2017 FOREST SURVEY RESULTS - MARBLED MURRELETS IN THE SANTA CRUZ MOUNTAINS

By
Steven W. Singer
Steven Singer Environmental & Ecological Services
Santa Cruz, California

ABSTRACT

Simultaneous A-V surveys were conducted at the Butano, Gazos Camp, Big Basin, and at Pescadero Creek County Park (new location) survey stations on 5 days in July 2017. Data from the three pre-existing stations were compared with existing prior year data. Total detection numbers for all three stations combined in 2017 were similar to the 2016 value. Of interest was the fact that the number of detections at Big Basin, although relatively small, reached an all-time high for recent years.

The total of below-one-canopy ("below-canopy") detections for the combined three stations were higher in 2017 than in 2016 although not for each individual station. Numbers at Gazos were dramatically lower while those at Big Basin were much higher. Big Basin also set a station record for recent years in the number of wing sounds reported, which was 22. This is three times the number reported in 2016.

INTRODUCTION

This report discusses the results of 2017 Marbled Murrelet audio-visual (A-V) surveys at four breeding areas in the Santa Cruz Mountains (see map in Appendix 2). One station, Pescadero Creek County Park, was moved 0.5 km downstream to a site with lesser visibility, so detections are not comparable to those from last year's site. This new location is herein designated as "Pescadero Creek County Park – B".

This effort is the continuation, on a reduced scale, of a long term inland murrelet monitoring program that was administered by the California State Parks Department and ended in 2011. That effort included 11 stations and 3 – 5 surveys at each station. Results of that effort can be found in Shaw (2011) and Singer (2017). Other long-term murrelet A-V surveys in Zone 6 are the Gazos Mountain Camp study which began in 1998, and, consisted of 7 surveys per year at one station (Singer, 2017; Singer 2013), and is now merged into this study, and the Upper Pilarcitos Creek study near Stone Dam on land belonging to the San Francisco Public Utility District which has been surveyed continuously every year since 2005 (Avocet Research Associates 2016, Singer 2017). A complete review of the history and extent of inland marbled murrelet monitoring efforts in the Santa Cruz Mountains can be found in the Marbled Murrelet Management Plan for Zone 6 (Halbert and Singer 2017).

There are several different types of murrelet detections that are reported in these A-V surveys. The meaning of these is discussed below.

Total Detections – These are any detection of a murrelet by either sight or sound and can include audio detections of murrelet vocalizations that are more than 400 meters away from the observer. These detection numbers are not useful for determining trend in activity levels at any one station due to high day-to-day variability of detections and the small number of surveys per station. However they do give an indication of the difference in murrelet activity levels between stations.

Occupied Behaviors and Below-canopy Detections – "Occupied behaviors" are observations of murrelets seen circling overhead at a height between one canopy and two canopy or flying below one-canopy height. This definition is slightly different than that used in the protocol, in Shaw (2011), and in Singer (2013), but the resulting values are very similar and the raw data from Shaw were not available.

"Below-canopy" detections are observations of murrelets flying below the tree top level. Since the vast majority of occupied behaviors are made by below-canopy birds, these two types of detections can be considered together, being very similar. Studies have shown that below-canopy detections are made by birds that either currently have or had earlier in the season a nest in the near vicinity (Plissner et al. 2015).

Single Silent Birds Below Canopy (SSBBC) Detections – These are observations of non-vocalizing solitary murrelets flying below one canopy. They are an even stronger indicator of nesting activity. "Early Single Silent Birds Below Canopy" are those observed 8 minutes or more prior to sunrise. These are strong evidence of an active nest. Although the cutoff time of 8 minutes is somewhat arbitrary, it does represent the approximate cut-off time for the earliest nest visits as made during studies of active nests in California and Oregon (Nelson and Peck 1995, Singer et al. 1995). These individuals are most likely visiting the nest to make an incubation exchange or to provide the first feeding of the day to a nestling.

Wing Sound Detections – These are non-vocal sounds made by murrelets and believed to be agnostic in nature. They are usually made by birds flying below canopy and often are made by birds flying behind the observer so are not actually seen. We include wing sound detections of birds not seen as below-canopy detections. They are believed to be strong indicators of nesting nearby.

METHODS

Audio-visual (A-V) Survey Methodology

Survey procedures followed the 1994 Pacific Seabird Group (PSG) protocol for forest surveys (Evans et al. 2003), starting 45 minutes before sunrise and lasting for a minimum of two hours, or 15 minutes from the last detection (but see below). Audible wing sounds from murrelets not seen were considered to be below-canopy flights by single birds.

As in 2016, A-V surveys at all sites in 2017 were done simultaneously. Surveys were done at Big Basin, Butano, Gazos, and Pescadero Creek County Park on these dates: July 7, July 13, July 14, July 21, and July 28. A map showing survey station locations appears in Appendix 2. Surveys were primarily done by Ramona Arechiga, Portia Halbert, Michelle Laskowski, Bryan Mori, and Bill Webb.

In 2011 and prior years A-V surveys were not conducted simultaneously and the number of surveys per season (normally 3) was different at Portola and Gazos Camp. Portola had 5 surveys per season and Gazos Camp had 6 - 7 surveys per season. Surveys at Portola ended in 2016 and at Memorial they ended in 2014. No surveys were done at Gazos Camp in 2005, and no surveys were done at any of the other sites in 2012 and 2013.

