuming sample size = 10 transects. For a sample size of 8 transects, power after 20 years is only 69% to 77%, depending on alpha level.

4) Neither **a 3.4% nor a 5.0% decline per year** can be detected with sufficient power after 10 years (Figure 1B). However, after 15 years, a 3.4% decline per year can be detected with more than 80% power assuming a sample size of 10 transects. With eight transects, statistical power approaches 80% (i.e., is 79%). **We conclude that detecting a 3.4% decline over 15 years is a valid, attainable sampling objective**.

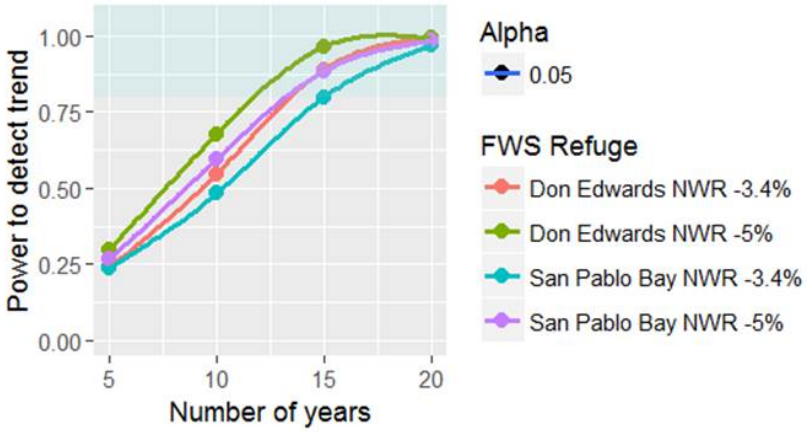



Figure 1B. Power to detect decreasing trends of 3.4% and 5.0% per year given current sampling effort at DESFB (10 transects) and SPB (8 transects), over a span of 5, 10, 15, and 20 years, for Type 1 error rate of 0.05.

5) **Conclusion from component 1: The ability to detect a 4.3% increase with 80% power after 10 to 15 years is a valid sampling objective**, given current sample size. We assert that this sampling objective is applicable to both SPB and DESFB. Detection of 1.9% increase after 10 to 15 years is **not** a valid sampling objective with the current level of effort. **Detection of a 1.9% increase per year can reasonably be accomplished with a 20-year time frame.** Alternatively, detecting 1.9% increase after 15 years will require a substantially larger sample size.

   The reason that 1.9% increase cannot be detected after 10 years is that such an increase is equal to a cumulative increase of only 20.7%. Such a "signal" is too subtle to detect given the intrinsic variability in the analysis of CA Ridgway's rail surveys. Even after 15 years, a 1.9% increase per year only yields a cumulative increase of 32.6%, hence requiring greater than current effort of 8 or 10 transects to ensure high statistical power.

Component 2:

1) A one-year "step change" of 40%, either increasing or decreasing, can be detected with 80% power (assuming alpha = 0.05), provided that the sample size is 10 transects. With alpha = 0.10, power is at least 85%. With only 8 transects, power is 75% or less, whether alpha = 0.05 or 0.10, and for both increases and decreases. Note that these calculations assume that abundance varies around a single baseline value for three years before either increasing or decreasing by 40%

2) **We conclude that the sampling objective of detecting a one-year, 40% change is supported,** given current sampling effort. This objective is feasible to attain.

Component 3:

1) Detecting a 4.3% increase after 10 years can be achieved with 80% power, if the sample size is at least 15 transects (Figure 2A).

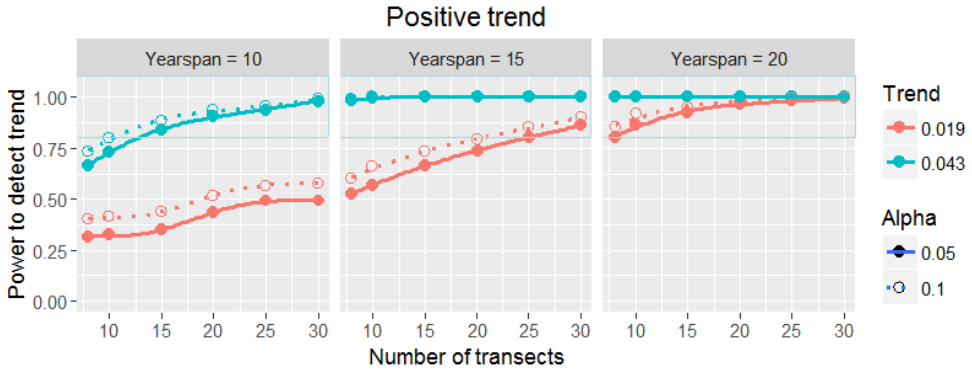



Figure 2A. Power to detect increasing trends of 1.9% and 4.3% per year in relation to number of transects, from 8 to 30 transects, over a span of 10, 15, and 20 years, for Type 1 error rate of 0.05 and 0.10.

2) Detecting a 1.9% per year increase cannot feasibly be achieved after 10 years even if 30 transects are monitored (Figure 2A).

3) Detecting a 1.9% per year increase with at least 80% power requires 20 years, assuming 10 transects (Figure 2A). With 8 transects, even after 20 years, the power is under 80%, assuming alpha = 0.05, though if alpha = 0.10, the power to detect is approximately 80%.

4) A declining trend of 5% per year can be detected with 80% power after 10 years provided that the sample size is 15 transects (Figure 2B). If the trend is a decrease of 3.4% per year, then 20 transects will be required after 10 years to achieve 80% power (Figure 2B).

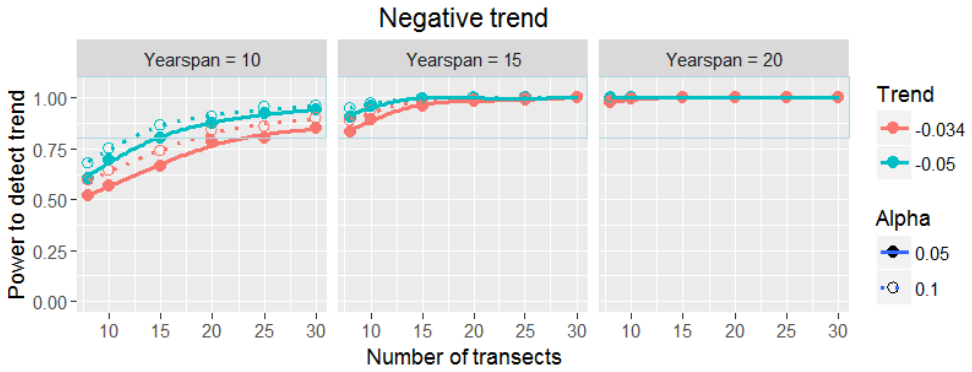



Figure 2B. Power to detect decreasing trends of 3.4% and 5.0% per year in relation to number of transects, from 8 to 30 transects, over a span of 10, 15, and 20 years, for Type 1 error rate of 0.05 and 0.10.

5) **Conclusion from component 3:** A sample size of 15 transects over 10 years is required to detect changes of 4.3% increase or 5.0% decrease. A sample size of 10 transects over 20 years can detect an increase of 1.9% with 80% power. Note that a 1.9% increase per year translates into a cumulative change of 46% after 20 years.

Component 4:

1) A trend of 6.0% per year increase can be detected with approximately 80% power after 10 years with a sample size of 8 transects (Figure 3A). With 10 transects, the trend that can be detected after 10 years is a little smaller, about 5.5% per year increase (Figure 3A).

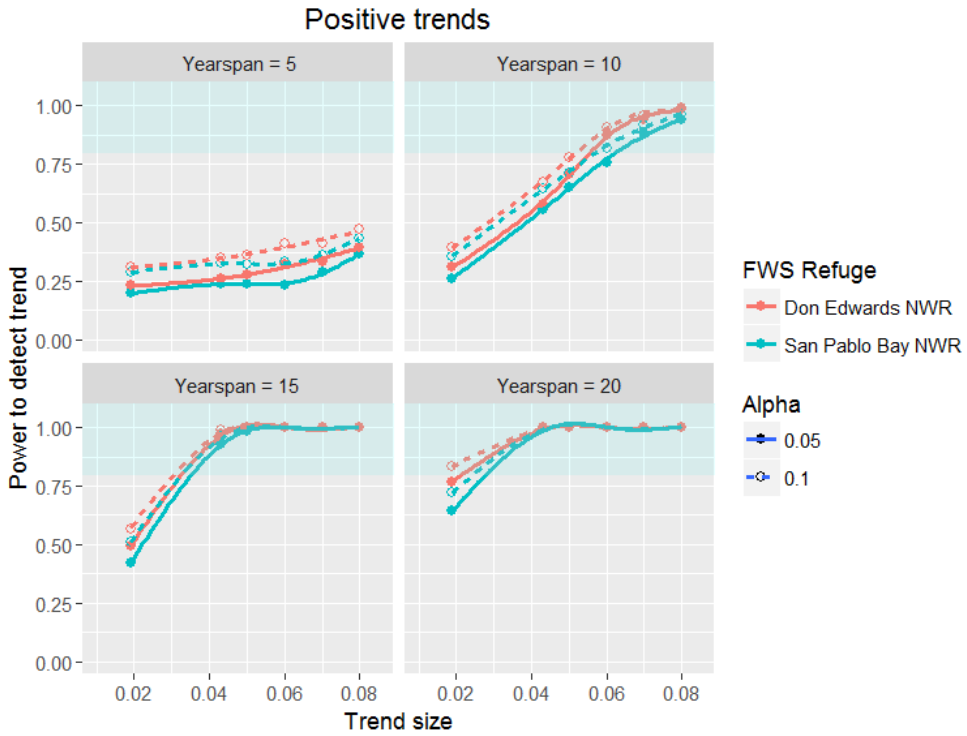



Figure 3A. Power to detect increasing trends ranging from 1.9% to 8.0% per year given current sampling effort at DESFB (10 transects) and SPB (8 transects), over a span of 5, 10, 15, and 20 years, for Type 1 error rate of 0.05 and 0.10.

2) After 15 years, the magnitude of the trend that can be detected with 80% power is between 3.0 and 3.5% per year, depending on the sample size (10 and 8 transects, respectively; Figure 3A).

3) **After 20 years, trends as little as 2.0% increase per year can be detected**, assuming 10 transects per year (Figure 3A).

4) **Declining trends will generally require at least 15 years to detect with at least 80% power.** The exception is that a magnitude decline of 7% per year can be detected after 10 years, assuming 10 transects, with 75% to 80% power (for alpha = 0.05 and 0.10, respectively). Declines exceeding 7% per year were not analyzed. Note that a 7% decline after 10 years equals a 52% decline. In contrast, after 15 years, a 3.4% decline per year can be detected with 80% power; here, the cumulative decline only amounts to 40.5%. The increased sample size (16 years analyzed vs. 11 years), resulting in a tighter confidence interval around the regression slope, thus allows a smaller cumulative decline to be detected.

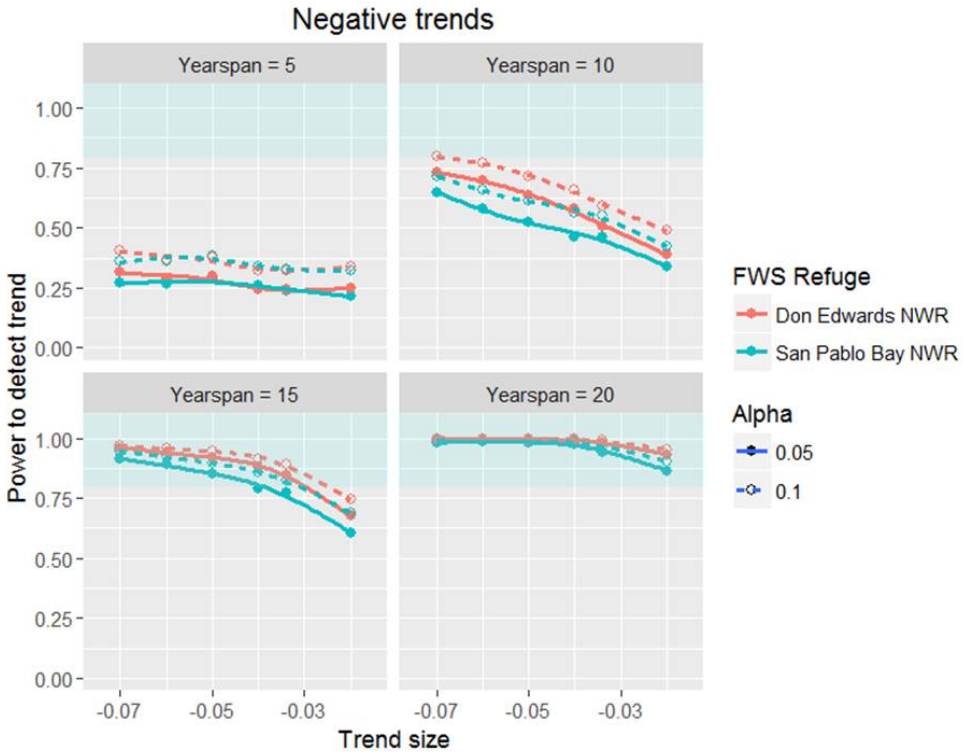



Figure 3B. Power to detect decreasing trends ranging from 2.0% to 7.0% per year given current sampling effort at DESFB (10 transects) and SPB (8 transects), over a span of 5, 10, 15, and 20 years, for Type 1 error rate of 0.05 and 0.10.

The above analyses make clear that **"moderate" increasing and decreasing trends can be detected** with adequate power, given the current level of effort, **within 15 years**. Here "moderate" is in the vicinity of 3.4% to 4.3% increase. However, slight trends (c. 2%) will require 20 years to meet the 80% criterion. That is not to say that a 2.0% trend cannot be detected after 10 to 15 years, but the probability is not high. In addition, the protocol described here has adequate power to detect a one-year increase or decrease of 40%

**Comment [CTO64]:** This is a near doubling of the population (at 4.3%) or 65% higher (at 3.4%) is that really considered moderate?

The protocol as described here can detect increasing or decreasing trends **within 10 years** with at least 80% power, but only if the sample size is increased substantially, or if the effect size (i.e., the magnitude of the trend to be detected) were larger than 4.3%.

An additional consideration is that **statistical power will increase with reduction in error** (or in statistical terms, reduction in residual variance); one way this can come about is by improving detection probability. Detection probability can be increased by increasing the number of visits per station, e.g., from three visits to five. Liu et al. (2009) evaluated the advantage of using five visits. However, the current protocol uses three visits, because field effort is limited; it is of greater value to monitor five sites with three visits per station than to monitor only three sites but with five visits to each station. In particular, stratification may not even be possible if the number of sites is reduced from the current number, as a consequence~~consequences~~ of adding additional survey visits per station.

A second means to increase detection probability is to use playback on every visit. The power analysis presented here relied on historic data, collected with the standard Type A survey method, which is mostly passive (no playback), except that mid-way through the third visit, a playback is used if no rails were detected on the previous two visits. However, Salas et al. (2016) have completed an extensive experimental comparison of two survey methods: Type A (described above) and the Standardized North American Marsh Bird Monitoring Protocol (Conway 2011, hereafter "North American"), which uses playback on every visit. Wood et al. (unpublished) found that the North American survey method increased detection probability and also decreased standard errors in estimating abundance, and thus statistical power increased up to 10% relative to the Type A survey method.

***Sample selection***

The goal of the sample selection process was to select a subset of core sites that would receive long-term, dedicated annual monitoring through 2063. The selection of sampling units for this protocol considered the site-specific sampling strata outlined above, current logistical constraints, and legacy (historical) monitoring efforts. These three criteria were used to determine the specific sites to be monitored (Table 3).

The site selection process began with a list of sites provided by the Refuge that were Refuge-owned or managed. These included sites with CA Ridgway's rail habitat and sites projected to have habitat by at least 2030. Refuge staff delineated site boundaries, and USFWS Inventory and Monitoring Program (I&M) ~~I&M s~~staff~~ staff~~ produced a shapefile of sites. The site list included sites surveyed by the USFWS as well as other organizations. Based on the desired effort level of 8 transects in SPB and 10 in DESFB, the sites were selected to achieve a balance with respect to the four strata combinations (old marsh and high quality; old marsh and low quality; young marsh and high quality; young marsh and low quality). ISP and Point Blue currently survey selected sites at DESFB. However, long-term funding of rail surveys by ISP and Point Blue is uncertain. Rail surveys at SPB are currently conducted by the refuge, and this is not expected to change in the future.

