Seasonal and tidal patterns in survival of California clapper rails: Will floating islands mediate the effects of critically limiting high tide refugia?

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Introduction:

The California clapper rail (*Rallus longirostrus obsoletus*) is a federally and state listed endangered bird extant only to San Francisco and Suisun Bay tidal marshes. On-going threats of habitat loss and fragmentation are compounded by emerging threats of non-native predators, control of non-native plants, and sea-level rise. We analyzed 166 weeks of telemetry from 2007 to 2010 data on 108 birds to investigate the impact these threats have on clapper rail survival. Our results indicated a severe risk to clapper rail population persistence due to seasonal variation in survival and extreme tide events. Subsequently, use of artificial refuge islands to temporarily mitigate these factors is being investigated.

Methods:

Four sites in South San Francisco Bay were selected with high clapper rail density and varying levels of invasion by hybrid cordgrass (*Spartina alterniflora x foliosa;* Fig. 1). Clapper rails were trapped Jan 2007 to Nov 2009 (n = 108) and fit with 9.5 gram VHF transmitters attached with a teflon ribbon Dwyer harness. We used the Known Fate subroutine in Program MARK to calculate Kaplan-Meier product limit estimates of weekly survival rates. Models were evaluated using information theory from a candidate set of 41 models incorporating group, and temporal covariates.

Group covariates included site, sex, and both individual occurrence within and marsh-wide presence of Spartina eradication. Temporally varying covariates included year of study, three seasons (breeding, post breeding, and winter periods), # of years with Spartina eradication, and both weekly maximum and average higher high water levels. Tide data was obtained from observed values at the NOAA San Francisco tide gauge.

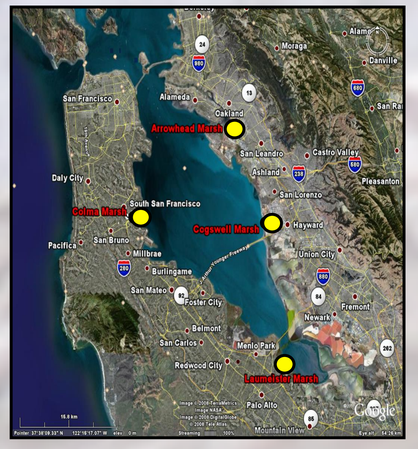

Figure 1. California clapper rail survival was analyzed at four tidal salt marshes in South San Francisco Bay between 2007 and 2010.

Feral cat kills typically are found at the upper margin of the marsh where birds congregate in limited refugia during high water

Model Rank	Model	Delta AICc	AICc weight	Model Likelihood
1	Constant survival + Seasonal Maximum HHW	0	0.15262	1
2	Seasonal survival + Maximum HHW	0.5208	0.11763	0.7707
3	Seasonal Survival	1.2243	0.08275	0.5422
…				
6	Constant survival + Seasonal Average HHW	2.161	0.0518	0.3394
…				
28	Constant survival	15.4284	0.00007	0.0005
…				
36	Constant survival + Site	19.9757	0.00001	0.0001

Table 1. Modelling performance comparisons for Seasonal and Tidal effects on California clapper rail survival.

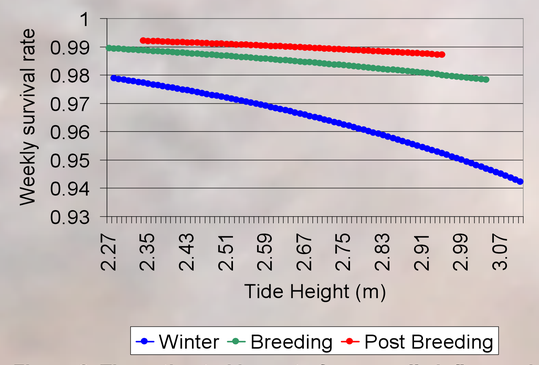

Figure 2. The estimated impact of seasonally influenced maximum higher high water shows dramatic decreases in California clapper rail survival during winter periods when available refuge cover senesces.

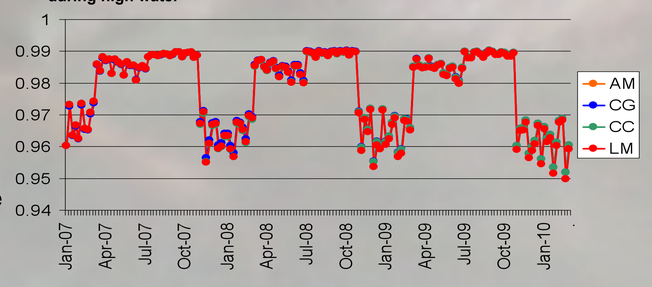

Figure 3. Model averaged weekly survival rate parameters from 41 models estimating California clapper rail survival from 2007 to 2010.