Observations were recorded live into tape or digital recorders and later transcribed onto standard forest survey forms. Surveys at Gazos this season had to end 4 – 15 minutes before official end time on several days due to a daily road closure of the only access road. However only on July 13 was there the likelihood that some detections were missed. There were late detections on that day, and the observer had to leave 14 or more minutes before the official end time (based on 15 minutes since the last detection).

The maximum number of Common Ravens detected simultaneously and the maximum number of Steller's Jays detected simultaneously were also recorded. It should be noted that corvid detections can't be collected in the same manner as murrelet detections. This is because a single raven or jay, unlike a murrelet, can perch on a branch nearby and make intermittent calls all morning long. Corvid sampling was more comprehensive in 2011 and prior years, and those findings can be found in Shaw (2011). In 2017, as in 2015 and 2016, the maximum number of murrelets seen in the sky at the same time was also recorded.

Statistical analyzes of prior years' data were conducted in 2016 and results can be found in last year's report (Singer 2016) and in Comfort (2016, 2017) and Singer (2017).

RESULTS AND DISCUSSION

Note on A-V Data and Statistical Analysis ***-*** *No statistical analysis was done in 2017. A statistical analysis of the data was conducted in 2016 to see if there were any trends among the different types of detections that reached a statistical level of significance. That review found there to be only two significant trends. One was the decline of total detections at Big Basin from 1995 to 2006 (Singer 2017). The other was a slightly positive trend in the number of SSBBC detections at Gazos from 1998 to 2015 (Comfort 2016). Due to the small number of A-V surveys done at each site each year and the inherent high variability in murrelet inland use from day to day, the discovery of statistically-significant trends is not anticipated in the near future if A-V surveys alone are utilized. However we are exploring the combined use of A-V surveys and ARU surveys to increase our statistical power. Even if they can never rise to a level of statistical significance, A-V survey results are valuable because they can indicate whether or not nesting is*

occurring in the season and can provide a general comparison of the relative level of murrelet use at different survey sites.

Total Detections

Total Detection values are presented in Tables 1, 3, 4, and 6, and Graph 1; all of which can be found in Appendix 1.

Because murrelet A-V surveys at different sites have been done simultaneously since 2014, and because five surveys were done at each site since 2015, we can get a good sense of the year-to-year changes by looking at the combined values of the three stations surveyed regularly each year since then. In 2017, for 5 days combined, there was a sum of 740 detections, compared to 734 and 714 in the two previous years – 2016 and 2015, respectively. Daily totals for the combined stations in 2017 ranged from 112 to 210 (Table 3) compared to last year's range of 111 to 209. The daily mean of the 15 surveys conducted at the three long-term stations in 2016 was 48.7 and this year was 49.3 (Table 4). The range of total detections at Pescadero Creek County Park–B was 11 to 32, with the mean being 24.8. In 2017, the highest number of detections in a single day was 99 recorded at Gazos Mountain Camp on July 13. The fewest detections on any one day occurred at Big Basin with zero detections on July 28. The maximum Number of murrelets seen in the sky at once was six at Butano on July 14.

In 2017, about 74% of all detections at the combined three stations came from the combination of Butano and Gazos, compared to 75% in 2016 and 87% in 2015.

Graph 1 compares means of total detections per station in 2017 with values from 2016, 2015, 2014, and 2011.

Below-one-canopy Detections

Below-one-canopy detections are similar to, but slightly less than, occupied behavior detections. Below-one-canopy detections or occupied behavior detections are shown in Tables 2, 3, 4, and 6; and Graph 2.

For the same three stations surveyed in 2016, the sum of below-one-canopy detections in 2017 was 239 compared to 165 in 2016 – a considerable increase this year (Table 3). This resulted from a large increase in below-canopy birds at Big Basin – 112 this year versus 18 last year. Daily totals for the combined stations ranging from 22 to 70 compared to last year's range of 13 to 49.

The highest station total numbers of below-one-canopy detections were made at Big Basin (112) and Butano (95), with last year's respective values at these two stations being 18 and 36 (Table 3). In contrast, the total number of below-canopy detections at Gazos was down dramatically in 2017 – 32 compared to 111. The total number of below-canopy detections at Pescadero Creek County Park-B, a site with limited visibility, was only 3.

Graph 2 compares means of occupied behavior detections in 2017 for most stations with those going back to 1995, 1998, 2003, or 2009 depending on the station using data from Shaw (2011) and Singer (2010).

SSBBC and Wing Sound Detections, and Other Evidence of Nesting

Certain murrelet behaviors and physical artifacts are believed to be indicative of an active or inactive nest site nearby. In order of decreasing strength of prediction, these are (1) grounded fledgling found, (2) eggshell fragments found, (3) branch landing heard or seen on a potentially suitable nest tree, (4) Jet plane sound heard, (5) SSBBC detections early during the survey period, (6) wing sounds, (7) Other SSBBC detections, and (8) below-one-canopy and other occupied behaviors (Evans et al 2003, Nelson and Peck 1995, and Singer et al 1995). It should be noted that only the first two finds are proof certain. A branch landing might be a nest or it might just be a bird practicing tree landings. Information not widely publicized but made available in Plissner (2015) disclosed the fact that below-one-canopy flights may be made by a nesting pair at a site throughout the breeding season even when the nest is no longer active.

No eggshell fragments were found and no branch landings or jet plane sounds were heard in 2017. SSBBC and wing sound detection data are presented in Tables 4 and 5, and graph 3. As Table 4 shows, there were nearly twice as many SSBBC detections in 2017 as in 2016, and more than twice as many wing sound detections in 2017 as in 2016. Also revealed in Table 5 is that he greatest number of SSBBC detections was at Big Basin, which had twice as many as the next highest station.