The site selection process involved the following steps:

**Comment [JE65]:** This raises a question that I've wondered about for some time. Does playback stimulate individuals to vocalize that would not under 'passive' conditions? That is, do tapes trigger otherwise silent females or non-territorial males to respond? We are simply measuring detection rates, understood, and of course outbursts of clatters confound all sampling efforts!

**Comment [JW66]:** Good question and I wish I knew the answer! The broadcasts definitely stimulate more calling than passive but obviously we don't know what proportion of those elicited calls are from non-breeders. I would argue that they should be included in the density estimate regardless of whether they are mated or not.

**Comment [BG67]:** Spell out if this is the first time acronym is used

1. Identify and map all sites with suitable or projected future habitat owned or managed by the Refuge.
2. Remove sites not projected to have suitable rail habitat in 2017, the first year of protocol implementation.
3. Remove sites with difficult access (e.g., boat required, long walk to reach transect).
4. For SPB, randomly select 8 sites distributed evenly among the four strata combinations.
5. For DESFB, for each segment group, randomly select 4 sites distributed evenly among the four strata combinations (12 sites total). For DESFB, remove two sites based on logistical considerations and/or based on marsh age (the sampling design slightly favored young sites) to reach 10 sites.

After completing these steps, 7 sites at SPB and 10 sites at DESFB were identified for long-term monitoring with one to two transects per site (Tables 3 and 4; Figures~~Figs~~ 4-7). For DESFB, 4 of the 10 selected long-term monitoring sites are currently being monitored by ISP and/or Point Blue; we assumed that these sites would continue to be monitored by ISP/Point Blue for the foreseeable future using this protocol and that data would be shared with the refuge. DESFB staff will survey the remaining 6 sites. Ideal Marsh North was one of the selected sites that will be monitored by the refuge; in addition, the refuge will survey Ideal Marsh South (a non-selected site) because surveys have been conducted there for a number of years and the refuge wanted to maintain continuity of the data set. If ISP/Point Blue stop surveying one or more of their sites in the future, the refuge could stop surveys at Ideal Marsh South and shift that effort to cover the ISP/Point Blue selected sites.

Table 3. All tier 1 survey sites selected for surveys during the 2017-2021 period. High quality sites represent the top quartile in CA Ridgway's rail density with remaining sites categorized as low quality. Young marshes are <50 years and old marshes are ≥50 years. Habitat suitability projections for 2020, 2025, and 2030 are presented. Sites selected for surveys during the 2017-21 period are indicated.

| Unit Name | Transects | Refuge | Marsh Quality | Marsh Age |
|---|---|---|---|---|
| Lower Tubbs Island | 2 | SPB | high | young |
| Sonoma Baylands | 1 | SPB | low | young |
| Sonoma Creek West | 2 | SPB | low | old |
| Strip Marsh East | 1 | SPB | low | old |
| Strip Marsh West | 1 | SPB | low | old |
| Tolay Creek | 1 | SPB | low | old |
| Tubbs Island Setback | 1 | SPB | low | young |
| B2 North Quadrant* | 1 | DESFB | high | young |
| Coyote Creek Lagoon | 1 | DESFB | low | Youngyoung |
| Coyote Creek SE* | 1 | DESFB | low | Oldold |
| Dumbarton Marsh | 1 | DESFB | high | Oldold |
| Faber Marsh | 1 | DESFB | high | Youngyoung |
| Ideal Marsh - North | 1 | DESFB | low | Oldold |

**Comment [BG68]:** Table only symbolizes 3

**Comment [JE69]:** The Gallinas Creek complex is not included; It doesn't fit the ownership criteria, but given it's importance as an apparent source pop. for the north bay, it seems that it should be included.

**Comment [JW70]:** This was a tough decision- whether to include efforts by other orgs/agencies and lands outside the refuge. In the end, we decided it needed to be specific to lands owned or managed by the Refuge. It is definitely NOT an estuary-wide monitoring plan.

**Comment [BG71]:** Move 'Refuge' field to first position rather than 3rd

**Comment [TR72]:** Is this really >50 years old? I thought most of it was a restoration project that occurred in the 1990s. The main marsh portions (i.e. former "CDFG Lagoon") and the new mudflat ("Proposed CDFG Pond") converting to marsh by Hwy 37 are new, I thought. Those portions have only been getting vegetated for at least ten years, and rails are totally showing up.

**Comment [TR73]:** http://www.calwater.ca.gov/Admin_Record/I-006994.pdf

| Unit Name | Transects | Refuge | Marsh Quality | Marsh Age |
|---|---|---|---|---|
| Ideal Marsh – South** | 2 | DESFB | low | Old~~old~~ |
| LaRiviere Marsh | 1 | DESFB | high | Young~~youn~~ g |
| Laumeister Marsh* | 1 | DESFB | high | Old~~old~~ |
| Mayhew's Landing | 1 | DESFB | low | Young~~youn~~ g |
| Redwood Point Marsh | 1 | DESFB | low | Old~~old~~ |

*Currently surveyed by ISP/Point Blue
**Non-selected site that will be surveyed by the refuge to maintain a historical dataset

Comment [TR74]: interesting that Refuge changed this to "high," since it was only high when covered in hybrid Spartina. It is currently not high quality, and hasn't been for several years, though hopefully it has the potential to develop better quality native veg to be "high" again.

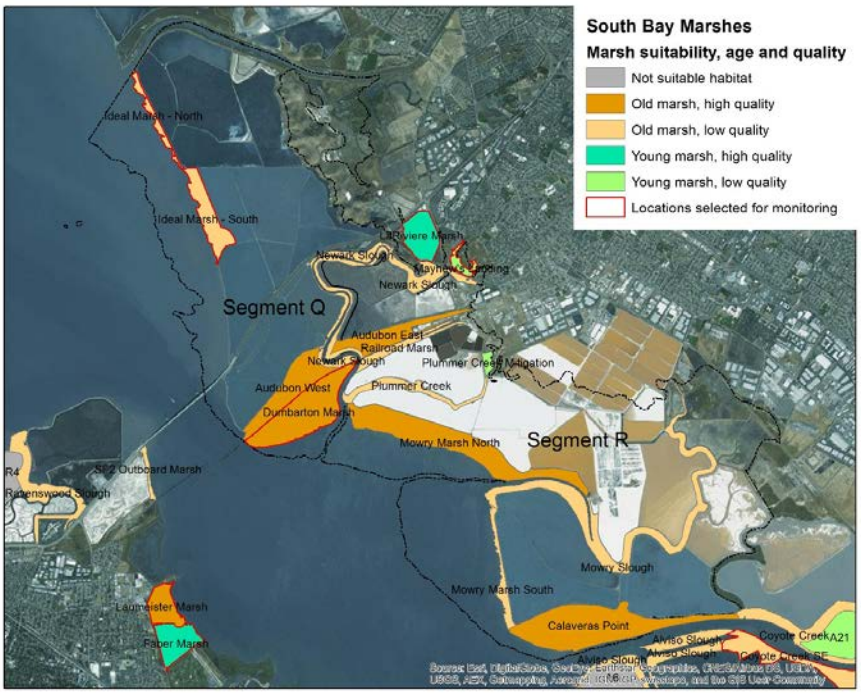
Comment [TR75]: surveyed by ISP

Table 4. The number of transects in each strata for San Pablo Bay NWR (SPB) and Don Edwards San Francisco Bay NWR (DESFB). High quality habitat is the top quartile CA Ridgway's Rail density, Low quality is the bottom three quartiles, young marsh is <50 years old and old marsh is ≥50 years old.

| Refuge | Strata | Number of Transects |
|---|---|---|
| SPB | Low quality, young | 2 |
| SPB | Low quality, old | 5 |
| SPB | High quality, young | 2 |
| SPB | High quality, old | 0 |
| DSFB | Low quality, young | 2 |
| DSFB | Low quality, old | 5* |
| DSFB | High quality, young | 3 |
| DSFB | High quality, old | 2 |

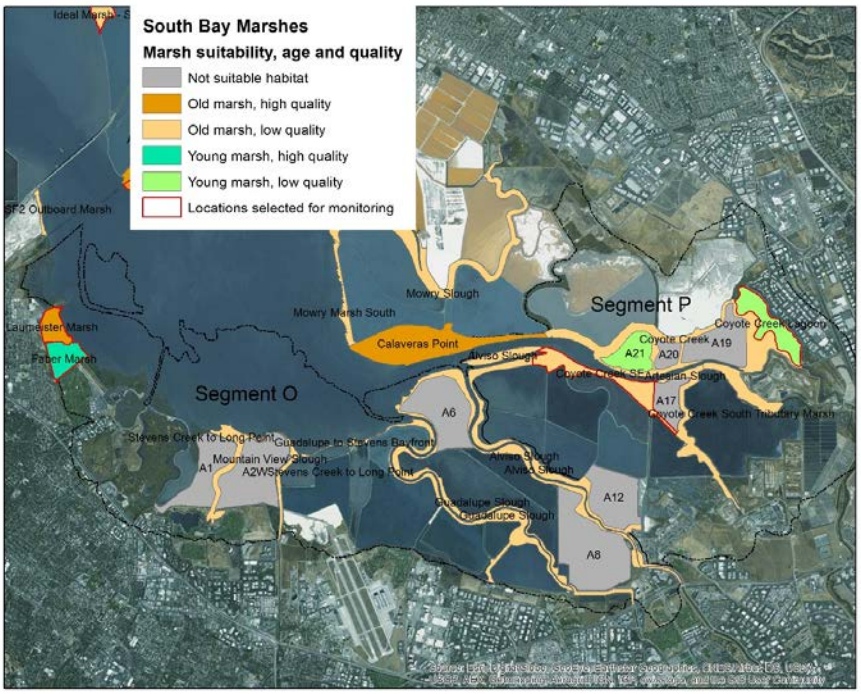
*Two of these transects are at a non-selected site (Ideal Marsh South) that will be surveyed by the refuge to maintain a historical dataset

Comment [BG76]: Why 0 here. Discuss in previous text or somewhere. Maybe I missed the discussion. Or put a note under the table

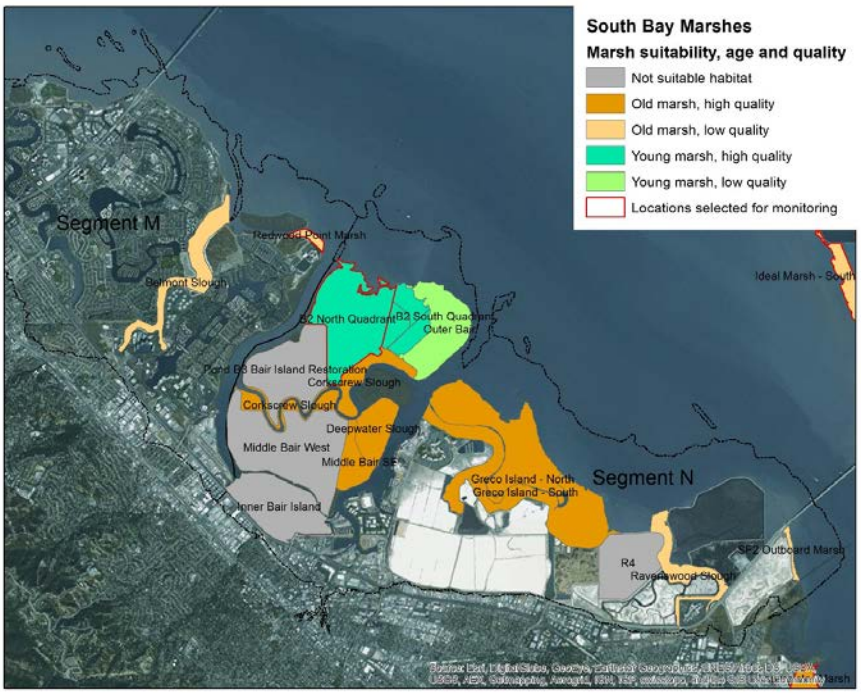



FigureFig. 4. Selected survey sites in Tidal Marsh Recovery Plan segments Q and R showing marsh suitability, age and quality.

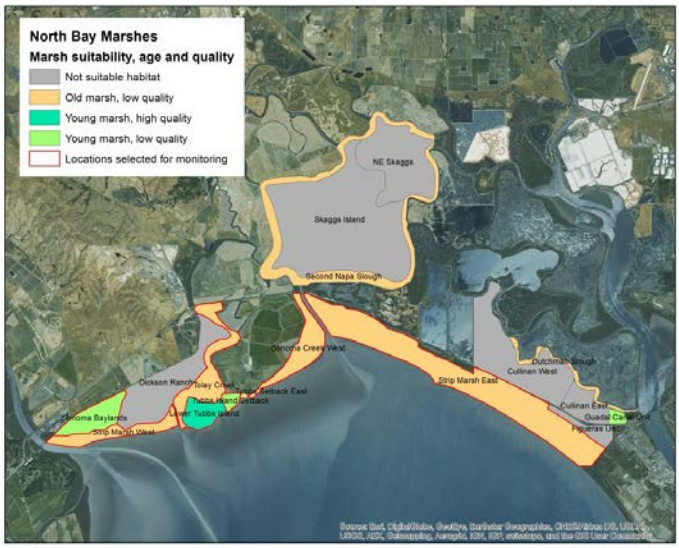
**Comment [BG77]:** Hard to match up areas and area names. Consider revising and have titles with lines pointing to areas. Same with subsequent maps




FigureFig. 5. Selected survey sites in Tidal Marsh Recovery Plan segments O and P showing marsh suitability, age and quality.




Figure~~Fig~~. 6. Selected survey sites in Tidal Marsh Recovery Plan segments M and N showing marsh suitability, age and quality.




FigureFig. 7. San Pablo Bay National Wildlife Refuge selected survey sites and marsh suitability, age and quality.

We recommend that one representative transect per site should be used for monitoring, if possible. Most of the selected sites have existing transects. For new marsh sites that are added, the protocol is to establish a single transect that spans a representative portion of the marsh based on habitat suitability. Each transect should have 6-8 points (8 preferred) with a spacing of at least 200 m between adjacent stations. Spacing points farther apart (up to 400 m, is desirable but only if 6-8 points can be established and visited within the survey window. Random placement of stations is not recommended because space is usually limited in San Francisco Bay marshes. Second, maintaining consistent spacing between points is desirable from a logistical standpoint (completing a transect within the desired time frame). Third, many marshes are not accessible throughout their extent. However, the order in which stations can be surveyed is flexible (see below).

### *Survey timing and schedule*

Surveys will take place during the late winter and early spring period (15 January – 15 April) when CA Ridgway's rails have established their breeding territories and vocalizations are at their peak. Extensive analysis (Liu et al. 2012) has revealed that the peak in detection probability is about 20 February (FigFigure 8Fig. 8). Thus, the period of peak detections is approximately 15 January to 25 March. For each survey station, there will be three "rounds" of surveys spread out over the survey season, which can maximally extend from 15 January to 15 April. However, because detection probability drops precipitously later in the season (FigFigure 8Fig. 8), surveys should be completed by 31 March if possible. If that is not possible, then surveys will be completed as soon as possible after that date. Ideally, round 1 should be completed from 15

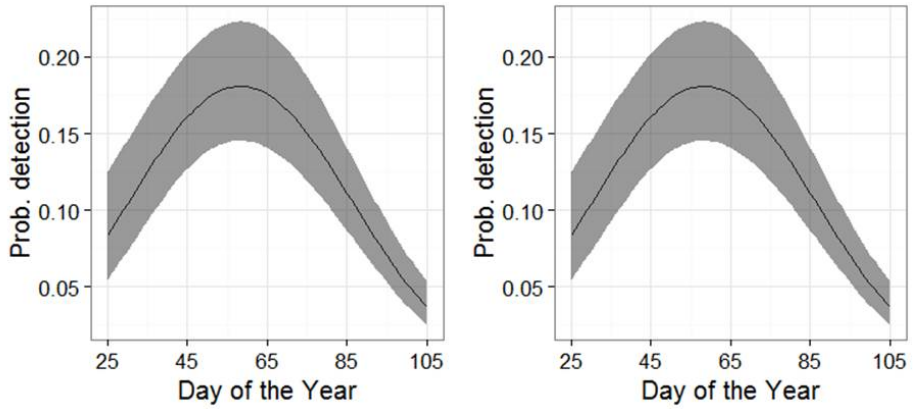
**Comment [BG78]:** In this protocol you use 'Estuary' and 'San Francisco Bay'. I think they mean the same thing so choose one and be consistent. Earlier in protocol its "estuary' later 'San Francisco Bay'

**Comment [A79]:** Add a note that this is new for this protocol and previously the 3 rounds were 1/15-2/14, 2/15-3/15, 3/14-4/15

**Comment [JE80]:** This may be true for the prescribed protocol period, however I would suggest, based on (unpublished!) field work conducted prior to the restrictions of the protocols, that in SF Bay Dec. and early Jan. are actually the peak vocal periods for spontaneous vocalizations.

