CISNET San Pablo Bay
Avian Monitoring

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PROJECT SUMMARY

In 1999, the Point Reyes Bird Observatory initiated the Avian Reproductive Studies component of the CISNet San Pablo Bay Project. The study continued during spring of 2000 and 2001.
Goals of this component were four-fold:
1) obtain samples of eggs of tidal marsh song sparrows breeding in tidal marshes of San Pablo Bay (both viable and inviable), to test for contaminants,
2) determine components of reproductive success (including hatchability of eggs) for marshes in San Pablo Bay,
3) compare parameter values for marshes in San Pablo Bay with values for adjacent habitat (song sparrows breeding in upland habitat as well as marshes in Suisun Bay), and
4) determine relationships between contaminant loads and reproductive parameters (e.g., Was hatching failure more likely for eggs or for marshes in which contaminant loads were greater?). We conceive of this effort as a pilot study whose goal is to make recommendations for subsequent long-term monitoring (e.g., regarding spatial and temporal distribution of sampling).

Study Sites

In 1999, study plots were established for Song Sparrows (*Melospiza melodia samuelis*) breeding at four sites in three San Pablo Bay marshes: China Camp State Park (two sites), Petaluma River Mouth (E of Petaluma River and on the bay side of Sonoma Baylands), and Black John Slough (adjacent to the Bahia development in Novato). The first two marshes have been studied by PRBO since 1996, while the Black John Slough study plot was established in 1999. The study continued in 2000 and 2001 at these four study plots.

Each year Song Sparrow nests were also monitored by PRBO in two Suisun Bay tidal marshes (Benicia State Park and Rush Ranch), both studied since 1996 and at which the subspecies *M. m. maxillaris* is found breeding; and at PRBO's upland Palomarin field station (in the Point Reyes National Seashore, studied since 1980) at which the subspecies found breeding is *M. m. gouldii*.

Methods

Nest searching and monitoring - Field biologists searched for and monitored song sparrow nests during the breeding season (March - July). For each site, a focal study plot containing at least 30 pairs of song sparrows was established and as many nests as

possible were located and monitored, using standardized methodology (Martin and Geupel 1993). Nest contents were recorded at each visit and the ultimate outcome of each nest was decided based on nest condition and behavior of the breeding pair. Nestlings were banded on the 8th day with USFWS bands and a unique combination of colored leg bands to facilitate field identification after fledging.

Egg collection for chemical contaminant analysis - Song sparrow eggs were collected to form two samples for each marsh in San Pablo Bay only:
1) Viable sample: Freshly laid or partially incubated eggs, which were assumed to be viable. These eggs were collected before clutch completion or early in incubation. Eggs were also collected from nests abandoned during incubation due to tidal flooding or bad weather.
2) Unhatched sample: Eggs that did not hatch in an otherwise viable clutch. Eggs were collected at least 3 days after all other eggs in the nest had hatched.

Eggs were collected, wrapped in aluminum foil, placed inside a storage container and refrigerated until analysis. Although some eggs collected early in incubation cracked during storage, many more failed-to-hatch eggs broke during and after collection. Because the contents could become contaminated, they could not be analyzed. It is unknown if the shells of these eggs were thinner than normal. For 2000, we revised our methods to ensure a low proportion of cracked eggs. Chemical analysis was conducted under the leadership of Dr. Jay Davis (SFEI).

Egg hatchability - In order for a nest to be included in the egg hatchability analysis, the nest must have been observed active after the hatching date. Eggs vanishing during incubation were not included in the analysis. We also excluded nests that were depredated around the hatch date and last observed before day 2 with both eggs and young. All eggs in a clutch normally hatch within a 2day period, so to be conservative, we only included nests observed on or after the 2nd day after the first nestling hatched. Hatchability was analyzed both with the egg as the unit of analysis and the nest as the unit of analysis. For the former, we calculated hatchability as the proportion of eggs that hatched in a nest where nestlings were present. For the latter, we calculated the proportion of nests in which all eggs hatched that were present before hatching. A separate analysis will be conducted to explore patterns of egg loss during incubation.