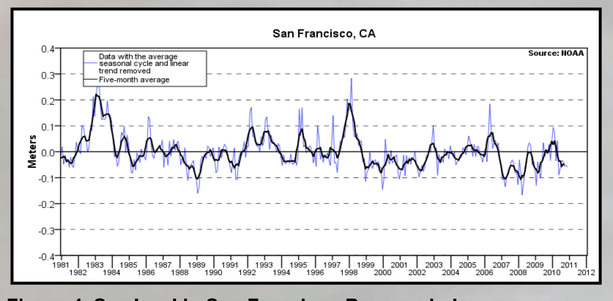

Figure 4. Sea level in San Francisco Bay was below average during our study indicating more dramatic declines in survival could be expected in the future.

Discussion and Conservation Implications:

Our estimated survival rates for California clapper rail are lower than previous estimates (44-67%) for California or Yuma clapper rail and point toward a major emerging threat, sea-level rise, as a risk to California clapper rail persistence. Of additional concern is that this study took place when the mean sea level in San Francisco Bay was below long term trends due to Pacific Ocean conditions (Figure 4). In light of this, our models suggest clapper rail survival during our study was marginally higher relative to normal water levels in San Francisco Bay.

In the fall of 2010, we initiated a short term project to evaluate the impact additional high tide refuge cover would have on space use patterns and survival of California clapper rails at Arrowhead Marsh. Ten floating islands (measuring 5' x7') were anchored on the north-east edge of the marsh. Each island was fit with woven palm leaf screens placed on a PVC frame attached to the island. The islands provide continuous cover throughout the tidal cycle and a significant proportion of available cover in the marsh during equinoxal high waters.

Rail use of islands was swift and dramatic. Cameras positioned on the islands allowed us to quantify use by rails and identify non-target species also using the islands. By the first of the seasonal high tides in late October rail use on some islands exceeded 24 hours per week – with all islands being occupied at least once per week. Use of islands was most frequent during high tide periods indicating appropriate high tide refuge is limiting (Figure 5). As we progress through the winter we will investigate whether use of refuge islands increases as marsh vegetation senesces and whether survival of radio-marked birds has increased with additional available refuge.

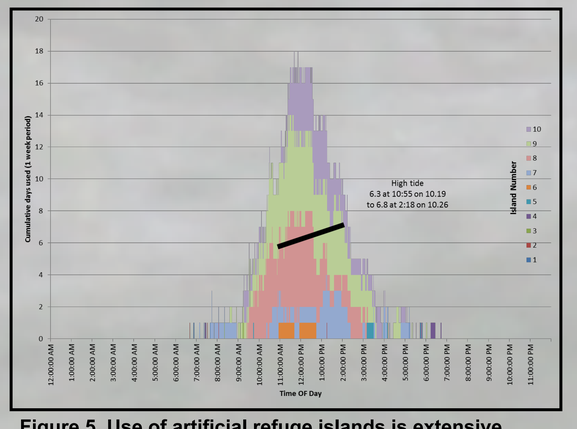

Figure 5. Use of artificial refuge islands is extensive during high tide periods indicating critical limitation of cover during periods of marsh inundation.

Results:

Season and tide heights had the greatest predicted effect on survival rates of California clapper rails.

- Models (Table 1) showed strong evidence for seasonal differences in survival (Likelihood Ratio Test [LRT] with null model: $X^2_2 = 18.2$, $p = 0.0001$).
- Maximum weekly higher high water was ranked above average weekly higher high water in all comparable models suggesting better model performance.
- Incorporating the seasonal influence of tide height on survival rates has support as an improved model over seasonal survival (LRT with seasonal model: $X^2_1 = 3.22$, $p = 0.07$).

Despite uncertainty in model selection (i.e. competing models within 2 AIC units) the relatively large effect sizes illustrate the reduced winter survival compared to equivalent tides during other seasons (Figure 2).

Model averaged parameter estimates (Figure 3) show greatly reduced and variable survival probabilities during winter periods with little annual or site-specific differences.

- **Seasonal survival rates from top model at average observed tide height:**
  - **Winter 53%**
  - **Breeding 75%**
  - **Post-Breeding 83%**
- **Composite annual survival rate from model averaged parameters:**
  - **35.5% (95% C.I.: 15.3 to 52.8%)**

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