**Comment [JW81]:** Fig 8 was based on passive surveys, not the N. Am protocol. But I agree that ideally, the survey period should begin mid-December as calling rates are likely higher than at the end of the survey season. December is a bit early for BLRA (and a bit early for our own family schedules!) so I'm ok with keeping the start date to Jan 15.

January to 6 February, round 2 from 7 February to 28 February, and round 3 from 1 March to 25 March. The period between 25 March and 15 April can be used to finish any remaining surveys if previous visits were cancelled due to weather or other logistics.

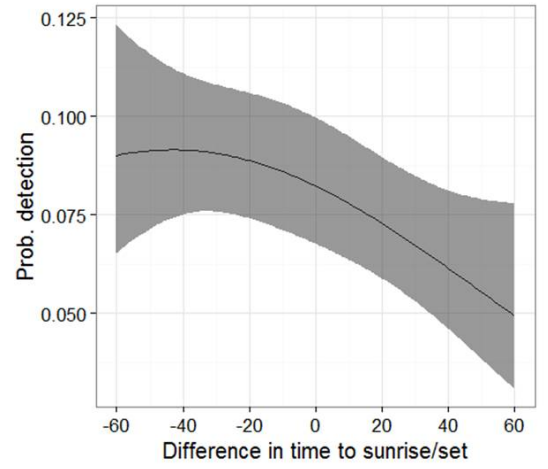


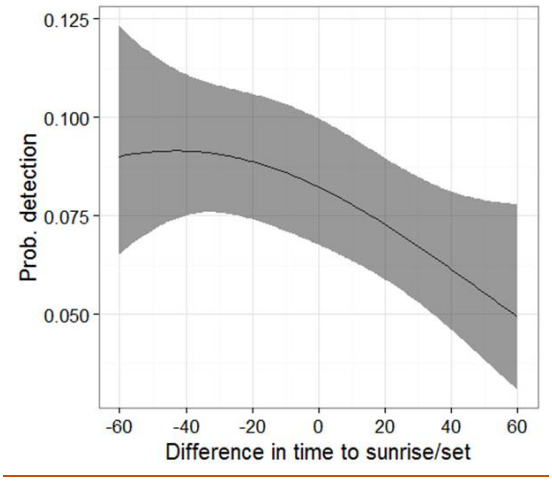

FigureFig 8. Detection probability for CA Ridgway's rail in relation to Day of Year (1= 1 Jan). Best estimate (dark line) and confidence interval (gray band) are shown, setting all other covariates to their mean level. Results from Type A Survey Protocol (Liu et al. 2012).

Surveys will be conducted during the periods before and after sunset and sunrise, which are peak calling hours for CA Ridgway's rail (FigureFig. 9). All surveys must be conducted within a two hour (120-minute) period surrounding sunrise/sunset, starting no more than 60 minutes before sunrise or sunset and must terminate within 60 minutes of sunrise and sunset. Ideally, If surveys should can be conducted in a shorter period surrounding sunrise/sunset (i.e., within 40-45 min of sunrise/sunset) this is preferred. However, use of a shorter survey period will not be possible where a large number of stations are being surveyed in a marsh, during one survey period. Furthermore, the decline in detection probability as surveys approach 60 minutes before or after

**Comment [BG82]:** Previously use the term 'points' – check throughout for consistency in terminology

sunrise/sunset will be less evident when the North American protocol is used, with playback at every visit. Regardless, the time of the survey is included as a covariate in estimating detection probability (see Element 4).


0.125
0.100
0.075
0.050
Prob. detection
-60
-40
-20
0
20
40
60
Difference in time to sunrise/set


0.125
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Prob. detection
-60
-40
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0
20
40
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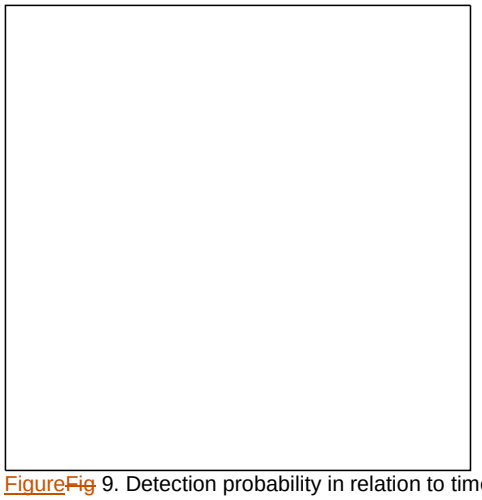
Difference in time to sunrise/set



FigureFig 9. Detection probability in relation to time relative to sunrise/sunset for CA Ridgway's rail. Negative values refer to minutes before sunrise or after sunset; positive values refer to minutes after sunrise or before sunset. Best estimate (dark line) and confidence interval (gray band) are shown, setting all other covariates to their mean level. Results from 5-species playback survey protocol (Salas et al. 2016).

### *Sources of error*

Detection probability is much less than 100%, even if playback is conducted on every visit (Wood et al. 2016);) (;); see FigsFiguressFigs. 8 and -9).- It is imperative to conduct repeated visits at each station in order to estimate detection probability, (, i.e., three visits per station per survey season as stipulated in this protocol).-

We recommend that the same observer be used for all stations within a site-visit, that is, within one 2-hr session. However, it is preferable to use different observers for different visits within the same year. Across years, to the extent possible, it is desirable to retain a similar mixture of observers at an individual site, at least at a subset of sites. What we seek to avoid is having observer and year confounded. Thus, if observer 1 surveys a marsh site in Year 1 (all three visits) and observer 2 surveys the same site in Year 2 (again, all three visits), it will be hard (but not impossible) to tease apart "year effects" from "observer effects."

Environmental conditions at the sites can be a source of error. During higher tides, birds may move out of their core territories to seek refuge thereby introducing a source of error into the counts. Therefore, surveys should be conducted when tides are < 4.5 ft (< 137 cm) relative to mean lower low water (MLLW) as measured at the Golden Gate or are not higher than the marsh plain (bank full) at the site. Surveys during a full moon should be avoided as birds may be distracted by the broadcast vocalizations and become more vulnerable to predators that are taking advantage of the increase in ambient light. Ambient noise including winds > 10 mph is another source of error. The protocol addresses ways to minimize ambient noise (see Element 3).

**Comment [JE83]:** We've used the concept of sloughs being "bank full" as a measure of maximum tide levels, although I'd suggest even this level suppresses vocalizations.

**Comment [JW84]:** We looked at tide level and didn't find an effect on detection probability but that doesn't necessarily mean there isn't one. If there is, it's probably slight.

**Comment [BG85]:** Throughout this document where you refer to other sections it would be good to insert bookmarks.

## Element 3: Field Methods and Processing of Collected Materials

Detailed field methods and data collection methods are described in SOP 1.

**Comment [BG86]:** Book mark would be useful…and others like this reference

## Element 4: Data Management and Analysis

For complete details on data management, see SOP 2 Data Management.

### *Analysis methods*

Two types of analyses are described in the protocol, analyses of individuals detected, which provides an index of density, and analyses of absolute density based on the statistical estimation of detection probability.

*Analysis of density indices*

While analyses of detection probability provide the keystone to analyses described in this protocol, we recognize that there may be circumstances when simpler analyses of density indices are appropriate. For example, for analyzing change over time, it may be sufficient to conduct analyses of detection probability only once every several years (at least once every five years, but more often as needed); however, in other years not so analyzed, analysis of the density index (number of individuals detected per survey per ha of surveyed area) will generally suffice. Density index analyses can also be carried out to provide preliminary information regarding spatial variation. Limitations of indices for such applications are discussed by Johnson (2008).

**Comment [BG87]:** For each of the two analysis sections, need to tie back/link to the management objectives they would inform.

I'm also curious to know if the refuge thinks there is enough information here to guide them through the analysis process or if they will require assistance OR an SOP for analysis is needed. Another words, is the information clear enough for them to answer the objectives/do the job themselves, do they have the capacity? Need to think this through.

**Comment [BG88]:** ?

**Comment [BG89]:** confusing

On an annual basis, the number of individuals detected per survey station is compiled and can then be used to construct annual summaries (see SOP 1 for details regarding data collection and processing). This metric provides an index of abundance at a survey station, and can be translated into an index of relative density, taking into account area surveyed (e.g., 12.57 ha, where radius of detection is 200 m). The station-level density index can then be analyzed with regard to assessing variation over time and space. This approach provides a simple index, easy to calculate, but recognizing that it also has drawbacks as described below.

**Comment [BG90]:** include equation below paragraph

Nur et al. (1999) provides guidance on how to conduct statistical analyses of density indices based on data collected as part of avian monitoring programs. That reference provides examples both with regard to trend estimation as well as analysis of habitat associations or other variables relevant to management. One primary concern when conducting such analyses is to ensure that the probability distribution of residuals is appropriate to the analysis. Either log-transformation of index values (Nur et al. 1999) or use of a log-link with count data is recommended; the latter can be carried out using a Generalized Linear Model (GLM; Dobson and Barnett 2008).

We note that use of a log-transformation or a log-link, while necessary, may not be sufficient. Whereas Poisson regression is commonly available, and many statistical procedures allow for Poisson-distributed residuals, count data in real life almost always display "over-dispersion" relative to the Poisson distribution (Nur et al. 1999). Analysts must evaluate the distribution of residuals and implement the appropriate procedure. For count data (as exemplified by the analyses described in this section), negative binomial regression (Hilbe 2011) is generally the most appropriate, and thus recommended, approach. For example, tidal marsh survey data from

three marsh bird species were analyzed by Stralberg et al. (2010); two species were best modeled by negative binomial regression (black rail and salt marsh yellowthroat *Geothlypis trichas sinuosa*), analyzing counts of individuals for each survey-visit-station, while the third species (tidal marsh song sparrows, *Melospiza melodia samuelis* and *M. m. maxillaris*) was best analyzed with a linear model (i.e., normally-distributed residuals with an identity link). Negative binomial regression models and other GLMs can be fit with many statistical packages such as R, STATA, and SAS. Analyses using negative binomial regression should be carried out on the counts of individuals detected at each survey station in each visit, rather than on the summary statistics obtained by summing over stations or over visits; or calculating mean values.

Even though "density index analysis" as described here does not explicitly estimate detection probability, it is recommended that, where possible, such analyses include covariates associated with variation in detection probability (as determined by other studies). For example, time of day relative to sunrise/sunset is an important determinant of detection probability (Wood et al. 2014, Wood et al. 2016). The exact time and date of each survey visit at each survey station will be known, and these variables can be entered in a multi-variable model (e.g., a GLM, such as negative binomial regression). Negative binomial regression and similar methods can account for the area being surveyed as an offset term (Hilbe 2011).

*Hierarchical modeling: Analysis of detection probability*

The second type of analysis is more complex and requires estimation of detection probability for individual marsh birds. Detection probability for CA Ridgway's rails is substantially less than 100% (Liu et al. 2012, Wood et al. 2014, Conway 2015). Furthermore, detection probability for the species demonstrates strong temporal variation (Liu et al. 2012, Wood et al. 2014, 2016). Thus, statistically controlling for detection probability improves the estimation of abundance by: a) reducing statistical error, and thus improving statistical power, and b) controlling for variation due to factors that influence detection probability independent of variation in abundance. Notably, detection probability has been shown to vary with time of day relative to sunrise/sunset, day of year, and among years (Liu et al. 2012, Wood et al. 2014, Wood et al. 2016). The dependence of detection probability for CA Ridgway's rail on time of day and day of year is illustrated in Element 2 (see Fig 2 and 3, above). It is also possible that detection probability varies with habitat characteristics. Wood et al. (2016) investigated whether detection probability differed with respect to density of CA Ridgway's rail, where marshes were categorized as either "low" or "high" density, relative to median density. Wood et al. (2016) found no statistically significant difference, but this should not be taken as demonstration of no difference, especially since the sample size was small. The analysis method outlined here is able to accommodate the possibility of spatial or temporal variation in detection probability, whether or not such variation has been previously demonstrated or not. Where there may be concern about possible variation in detection probability, the appropriate covariates can be modeled as illustrated below.

The analysis of detection probability is complex. A hierarchical model is required, as described by Royle and Dorazio (2008). In such a model, one **simultaneously** analyzes two components, which together determine the number of individuals actually detected during a survey: (1) the number of individuals actually present (whether detected or not) in the surveyed area, during the time of the survey, symbolized D, and (2) the probability of detection of an individual, provided that it is present in the area being surveyed during the time of the survey.

**Comment [BG91]:** is this the same as analyses of absolute density based on the statistical estimation – see first paragraph that identifies this as one of the two types of analyses. The titel of this section does not match up.

**Comment [BG92]:** Any values to present here?

**Comment [BG93]:** Spell out throughout

**Comment [JE94]:** Should'nt this say "estimates of density"?

**Comment [JW95]:** I'd rather just say density since it's shorter and because we describe how it's calculated. We don't claim it is 'true' or 'absolute' density.

**Comment [JE96]:** This reference is not in the reference list. I'd like a copy, if available!

**Comment [JW97]:** It's not quite finalized and I will send you a copy later this month when it's final.

More formally this can be presented as an equation, with each term calculated with respect to the appropriate area:

N = pDet x D,

Where N is the number of individuals detected per area surveyed, pDet is the probability of detection (defined above), and D is the true number of individuals present in the area being surveyed during the time of the survey and calculated per area surveyed. Hierarchical models applicable to this protocol are described by Royle and Dorazio (2008) and Dail and Madsen (2011).

The direct analysis of detection probability through a hierarchical model is both complex and challenging, but provides a statistically-based means to partition differences in the number of detections due differences in detection probability from differences due to the true difference in abundance. In addition, to estimate the actual absolute density (or abundance) requires knowledge of detection probability.

The protocol outlined here uses repeated surveys as a means to estimate detection probability as part of a hierarchical, so-called "mixture" model (Royle and Dorazio 2008). The package used to conduct the analysis is `unmarked` part of the R statistical language; `unmarked` is documented in Fiske and Chandler (2011). Thus, a key provision of implementing the protocol is that the same stations are surveyed three times per breeding season. Fewer visits per station per breeding season will compromise the ability to estimate detection probability. More than three visits per station per breeding season is not recommended in order to optimize the number of stations and number of marshes being surveyed. That is, there will be a trade-off between the number of visits per station and the number of stations; three visits represents the optimum.

`Unmarked` provides the means to analyze variation in abundance and in detection probability, as a function of variables of management interest as well as "nuisance" variables, for which we seek to statistically control and thus reduce error. Variables that can be modeled include temporal variation (e.g., abundance as a function of year) as well as spatial variation. The analysis is conducted at the level of the individual survey "event" (one station surveyed at one visit); thus, abundance is estimated for each survey station in each breeding season. The assumption we make is that true abundance at a survey station does not vary from one visit to another within the same breeding season, which defines the "closure". Thus, variation in the number of detections (including zero detections at a visit) for one survey station during one breeding season allows us to make inferences regarding detection probability. Examples of such analyses are presented in Liu et al. (2012), Wood et al. (2014) and Wood et al. (2016). Liu et al. (2012) specifically highlight and illustrate three distinct applications of these types of models: (1) analysis of models to provide site-specific estimates of abundance, (2) analysis of models to provide year-specific estimates of abundance, while correcting for variation in site-specific abundance, and (3) analysis of ecological variables (within a marsh site and at the landscape-level) that may influence abundance of CA Ridgway's rail. For example, analyses in Liu et al. (2012) indicated a highly significant drop in abundance in the Estuary from 2007 to 2008, both in the North Bay and South Bay regions. Liu et al.'s (2012) analysis also identified marsh size

**Comment [CTO98]:** Low detection probabilities can produce unreliable estimates of population abundance particularly with limited number of sites, or repeat visits. Simulations suggest that ~20 sites and <5 visits don't produce reliable estimates until detection probability is nearly 0.33. (http://www.mbr-pwrc.usgs.gov/workshops/BaysianPop2013/Nmix_intro_Euring_2013.pdf)

Prior estimates of detection probability were 0.18 and 0.2

Heterogeneity in detection probability may also need to be investigated and methods for doing so (independent assessments etc) should be outlined.

