

**2016 FOREST SURVEY RESULTS -
MARBLED MURRELETS IN THE SANTA CRUZ MOUNTAINS**

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ABSTRACT

Simultaneous A-V surveys were conducted at the Butano, Gazos Camp, Portola, Big Basin, and, for the first time, Pescadero Creek County Park breeding areas on 5 days in July 2016. Data from the four pre-existing stations were compared with existing prior year data, and the 2014 - 2016 data were subject to statistical analysis. Total detection numbers for all four stations combined were up in 2016. The number of total detections at Portola reached an all-time high, although mostly due to heard-only detections. Total detection numbers and below-one-canopy detection numbers were down considerably at Butano, including wing sound detections. As in previous years, every station had at least a few below-one-canopy detections.

The only statistically significant findings of year-to-year changes were an increase in the number of single silent birds flying below one canopy (SSBBC) from 2015 to 2016 at Gazos Creek, a decrease in below-one-canopy detections from 2014 to 2016 at Butano, and an increase in heard-only detections from 2014 to 2016 at Big Basin. Over the same period in Big Basin, there was also an increase in total detections and below-one-canopy detections, but it was not statistically significant.

INTRODUCTION

This report discusses the results of 2016 Marbled Murrelet audio-visual (A-V) surveys at five breeding areas in the Santa Cruz Mountains. A new station, Pescadero Creek County Park, was added to the four stations surveyed last year. 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). 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 2013), and the Upper Pilarcitos Creek study near Stone Dam on land belonging to the San Francisco Public Utility District.

A good long-term murrelet monitoring program should strive to obtain information that will eventually provide answers to the following questions:

- (1) Which sites are the most important murrelet breeding areas and how does breeding effort (as indicated by nesting-associated-behaviors) vary from year to year?

- (2) What is the long-term trend for murrelet use at each site, and for the Santa Cruz Mountains as a whole?
- (3) How does murrelet use or murrelet breeding effort correlate to corvid control efforts or lack of same at each site?
- (4) Is more supporting evidence available for the hypothesis that murrelets in the Santa Cruz Mountains population divide themselves into subgroups that regularly use specific watersheds, flyways, and breeding areas; and that they do not visit more than one breeding site in the same morning?

Consequently, A-V surveys at breeding sites are an important component of any comprehensive Marbled Murrelet monitoring program.

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. Occupied behavior is defined as flights below one-canopy or circling above one-canopy height but below two-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. Audible wing sounds from murrelets not seen were considered to be below-canopy flights by single birds.

As in 2015, A-V surveys at all sites in 2016 were done simultaneously. Surveys were done at Big Basin, Butano, Gazos Camp, Portola, Pescadero Creek County Park on these dates: July 1, July 14, July 15, July 21, and July 22. A map showing survey station locations appears in Appendix 2. Surveys were done by Ramona Arechiga, Portia Halbert, Michelle Laskowski, Mark Morrisette, Sean McAllister, Bryan Mori, Bill Webb, and the author. Emily Comfort provided a statistical review of the data to the author for use in this report.

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. 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. After many years of problem-free survey data collection, this year had several equipment/observer problems arise. On July 1 at Pescadero Creek County Park, coverage accidentally ended 19 minutes before the official end survey time. On July 15 at Portola, 10 minutes of data was lost in the middle of the survey and probably about 20 (more or less) detections. On July 22 at Gazos Mountain Camp, data collection started 10 minutes late.

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 2016, as in 2014 and 2015, the maximum number of murrelets seen in the sky at the same time was also recorded.

Statistical Review Methods

A statistical review of the data was performed separately by Emily Comfort (Comfort 2016). She used analysis of variance (ANOVA) to test for differences in the mean number of each detection type among four stations (Big Basin, Butano, Gazos Camp, and Portola) over the course of the three years. Tukey's Honest Significant Difference Test (Tukey's HSD) was used to compare means across the four stations. Year-to-year variation of all stations combined was analyzed using a linear mixed effects model.

The data analyzed included a number of different detection types. However only total detections, below-one-canopy detections, SSBBC detections, and heard-only detections will be discussed here.

All analyses were performed using R Statistical software (R Core Team 2016) and RStudio (RStudio Team 2016). More details about the methods used and software sourcing can be found in Comfort (2016). Key findings of this statistical review are reported in the Results and Discussion section.

RESULTS AND DISCUSSION

Total Detections

Total Detection values are presented in Tables 1, 2, and 4, graphs 1 and 2, and Boxplots B-1 and B-2.

Because murrelet A-V surveys at different sites have been done simultaneously since 2014, we can get a good sense of the year-to-year changes by looking at the combined values of the four stations surveyed each year since then. In 2016, they had a sum of 1100 detections, compared to 853 in the previous year. Daily totals for the combined stations ranging from 162 to 291 (Table 1) compared to last year's range of 108 to 263. The daily mean of the 20 surveys conducted at the four long-term stations in 2016 was 55 (Table 2). The range of total detections at Pescadero Creek County Park was 15 to 92, with the mean being 46.8. The highest number of detections in a single day was 109 (recorded at Butano on July 21), but this would probably have been exceeded by single day detections at Portola on July 15 when 101 detections were recorded, but ten minutes of prime activity time was lost. The fewest detections on any one day, excluding Pescadero Creek County Park, occurred at Butano with only 25 detections on both July 14 and July 15. Pescadero Creek County Park had one day with fewer total detections – 15 on July 22.

