5. SURVEY TRENDS 2004 – 2010

Annual data were collected on both *Spartina* and clapper rail populations from 2004 to 2010 at thirty (n=30) sites within four regions in the San Francisco Bay (**Figure 35, Table 15**). These data are plotted together to demonstrate the change in both populations over time. Straight lines fitted to the *Spartina* and clapper rail data show a declining population bay-wide over the study period. Although the linear regression poorly fits the data (which are non-linear), it serves to illustrate a general trend over this six year period. Clapper rail numbers declined in all regions during the study period. The negative trend in rail populations is greatest in regions heavily invaded by non-native *Spartina*.

At the 30 sites invaded by non-native *Spartina*, clapper rail populations increased for the first three years of the study period and declined for the subsequent three years. Between 2005 and 2006 annual clapper rail numbers increased by 42% and again in 2007 by 25%. From 2007 to 2008, clapper rail call count numbers decreased by -35%. Liu, et al (2009) also detected the decline during these years, using different methods of analysis. Clapper rail numbers declined again from 2008 to 2009 by about -32%, and to a lesser degree, from 2009 to 2010 by about -13%. During the study period, clapper rail numbers declined overall by about -32% from 2005 to 2010 at the 30 sites invaded by non-native *Spartina*.

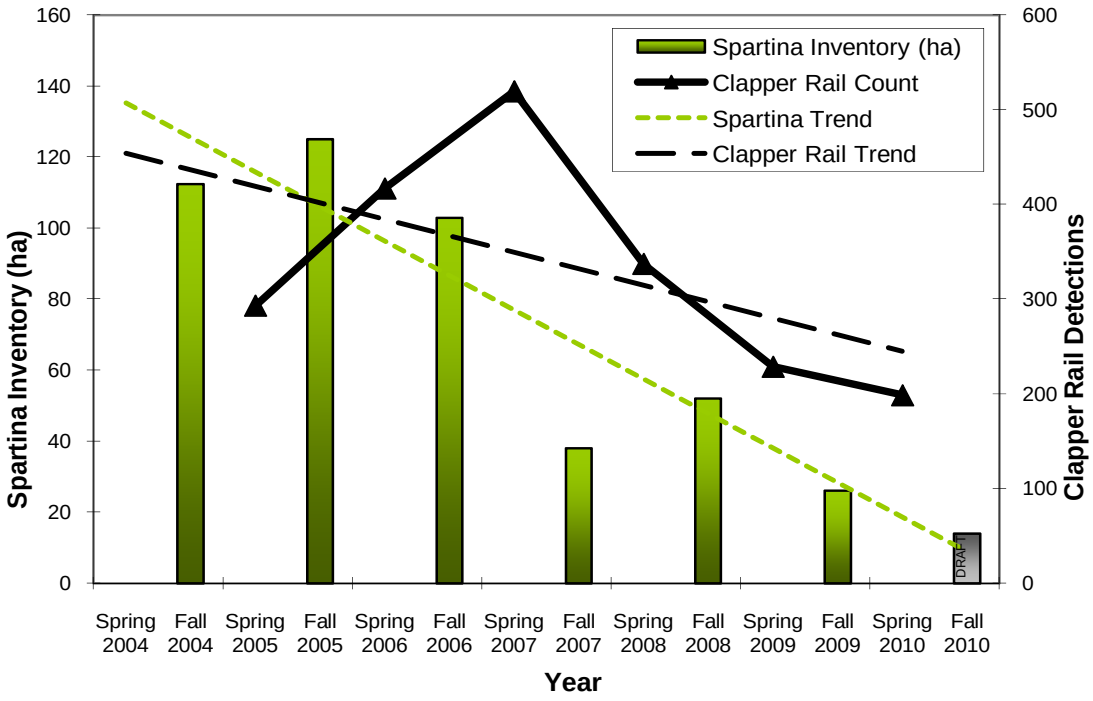

Figure 35. Annual inventory of *Spartina* and clapper rail populations at *Spartina* treatment sites within four regions of San Francisco Bay (n = 30 sites).