Common Raven and Steller's Jay Numbers in 2017

Although individual raven or jay detections were not recorded, the maximum number of ravens and jays detected at any one moment (seen and/or heard) was recorded. The greatest simultaneous number of ravens was 5 at Butano on July 28. Four ravens were detected simultaneously at Big Basin on July 14 and 3 at Pescadero Creek County Park-B on July 13. Five days of murrelet surveys at Gazos were associated with zero raven detections.

In terms of frequency, ravens were detected on all five days at Pescadero Creek County Park-B, and on 4 days at Big Basin. At Butano, 2 days had detections of ravens.

The maximum number of jays detected simultaneously was 7 which were detected on one day at Big Basin. At least one jay was present on all 5 survey days at Big Basin and Gazos. Jays were detected on 4 days at Butano and only 2 days at Pescadero Creek County Park-B.

Other Inland Murrelet Detections in 2017

Three other monitoring efforts were undertaken in 2017. Although not part of this monitoring program, the agencies or researchers involved have shared their findings with us.

Three A-V surveys were conducted at Fall Creek State Park by Brian Mori on June 8, 15, and 22, but no murrelets were detected. These surveys were funded by California State Parks.

Six A-V surveys were conducted this year by Avocet Research Associates for the San Francisco Public Utility District (SFPUD) on their watershed land in the Upper Pilarcitos Creek Watershed. Surveys have been conducted there annually since 2005 (Halbert and Singer 2017). Surveys were done on June 6, June 14, June 21, June 28, July 5, and July 12, 2017. A total of 284 detections were recorded which was an all-time high. This number is slightly higher than 2017 totals from Butano (274), and Gazos (276), although these sites had one fewer survey. There were 116 below-one-canopy detections on the SFPUD lands which is similar to the number of below-canopy detections at Big Basin, 112, and Butano, 95. The SFPUD surveys included 45 SSBBC detections and 2 wing sounds (Evens, pers. comm.)

In a separate study funded by California State Parks, acoustic recording units (ARUs) were used to monitor murrelet vocalizations and wing sounds at 3 different sites. These sites were Fall Creek State Park, Berry Creek in Big Basin State Park, and Gazos Mountain Camp. Seven A-V surveys were also done at Gazos Mountain Camp to allow comparison and possible synthesis of the two types of monitoring data.

Fall Creek was monitored for only the last half of the breeding season, but the other two sites were monitored over most of the breeding season. Details can be found in Fleishman and McKown (2017). There were no detections at Fall Creek, but there were detections at the other two sites. The exact number of detections is unknown since the ARU results were reported as vocalizations per minute and not by the number of detections. It is hoped that the reporting methods can be standardized in the future to allow the combined use of season-long ARU monitoring in conjunction with a few days of A-V survey monitoring at the same site to produce a better index of murrelet activity levels at that site.

In addition to these monitoring efforts, two grounded murrelet fledglings were collected at different locations on the ground by others in 2017. Both birds were examined, found to be healthy, and released into the ocean. The first was found at Gazos Creek Road west of Barranca Knolls Road on June 17, 2017. This is not far from the Gazos A-V survey station. The second juvenile was found on Pescadero Creek Road in the town of Loma Mar on September 1, 2017.

RECOMMENDATIONS

1. If funds are available, restore A-V surveys to the old Portola survey station. The Pescadero Creek Watershed is an important murrelet flyway and at least one station at a good quality site should be surveyed there each year. The existing Pescadero Creek County Park-B station has limited visibility and is not located in an old-growth stand, so results from it are not directly comparable to the results from the other stations.

2. Work with Conservation Metrics, to revise their reporting protocol for ARU surveys so that the results are expressed in terms of murrelet detections and can be compared directly with the results of standard A-V surveys.

3. Conducg ARU surveys in 2018 at Fall Creek State Park, Big Basin State Park, and Gazos Creek Mountain Camp. If permission from Big Creek Lumber can be obtained, also do ARU surveys at the Hidden Gulch stand in their Pescadero Unit.

4. Work with Conservation Metrics to devise a monitoring scheme that utilizes both ARU and A-V surveys to produce results with greater statistical power.

5. Work with all agencies doing or planning to do A-V surveys in the Santa Cruz Mountains so that methodology is the same and that, to the extent possible, surveys are done in July of each year with all sites surveyed simultaneously.

6. Ask all agencies doing or planning to do A-V surveys in the Santa Cruz Mountains to archive their annual murrelet A-V and ARU reports with the State Parks Department and also to archive with them the full data spreadsheets for each year's effort.

ACKNOWLEDGEMENTS

Thanks to Bill Webb, Bryan Mori, Michelle Laskowski, Portia Halbert, and Ramona Arechiga for conducting A-V surveys. Special thanks to the San Mateo County Parks Department for conducting the surveys at Pescadero Creek County Park -B at their own expense. Thanks also to the San Francisco Public Utilities District and Avocet Research Associates for sharing their A-V survey results with us.

This work was supported financially by the Luckenbach Oil Spill Trustee Council and the California State Parks Department. Thanks to California State Parks Department staff for their assistance and especially to Portia Halbert, Joanne Kerbavaz, Stanley Kopacz, Terry Kiser, and Scott Sipes.

LITERATURE CITED

Avocet Research Associates 2016. Protocol-level Nesting Season Surveys for the Marbled Murrelet, San Francisco Public Utility Commission Lands, Upper Pilarcitos Creek, San Mateo County California, 2016. Unpublished report prepared for the SFPUD by Avocet Research Associates, Point Reyes Station, CA.