Clutch size- The average and median clutch size were calculated at each site. To be included in the analysis, a nest needed to be seen active with the same number of eggs at least twice during the incubation period. We analyzed the effect of site and year on clutch size with ANOVA.

Nest survivorship- Nest survivorship was calculated in two ways:
1) The proportion of successful nests which is defined as the number of successful nests divided by the total number of nests observed active in that marsh
2) A widely used method developed by Mayfield (1975), which takes into account the number of days each nest was observed active. This should theoretically reduce one large source of bias in calculating success based on the raw proportion of nests. Nests

that are lost quickly are less likely to be found, and thus proportional success estimates will be biased (if nests are found during the nesting period). The average daily survivorship (the probability of a nest surviving to the next day) is first calculated and then raised to the to the power equal to the number of days in the nest cycle for an estimate of the probability of a nest surviving for the nest period. Survivorship may vary between egg laying, incubation and the nestling period, so we calculated values for each phase separately as well as for the entire nest cycle.

RESULTS

We report here preliminary results for 1999 through 2001.

In 2001 we collected 18 viable and 5 inviable eggs at China Camp, 7 viable and 4 inviable eggs at Petaluma Rivermouth and 4 viable eggs at Black John Slough. These eggs are awaiting analysis under the supervision of Jay Davis.

In 1999 Song Sparrow nest success was lower at our tidal marsh sites than at the Palomarin field station (Table 1). In 2000, the rates were similar (Table 2). The average success for Palomarin from 1992 to 2000 (0.230) was within the range of tidal marsh sites. Figures for 2001 are not yet available for Palomarin (Table 3).

San Pablo Bay sites had consistently higher success than Suisun Bay sites in all years except 1999. Rush Ranch in Suisun Bay had the lowest success overall, primarily due to predation.

At all marsh sites during the focal years of 1999 to 2001, overall nest survivorship for the entire nest cycle was lower than 26% (Table 1-3, Figure 1) and at the Suisun Bay sites was often under 10%. Success was much higher in 1996, around 30% at China Camp and Petaluma Rivermouth, which is close to the average for Palomarin. Success was lowest in 1997 and 1998, but increased slightly in the focal years of 1999-2001, although the trend among sites varied during that time (Figure 1).

Pooling all tidal marsh nests from 1996 through 2000, 23.2% of nests were successful, 65% failed due to predation, 6.5% failed due to high tidal flooding and 5.3 % failed due to other causes. Predation was the most significant cause of nest failure at all sites.

Tidal marsh Song Sparrow nest success is low both in San Pablo and Suisun Bay, but further analysis is needed to determine if this level of success may indicate a threat to population viability. Tidal marsh song sparrows have up to 5 attempts at a successful nest during a season, so many produce one successful brood and a small proportion produce 2 successful broods. If all pairs were to try 5 times to produce a successful nest, and 80% of all attempts were unsuccessful, then only $(0.8)^5 = 32.8\%$ of pairs would fail to produce a successful brood, fewer than one would expect by looking at the low success rate of any single nest.

Egg hatchability was similar in 1999 and 2000 (Table 4) with some notable exceptions. Hatchability increased at China Camp, but decreased at Black John Slough and at both Suisun sites. In 2001 hatchability was higher at all sites except at China Camp. Patterns are less clear in the proportion of nests where no eggs remained unhatched. Hatchability data for 2001 are not yet available for Palomarin birds. Mean clutch sizes in San Pablo Bay tended to be smaller than in the Suisun Bay reference sites (Table 5). China Camp had the consistently highest clutch size every year. Between site differences were highly significant for 1999 to 2001 ($F = 16.0$, $P < 0.001$), and when

years were analyzed separately. This difference between sites was just as significant when controlling for the effect of year ($F = 16.2$, $P < 0.001$). The causes of geographic variation in clutch size are well known in some species but are unknown in the subspecies studied here. Potential contributing factors will be explored in the final report.