Table 15. Summary of California clapper rail survey results and *Spartina* inventory monitoring at invaded sites within the San Francisco Estuary.

	Number of CLRA detected during call count surveys (Jan - April)						***Hectares of Spartina mapped during inventory monitoring (June - Sept)***[1]						
Annual Inventory in the San Francisco Estuary	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***[2]
Invaded Sites (n = 30 sites)	293	416.5	519	337	228.5	202	112.3	125.0	102.9	38.0	52.0	26.0	14

[1] Data source: Ingrid Hogle, December 2010 (ibhogle@spartina.org)

[2] Analysis of 2010 *Spartina* monitoring data is incomplete; data are best estimate.

The *Spartina* population showed a similar trend, increasing at the beginning of the study period and declining subsequently. A perceived increase in *Spartina* levels from 2007 to 2008 is likely a false rise due to a change in survey methods between the two years. The *Spartina* population declined by about -71% at these 30 sites between 2004 and 2009.

5.1 SAN LEANDRO BAY TREND

The trend analysis in the San Leandro Bay Region included ten (n=10) sites invaded by hybrid *Spartina* (**Figure 37, Table 16**). During the first three years of the study period, clapper rail populations increased: by 54% from 2005 to 2006 and by 30% from 2006 to 2007. After 2007, clapper rail detections decreased annually: by -22% from 2007 to 2008, by -42% from 2008 to 2009, and by -37% from 2009 to 2010. Since the beginning of the study, clapper rail detections have declined in the region by about -25%.

The *Spartina* population shows a similar pattern but with a greater decline over the course of the study period. The net area of *Spartina* increased during the first 3 years of the study, from 2004 to 2006. Effective methods of non-native *Spartina* control began in 2006 and evidence of this was seen by 2007, when *Spartina* populations in the region had dropped by -62% from the previous year. From 2004 to 2009, non-native *Spartina* declined by a total of -62% at these ten sites in the San Leandro Bay.