Comfort, E. 2016. Statistical Analysis of 2014-2016 Marbled Murrelet Surveys in the Santa Cruz Mountains. Unpublished report prepared for Steven Singer Environmental and Ecol. Services.

Comfort, E. 2017. Statistical Analysis of Annual Marbled Murrelet Surveys at Butano, Portola, and Big Basin. Unpublished report prepared for Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

Evans, M.D., W. Ritchie, S. Nelson, E. Kuo-Harrison, P. Harrison, and T. Hamer 2003. Methods for Surveying Marbled Murrelets in Forests: A Revised Protocol for Land Management and Research. Pacific Seabird Group Technical Publication #2.

Fleishman, A.B. and M. McKown. 2017. Automated Acoustic Surveys for Marbled Murrelets in the Santa Cruz Mountains, 2017. Unpublished report for the California State Parks Department. Conservation Metrics, Santa Cruz, CA.

Halbert, P. and S.W. Singer. 2017. Marbled Murrelet Landscape Management Plan for Zone 6. Unpublished report. Santa Cruz District, California Department of Parks and Recreation, Felton, CA.

Nelson, S.K., and R.W. Peck. 1995. Behavior of Marbled Murrelets at Nine Nest Sites in Oregon. Northwest Naturalist 76: 43 – 53.

Plissner, J.H., B.A. Cooper, R.H. Day, P.M. Sanzenbacher, A.E. Burger, and M.G. Raphael. 2015. A Review of Marbled Murrelet Research Related to Nesting Habitat Use and Nest Success. Unpublished report prepared for the Oregon Dept. of Forestry by ABR, Inc., Forest Grove, OR.

Shaw, B. 2011. Summary of 2011 Marbled Murrelet Monitoring Surveys in the Santa Cruz Mountains (Draft). Unpublished report prepared for the Santa Cruz District of California State Parks Department. Klamath Wildlife Resources, Redding, CA.

Singer, S.W. 2017. "Murrelet Inland Distribution and Detection Numbers in Zone 6 " in Halbert, P. and S.W. Singer, eds., 2017, Marbled Murrelet Landscape Management Plan for Zone 6. Unpublished report. Santa Cruz District, California State Parks Department, Felton, CA.

Singer, S.W. 2016. 2016 Forest Survey Results – Marbled Murrelets in the Santa Cruz Mountains. Unpublished report prepared for the Santa Cruz District of the California State Parks Department. Steven Singer Environmental & Ecol. Services, Santa Cruz, CA.

Singer, S.W. 2010. Final Report – Part II, Results of Marbled Murrelet Audio-Visual Surveys at Gazos Mountain Camp 1998 – 2010. Unpublished report prepared for the Apex Houston Trustee Council and the California Department of Fish and Wildlife. Steven Singer Environmental & Ecological Services, Santa Cruz, CA.

Singer, S.W., D.L. Suddjian, and S.A. Singer. 1995. Fledging Behavior, Flight Patterns, and Forest Characteristics at Marbled Murrelet Tree Nests in California. Northwest Naturalist 76: 54 – 62.

APPENDIX I – Tables and Graphs

Table 1. Mean Number of Total Detections 2003 - 2017

Mean Number of Total Murrelet A-V Detections 2003 – 2017 (Empty boxes are years where no surveys were done)							
Year	**Big Basin**	**Portola**	**Gazos Mtn. Camp**	**Butano**	**Memorial**	**Pescadero Ck. Co. Pk.**	**Pescadero Ck. Co. Pk. - B**
2003	16.3	33.2	59.7	34	4.3		
2004	17	35.6	44.7	68.3	1		
2005	14	18		26.7	1.3		
2006	18.3	18.6	79.7	48	4.7		
2007	16.3	30.6	31.2	46.3	0.7		
2008	12	19	71.8	20.7	0.7		
2009	1.7	5.4	6.8	17.7	0.7		
2010	15.3	33	66	62	11		
2011	22	55	44.3	32	4.7		
2012			53.1				
2013			28.1				
2014	8.3	27.7	37	78	10.3		
2015	18	27.8	62.2	62.6			
2016	36.4	74.2	61.2	48.2		46.8	
2017	38		55.2	54.8			24.8

Table 2. Mean Number of Occupied Behavior Detections 2003 -2017

Mean Number of Murrelet Occupied Behavior Detections 2003 – 2017 (Empty boxes are years where no surveys were done)							
Year	**Big Basin**	**Portola**	**Gazos Mtn. Camp**	**Butano**	**Memorial**	**Pescadero Ck. Co. Park**	**Pescadero Ck. Co. Park-B**
2003	1.3	6	9.7	6	0		
2004	2.3	4.4	9.5	22	0		
2005	1.3	0.2		4	0		
2006	9	2.4	19.8	4.3	0.3		
2007	2.7	0.8	9.2	5.7	0		
2008	0	0.6	27.2	3	0		
2009	0	0	0.8	2	0		
2010	3	5.8	25.7	19.7	1		
2011	3	16.7	7.4	6.7	0.3		
2012			15.1				
2013			2.1				
2014	1.33	2.33	8	28.7	7.7		
2015	2.4	5.6	20.4	21.6			
2016	6.4	13.4	29.8	10.8		6.6	
2017	25		10.8	19.6			0.6

Table 3. 2017 Total Detections and Below-one-canopy Detections

Table 3 provides the number of total detections and below-one-canopy detections (which are shown in parentheses) on every 2017 survey at all sites and provides the Standard Deviation (STDEV) and Coefficient of Variation (CV) for each site.