**Comment [JE99]:** Confusing sentence structure: this doesn't mean 3 stations, rather 3 visits, correct?

**Comment [JW100]:** Correct. Will clarify.

and marsh shape as significant predictors of CA Ridgway's rail abundance: density (birds per ha) is greatest at large, compact marshes~~,~~ (rounder vs. linear), but the effect of marsh size exhibited diminishing returns.

The site-specific protocol outlined here can be used for analysis of other species, but a limiting factor is the number of detections. For example, black rails may be detected in sufficient numbers at SPB to permit this type of analysis, but it is not clear whether that is the case for other secretive marsh bird species, besides black rails and CA Ridgway's rail. That said, other tidal marsh species such as tidal marsh song sparrows and common yellowthroats can be analyzed with these methods. Similar limitations apply at DESFB.

Another means to analyze detection probability is through distance sampling, specifically using the program DISTANCE (Buckland et al. 2001). We do not describe this approach in any detail since the use of repeated-visits in a mixture model is preferable. However, were repeated visits not available for a refuge for some reason, this would be a viable option. Note that distance sampling requires a number of restrictive assumptions, such as absence of movement during the survey period at a station.

**Comment [JE101]:** YES!

**Comment [JE102]:** Does "compact" mean "broad," i.e. non-linear? Also, degree of channelization (a function of configuration and size) is a variable.

**Comment [JW103]:** Yes, compact refers to the shape being more round than linear. I'll clarify.

## Element 5: Reporting

Reporting the results of marsh bird surveys is critical to the success of the monitoring program and involves presenting accurate, timely information in a format that can be used by those who can act on that information. This section describes two types of reports, annual reports and synthesis reports, and provides recommendations on the format and content of these reports, their distribution schedules and their recipients.

Annual reports are designed to briefly describe the survey effort for that season, to assess population indices, and to alert resource managers of sudden changes that could trigger more investigation. Annual reports also serve the purpose of fulfilling permit requirements. Synthesis reports involve analysis of multiple years of data to estimate population trends, assess response to conservation actions, and provides specific recommendations for improving habitat and species management.

*Annual reports*

After the completion of each survey season, an annual report will document the survey effort describing, at minimum, the sites and survey stations that were visited, survey dates, observer names, and number of unique detections by site (a.k.a. an observer-derived site estimate), and a density index (see Element 4, Analysis of density indices). The annual report should reference the methods described herein and document in detail any changes, interpretations or assumptions regarding the field methods or sampling design. Any problems or difficulties encountered and corrective measures taken as well as recommendations for improving the protocol should also be described.

The annual report should include an introduction, methods, results, and brief discussion. Describe conditions at the site or regionally that may affect the population (e.g., management activities, presence of predators, and changes in hydrology). However, relating changes in density indices to site conditions should be done with caution because CA Ridgway's rail data are highly variable and probability of detection, which is very low for this species, is not accounted for. The density indices can be useful in identifying sudden changes in the estimates which should prompt more in-depth analyses.

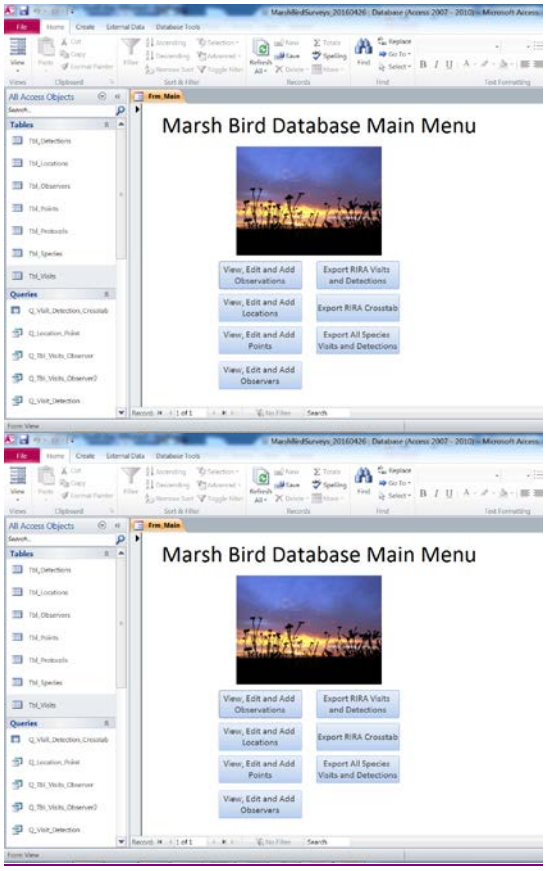
The marsh bird Access database has three built-in queries that can facilitate annual reporting: (1) RIRA Visits and Detections; (2) RIRA Crosstab and (3) All Species Visits and Detections. These queries are accessed from the database Main Menu by the three buttons in the right column.

**Comment [BG104]:** Not seeing a clear link between data collection/analysis and ultimately answering to mgt. objectives in this section. The point of all this, in the long-term is to determine whether we are successful (meet objectives) or not…and then to adapt as needed. Likely more appropriate in the synthesis reports. Just would like to see the link back to objectives somewhere in Element 5.

**Comment [BG105]:** Where do the management objectives fit in?

**Comment [BG106]:** Reference protocol or particular SOPs here? Be clear about what info should be included from this protocol.

**Comment [BG107]:** Developed as part of this protocol? Describe. First time this is mentioned in protocol (I think). Described in more detail in an SOP? If yes, reference here.




The RIRA Visits and Detections query exports core CA Ridgway's rail visit and detection information for all years and locations for DEFSB and SPB as a Microsoft Excel file; the file can be sorted by project, year, location, etc. for generating the annual density index and performing other specific analyses. This query excludes records that are > 200 m from the point, Outside Site, Outside Time, and Duplicate Birds.

The RIRA Crosstab query (built using the RIRA Visits and Detections query, above) exports a crosstab table that summarizes counts of CA Ridgway's rails on DESFB and SPB by location, year and visit. This query excludes records that are Outside Site and Duplicate Birds, and will be used to generate the observer-derived site estimates for complying with permitting reporting requirements. The total number of birds for a site should match the summary totals on the data form.

**Comment [BG108]:** Of what?

The All Species Visits and Detections query exports core marsh bird visit and detection information for all species, years and locations for DEFSB and SPB as a Microsoft Excel file;

the file can be sorted by project, year, location, etc. for specific analyses. This query excludes records that are Outside Site, Outside Time, Duplicate Visits and Duplicate Birds.

*Synthesis reports*

The format for synthesis reports should follow the recommended format for the annual report but will contain more details for the analysis methods, results, discussion and recommendations. Survey data from multiple partners operating throughout the Estuary should be solicited and compiled prior to the analysis. Solicited data would be in a format defined in the California Avian Data Center using the National Secretive Marshbird protocol standards (see here for descriptions: http://data.pointblue.org/science/biologists/php/protocolsearch.php). Current and historic data collected using different but compatible field methods (e.g., various "Type A" surveys with a 10-minute repeated visit structure) should also be included but the analysis will need to consider that the probability of detection may vary with survey method. Synthesis reports should be carried out by scientists with expertise in modeling zero-inflated data (excess number of points with zero detections) in conjunction with biologists familiar with the field methods and knowledgeable in the focal species' natural history. Synthesis reports will likely require three or more weeks of time for a statistician to complete in addition to the biologists' time. The analysis should follow the recommendations described in Element 4 Hierarchical modeling: Analysis of detection probability.

Analysis and synthesis reports should include:

- Estimates of detection probability
- Average density by site
- Trends in density by bay region and by refuge, if applicable
- Assessment of short-term trends and changes
- Response to restoration and management
- Associations with habitat and landscape characteristics

**Comment [BG109]:** What about the management objectives?

**Comment [BG110]:** Link back to management objectives?

**Comment [CTO111]:** Estimates of density and abundance at individual sites is also important. I recognize that these values are likely to be biased but "average density per site" is not an actionable metric for mitigation or prioritization of conservation action locations.

*Reporting schedule*

Annual reports should be distributed as soon as possible after the surveys are completed and no later than January of the following year. Synthesis reports should be completed every 3-5 years or as needed and as funding allows.

*Report distribution*

Reports will be distributed to all Estuary partners involved in CA Ridgway's rail and CA black rail surveys, Bay-Delta U.S. Fish and Wildlife Office, and any other interested partners such as tidal marsh landowners, and managers.

Copies of reports will be printed and stored at DESFB and SPB headquarters and on ServCat at the following address _____.

## Element 6: Personnel Requirements and Training

### *Roles and responsibilities*

Each refuge will have one coordinator (typically the refuge biologist) who will plan, schedule, and coordinate, and report on marsh bird surveys in each year. The coordinator is responsible for ensuring that all marsh bird surveyors are covered by a USFWS 10(a)(1)(A) permit (see Qualifications, below), all marsh bird surveyors have received adequate training (see Training, below) and all equipment is in working order (see SOP 3 and Element 3). The coordinator is responsible for planning and coordinating each season's surveys (see Schedule below), ensuring that new data sheets and maps are available for surveyors (see SOP 3 and Element 3 above) and analyzing and reporting on survey results (see Element 5). Marsh bird surveyors are responsible for completing the required training (see Training, below), conducting surveys (see SOP 3 and Element 3) and entering data into the database following surveys (see Element 4). Occasionally other refuge staff (e.g., biological technicians or volunteers) will assist with data entry.

**Comment [BG112]:** Consistent font – different from previous

### *Qualifications*

Marsh bird surveyors, those collecting data using this protocol, must be listed on the USFWS 10(a)(1)(A) (issued by the USFWS Ecological Services Program). This requirement stems from the presence of the federally listed CA Ridgway's rail in the tidal marshes on the refuges. All marsh bird surveyors must have average to above average hearing and vision and must be in good physical condition (e.g., able to walk long distances in cold and hot temperatures).

### *Training*

The following steps should be taken to train individuals in conducting marsh bird surveys:

1) Read the "Walking In the Marsh" document (Appendix A). This document provides information on increasing safety and reducing wildlife/plant impacts while conducting surveys.
2) Review SOP 1, including instructions for conducting surveys and recording data using the data sheet.
3) Learn to recognize calls of secretive marsh bird species using recorded vocalizations. Common rail species in the Estuary are Virginia rail, sora, CA black rail, and CA Ridgway's rail. Virginia rail and Ridgway's rail calls can sometimes be confused. Learn to recognize the calls of other marsh bird species (e.g., marsh wren, mallard, and ring-necked pheasant) as they can be confused with focal species calls when heard under less than optimal conditions.
4) After reviewing rail recordings, visit sites (at dawn and dusk) that are known to have rails or assist with surveys where rails are likely to be detected. Suggested sites include:
    a. CA ~~clapper~~Ridgway's-Ridgway's rails: Gallinas Creek (San Pablo Bay), Arrowhead Marsh (Central San Francisco Bay) and Faber Marsh (South San Francisco Bay).
    b. CA black rails: Gallinas Creek, Lower Tubbs Island/Tolay Creek (San Pablo Bay NWR), Rush Ranch, Peytonia Slough Ecological Reserve, and Hill Slough.

c. Sora and Virginia rails: Hill Slough diked marshes (right off Grizzly Island Road), Rush Ranch at Suisun Slough, Peytonia Slough Ecological Reserve and levee north of the Benicia-Martinez Bridge.

5) During site visits, someone experienced at identifying the variety of vocalizations that each rail species can make should accompany the ~~person~~trainee~~person~~ being trained.

6) All trainees should attend the annual survey training hosted by ISP and Point Blue.

7) All observers are required to receive training from a biologist carrying a 10(a)(1)(A) permit and to accompany her/him on at least ten surveys where Ridgway's Rails are detected. More training may be required and is up to the discretion of the permitted biologist.

8) Following the above steps, a person should demonstrate an ability to recognize and distinguish calls of different rail species and other similar sounding marsh birds. The person in training should also be able to demonstrate knowledge of how to avoid impacts to the marsh environment and the species it supports.

**Comment [BG113]:** Does the training include distance estimation – if not, include this as a training element here

## Element 7: Operational Requirements

### *Staff Time and Budget*

Table 5. Annual budget estimate for completing marsh bird surveys at Don Edwards San Francisco Bay National Wildlife Refuge (DESFB) assuming 10 transects and San Pablo Bay National Wildlife Refuge (SPB) assuming 8 transects.

| Refuge | FWS Staff Training and Preparation Time (hours) | FWS Staff Survey Time (hours) | Volunteer Time (hours) | Equipment Costs (e.g., batteries, fuel, etc.) |
|---|---|---|---|---|
| **DESFB** | 41 | 120 | 48 | $600 |
| **SPB** | 8 | 126 | 65 | $400 |

**Comment [A114]:** Don Edwards currently doesn't digitize maps, make maps or enter data. Not sure how long that takes and is not included in this number.

**Comment [JW115]:** Draft numbers

**Comment [TR116]:** Keep formatting consistent ($)

**Comment [JW117]:** Birds Draft numbers

**Comment [JW118]:** Draft numbers

### *Schedule*

Nov or Dec: Prior to the beginning of the rail breeding season, marsh bird surveyors attend the annual CA Ridgway's rail coordination meeting with ISP, Point Blue, CDFW, EBRPD, and others that may be conducting rail surveys that year. U.S. Fish and Wildlife Service Ecological Services staff are invited to attend as well. Research, studies and management are discussed, as well as planning and coordination of the upcoming field season.

Dec: The survey coordinator inventories equipment, purchases additional equipment if needed and tests/purchases batteries.

Jan: Marsh bird surveyors and trainees attend the annual field training (usually coordinated by ISP), which includes bird call id, compass skills, estimating distances and a mock survey.

Jan: The survey coordinator for each refuge determines the marsh transects that will be surveyed in that year, and the number of surveyors needed for each location. If time permits, one to two staff go out prior to the start of surveys to place numbered pinflags at survey stations, using a GPS unit and map.

Jan-Apr: The survey coordinator develops a schedule ~~for~~for when surveys will be completed on a weekly basis during the survey period (Jan 15-Apr 15). Factors to consider in the scheduling include weather, tide, date of the previous survey, moon cycles (See SOP 3), accessibility, and number of transects per marsh. Accessibility depends predominantly on levee conditions in wet weather.

**Comment [BG119]:** Scheduling should be initiated before Jan

Levees require 3 days minimum and up to two weeks to dry after a rain before they are safe to drive; this also limits damage to levees.

Jan-Apr: Permitted marsh bird surveyors conduct surveys.

Jan-Jun: Mapping marsh bird detections (immediately following a survey), data entry and proofing

Jun-Aug: Data preparation, ~~summarizing~~analysissummarizing, report writing

Comment [BG120]: Of what?

### *Coordination*

January surveys may coincide with waterfowl hunt days, and therefore we recommend scheduling surveys near hunt areas on non-hunt days, if applicable, or surveyors should wear orange safety vests.

DESFB staff often assist SPB staff with marsh bird surveys.

Communicating the survey schedule to other surveyors to avoid being in the same areas at the same time is critical to reduce the chances of an observer recording the broadcasts of another observer as a unique detection. (e.g., Point Blue will need to coordinate site visits with Avocet Research Associates at Sonoma Baylands because some of the survey stations are < 200 m apart.)

**Element 8: References**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## SOP 1: Field Methods – Version 1.0 – May 2016

## San Francisco Bay Secretive Marsh Bird Survey Field Methods

The following list of instructions describe the necessary steps to prepare for and conduct a secretive marsh bird survey. Refer to the numbered Elements in the San Francisco Bay Secretive Marsh Bird Survey Protocol for details.

### *Pre-survey Requirements*

1. Obtain required survey permits (See Element 6)
    a. USFWS Endangered Species Permit, ESA Section 10(a)(1)(A) including a List of Authorized Individuals containing the observer's name.
    **b.** California DFW Memorandum of Understanding (if applicable)
    **c.** Site-specific permissions (e.g. Special Use Permit from a NWR)
2. Training (See Element 6)
    a. All observers conducting surveys under this protocol are required to receive training from a biologist carrying a 10(a)(1)(A) permit and to accompany her/him on at least ten surveys where Ridgway's Rails are detected (see Element 6). More training may be required and is up to the discretion of the permitted biologist
    b. Attend annual secretive marsh bird field training and calibration sessions to identify secretive marsh bird calls, estimate distance to calling birds, record accurate bearing and review other aspects of data collection.
    c. Read and understand the "Walking in the Marsh" document (Appendix A).