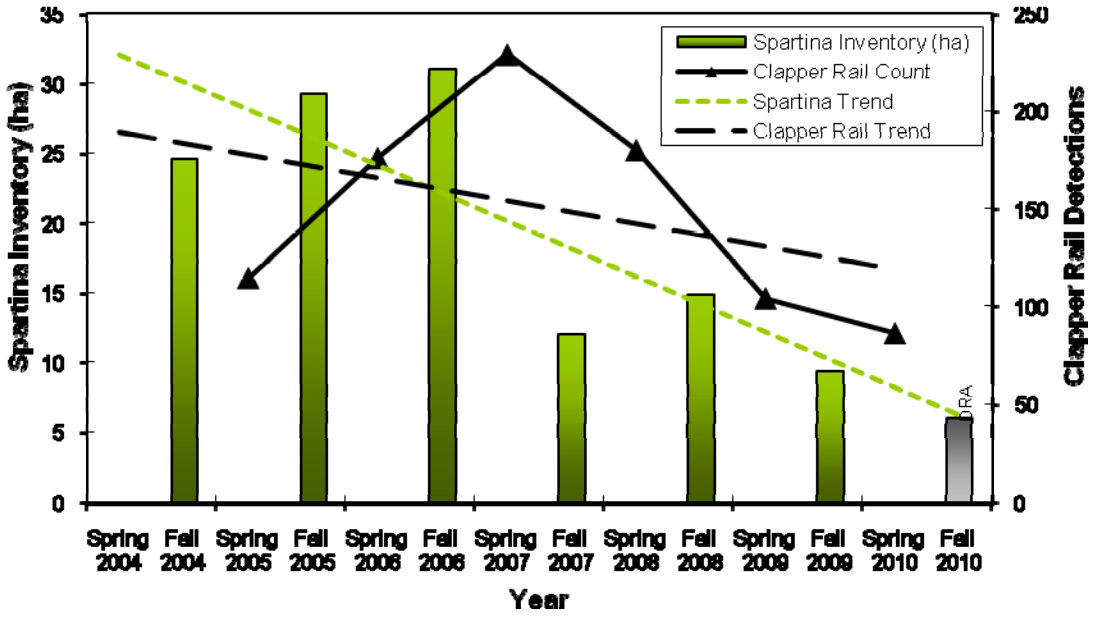

Figure 37. Annual Inventory of *Spartina* and Clapper Rail Populations in the San Leandro Bay Region (n = 10 sites).

Table 16. Summary of California clapper rail surveys (2005-2010) and *Spartina* inventory monitoring (2004-2009) in the San Leandro Bay Region

	Number of CLRA detected during call count surveys (Jan - April)						***Hectares of Spartina mapped during inventory monitoring (June - Sept)***[1]						
San Leandro Bay REGION	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***[2]
Elsie Roemer (17a)	7	14.5	6.5	10	1.5	1.5	4.6	4.6	4.8	1.0	1.8	1.0	DRAFT
Bay Farm Island (17b)	6	7.5	6	2	0	0	0.7	1.8	1.2	0.4	0.1	0.0	
Arrowhead Marsh (17c)[3]	72	80	110	112	55	40	8.1	9.1	10.8	5.0	7.5	4.3	
MLK Regional Shoreline (17d)	4	22	20	9	6.5	7.5	4.3	4.4	4.9	1.7	0.7	0.5	
San Leandro Creek (17e)	1.5	4.5	7.5	4	3	3.5	0.3	1.0	0.2	0.4	0.1	0.1	
MLK Marsh (17h)	5.5	26.5	41	21	16.5	16	0.7	1.9	3.0	1.3	1.6	1.6	
Fan Marsh (17j)	5	9	19	11	12	13	2.7	2.7	2.9	0.5	1.6	1.1	
Airport Channel (17k)	9	8.5	13.5	9	3.5	1.5	1.8	2.3	1.9	0.6	0.7	0.5	
Doolittle Pond (17l)	3	1.5	4	2	4.5	1.5	0.1	0.2	0.1	0.1	0.1	0.1	
Alameda Island - East (17m)	1.5	2	2	0	1.5	1.5	1.1	1.2	1.4	0.8	0.6	0.2	
REGIONAL SUMMARY	**114.5**	**176**	**229.5**	**180**	**104**	**86**	**24.5**	**29.3**	**31.1**	**12.0**	**14.8**	**9.3**	**6**

[1] Data source: Ingrid Hogle, December 2010 (ibhogle@spartina.org)

[2] Analysis of 2010 *Spartina* monitoring data is incomplete; data are best estimate.

[3] Clapper rail data collected by EBRPD during winter high tide airboat surveys (December – January).

5.2 HAYWARD TREND

Analysis in the Hayward region included data from nine sites (**Figure 38, Table 17**). Similar to the San Leandro Bay, clapper rail populations in the Hayward Region increased at the beginning of the study period. From 2005 to 2006, clapper rail detections increased by 53% and from 2006 to 2007, they increased again by 23%. Clapper rail numbers decreased from 2007 to 2008, coincident with the declining *Spartina* population in the region. However, as *Spartina* continued to decrease though the end of the study period, clapper rail detections increased by +17% from 2009 to 2010. This rise in rail numbers may be a response to a new equilibrium in habitat change. In Hayward, most of the *Spartina* cover has been removed due to successful control efforts (-80% reduction from 2004 to 2009) and native vegetation is rebounding at these marshes. Overall, clapper rail populations have decreased by about -16% in the Hayward Region.