CV values for total detections were high at Big Basin and Gazos Camp. CV values for below-canopy detections were reasonable for Butano but high for all other sites including 3 sites combined. 2016 values are included on bottom line for comparison.

Date	Big Basin	Butano	Gazos Camp	Pescadero Crk Co Pk-B	3 Sites Combined*
July 7	49 (23)	38 (18)	35 (0)	11 (0)	122 (41)
July 13	64 (37)	47 (21)	99 (11)	22 (2)	210 (69)
July 14	12 (8)	62 (26)	41 (3)	30 (0)	115 (37)
July 21	65 (44)	45 (11)	71 (15)	32 (0)	181 (70)
July 28	0 (0)	82 (19)	30 (3)	29 (1)	112 (22)
2017 TOTAL	**190 (112)**	**274 (95)**	**276 (32)**	**124 (3)**	**740 (239)**
MEAN	**38 (22.4)**	**54.8 (19.0)**	**55.2 (6.4)**	**24.8 (0.6)**	**148 (47.8)**
STDEV	30.2 (18.6)	17.54 (5.43)	29.21 (6.31)	8.58 (0.89)	44.7 (21.04)
CV	0.8 (0.8)	0.32 (0.29)	0.53 (0.99)	0.35 (1.49)	0.3 (1.48)
2016 TOTAL	***182 (18)***	***241 (36)***	***311 (111)***	___	***734 (165)***

Table 4. Frequency of Detection Types in 2017, 2016, and 2015 – Three Stations Combined*

Type of Detection	Total 2017 - Daily Mean Per Site (of 15 survey-days)	Total 2016- Daily Mean Per Site (of 15 survey-days)	Total 2015 Daily Mean Per Site (of 15 survey-days)
Total Detections	49.3	48.9	47.6
Total Visual Detections	18.9	19.7	17.7
Below 1 Canopy Detections	15.9	11.0	12.3
Single Silent Birds Below 1-Canopy	8.1	4.3	5.5

Notes: * Excludes values from Portola and Pescadero Creek County Park (both sites).

Table 5. 2017 and 2016 Single Silent Birds Below-one-canopy (SSBBC) and Wing Sound (W) Detections. Wing sound detections are shown in parentheses. C.V. stands for Coefficient of Variation. Note that SSBBC excludes vocalizing birds but includes single birds making a wing sound, but not a pair of birds making a wing sound. SSBBC and W detections are believed to be associated with a current season nesting effort nearby, especially when detected on multiple days. 2016 total included at bottom and in last column for comparison.

Date	Big Basin 2017	Butano 2017	Gazos Camp 2017	2017 3 Sites Combined	2016 3 Sites Combined
Day 1	16 (2)	10 (3)	0 (0)	**26 (5)**	**7 (7)**
Day 2	23 (6)	6 (5)	6 (0)	**35 (11)**	**14 (2)**
Day 3	6 (2)	7 (5)	0 (0)	**13 (7)**	**22 (3)**
Day 4	25 (12)	10 (10)	9 (0)	**44 (22)**	**9 (5)**
Day 5	0 (0)	2 (5)	1 (0)	**3 (5)**	**12 (3)**
2017 TOTAL	**70 (22)**	**35 (28)**	**16 (0)**	**121 (50)**	**64 (20)**
MEAN	14.0 (4.4)	7.0 (5.6)	3.2 (0)	**24.2 (10)**	**12.8 (4)**
STDEV	10.8 (4.8)	3.3 (2.6)	4.1 (0)	**16.5 (7.1)**	**5.6 (1.3)**
CV	0.8 (1.1)	0.5 (0.5)	1.3 (0)	**0.6 (0.71)**	**0.43 (0.31)**
2016 TOTAL	***10 (7)***	***11 (9)***	***43 (4)***	*--*	***64 (20)***

Table 6. Comparison of Murrelet Activity Levels at Each Park for All Data Years.