### *Equipment*

- Vehicle and/or boat
- GPS Unit
- binoculars
- rangefinder
- thermometer (optional)
- anemometer (wind meter)
- compass with adjustable declination
- clipboard (optional: rope sling for carrying)
- rubber bands or clips (for holding forms on clipboard)
- sufficient blank data forms (Appendix B)
- map of the site and surrounding area with survey points
- portable speaker
    - Speaker volume should be between 80-90 dB at 1-m in front of the speaker without distortion
- audio player
    - USFWS-approved audio file with California Ridgway's rail and California black rail vocalizations and minute call-outs <insert link or contact for file>
- cell phone or radio (for safety and communication)
- water and snacks
- headlamp
- spare supplies (e.g., batteries, pens)

**Comment [BG121]:** Add bookmarks where appropriate throughout

**Comment [BG122]:** Loaded with survey points? And background imagery?

**Comment [BG123]:** Suggest rite-in-the rain paper?

- hat (large brimmed hats such as lifeguard hats that interfere with one's ability to hear clearly in all directions should be avoided. Hats that muffle one's ears should be folded or lifted fashionably above the ears during the 10-minute survey period.)
- sunscreen

***Environmental Restrictions***

1. Conduct surveys at tides when tidal sloughs are no more than bank full, approximately <4.5-ft MLLW at the Golden Gate tide station. Tide height at bank full will vary by site. Avoid high (flood) tides when possible.
2. Full moon periods should be avoided because birds may be attracted out of cover or a response may be elicited, and increase the likelihood of predation
3. Surveys should not be conducted in winds averaging >10 mph or with gusts reaching 15 mph which alters, distorts, or muffles rail vocalizations. An anemometer should be used to accurately measure wind speed.
4. Surveys should not be conducted during steady rain. Conducting surveys during precipitating fog and light, short duration showers is acceptable provided that observer's ability to accurately estimate distance and to record data onto the paper datasheets is not adversely affected.
5. Avoid surveying sites during particularly noisy periods such as commute hours or during construction. In some cases this will not be possible highlighting the importance of modeling the probability of detection.

***Survey Timing***

1. Conduct surveys between 15 January and 15 April. Because detection probability decreases later in the season, efforts should be made to complete most surveys by 25 March.
2. Surveys at a particular location should be spaced at least 1 week apart.
3. Surveys will be conducted within a 2-hour window and ideally, 80-90 minutes, centered on local sunrise or sunset (e.g., surveys may begin no earlier than 1 hour before sunrise or sunset and may extend no longer than 1 hour after sunrise or sunset).
4. Alter the direction or time of day (am vs. pm) of your surveys such that the same points are not surveyed during very dark or very light hours on each round. Ideally, each point should be visited close to peak calling time (sunrise/sunset) in at least one round which may involve arriving at the site earlier to start at the far end of the transect.
5. Ideally, round 1 should be completed from 15 January to 6 February, round 2 from 7 February to 28 February, and round 3 from 1 March to 25 March. The period from 25 March to 15 April can be used to finish any remaining surveys if previous visits were cancelled due to weather or other logistics.

***Data collection procedures***

*Pre-survey procedures and considerations*

1. We recommend that the same observer be used for all stations or points within a site-visit, that is, within one 2-hr session. However, it is preferable to use different observers for different visits within the same year (see *Sources of error*, pg. 38).
2. Approach the point count station with as little disturbance to the birds as possible, and begin your survey as soon as you are oriented and are confident you can estimate distances accurately and all necessary gear is ready (ideally, less than 1 minute).

3. Any bird flushed by an approaching observer within 10 m of the point count station should be recorded as within the survey. These individuals would have been detected during the survey had the observer's disturbance not flushed them. Birds that are flushed from farther away should be recorded as "outside survey time."
4. If something substantially interferes with your ability to detect birds during the 10-minute count (e.g., a loud airplane or vehicle), stop the count until the disturbance has passed and start over. Cross out the interrupted data and note what happened on your form.
5. Call-broadcast should be halted in the presence of a potential rail predator within 200 m of the point count station and not resumed until the predator leaves the area. If the predator does not leave the area within 10 minutes, resume the count without employing the broadcast.

*Document Site Conditions*

1. Record weather conditions at the beginning of each survey and, if desired, from any point count station during the transect as conditions change. Additional weather data can be recorded on the back of the form.
2. Record the temperature (in Farenheit or Celsius) either by estimating or using a thermometer.
3. Record sky conditions: 0 clear or a few clouds, 1 partly cloudy or variable sky, 2 cloudy or overcast, 4 fog or smoke, 5 drizzle, 6 rain, 8 showers.
4. Record wind speed using the Beaufort wind scale: 0 smoke rises vertically, 1 wind direction shown by smoke drift; 2 wind felt on face, leaves rustle; 3 leaves & small twigs in constant motion, light flag extended; 4 raises dust and loose paper, small branches are moved, 5 small trees with leaves sway, crested wavelets on inland.
5. Record noise levels at the site either by estimating and using the noise code or using a decibel meter and recording an average over a 10-second period and marking whether in dbA or dbC.

*Survey Procedure*

1. To begin the 10-minute survey, record the Station ID using the Site or Location code representing the marsh site and the 2-digit point number (e.g., DUMW01), record the time (24-hr clock) and press play on the audio device. The first bird detection will be entered on the next line below. The speaker should be placed on the ground or on the bow of the boat pointing toward the majority of the marsh and away from the observer. For your convenience, the sound track will announce the beginning of each 1-minute segment and the species call broadcasts will begin at minute 6. The call broadcasts should continue regardless of rail response. Rail vocalizations will be broadcast on each visit to every point, unless a potential rail predator is present (see above). If the broadcast is halted or not employed for any reason, enter a "Y" under "Playback halted?" and record in the notes a description of why.
2. Record all vocalizations for focal marsh birds on the datasheet
    a. Each individual bird is given its own line on the data sheet; detections for each bird are recorded by writing the call type within the minute it was detected (minute 1-10). A duetting pair will be recorded on two separate lines or rows with each individual receiving its own line of data. Only record the call type once per minute segment, even if a bird repeats the same vocalization multiple times within the same minute. Do not record detections from same individual on more than one

**Comment [BG124]:** This sentence does not seem necessary

line at a survey station. This may involve crossing out a line of data if the individual is discovered to have been already recorded from the *same* point. Individuals that were recorded from another point will be kept and marked as "detected from another point."

b. Record all detections using the following species-specific codes that correspond to the type of detection:
    i. All species: V = visual sighting
    ii. Ridgway's Rail: C = Clatter, D = duet, K = kek, B = kek-burr, KH=kek-hurrah, SK = squawk, CH = churr, P = purr.
    iii. Black Rail: KKD= ki-ki-doo, GR = grr, CHT = churt/krup, PE = peep, TCH = laugh.
    iv. Virgina Rail: G = grunt, T = tick-it, KI = kicker, KIU = kiu.
    v. Sora: WH = whinny, PW = per-weep, KEE = kee.
    vi. American Bittern: PL = pump-er-lunk, CP = chu-peep, KO = kok.
    vii. Least Bittern: COO = coo; KAK = kak, ERT = ert
    viii. Yellow Rail: CC = click click, CA = cackle, WHZ = wheeze
    ix. Predators (e.g., feral cats, raptors and corvids) and any notable behavior (e.g. nest building) should be recorded in the notes along with the station or point number the predator is closest to.
    x. Other bird species of interest can be recorded in the notes column.
c. Record the bearing to each individual rail detected relative to true north (i.e., compass declination should be set annually)
d. Record the distance to each individual marsh bird detected from the surveyor, standing at the center of the point count station. The distance should be to the location where an individual was first detected, regardless of its behavior. If the bird subsequently moves, do not change the original distance recorded.
e. Mark any rails detected from non-focal sites as "outside site." Whether a site is considered "focal" should be determined prior to the season and may depend on factors such as restoration, marsh type, and if a site is surveyed by another observer.

3. Rails detected before or after the 10-minute point count period will be recorded as "outside time."
4. If no birds are detected at a point, enter a zero under minute 1 and draw a line through the boxes to minute 10.
5. Skip a line to leave a blank row before entering the next point.

***Mapping detections and determining unique counts***

1. All detections will be mapped onto a paper map of the site AFTER the transect is complete to determine whether each detection is unique.
2. Using the compass with adjusted declination and a map of the site showing true north, plot the location of each detection onto the paper map.
3. To map the location, turn the compass dial until the desired bearing is aligned with the notch or arrow at the top of the compass. Place the compass on the map and rotate the compass until the north of the compass (marked "N" or 0 degrees) with the true north on the map. Most compasses with adjustable declination will have a series of red or black parallel orientation lines on the bottom of the dial that are aligned with true north.

**Comment [JW125]:** These codes might change in the FINAL to conform to definitions in the National Database in AKN.

4. Place the edge of the compass on the point count station. The edge of the compass will now be pointing in the direction indicated on the dial.
5. Create a scale bar by marking a small piece of paper that exactly matches the scale bar on the map. Alternatively, creating maps with concentric circles of known distance from each survey point will speed up the mapping process.
6. Hold the scale bar to the compass edge with 0 m originating at point count station.
7. Mark the map based on the estimated distance from the point count station to the individual.
8. Each mapped individual or pair is marked with a number or letter on the map that corresponds to the "map ref" field on the datasheet.
9. After mapping all individuals, assess which birds may be duplicates by looking for locations that fall within your distance estimation and bearing measurement error. Note that many factors can influence the estimated distance to calling birds such as wind, background noise, whether the bird is calling from within a channel, the direction of the bird's head relative to the observer, etc.
10. If there is reasonable doubt that two or more detections are duplicates, do not enter the suspected duplicates as unique individuals.
11. If two or more birds are considered duplicates, assign the unique detection to the point that is closest to the calling center (duplicate bird? = N). The other detection(s) will be entered as duplicate bird? = Y.
12. Sum the number of unique detections (duplicate bird = N) for each species (separately) for the entire focal site including birds detected outside the survey time (i.e., not during a 10 min count). Sum the number of unique detections for each focal site separately if more than one focal site is surveyed on the same datasheet.

## SOP 2 Data Management – Version 1.0 – April 2016

This SOP describes the database for storing marsh bird monitoring data and provides instructions for data entry, data validation, and database administration. The marsh bird monitoring data will temporarily reside in an Access database. In the future, the data will be migrated to the online California Avian Data Center (CADC; http://data.prbo.org/cadc2/), which is a node of the Avian Knowledge Network (AKN). A project for the marsh bird monitoring data has already been established in CADC, but the database requires some additional work before it is ready to be used. The fields in the Access database are consistent with the fields used by the National Marsh Bird Monitoring database.

**Comment [BG126]:** In the future, the refuge will enter that data in CADC and not the access database? Is the refuge ok with this? Is there a way the refuge could keep its database and just do a batch upload?

*Database description*

The marsh bird monitoring database is a relational database created in Microsoft Access that is a tool for storing and managing marsh bird survey data based on the North American Standardized Marsh Bird Monitoring Protocol (Conway 2015). The database consists of seven tables (Table 1). Note that some fields are a legacy of previous studies (e.g., the protocol comparison study <<insert citation>>), thus not all fields will be used for data entry and management in this SOP.

Table 1. Marsh bird Access database tables, fields and field definitions.

| Table Name | Field Name | Field Definition |
|---|---|---|
| Tbl_Detections | Visits_ID | Unique identifier that links to Tbl_Visits |
| | LocationDetected | Location/marsh site where the bird was detected (may be a location adjacent to the target survey location) |
| | MapRefCode | Map reference code |
| | SpeciesCode | 4-letter AOU bird species code |
| | NumDetected | Number of birds detected (historical data only; new data assumes one bird per detection record) |
| | Bearing | Direction to bird in degrees 0-360 |
| | Distance | Estimated distance to bird (meters) |
| | | |
| | Min1 – Min10 | Select detection type of bird during each time segment |
| | OutsideSite | Was this detection in the target site(s)? Y/N |
| | OutsideTime | Was this detection during the 10-minute survey period for the survey point? Y/N |
| | DuplicateBird | Was this bird counted from another station? Y/N (Mark "Y" only if the individual was entered as "N" from another point.) |
| | Obs_X | Enter X-coordinates of observer location if detection was not at an official survey station. UTM NAD83 |
| | Obs_Y | Enter Y-coordinates of observer location if detection was not at an official survey station. UTM NAD83 |
| | OtherCallType | Enter any non-standard detection types |
| | Notes | Additional details |
| Tbl_Locations | ID | Unique identifier |
| | Project | Project associated with the location; e.g., Don Edwards SF Bay NWR or San Pablo Bay NWR |

**Comment [BG127]:** My comments are from the perspective of someone first seeing these data fields/definitions – someone new to this needs to know what everything means and characteristics of values

A more complete database dictionary is needed (see RLGIS data dictionary as an example). I stopped reviewing after 1st page of this table. How is this linked to info starting on page 70 – which seems more like a data dictionary. If they are directly linked then put a note under this table telling reader where to go for more info on field values

**Comment [BG128]:** What is this? Where does this info come from? Describe more here

**Comment [BG129]:** ?

**Comment [BG130]:** List of 'target types'?

**Comment [BG131]:** Station or point – both terms used through this protocol. Check throughout

| | | |
|---|---|---|
| | Location | Site/location name |
| | LocationCode | Site/location code |
| | ISPName | Invasive Spartina Project site/location name |
| | ISPCode | Invasive Spartina Project site/location code |
| | Ownership | Site/location ownership |
| | Management | Entity that owns the site/location |
| | ProtectedAreaName | Entity that manages the site/location |
| | MarshQuality | Marsh quality for RIRA derived from Point Blue marsh quality model (high/low) |
| | MarshAge | Marsh age in 2016 (> or < 50 years) |
| | MarshAgeCode | Marsh age code (old or young) |
| | StrataCode | Strata code (old_high; old_low; young_high; young_low) |
| | AccessDifficulty | Access difficulty (low=drive or short walk; med=drive on levees, long walk; high=boat) |
| Tbl_Observers | ObserverName | Observer last name, first name |
| Tbl_Points | ID | Unique identifier |
| | Point | Survey point identification code |
| | Location | Location name/marsh name associated with the point |
| | Easting | X coordinate; UTM Zone 10 |
| | Northing | Y coordinate; UTM Zone 10 |
| | BAY | Bay code |
| | BAY2 | Bay code 2 |
| | PercHab50 | Percent of habitat within 50 meters of the point |
| | PercHab100 | Percent of habitat within 10 meters of the point |
| | FocalSite | Focal site associated with the point |
| | FocalSite2 | Second focal site associated with the point |
| | FocalSite3 | Third focal site associated with the point |
| | StationID | Secondary station/point identification code |
| | Subsite | Subsite associated with the point |
| | Area | Area of the location/marsh site associated with the point (hectares) |
| | PerimeterAreaRatio | Perimeter to area ratio of the location/marsh site associated with the point |
| | Perimeter | Perimeter of the location/marsh site associated with the point |
| | COMPLEX | Marsh complex |
| | MarshType | Marsh type |
| | YearRestored | Year marsh associated with the point was restored |
| | BinRestored | Bin restored |
| Tbl_Protocols | ID | Unique identifier |
| | ProtocolName | Marsh bird survey protocol name |
| | ProtocolDescription | Marsh bird survey protocol description |
| Tbl_Species | SpeciesCode | American Ornithologists' Union (AOU) 4-letter species code |