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TABLE 1. Song Sparrow nest survivorship: Mayfield method and proportion of nests successful. A comparison of San Pablo Bay song sparrow populations (*Melospiza melodia samuelis*) with reference sites in Suisun Bay (*M. m. maxillaris*) and Palomarin field station (*M. m. gouldii)* . 1999 field season

SITE	Nest phase	Sample size	Daily Mayfield nest success [1]		Mayfield nest success rate for period [2]	Mayfield period nest success confidence limits		Proportion successful [3]
SAN PABLO BAY			Rate	S. E.		Lower	Upper	
China Camp	All	181	0.9090	0.0072	0.1136	0.0790	0.1623	0.1934
	Laying	52	0.9355	0.0255	0.8753	0.7828	0.9731	
	Incubation	156	0.9155	0.0089	0.3573	0.2844	0.4469	
	Nestling	93	0.8922	0.0135	0.3525	0.2663	0.4628	
Petaluma River Mouth	All	58	0.9287	0.0101	0.1853	0.1121	0.3030	0.2069
	Laying	7	0.9091	0.0867	0.8267	0.5419	1.1714	
	Incubation	49	0.9528	0.0109	0.5687	0.4345	0.7399	
	Nestling	38	0.8935	0.0194	0.3570	0.2380	0.5264	
Black John Slough	All	60	0.9338	0.0100	0.2098	0.1282	0.3400	0.3167
	Laying	22	0.8333	0.0680	0.6949	0.4868	0.9399	
	Incubation	53	0.9357	0.0136	0.4606	0.3267	0.6430	
	Nestling	33	0.9430	0.0143	0.5845	0.4410	0.7681	
SUISUN BAY								
Benicia State Park	All	95	0.917318	0.0092	0.1397	0.0880	0.2199	0.2211
	Laying	21	0.952381	0.0329	0.9072	0.7865	1.0365	
	Incubation	77	0.936318	0.0109	0.4343	0.3528	0.6071	
	Nestling	60	0.885877	0.0170	0.3301	0.2309	0.4657	
Rush Ranch	All	32	0.8996	0.0180	0.0897	0.0354	0.2193	0.1250
	Laying	6	1.0000	0.0000	1.0000	1.0000	1.0000	
	Incubation	29	0.8960	0.0232	0.2777	0.1493	0.5005	
	Nestling	14	0.8969	0.0309	0.3697	0.1925	0.6797	
PALOMARIN FIELD STATION	All	79	0.9524	0.0072	0.3101	0.2170	0.4407	0.4557
	Laying		0.9149	0.0576	0.8370	0.6433	1.000	
	Incubation		0.9614	0.0092	0.6234	0.4971	0.7789	
	Nestling		0.9450	0.0112	0.5675	0.4493	0.7137	

1 The Mayfield method of calculating nest survivorship takes into account the number of days each nest was under observation (see text)

2 The success rate for each phase or period of the nest cycle is calculated as the daily survival for the period to the nth power where n = the number of days in the period: laying = 1.996 days, incubation = 11.661, nestling = 9.145.

3 The proportion successful is the number of nests that fledged at least one young divided by the total number of active nests found.

TABLE 2. Song Sparrow nest survivorship: Mayfield method and proportion of nests successful. A comparison of San Pablo Bay song sparrow populations (*Melospiza melodia samuelis*) with reference sites in Suisun Bay (*M. m. maxillaris*) and Palomarin field station (*M. m. gouldii)* for the 2000 field season