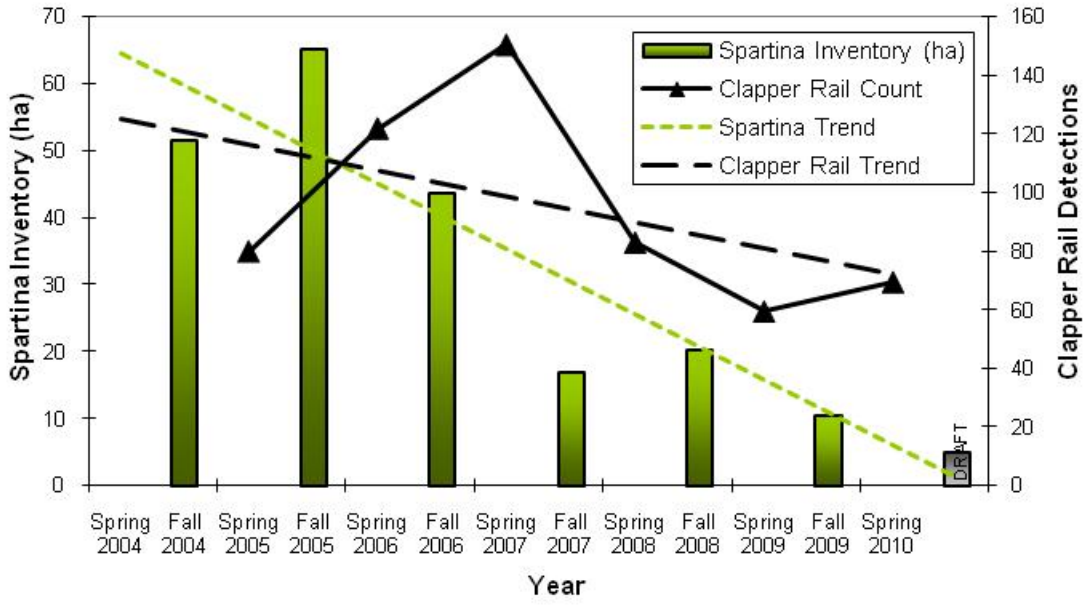

Figure 38. Annual Inventory of *Spartina* and Clapper Rail Populations in the Hayward Region (n = 9 sites).

Table 17. Summary of California clapper rail surveys (2005-2010) and *Spartina* inventory monitoring (2004-2009) in the Hayward Region.

	Number of CLRA detected during call count surveys (Jan - April)						***Hectares of Spartina mapped during inventory monitoring (June - Sept)***[1]						
Hayward REGION	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***[2]
Oro Loma - East (07a)	1.5	0	21.5	3	1.5	5	0.9	2.0	1.3	0.2	3.2	0.6	DRAFT
Dog Bone Marsh (20c)	0	1.5	2	2	2	0	1.0	1.2	1.4	0.1	0.2	0.0	
Citation Marsh (20d)	10	11	10.5	11	5.5	6.5	3.9	4.0	5.5	2.4	0.7	1.3	
North Marsh (20f)	12.5	15.5	20	14	8	14	0.6	3.0	7.2	0.4	0.9	2.2	
Bunker Marsh (20g)	9	9.5	6	6	3.5	6	5.6	5.1	4.7	1.6	0.3	1.4	
San Lorenzo Creek & Mouth (20h)	7.5	9.5	13.5	2	3.5	3.5	8.0	6.7	4.2	0.5	0.4	0.4	
Cogswell - Sec A (20m)	0	25.5	15.5	8	5.5	6	3.1	7.4	2.6	0.1	0.1	0.6	
Cogswell - Sec B (20n)	27.5	33	43	29	28.5	24	24.3	26.6	14.8	11.5	13.6	3.2	
Cogswell - Sec C (20o)	12	16.5	18.5	8	1.5	4.5	4.0	9.2	2.0	0.1	0.8	0.7	
REGIONAL SUMMARY	**80**	**122**	**150.5**	**83**	**59.5**	**69.5**	**51.4**	**65.2**	**43.7**	**17.0**	**20.1**	**10.4**	**5**

[1] Data source: Ingrid Hogle, December 2010 (ibhogle@spartina.org)

[2] Analysis of 2010 *Spartina* monitoring data is incomplete; data are best estimate.