| | | |
|---|---|---|
| | CommonName | Species common name |
| | SciName | Species scientific name |
| Tbl_Visits | ID | Unique identifier |
| | Project | Project associated with the visit; e.g., Don Edwards SF Bay or San Pablo Bay NWR |
| | Organization | Name of lead observer's organization (e.g., USFWS, Point Blue, CADFW, EBRPD, ISP, USGS) |
| | Location | Location name of the focal site for the survey |
| | FocalSite2 | Adjacent location/site that could get detections |
| | FocalSite3 | Adjacent location/site that could get detections |
| | ObservationProtocol | Marsh bird survey protocol used during the visit; see Tbl_Protocols for definitions |
| | SurveyDate | Survey date |
| | SurveyYear | Survey year |
| | Visit | 1 = first survey of a given year, 2 = 2nd survey of a given year, etc |
| | DuplicateVisit | Is this a duplicate entry for the visit (e.g., a trainee's data entered in addition to main surveyor's data) Yes/No |
| | DataSharing | Data sharing rating; default value is "RAW" |
| | Observer | Primary observer (Last name, First name) |
| | Observer2 | Other observer (Last name, First name) |
| | Observer3 | Other observer (Last name, First name) |
| | MultipleObservers | No: one official observer/counter used at this station; Yes: multiple official observers/counters used at this station (for double observer studies only) |
| | Point | Survey point/station code (e.g., IDEAS26) |
| | StartTime | Time the survey at the point was started, four digits in military time (e.g., 1625 for 4:25pm) |
| | Detections | Yes if there were detections of any marsh birds recorded at the point; No if there were no detections |
| | Temperature | Temperature (degrees) |
| | TemperatureUnits | Celsius or Fahrenheit |
| | WindSpeed | Wind speed code (0-9) |
| | WindSpeedMPH | Wind speed (mph) |
| | WindDirection | 0-360 degrees |
| | SkyCode | 0 clear/few clouds 1 partly cloudy/variable 2 cloudy/overcast 4 fog/smoke 5 drizzle 6 rain 8 showers |
| | HighTideTime | Time of high tide, four digits in military time |
| | TideCode | Tide code |
| | BoatType | Boat type |
| | BackgroundNoise | 0 none; 1 faint; 2 moderate; 3 loud; 4 intense; 9 not recorded |
| | Noise | Background noise in decibels |
| | NoiseAorC | dbA or dbC |

| | | |
|---|---|---|
| | CB_Min1_5 | Call broadcast for minutes 1 through 5, enter "PASSIVE" |
| | CB_Min6 | Call broadcast for minute 6: enter PASSIVE or species code ending in "C" for complete or "I" for interrupted (e.g., "BLRAC" or "BLRAI") |
| | CB_Min7 | Call broadcast for minute 7: enter PASSIVE or species code ending in "C" for complete or "I" for interrupted (e.g., "RIRAC" or "RIRAI") |
| | CB_Min8 | Call broadcast for minute 8: enter PASSIVE or species code ending in "C" for complete or "I" for interrupted (e.g., "SORAC" or "SORAI") |
| | CB_Min9 | Call broadcast for minute 9: enter PASSIVE or species code ending in "C" for complete or "I" for interrupted (e.g., "VIRAC" or "VIRAI") |
| | CB_Min10 | Call broadcast for minute 10: enter PASSIVE or species code ending in "C" for complete or "I" for interrupted (e.g., "AMBIC" or "AMBII") |
| | BroadcastStopped | Was call broadcast stopped during the survey or not used during the survey? Yes/No; write the reason in Notes field (e.g., predator present, batteries died) |
| | Notes | Additional details |

Tbl_Visits stores information about visits to survey points such as observer, location name, date, start time, weather codes and call broadcast protocol. Each visit has a unique identifier (ID) that is an autogenerated number. This ID field is linked to Tbl_Detections in a one-to-many relationship (one visit record can have multiple detection records, but not the other way around). Tbl_Detections stores information about the detections made of individual birds during each unique visit to a survey point, such as visit ID, species, bearing, distance, call type and detection history (which call types were detected in 1-minute increments during the survey). The Tbl_Locations and Tbl_Points tables store information about survey locations and survey points, respectively. A location is a marsh site, and a point is a survey station along a transect. Tbl_Observers, Tbl_Species and Tbl_Protocols are lookup tables that are used to standardize data entry (e.g., ensure that the spelling of observer names is consistent), provide additional data for queries (e.g., provide the scientific name for a given species code), or document metadata (e.g., provide protocol descriptions).

The survey coordinators for Don Edwards San Francisco Bay National Wildlife Refuge (DESFB) and San Pablo Bay National Wildlife Refuge (SPB) will each manage their own local copies of the marsh bird database. In the future, the marsh bird monitoring database will be uploaded to the California Avian Data Center (CADC), which is managed by Point Blue Conservation Science (Point Blue).

*Data entry, verification, and editing*
**Proofing Data Sheets**

1) Upon returning from the field, surveyors should proofread their data sheets, making sure that they have been filled out completely. All data sheets should have been reviewed for completeness while in the field. However, some deficiencies in data recording may not be identified until all data sheets have been reviewed as a group and some errors are inevitable.
2) As part of the proofing process, surveyors must determine: (1) how many unique marsh birds were detected at each survey point; (2) the locations (marsh sites) where each bird was located when detected; (3) whether any of the marsh birds detected at a given point were detected previously at a different point; and (4) whether any of the detections were outside of the survey time (outside of the 10-minute survey window). Surveyors can use a variety of methods to confirm the information above, such as plotting locations of marsh bird detections on an aerial photo using the bearing and distance information recorded in the field. Surveyors have to individually determine whether two detections that are close together represent a single bird or two different birds (see SOP 1 for details). A given survey point may have multiple target locations/sites (e.g., a transect runs along a levee with two different marshes on either side that are both of interest for the survey). It is important to accurately identify the location/site where each bird was located when detected ("Location Detected"). If a bird is outside of all target site(s)/location(s) (e.g., an adjacent marsh that is not of interest for the survey), then the bird must be marked as "Outside Site." Birds that were detected outside of target site(s) are filtered out for reporting. Marsh birds that were detected at a previous point should be kept on the data sheet and entered into the database, but they must be marked as duplicate birds ("Duplicate Bird"). Duplicate bird records are filtered out for reporting. Likewise, birds detected outside of the 10-min survey window are marked as "Outside Time" and are filtered out for reporting.

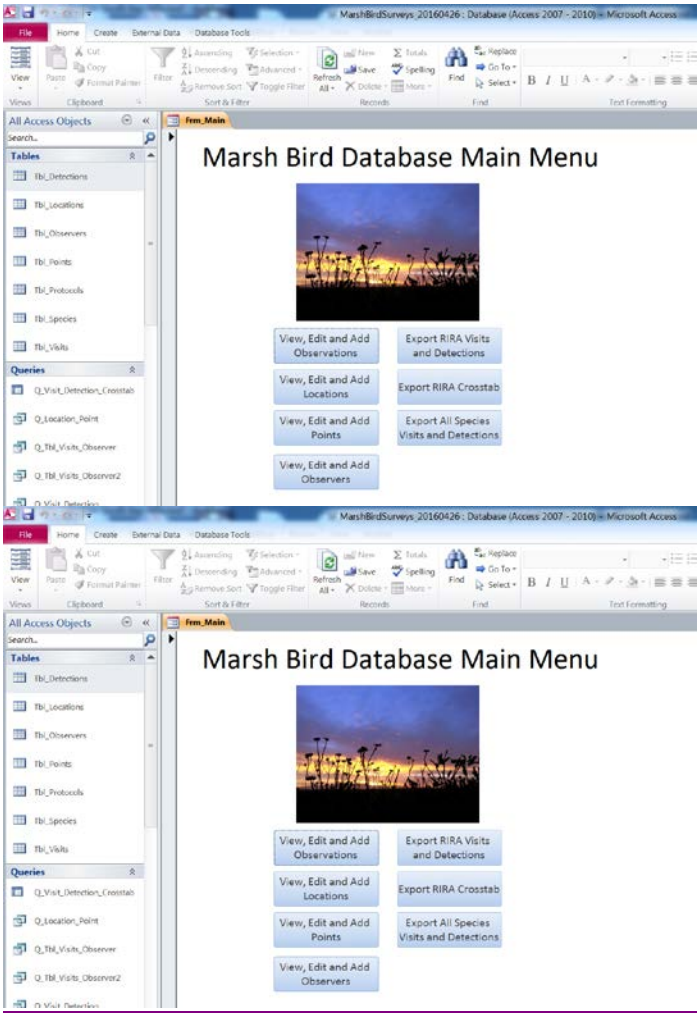
**Scanning Data Sheets**

3) After proofing the original data sheets and as soon as possible upon returning from the field, surveyors should scan each original field data sheet and review each resulting pdf for clarity. The scanned data sheets are a back-up copy in the event that the original data sheet is lost, thus it is important that they are readable. All scans should be saved to the appropriate refuge server (<<insert folder paths on DESFB servers where pdfs are stored>>) with filename "YYYY RIRA datasheets xxxNWR YYYY~~YYY~~_MM_DD.

**Entering Data into the Marsh Bird Database**

4) Once the hardcopy datasheets are scanned, the data are entered into the Access database for the appropriate refuge, preferably by the marsh bird surveyor who collected the data (sometimes data entry will be completed by a refuge intern or volunteer). All information that is included on a data sheet should be included in the database.
5) When the surveyor opens the Access file, they will see the Marsh Bird Database Main Menu. The main menu shows four buttons for data entry (left column) and three buttons for data export (right column).

**Comment [BG132]:** Has the refuge used these directions to enter data into the database? If not, I think it would be good for them to do a quick test/run through before finalizing this protocol.

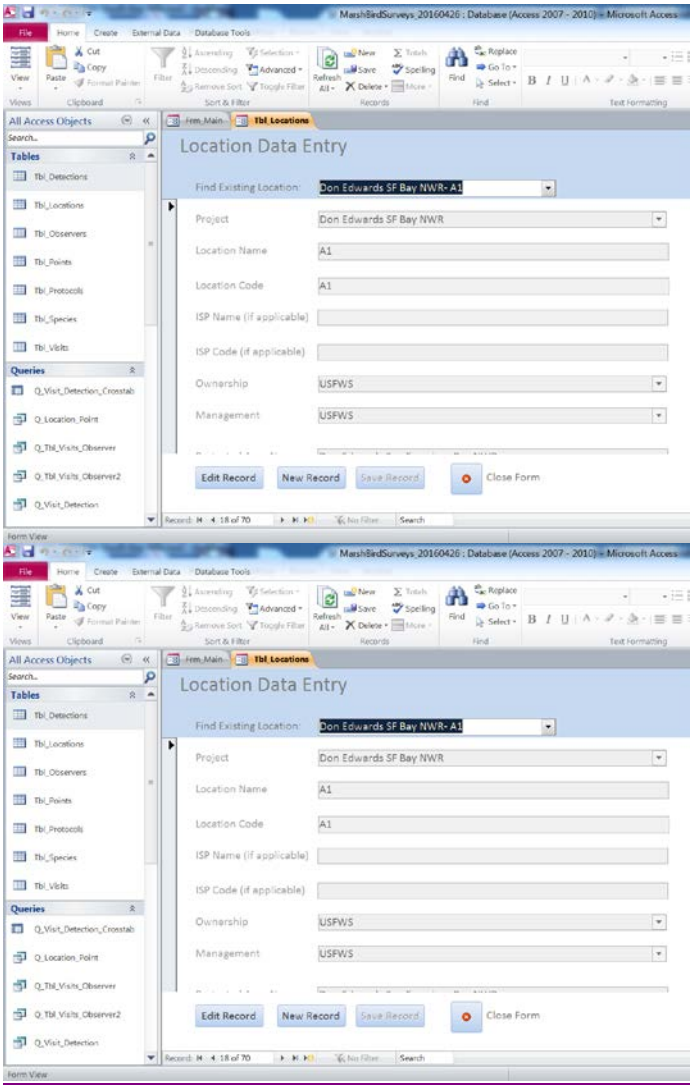



6) Survey locations, points and observers are not manually keyed in during data entry for each visit; rather, the data entry person will select from a list of locations, points and observers that have been prepopulated in the Locations, Points and Observers tables. This minimizes errors due to mistyping. Before entering any data for a given survey season, the survey coordinator should ensure that all survey locations, points, and observers are already in the database.

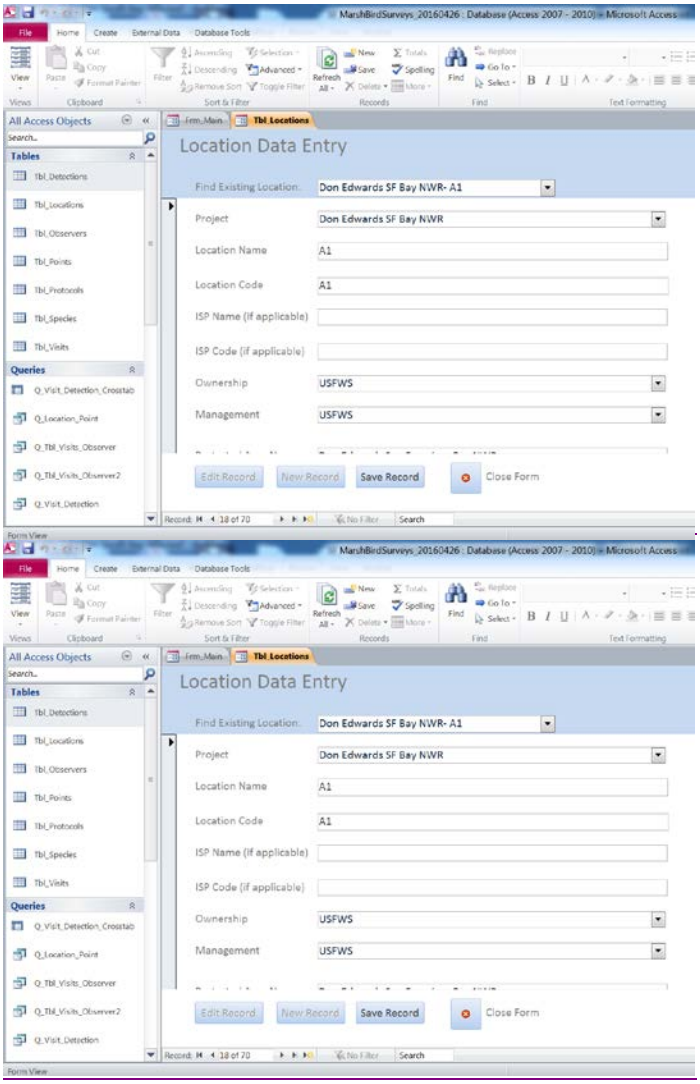
**Viewing, Editing and Adding Locations**

7) To **find and view an existing location**, click the "View, Edit and Add Locations" button from the Main Menu. Use the "Find Existing Location" toggle list at the top of the Location Data Entry page. When you select the location of interest, you will be able to

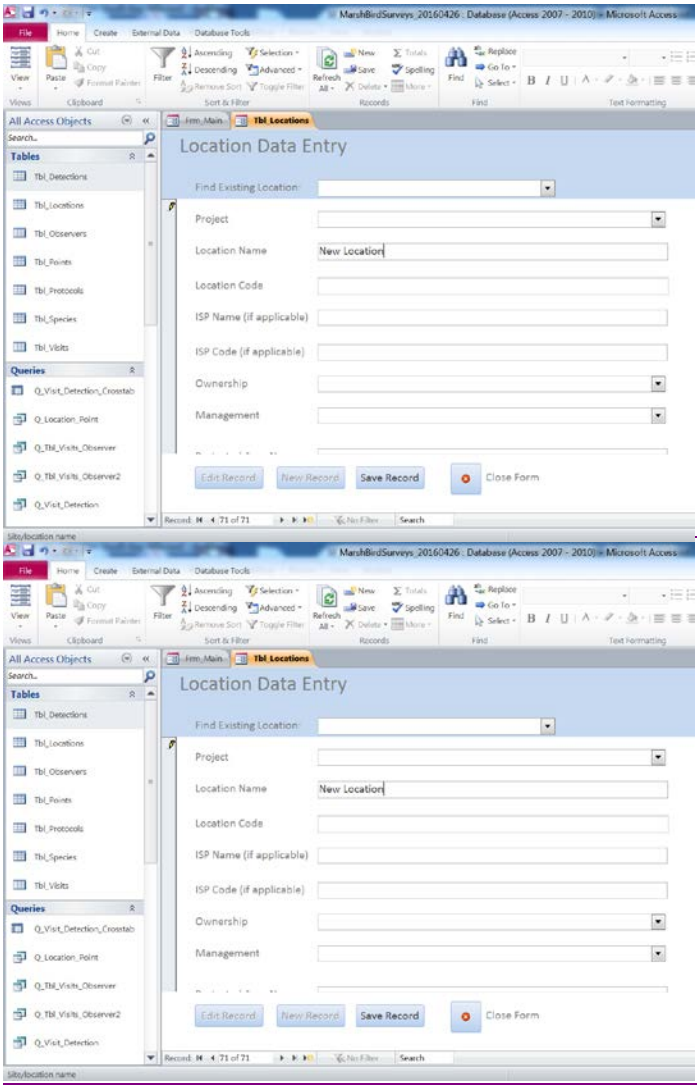
view information for that record.