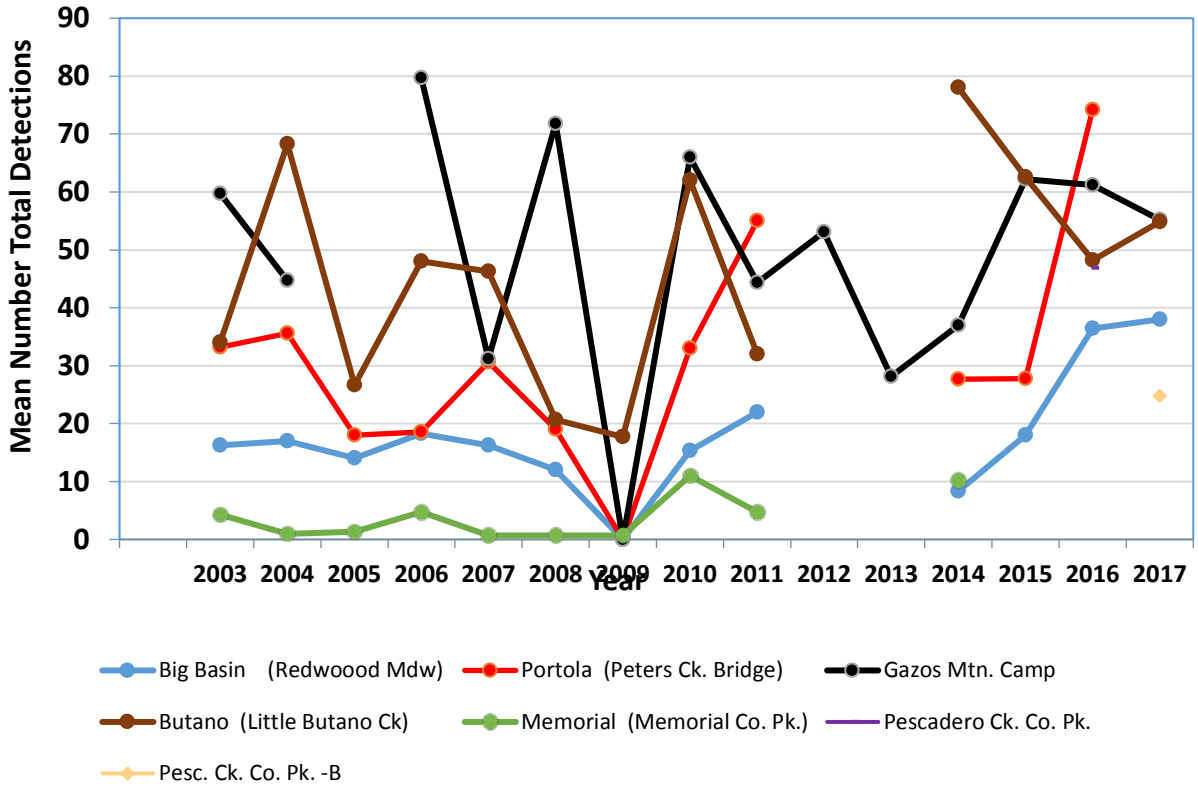
Values from 2011 and prior years are from Shaw (2011) or Singer (2013, 2010). The multiple park monitoring program began in 2003, but two stations had earlier data that is included here. Only the Gazos Camp station was surveyed in 2012 and 2013.
Note that only since 2014 were different stations surveyed on the same day.

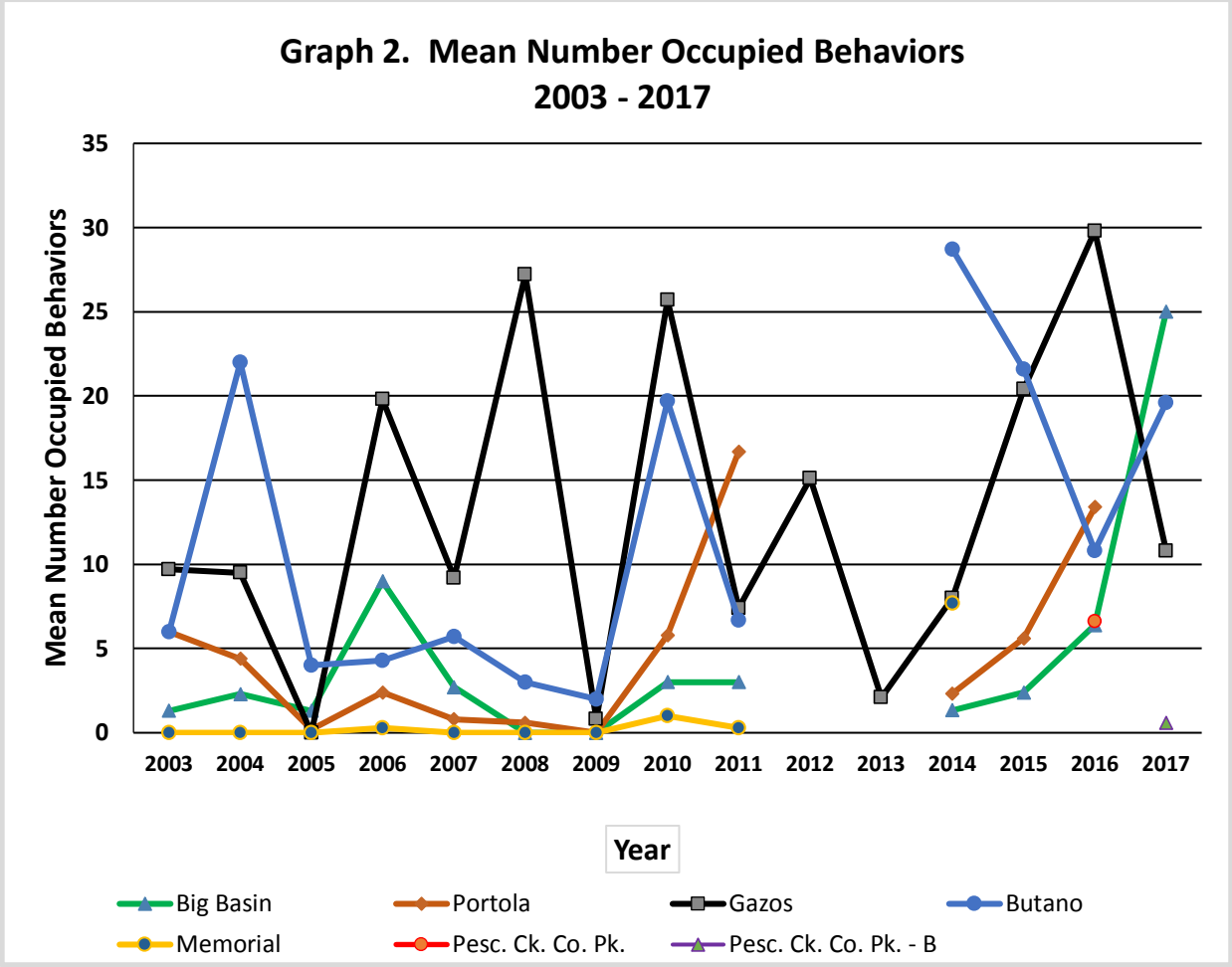
Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
Big Basin – Redwood Meadow	1995	4	177.0	64.0
" "	1996	4	97.0	27.5
" "	1998	4	92.3	33.5
" "	2001	3	86.3	8.0
" "	2002	3	18.7	1.3
" "	2003	3	16.3	1.3
" "	2004	3	17.0	2.3
" "	2005	3	14.0	1.3
" "	2006	3	18.3	9.0
" "	2007	3	16.3	2.7
" "	2008	3	12.0	0.0
" "	2009	3	1.7	0.0
" "	2010	3	15.3	3.0
" "	2011	3	22.0	3.0
" "	2014	3	8.3	0.3
" "	2015	5	18.0	2.4
" "	2016	5	36.4	6.4
" "	2017	5	38.0	24.6
Portola – Peters Creek Bridge	2003	5	33.2	6.0
" "	2004	5	35.6	4.4
" "	2005	5	18.0	0.2
" "	2006	5	18.6	2.4
" "	2007	5	30.6	0.8
" "	2008	5	19.0	0.6
" "	2009	5	5.4	0.0
" "	2010	5	33.0	5.8
" "	2011	5	55.0	16.7
" "	2014	3	27.7	2.3
" " – near Peters Creek Bridge	2015	5	27.8	5.6
" " – near Peters Creek Bridge	2016	5	74.2	13.4