5.3 SAN FRANCISCO PENINSULA TREND

Data from eight sites (n=8) in the San Francisco Peninsula Region were included in the trend analysis (**Figure 39, Table 18**). Similar to other regions invaded by *Spartina*, clapper rail numbers rose between 2005 and 2007, by 31% over the 3 year period. The rail population in the region fell in 2008 by -50%, again in 2009 by another -33%, and once more in 2010 by -76%. Clapper rail populations show a dramatic decline in this region, from 61 rails in 2005 to 6.5 rails in 2010, a decline of -89% over the six year study period. *Spartina* within the San Francisco Peninsula Region has also shown a dramatic decline during the study period, decreasing by -86% over the course of six years. Non-native *Spartina* was the dominant plant at most sites in the region and the decline in clapper rails is likely due to loss of nesting and foraging cover previously provided by the invasive cordgrass. As *Spartina* cover has been removed, the hybrid cordgrass meadows that once dominated are returning to tidal mudflat, a habitat type unsuitable for breeding rails.

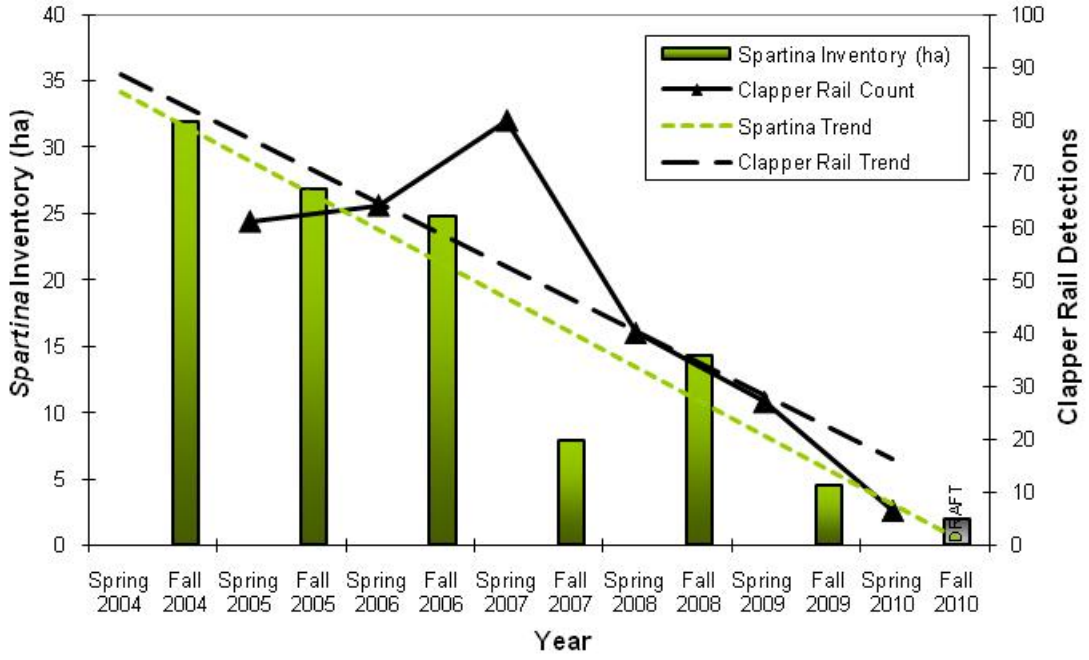

Figure 39. Annual Inventory of *Spartina* and Clapper Rail Populations in the San Francisco Peninsula Region (n = 8 sites)

Table 18. Summary of California clapper rail surveys (2005-2010) and *Spartina* inventory monitoring (2004-2009) in the San Francisco Peninsula Region.