8) To **find and edit an existing location**, click the “View, Edit and Add Locations” button from the Main Menu. Use the “Find Existing Location” toggle list at the top of the Location Data entry page to select the location you want to edit. When you have selected the location of interest, click the “Edit Record” button at the bottom of the page. The fields for that record will now be editable. Make the edits, then click “Save Record” at the bottom of the page. Click “Close Form” to return to the Main Menu.

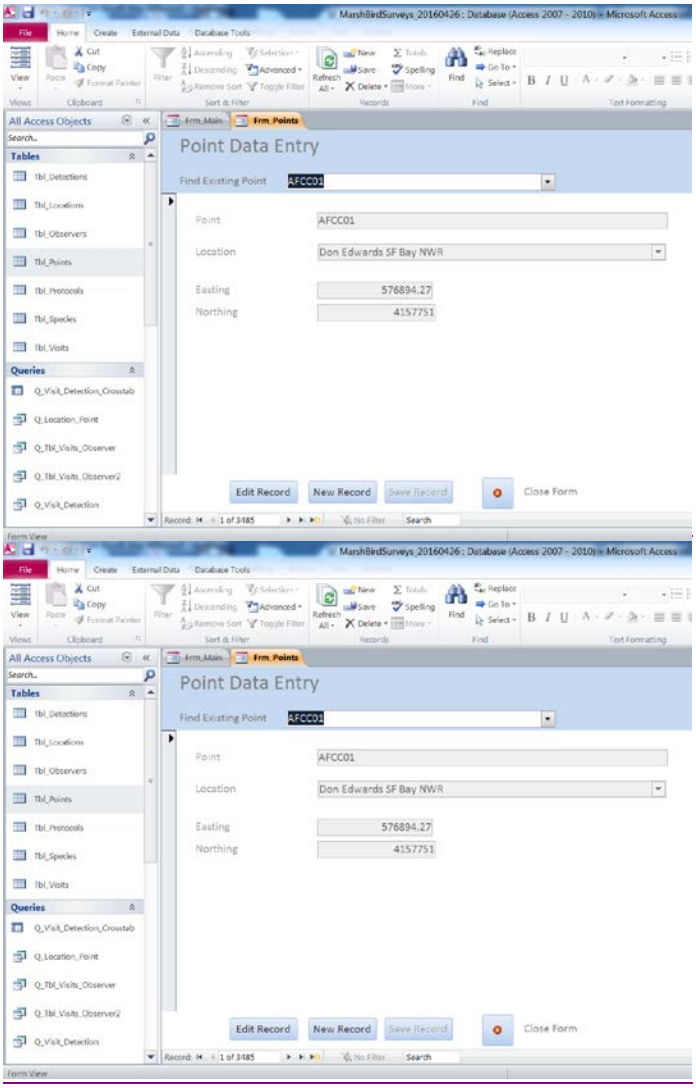



9) To **add a new location**, click the "View, Edit and Add Locations" button from the Main Menu. Use the "Find Existing Location" toggle list at the top of the Location Data Entry page to make sure the location isn't already in the database. If it isn't in the database, click the "New Record" button at the bottom of the page. This will open a new record with editable fields. Add the information for the new location, then click "Save Record" at the bottom of the page. Click "Close Form" to return to the Main Menu.

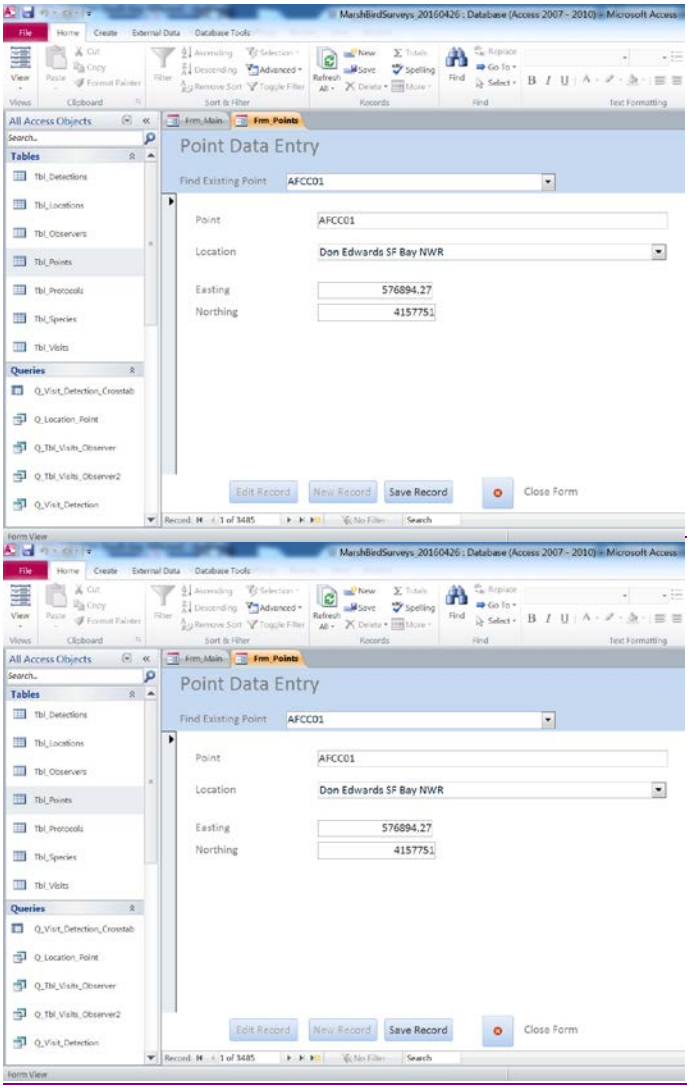



**Viewing, Editing and Adding Points**

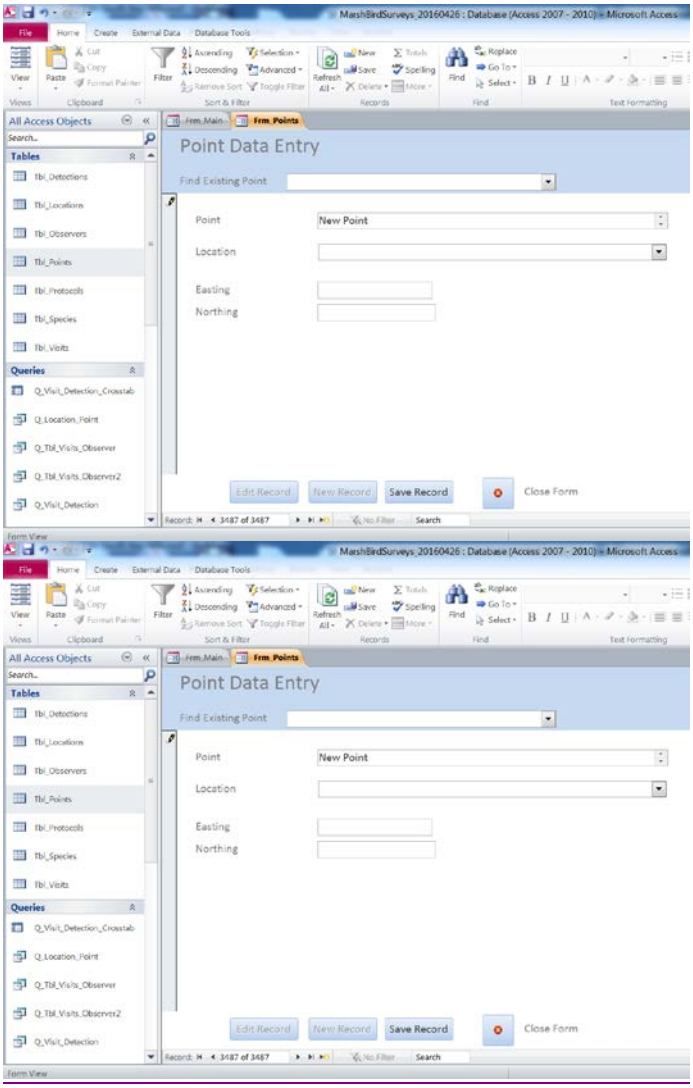
10) To **find and view an existing point**, click the "View, Edit and Add Points" button on the Main Menu. Use the "Find Existing Point" toggle list at the top of the Point Data Entry page. When you select the location of interest, you will be able to view information for that record.




11) To **find and edit an existing point**, click the "View, Edit and Add Points" button on the Main Menu. Use the "Find Existing Point" toggle list at the top of the Point Data Entry page to select the point you want to edit. When you have selected the point of interest, click the "Edit Record" button at the bottom of the page. The fields for that record will now be editable. Make the edits, then click "Save Record" at the bottom of the page. Click "Close Form" to return to the Main Menu.

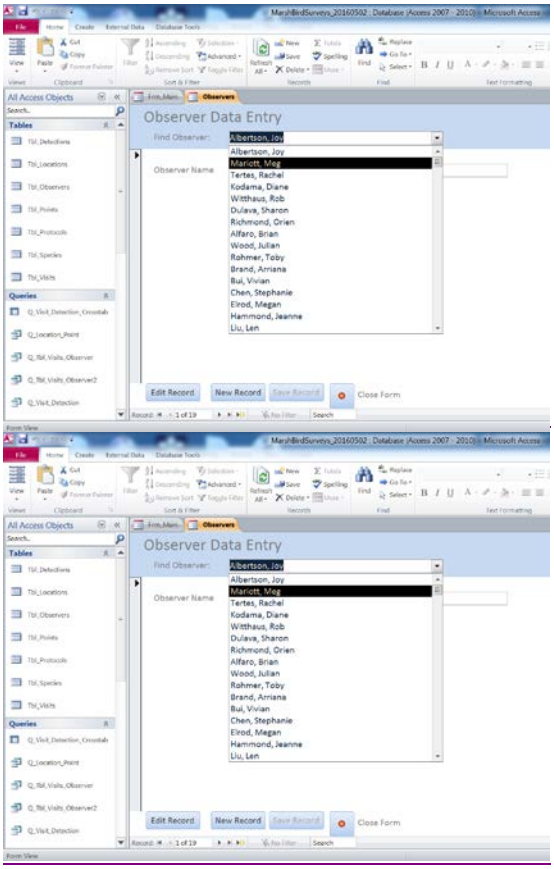



12) To **add a new point**, click the "View, Edit and Add Points" button on the Main Menu. Use the "Find Existing Point" toggle list at the top of the Point Data Entry page to make sure the point isn't already in the database. If it isn't in the database, click the "New Record" button at the bottom of the page. This will open a new record with editable fields. Add the information for the new point, then click "Save Record" at the bottom of the page. Click "Close Form" to return to the Main Menu. Note: if the new point is at a new location, you will need to add the new location first before you add the new point.

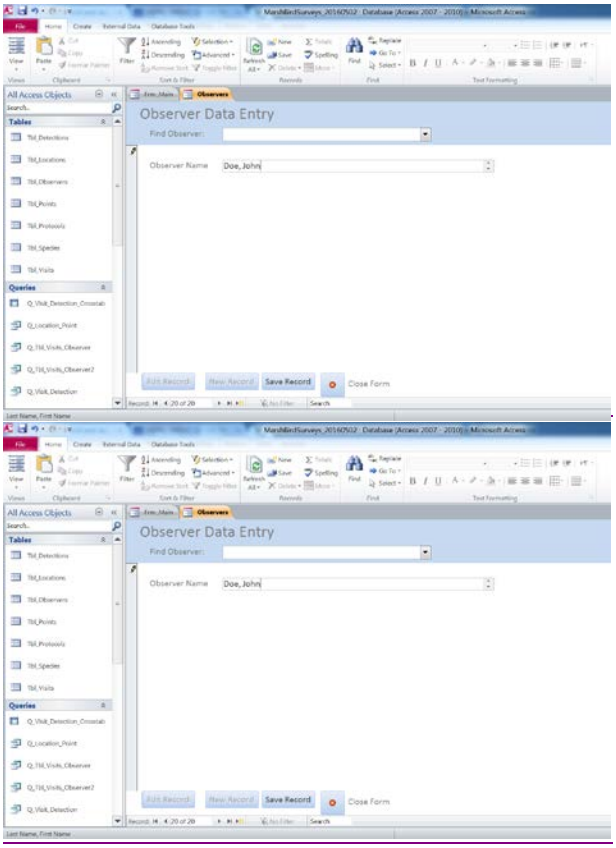



**Viewing, Editing and Adding Observers**

13) To **find and view an existing observer**, click the "View, Edit and Add Observers" button on the Main Menu. Use the "Find Observer" toggle list at the top of the Observer Data Entry page to view existing observers.



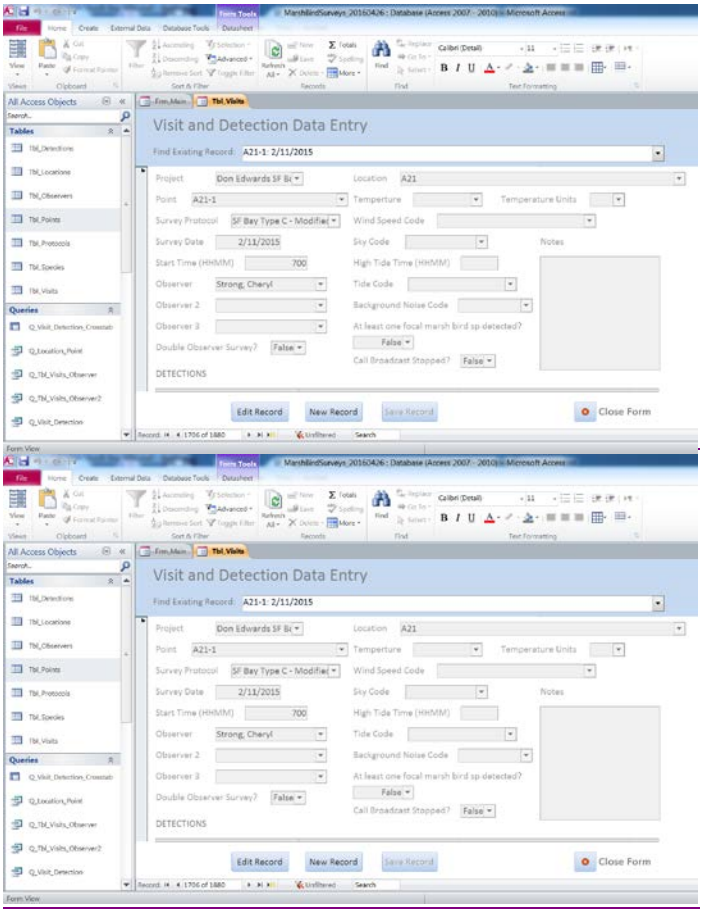

14) To **find and edit an existing observer**, click the "View, Edit and Add Observers" button on the Main Menu. Use the "Find Observer" toggle list at the top of the Observer Data Entry page to select the observer you want to edit. When you have selected the observer of interest, click the "Edit Record" button at the bottom of the page. The field for that record will now be editable. Make the edits, then click "Save Record" at the bottom of the page. Observer names should always be in this format: "last name, first name". Click "Close Form" to return to the Main Menu.
15) To **add a new observer**, click the "View, Edit and Add Observers" button on the Main Menu. Use the "Find Observer" toggle list at the top of the Observer Data Entry page to make sure the observer isn't already in the database. If they aren't in the database, click the "New Record" button at the bottom of the page. This will open a new record with editable fields. Add the name for the new observer, then click "Save Record" at the bottom of the page. Observer names should always be in this format: "last name, first name". Click "Close Form" to return to the Main Menu.