SITE	Nest phase	Sample size	Daily Mayfield nest success [1]		Mayfield nest success rate for period [2]	Mayfield period nest success confidence limits		Proportion successful [3]
SAN PABLO BAY			Rate	S. E.		Lower	Upper	
China Camp	All	157	0.9349	0.0058	0.2156	0.1620	0.2858	0.2548
	Laying	65	0.9331	0.0229	0.8708	0.7877	0.9581	
	Incubation	139	0.9470	0.0070	0.5298	0.4459	0.6281	
	Nestling	94	0.9158	0.0110	0.4472	0.3582	0.5553	
Petaluma River Mouth	All	115	0.9401	0.0065	0.2447	0.1786	0.3339	0.2957
	Laying	28	0.9318	0.0380	0.8658	0.7328	1.0000	
	Incubation	99	0.9638	0.0067	0.6507	0.5525	0.7646	
	Nestling	84	0.9065	0.0126	0.4077	0.3151	0.5237	
Black John Slough	All	55	0.9224	0.0126	0.1585	0.0843	0.2930	0.3636
	Laying	12	1.0000	0.0000	1.0000	1.0000	1.0000	
	Incubation	42	0.9154	0.0173	0.3567	0.2278	0.5492	
	Nestling	31	0.9240	0.0203	0.4852	0.3219	0.7186	
SUISUN BAY								
Benicia State Park	All	103	0.9218	0.0087	0.1561	0.1009	0.2394	0.2816
	Laying	30	0.8990	0.0428	0.8085	0.6620	0.9696	
	Incubation	84	0.9310	0.0107	0.4343	0.3314	0.5656	
	Nestling	57	0.9095	0.0158	0.4200	0.3042	0.5735	
Rush Ranch	All	43	0.8889	0.0180	0.0682	0.0266	0.1683	0.2727
	Laying	8	0.7778	0.1132	0.6055	0.3048	1.0000	
	Incubation	33	0.8905	0.0220	0.2588	0.1432	0.4544	
	Nestling	17	0.9016	0.0311	0.3879	0.2016	0.7145	
PALOMARIN FIELD STATION 2000	All	27	0.9399	0.0156	0.2260	0.1024	0.4866	0.4815
	Laying		0.8889	0.1048	0.7901	0.4673	1.000	
	Incubation		0.9378	0.0246	0.4629	0.2458	0.8444	
	Nestling		0.9451	0.0202	0.5685	0.3708	0.8566	
PALOMARIN Average 1992 -2000	All	502	0.9406	0.0034	0.2298	0.1939	0.2725	0.4163

1 The Mayfield method of calculating nest survivorship or success takes into account the number of days each nest was under observation (see text)

2 The success rate for each phase or period of the nest cycle is calculated as the daily survival for the period to the nth power where n = the number of days in the period: laying = 1.996 days, incubation = 11.661, nestling = 9.145.

3 The proportion successful is the number of nests which fledged at least one young divided by the total number of active nests found.

TABLE 3. Song Sparrow nest survivorship: Mayfield method and proportion of nests successful. A comparison of San Pablo Bay Song Sparrow (*Melospiza melodia samuelis*) populations with reference sites in Suisun Bay (*M. m. maxillaris*) for the 2001 field season

Site	Nest Phase	Sample size	Daily Mayfield nest success [1]		Mayfield nest success rate for period [2]	Mayfield period nest success confidence limits		Proportion Successful [3]
SAN PABLO BAY			Rate	SE		Lower	upper	
China Camp	overall	135	0.9417	0.0060	0.2541	0.1893	0.3396	0.3481
	Laying	54	0.9441	0.0243	0.8916	0.8024	0.9855	
	Incubation	112	0.9441	0.0079	0.5116	0.4200	0.6211	
	Nestling	83	0.9377	0.0101	0.5554	0.4555	0.6743	
Petaluma River Mouth	overall	71	0.9210	0.0108	0.1530	0.0889	0.2600	0.3099
	Laying	7	1.0000	0.0000	1.0000	1.0000	1.0000	
	Incubation	48	0.9636	0.0108	0.6492	0.4989	0.8400	
	Nestling	59	0.8760	0.0188	0.2980	0.1994	0.4379	
Black John Slough	overall	42	0.9179	0.0149	0.1417	0.0669	0.2932	0.3333
	Laying	18	0.8077	0.0773	0.6529	0.4272	0.9261	
	Incubation	29	0.9278	0.0186	0.4175	0.2592	0.6600	
	Nestling	23	0.9256	0.0239	0.4932	0.3040	0.7809	
SUISUN BAY								
Benicia	overall	75	0.9159	0.0106	0.1350	0.0793	0.2271	0.2267
	Laying	33	0.9328	0.0325	0.8703	0.7535	0.9954	
	Incubation	66	0.9065	0.0137	0.3181	0.2222	0.4507	
	Nestling	29	0.9339	0.0184	0.5350	0.3700	0.7624	
Rush Ranch	overall	22	0.9206	0.0185	0.1515	0.0595	0.3717	0.2273
	Laying	7	0.8947	0.0996	0.8009	0.4845	1.1962	
	Incubation	18	0.9197	0.0244	0.3767	0.1997	0.6876	
	Nestling	11	0.9250	0.0294	0.4902	0.2686	0.8620	

1 The Mayfield method of calculating nest survivorship or success takes into account the number of days each nest was under observation (see text)

2 The success rate for each phase or period of the nest cycle is calculated as the daily survival for the period to the nth power where n = the number of days in the period: laying = 1.996 days, incubation = 11.661, nestling = 9.145.