	Number of CLRA detected during call count surveys (Jan - April)						***Hectares of Spartina mapped during inventory monitoring (June - Sept)***[1]						
San Francisco Peninsula REGION	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***[2]
Old Marina (18c)	5	1.5	0	2	0	0	1.1	1.2	1.2	0.9	0.5	0.4	DRAFT
Inner Harbor (18d)	17.5	4	4	0	0	0	2.0	2.2	2.3	0.1	1.1	0.2	
Sam Trans Peninsula (18e)	6.5	13.5	7.5	7	2	1.5	4.4	3.4	3.9	1.8	2.6	0.9	
Confluence Marsh (18f)	4.5	9.5	12	2	4	1.5	1.8	1.9	1.9	0.1	0.6	0.4	
San Bruno Marsh (18g)	25	14	13	18	10.5	0	8.2	7.1	7.8	2.5	5.6	1.4	
Sierra Point (19b)	0	1	3	2	2	0	0.4	0.2	0.3	0.4	0.0	0.2	
Point San Bruno (19f)	0	0	1.5	2	0	2	0.3	0.4	0.5	0.4	0.2	0.0	
Seal Slough Mouth (19p)	2.5	20.5	39	7	8.5	1.5	13.5	10.5	6.9	1.7	3.7	1.1	
REGIONAL SUMMARY	**61**	**64**	**80**	**40**	**27**	**6.5**	**31.9**	**26.8**	**24.8**	**7.9**	**14.3**	**4.6**	**2**

[1] Data source: Ingrid Hogle, December 2010 (ibhogle@spartina.org)

[2] Analysis of 2010 *Spartina* monitoring data is incomplete; data are best estimate.

5.4 NEWARK TREND

Analysis of the Newark Region (**Figure 40, Table 19**) included data from three sites (n=3). The pattern in clapper rail population at the Newark Region is similar to that observed in the other regions impacted by non-native cordgrass, though to a lesser degree. Clapper rail numbers rose from 2005 to 2007, by 42% in 2006 and by 25% in 2007. Numbers declined in 2008 by -42%, dropping from 59 to 34 clapper rails. However, clapper rail numbers seem to have stabilized in the past two years, increasing by 12% in 2009 and decreasing by -4% in 2010. Overall, the clapper rail population in the Newark Region has declined by -3% during the study period. Invasive *Spartina* has had a small presence in Newark, which is dominated by native tidal marsh vegetation that has rebounded with the removal of non-native cordgrass.