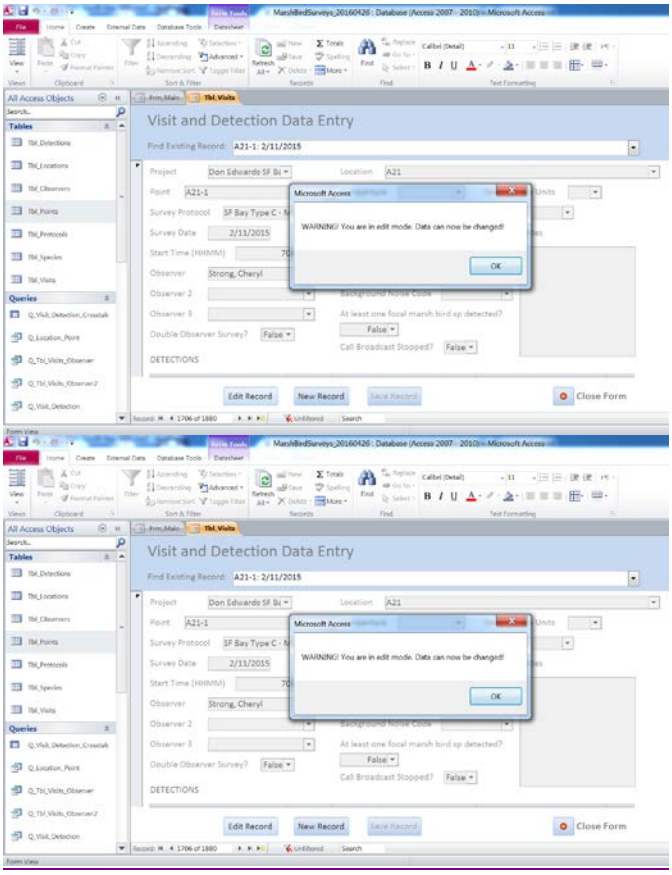

**Viewing, Editing and Adding Observations**

16) After all site locations, points and observers have been entered into the appropriate forms, you can then work with viewing, editing and entering observations (visit and detection data).

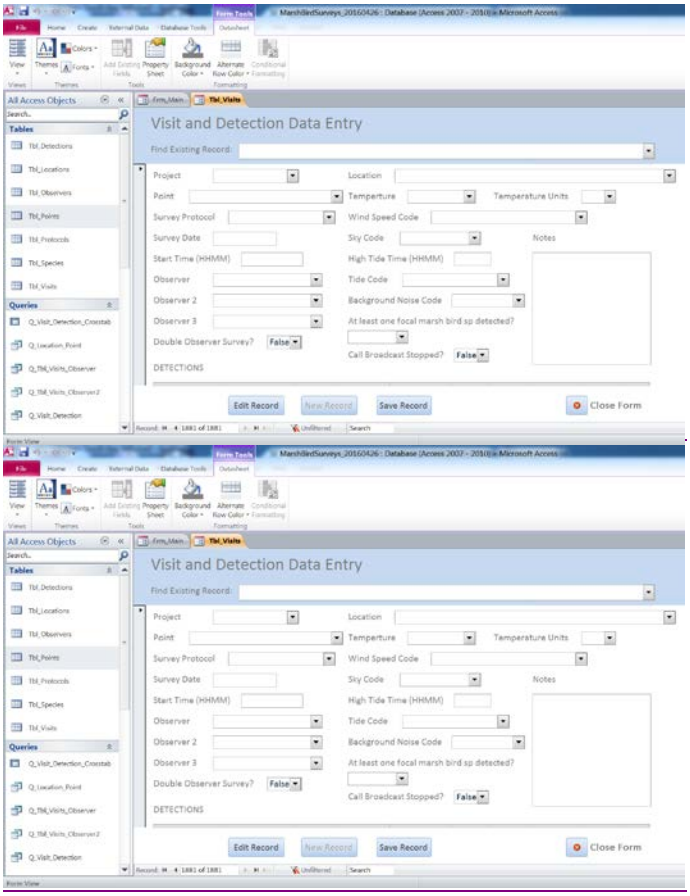
17) To **find and view observations**, click the "View, Edit and Add Observations" button on the Main Menu. Use the "Find Existing Record" toggle list at the top of the Visit and Detection Data Entry page. Observations are selected using the point name, date, visit and project. When you select the observation of interest, you will be able to view information for that record.




18) To **find and edit an existing observation**, click the "View, Edit and Add Observations" button on the Main Menu. Use the "Find Existing Record" toggle list at the top of the Visit and Dection Data Entry page to select the observation you want to edit. Observations are selected using the point name, date, visit and project. When you have selected the observation of interest, click the "Edit Record" button at the bottom of the page. A warning box will pop up saying "WARNING! You are in edit mode. Data can now be changed." Click OK. The fields for that record will now be editable. Make the edits, then click "Save Record" at the bottom of the page. Click "Close Form" to return to the Main Menu.




19) To **add a new observation**, click the "View, Edit and Add Observations" button on the Main Menu. You can use the "Find Existing Record" toggle list at the top of the Visit and Detection Data Entry page to make sure the observation isn't already in the database. Observations are selected using the point name, date, visit and project. If the observation isn't in the database, click the "New Record" button at the bottom of the page. This will open a new record with editable fields. Add the information for the new observation, then click "Save Record" at the bottom of the page. Click "Close Form" to return to the Main Menu. Note: if the new observation is at a new location or new survey point or conducted by a new observer, you will need to add the location, point or observer first (see above sections) before you add the observation (visit and detection data).




**More Details on Adding Observations: Visit Form**

20) More details on data entry for observations (visit and detection data) are provided below because this is the most critical part of the data entry process. The Visit and Detection Data Entry form is divided into two sections. The upper section contains the visit information (Visit Form), and the lower embedded subform contains the detection information (Detection Subform). Multiple detection records can be associated with a single visit. **Each unique marsh bird detected during a visit at a point should have exactly one record (row) in the Detection Subform**; e.g., RIRA duets should be entered as two unique birds, each with its own row of data in the Detections Subform. There are two exceptions to the "one bird, one record" rule: (1) **A bird detected at multiple points will have multiple records (rows) in the database, one record/row for each point where it was detected.** The first detection is the detection that we will use to summarize data at the location/marsh site scale; the other detections should be marked as "Duplicate Bird," see below. Duplicate birds are filtered out when we report abundance indices at the location/marsh site scale. (2) If you are recording flocking marsh birds (e.g., American

coots), you can enter one record/row of data for a flock and include the number of birds present in the Notes column.

21) **Project**: Select the project that the observation is associated with. Refuge staff should select "Don Edwards SF Bay NWR" or "SPB NWR".
22) **Location**: You must select the project first before you select the location (locations are filtered by project). Select the location where the survey point is located. If you don't see the appropriate location in the pick list, then add the location ("View, Edit and Add Locations button on the Main Menu", see above). Note: individual birds may be detected at a site adjacent to the site where the point is located. The site where individual birds are located is recorded later in the Detections Subform.
23) **Point**: You must select the location first before you select the point (points are filtered by location). Select the point where the survey was conducted. If you don't see the appropriate point in the pick list, then search existing points and add a new point if necessary ("View, Edit and Add Points" button on the Main Menu, see above).
24) **Protocol**: Select the protocol that was used for the survey. The options are:
    - 2-Species North American Marsh Bird Protocol: 10 min point count; all visits have 5 min passive listening; 30 sec each of BLRA, RIRA call broadcast interspersed w/ 30 sec silence each; 3 min passive listening
    - 5-Species North American Marsh Bird Protocol: 10 min point count; all visits have 5 min passive listening; 30 sec each of BLRA, RIRA, SORA, VIRA, AMBI call broadcast interspersed w/ 30 sec silence each
    - SF Bay Type A – Standard: 10 min point count; first 2 visits are passive listening; 3rd visit is passive if RIRA were detected previously at that point, otherwise 5 min passive listening; 1 min RIRA call broadcast; 4 min passive listening
    - SF Bay Type B – Stationary: 120 min point count; all passive, usually with one observer at each survey point
    - SF Bay Type C – Modified: 10 min point count; all visits have 5 min passive listening; 1 min RIRA call broadcast; 4 min passive listening
    - Passive: 10 min point count; passive (no call broadcast). Use of this protocol could be due to a predator being present or equipment trouble.

    For DESFB and SPB, we assume that each location/marsh site will be visited three times within a season using the 2-Species North American Marsh Bird Protocol. If a predator is close to a survey point or if a surveyor's equipment isn't functioning (i.e., low batteries), then the Passive protocol may sometimes be used.

25) **Survey Date**: Enter the survey date in MM/DD/YYYY format, or you can click on the calendar icon to select the date. Remember to double check the date to make sure it is correct.
26) **Visit**: Select the survey visit (1, 2, 3, etc.), which corresponds to the visit number for that point in a given year; e.g., the first visit of the season would be "1"; the second visit of the season would be "2", etc.
27) **Start Time**: Enter the time the survey at the point was started, four digits in military time (e.g., 1625 for 4:25pm)

28) **Observer**: Select the primary observer from the drop-down list. If you don't see the observer in the list, then add the observer to the Observer table ("View, Edit and Add Observers button on the Main Menu", see above).
29) **Observer 2**: If there is a second observer, select their name from the drop-down list. If you don't see the observer in the list, then add the observer to the Observer table ("View, Edit and Add Observers button on the Main Menu", see above).
30) **Observer 3**: If there is a third observer, select their name from the drop-down list. If you don't see the observer in the list, then add the observer to the Observer table ("View, Edit and Add Observers button on the Main Menu", see above).
31) **Duplicate Visit**: The default value for this field is False/No. Select "Yes" if the visit being entered is a duplicate; e.g., a trainer and trainee complete a survey. The trainer enters their data (the official data) but wants the trainee to get practice entering their data sheet. The trainee's data is a duplicate visit. Records marked "Yes" will be filtered out when reporting abundance indices by location.
32) **Temperature**: Select the temperature in degrees.
33) **Temperature Units**: Select Celsius or Fahrenheit.
34) **Wind Speed Code**: Select the appropriate wind speed code:
    - 0 – Calm: Calm, smoke rises vertically (<1 mph)
    - 1 – Light air: Smoke indicates direction (1-3 mph)
    - 2 – Light breeze: Wind felt on face (4-7 mph)
    - 3 – Gentle breeze: Leaves and twigs moving (8-12 mph)
    - 4 – Moderate breeze: Small branches moving (13-18 mph)
    - 5 – Fresh breeze: Small trees sway (19-24 mph)
    - 6 – Strong breeze: Large branches moving (25+ mph)
    - 8 – Other (does not fit a code)
    - 9 – Not recorded
35) **Sky Code**: Select the appropriate sky code:
    - 0 – Clear or few clouds
    - 1 – Partly cloudy (scattered)
    - 2 – Cloudy (broken) or overcast
    - 4 – Fog or smoke
    - 5 – Drizzle
    - 7 – Snow
    - 8 – Showers
    - 9 – Not recorded
36) **High Tide Time**: (Optional) Enter the time of the high tide at the nearest tide station using four digits in military time (e.g., 1625 for 4:25pm).
37) **Tide Code**: (Optional) Select the appropriate tide code:
    - 1 – High tide
    - 2 – Almost high and rising
    - 3 – Almost high and falling
    - 4 – Half tide, rising
    - 5 – Half tide, falling
    - 6 – Almost low, rising
    - 7 – Almost low, falling

- 8 – Low tide
- 9 – Not applicable

38) **Background Noise Code**: Select the appropriate background noise code:
    - 0 – No background noise during most of the survey
    - 1 – Faint background noise for >half of the survey
    - 2 – Moderate background noise; hard to hear birds >100 m
    - 3 – Loud background noise; hard to hear birds >50 m
    - 4 – Intense background noise; hard to hear birds >25 m
    - 9 – Not recorded
39) **At least one focal marsh bird species detected?**: Select "Yes" if at least one of the focal marsh birds was detected (this may depend on the project, for DESFB and SPB, the focal marsh bird species include RIRA, BLRA, VIRA, SORA, YERA, AMBI and LEBI). Otherwise, select "No."
40) **Call broadcast not used or stopped?**: Select "Yes" if call broadcast was interrupted *or* never used during the survey. This may be due to a nearby predator or equipment problems. Otherwise, the default value is set to "No."
41) **Notes**: Enter any notes about the visit that are relevant (e.g., sources of noise that could affect the survey, presence of predators, etc.).

**More Details on Adding Observations: Detection Subform**

42) **Species Code**: Select the species code for the bird that was detected:
    - RIRA – California Ridgway's Rail
    - BLRA – California Black Rail
    - VIRA – Virginia Rail
    - SORA – Sora
    - YERA – Yellow Rail
    - AMBI – American Bittern
    - LEBI – Least Bittern
    - PBGR – Pied-billed Grebe (optional)
    - COGA – Common Gallinule (optional)
    - AMCO – American Coot (optional)
43) **Map Reference Code**: Enter the map reference code used by the surveyor to identify the bird on a map/aerial photo.
44) **Bearing**: Enter the compass bearing to the bird (0-360)
45) **Distance**: Enter the estimated distance to the bird in meters
46) **Distance Aid**: Select the distance aid used to estimate distance:
    - 0 – None
    - 1 – Range finder
    - 2 – Distance bands on aerial photograph
    - 3 – Surveyor flags tied to vegetation
    - 9 – Not recorded
47) **Min1 – Min10**: For each minute of the 10-minute survey, the default value is "Absent," meaning there were no detections of the bird in each 1-minute segment. For each 1-minute segment in which the bird *was* detected, select "Present" *or* the method by which the bird was detected (visual or auditory by call type):

- Visual – V
- RIRA: B – kek burr
- RIRA: C – clatter
- RIRA: D – duet
- RIRA: CH – churr
- RIRA: H – hoo
- RIRA: K – kek
- RIRA: KH – kek-kurah
- RIRA: P – purr
- RIRA: SK – squawk
- BLRA: cht – churt/krup
- BLRA: gr – grrr
- BLRA: kkd – ki-ki-doo
- BLRA: tch – tch/laugh
- VIRA: G – grunt
- VIRA: KI – kicker
- VIRA: kiu – kiu
- VIRA: kk – kikik
- VIRA: T – tick-it
- SORA: kee – kee
- SORA: pw – per-weep
- SORA: wh – whinny
- YERA: ca – cackle
- YERA: cc – click-click
- YERA: whz – wheeze
- AMBI: cp – chu-peep
- AMBI: ko – kok
- AMBI: pl – pump-er-lunk
- LEBI: coo – coo
- LEBI: ert – ert
- LEBI: kak – kak
- COGA: gu – giddy-up
- COGA: wo – wipe-out
- AMCO: bu – burr-up
- AMCO: hk – honk
- AMCO: hu – hic-up
- PBGR: hy – hyena
- PBGR: ow – owhoop

48) **Location Detected**: Select the location/marsh site where the bird was detected. This may be different than the location where the survey point is located (e.g., an adjacent marsh that is also of interest for monitoring).

49) **Outside Site**: The default value for this field is False/No. Select “Yes” if the bird was detected outside of all locations/marsh sites of interest for the survey. Records marked “Yes” will be filtered out when reporting abundance indices by location.
50) **Outside Time**: The default value for this field is False/No. Select “Yes” if the bird was detected ONLY outside of the 10-minute survey period. Records marked “Yes” will be filtered out when reporting abundance indices by location.
51) **Duplicate Bird**: The default value for this field is False/No. Select “Yes” if the bird was already detected at a previous survey point/station during the same survey. Records marked “Yes” will be filtered out when reporting abundance indices by location.

**Proofing Entered Data**

52) After all data from each data sheet have been entered, the data entry person will initial and date the “Data Entered” line in the box on the bottom of that data sheet.

53) After initial data entry, each record in the database will be individually proofed for errors against the original data sheets. The same person that entered the data will proof the data in the database, reviewing the data and summaries (from queries) to check for typos, errors, and blank fields. As each datasheet is proofed, date and initial the “Data Proofed” line on the bottom of that data sheet. It is the responsibility of the survey coordinator at each refuge to ensure that data entry and data proofing are completed promptly following a survey (within one week).

*Metadata*

The Access databases that will be maintained by DESFB and SPB contain important metadata (e.g., field definitions in the design views of tables). This protocol document should be attached to each version of the Access database.

*Data security and archiving*

Original hardcopies of datasheets will be stored in 13-8.10 of the WLD Files at DESFB. Scanned copies of data sheets will be maintained on refuge servers, which are protected by the USFWS firewall M:\REFUGES & PROGRAMS\BIOLOGY\MARSH_BIRDS\Data. The Access databases for each refuge that store all marsh bird survey data will be backed up to refuge servers. The USFWS is responsible for performing periodic backups of all data residing on refuge servers. Each year, after all data for the survey year has been entered and proofed for each refuge, the survey coordinator for each refuge will export all of their data residing in the database and store as an archived copy (.csv or .txt). This archived flat file must be stored on each refuge’s server. Annual reports with data tables (raw counts per marsh site) will be archived on ServCat.

In the future, marsh bird data for both refuges will be managed online in the California Avian Data Center (CADC).

Appendix A. (Attached) Walking in the Marsh

Appendix B. (Attached) San Francisco Bay Marsh Bird Survey Datasheet


NATIONAL
WILDLIFE
REFUGE
SYSTEM