3 The proportion successful is the number of nests which fledged at least one young divided by the total number of active nests found.

TABLE 4. Song Sparrow egg hatchability. Proportion of eggs that hatched in nests observed both prior to hatch date and at least 2 days after hatching. A comparison of San Pablo Bay song sparrow populations (*Melospiza melodia samuelis*) with reference sites in Suisun Bay (*M. m. maxillaris*) and Palomarin field station (*M. m. gouldii)* . 1999, 2000 and 2001 field seasons.

Site	eggs hatched	total eggs	egg hatchability	Proportion nests where no eggs remained unhatched	N (number nests)
1999					
SAN PABLO BAY					
China Camp	267	276	0.967	0.909	88
Petaluma River Mouth	99	106	0.934	0.846	39
Black John Slough	103	110	0.936	0.842	38
SUISUN BAY					
Rush Ranch	37	38	0.974	0.923	13
Benicia	154	163	0.945	0.837	49
Palomarin1999	220	234	0.940	N.D.	84
Ave 1996-1999	555	583	0.952	N.D.	216
2000					
SAN PABLO BAY					
China Camp	255	261	0.977	0.955	88
Petaluma River Mouth	188	200	0.940	0.870	77
Black John Slough	56	64	0.875	0.692	26
SUISUN BAY					
Rush Ranch	42	44	0.955	0.875	16
Benicia	158	164	0.951	0.929	56
2001					
SAN PABLO BAY					
China Camp	212	221	0.959	0.877	73
Petaluma River Mouth	125	131	0.954	0.912	57
Black John Slough	45	45	1.000	1.000	17
SUISUN BAY					
Rush Ranch	34	35	0.971	0.909	11
Benicia	78	81	0.963	0.920	25

TABLE 5. Song Sparrow clutch size. A comparison of San Pablo Bay song sparrow populations (*Melospiza melodia samuelis*) with reference sites in Suisun Bay (*M. m. maxillaris*) for the 1999-2001 field season. Also includes average clutch sizes for each site for 1996-2001.

Site	Mean clutch size	S. D.	N	Median
1999				
SAN PABLO BAY				
China Camp	3.01	0.582	119	3
Petaluma River Mouth	2.79	0.466	43	3
Black John Slough	2.70	0.758	40	3
SUISUN BAY				
Rush Ranch	2.75	0.639	20	3
Benicia	3.22	0.559	59	3
2000				
SAN PABLO BAY				
China Camp	2.97	0.503	127	3
Petaluma River Mouth	2.67	0.561	90	3
Black John Slough	2.61	0.567	28	3
SUISUN BAY				
Rush Ranch	3.00	0.756	22	3
Benicia	3.12	0.612	70	3
2001				
SAN PABLO BAY				
China Camp	2.94	0.389	85	3
Petaluma River Mouth	2.56	0.564	32	3
Black John Slough	2.84	0.501	19	3
SUISUN BAY				
Rush Ranch	3.11	0.485	17	3
Benicia	2.91	0.622	54	3
Average 1996-2001				
SAN PABLO BAY				
China Camp	3.01	0.551	604	3
Petaluma River Mouth	2.77	0.550	276	3
Black John Slough	2.70	0.679	87	3
SUISUN BAY				
Rush Ranch	3.02	0.658	121	3
Benicia	3.08	0.624	478	3

FIGURE 1. SONG SPARROW NEST SURVIVORSHIP: MAYFIELD METHOD
COMPARISON OF SAN PABLO BAY (SOLID LINES) AND SUISUN BAY SITES (DOTTED LINES)
1996-2001