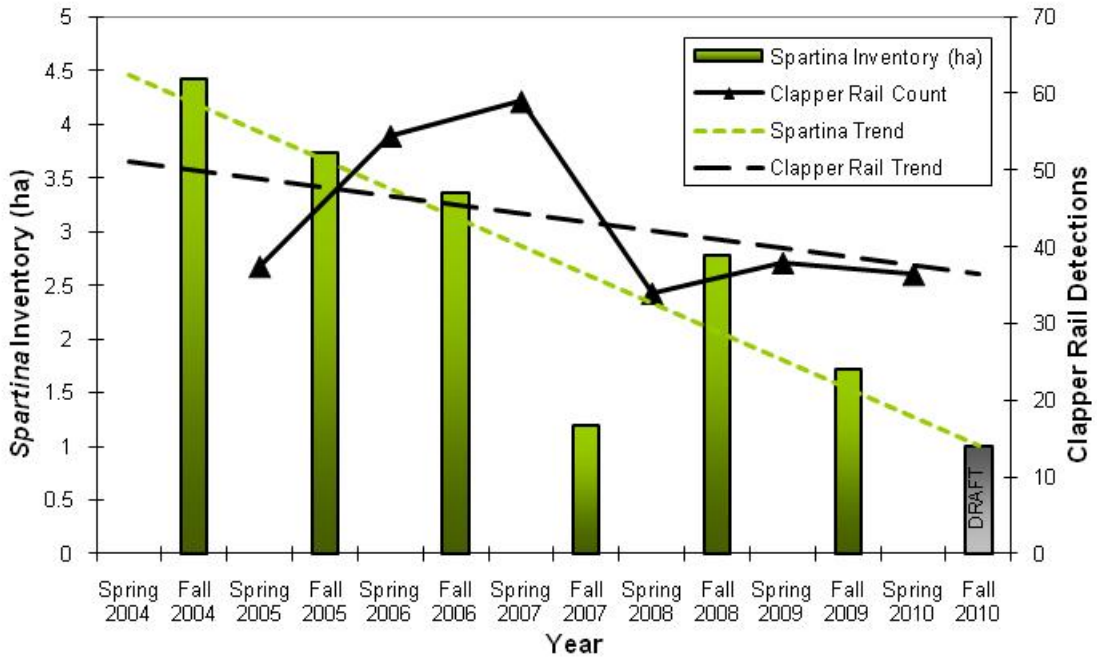

Figure 40. Annual Inventory of *Spartina* and Clapper Rail Populations in the Newark Region (n = 3 sites).

Table 19. Summary of California clapper rail surveys (2005-2010) and *Spartina* inventory monitoring (2004-2009) in the Newark Region.

	Number of CLRA detected during call count surveys (Jan - April)						***Hectares of Spartina mapped during inventory monitoring (June - Sept)***[1]						
Newark REGION	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***[2]
Dumbarton/Audubon (05b)3	18.5	26	30.5	12	13.5	15.5	2.5	1.3	2.9	0.7	1.6	0.9	DRAFT
Newark Slough (05c)	3	7.5	6.5	3	4.5	6.5	1.1	1.2	0.3	0.2	0.6	0.4	
LaRiviere Marsh (05d)	16	21	22	19	20	14.5	0.8	1.2	0.3	0.2	0.6	0.4	
REGIONAL SUMMARY	**37.5**	**54.5**	**59**	**34**	**38**	**36.5**	**4.4**	**3.7**	**3.4**	**1.2**	**2.8**	**1.7**	**1**

[1] Data source: Ingrid Hogle, December 2010 (ibhogle@spartina.org)

[2] Analysis of 2010 *Spartina* monitoring data is incomplete; data are best estimate.

6. DISCUSSION

Clapper rail numbers have declined in the Bay since 2005, most notably at sites heavily impacted by non-native *Spartina*. The peak in rail numbers around 2007 shadows the height of the hybrid *Spartina* infestation in 2006. Effective control work since 2007 has restored native habitat: from hybrid meadows to native salt marsh and from invaded shorelines to tidal mudflats. In the past two years, the rail population decline has slackened at sites where native vegetation has rebounded with *Spartina* removal. Still, these native habitat types may not be as effective at supporting breeding California clapper rail as the invasive *Spartina* monoculture.

Hybrid *Spartina* provides excellent cover for clapper rails, reducing their exposure to predators and tides. The aggressive invasion of hybrid *Spartina* allowed California clapper rail populations to grow and expand into new areas where they had not previously been supported in large numbers. With the successful control of hybrid *Spartina* in the Bay, rail numbers are likely to return to historic levels seen before the cordgrass invasion. Albertson and Evens (2000) estimated about 1,040-1,264 clapper rails in the Estuary between 1992 to 1998, when the distribution of non-native *Spartina* was still small and localized. Current estimates of the clapper rail population are a minimum of 1,425 (± 22) individuals detected from 2005-2008 (Liu *et al.*, 2009).

Sites that were mostly unvegetated prior to the *Spartina* invasion show the most dramatic decline in clapper rail populations. As these sites revert to their native state of tidal mudflat, clapper rail populations are replaced by foraging shorebirds. Sites that support native vegetation show a less dramatic decline in clapper rail numbers as non-native *Spartina* is diminished. We have observed that the native *Sarcocornia pacifica* understory quickly rebounds when the non-native *Spartina* canopy is removed. This native vegetation provides cover for rails in absence of hybrid *Spartina*.