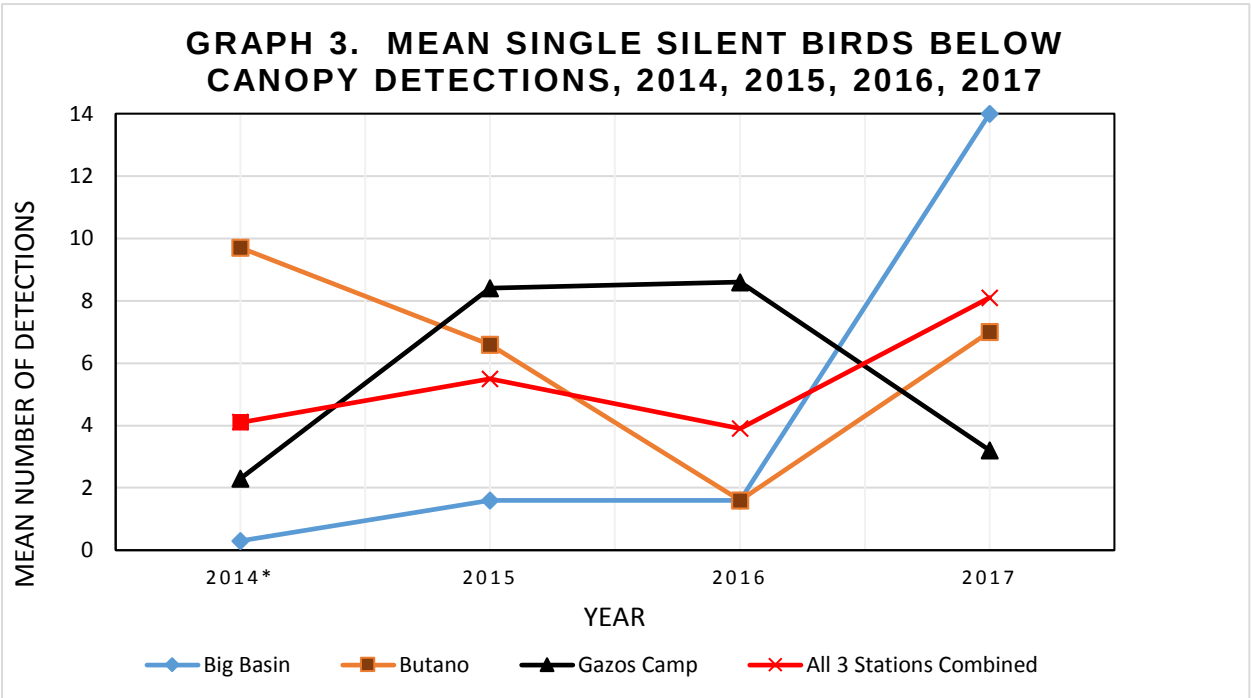
Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
Butano – Little Butano Creek	2003	3	34.0	6.0
" "	2004	3	68.3	22.0
" "	2005	3	26.7	4.0
" "	2006	3	48.0	4.3
" "	2007	3	46.3	5.7
" "	2008	3	20.7	3.0
" "	2009	3	17.7	2.0
" "	2010	3	62.0	19.7
" "	2011	3	32.0	6.7
" "	2014	3	78.0	27.7
" "	2015	5	62.6	21.6
" "	2016	5	48.2	10.6
" "	2017	5	54.8	19.6
Memorial – Memorial	2003	3	4.3	0.0
" "	2004	3	1.0	0.0
" "	2005	3	1.3	0.0
" "	2006	3	4.7	0.3
" "	2007	3	0.7	0.0
" "	2008	3	0.7	0.0
" "	2009	3	0.7	0.0
" "	2010	3	11.0	1.0
" "	2011	3	4.7	0.3
" "	2014	3	10.3	7.7
Gazos Camp – Gazos Mtn. Camp	1998	6	36.0	10.7
" "	2000	6	57.3	15.0
" "	2001	6	64.7	17.8
" "	2002	6	52.0	9.2
" "	2003	6	59.7	9.7
" "	2004	6	44.7	9.5
" "	2006	6	79.7	19.8
" "	2007	6	31.2	9.2
" "	2008	6	71.8	27.2
" "	2009	6	6.8	0.8
" "	2010	6	66.0	25.7
" "	2011	7	44.3	7.4
" "	2012	7	53.1	15.1

Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
" "	2013	7	28.1	2.1
" "	2014	3	37.0	3.3
" "	2015	5	62.2	20.4
" "	2016	5	61.2	30.0
" "	2017	5	55.2	10.8
Pescadero Creek County Park	2016	5	46.8	6.6
Pescadero Creek Co. Pk. – B	2017	5	24.8	0.6

Graph 1. Mean Number of Total Murrelet Detections 2003 - 2017

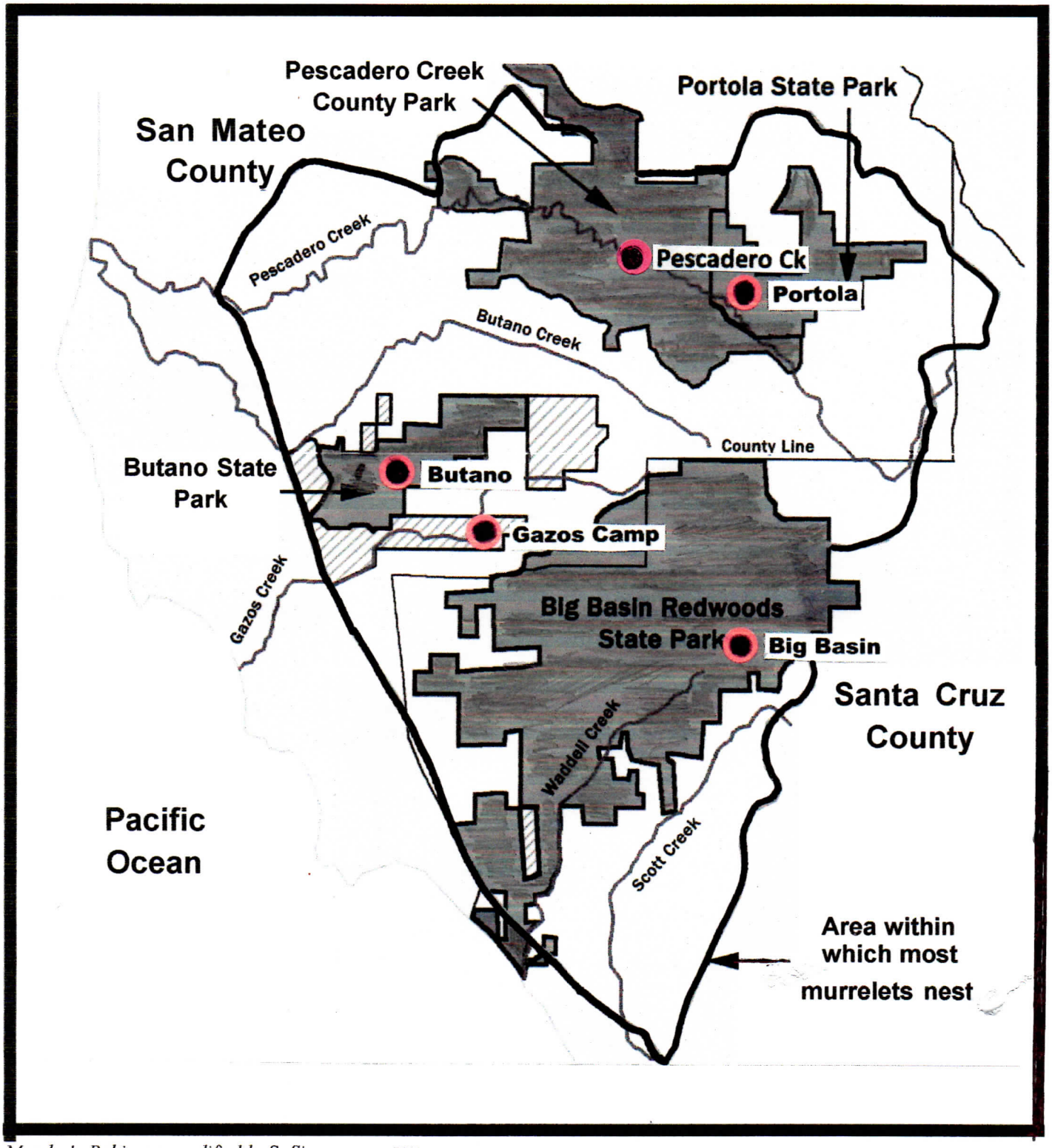



Graph 2. Mean Number Occupied Behaviors
2003 - 2017
Mean Number Occupied Behaviors
35
30
25
20
15
10
5
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year
Big Basin
Portola
Gazos
Butano
Memorial
Pesc. Ck. Co. Pk.
Pesc. Ck. Co. Pk. - B


GRAPH 3. MEAN SINGLE SILENT BIRDS BELOW CANOPY DETECTIONS, 2014, 2015, 2016, 2017
MEAN NUMBER OF DETECTIONS
14
12
10
8
6
4
2
0
2014*
2015
2016
2017
YEAR
Big Basin
Butano
Gazos Camp
All 3 Stations Combined

APPENDIX 2 – Station Location Map
(on following page)

Map 1. Location of Marbled Murrelet Audio-Visual Survey Stations



Map by L. Robinson, modified by S. Singer