Rail populations at predominately native marshes in Newark show a slight decrease of -3% during the study period, but fluctuated annually over the course of six years. Liu and Wood (2011) conclude that clapper rail detections have increased in the past two years in the San Pablo Bay and in South San Francisco Bay at sites where PRBO conducts surveys. These sites are mostly large mature marshes with modest impacts by non-native *Spartina*. They speculate that the increased number of detections may be due to immigration events from marshes heavily impacted by *Spartina* removal or may be the result of increased breeding success at these marshes.

There are many other factors which may influence changes in clapper rail populations including: weather and flooding events (Schwarzbach 2006); contaminants, particularly mercury and barium (Schwarzbach 2001 & 2006); and fluctuations in predator populations, including predators of adult rails, such as the red fox (Harding 2001) and northern harriers (Foin 1997) and predators of rail nests, such as the Norway rat (Schwarzbach 2006).

Because this study presents the summary of findings from multiple observers from several organizations, some fluctuation in rail numbers may be due to observer bias. Sources of variation other than changes in the clapper rail population sizes may be attributed to many factors. We did not calculate an estimate of the detection probability to control for some of these variables, a shortcoming of this study. The detection probability is defined by the product of the probability that a rail will vocalize and the probability that the observer will detect the vocalization (Conway 2004). Factors influencing the probability of vocalization included differences in time of survey (sunrise vs. sunset), differences in protocols (active vs. passive survey), and differences in season (early breeding season vs. late breeding season). Factors influencing the probability of detection included: differences in survey effort (e.g. number of rounds completed), variation in survey area (e.g. number and placement of stations per site), and observer bias (e.g. errors in distance estimates).

Our criteria for weather, tide phase, and moon phase were restricted by standard survey protocols; thus, some measure of control was gained over these three variables in our study. However, the greatest variation among organizations is likely to arise from decisions made in the field on whether a given detection was the same as or different from a bird that was previously detected. A single bird detected twice may be counted as two birds if the observer perceives a difference in volume, distance, or direction of the detection ("splitting" detections). Conversely, two birds may be counted as one if the observer does not perceive a difference in distance or direction ("lumping" detections). These assumptions are difficult to quantify using our survey methods, but they may play an important role in annual variation when surveys are completed by different organizations from year to year.

Continued monitoring of California clapper rails at both native and invaded sites is necessary to determine how their populations will stabilize in the wake of *Spartina* eradication. Additionally, ongoing surveys will provide a baseline population as large expanses of tidal wetlands are restored in the near future. Research is needed to identify: (1) the characteristics of high quality native clapper rail and (2) the methods of creating these features in new and existing restoration projects throughout the Bay.

7. PERMITS

Surveys were conducted under the authority of U.S. Fish and Wildlife Service permit TE118356-0 and a Memorandum of Understanding with the California Department of Fish and Game. Surveys were required by and conducted pursuant to conditions of the Programmatic Formal Intra-Service Endangered Species Consultation on the San Francisco Estuary Invasive *Spartina* Project (1-1-03-F-0216 dated August 27, 2003), and subsequent additional formal intra-Service consultations on implementation of the San Francisco Estuary Invasive *Spartina* Project *Spartina* Control Program (1-1-04-F-0305 dated September 7, 2004, 1-1-05-F-0243 dated September 7, 2005, and 810420-2008-F-1546 dated July 17, 2008).

Permission for site access was granted by East Bay Regional Park District, the City of San Leandro, California Department of Fish and Game, City of Mountain View, Mid-Peninsula Regional Open Space District, Redwood City Marina, WestPoint Harbor, SFO International Airport, and Don Edwards San Francisco Bay National Wildlife Refuge.

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