There was a decrease in the number of detections at Butano and an increase at Portola and Big Basin. In 2016, only about 50% of all detections came from the combination of Butano and

Gazos, compared to 73% in 2015 and 76% in 2014. Graph 1 compares means of Total detections in 2016 with values from 2015, 2014, and 2011. Graph 3 compares values back to 1995, 1998, 2003, or 2009, depending on the station, using data from Shaw (2011), Singer (2013), and Singer (2010).

With the assistance of Jules Evans of Avocet Research Associates and the San Francisco Public Utilities District, they adjusted their survey dates at Upper Pilarcitos Canyon to comply with ours to the extent feasible. Three of their surveys were conducted on the same days as ours. Their total detection numbers from those surveys and the dates: 67 (July 1), 8 (July 14), and 5 (July 21). For those same three days, their below-one-canopy detections were 16, 3, and 3. Historically, their detection levels have been lower than ours.

Below-one-canopy Detections

Below-one-canopy detections are shown in Tables 1 and 2, Graph 3, and Boxplots B-3 and B-4.

The four stations surveyed in 2015 had, in 2016, a sum of 186 below-one-canopy detections, compared to 250 last year (Table 1). Daily totals for the combined stations ranging from 20 to 51 compared to last year's range of 25 to 77. The daily mean for the four combined sites was 37.2 compared to last year's 42.7. All four stations combined yielded a sum of 186 below-one-canopy detections, which number represented 17% of all detections made at the four stations. This number is lower than the 29% experienced last year. The highest station total numbers of below-one-canopy detections were made at Gazos Camp (111) and Butano (36), with last year's respective values at these two stations being 102 and 108 (Table 1). These two stations in 2016 comprised 79% of all below-one-canopy detections at the four long-term stations. The corresponding value in 2015 was 90%. The total below-one-canopy detections at Portola and Big Basin were 21 and 18, respectively. The total below-one-canopy detections at Pescadero Creek County Park in 2016 were 20.

Graph 2 compares means of below-one-canopy detections in 2015 with those from 2014 and with occupied behavior values from 2011, since below-one-canopy data is not available prior to 2014. Graph 4 compares the related metric of occupied behavior back to 1995, 1998, 2003, or 2009, depending on the station using data from Shaw (2011) and Singer (2010). Numbers of below-one-canopy detections are usually only slightly less than occupied behavior detections. The only station with a statistically-significant difference from year to year was Butano, with a decline in numbers from 2014 to 2016. However the year-to-year changes were not significant.

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.

SSBBC and wing sound detections are presented in Tables 2 and 3, and in Boxplot B-5.

In 2016, all of our stations had at least some SSBBC detections and all but Pescadero Creek County Park had some wing sound detections (Table 3). The number of SSBBC detections increased at Big Basin, decreased at Butano, and remained nearly the same at Gazos Camp and Portola. The number of wing sounds decreased dramatically at Butano, increased at Gazos Camp and remained nearly the same at Big Basin and Portola. For the four stations with previous year data combined, the total number of wing sounds on all surveys was quite reduced from 2015 – 78 SSBBC detections then versus 27 detections this year. There was no station that had wing sounds heard on every survey-day, but Butano and Portola had wing sounds heard on four of the five days.

Heard-only Detections

Heard-only detections are shown in Graph 5 and Boxplots B-6 and B-7.

Heard-only detections are detections in which the bird or birds are heard, but not seen. All of our survey stations have reasonably good visibility (see Singer, 2015 for Effective Visibility values for each station), so these detections are often distant or very distant birds that may never approach the survey station. To the extent that this is true, they can be considered to be a different group of birds.

Heard-only detections spiked upward at Portola this year, totaling 278 compared to last years 107. Consequently, Portola led all stations in this type of detection, with Butano being second at 165. The percentage of total detections at each station that were heard-only detections was 84% at Pescadero Creek County Park, 75% at Portola, 75% at Big Basin, 69% at Butano, and 44% at Gazos Camp. The low value of heard-only detections at Gazos Camp are likely the result of the high degree of nesting activities that have been, and continue to be, associated with this site.

The only station with a statistically significant difference from year to year was Big Basin with a significant increase in heard-only detections from 2014 to 2016.

Activity at Individual Survey Stations

Big Basin – Total detections, occupied behavior detections, and below-one-canopy detections were higher this year than in 2015. From 2014 to 2016 there has been an upward trend in total detection numbers, but this trend was not found to be statistically significant at the alpha level of 0.05. In 2016, total detection numbers (daily mean of 36.4) were the highest since 2003.

From 2014 to 2016, the mean number of heard-only detections went from 6.33 to 15.4, and then to 27.2. If one extreme value from the 2015 database is removed, heard-only detections are statistically greater in 2016 than in 2015 or 2014 with an adjusted p-value of 0.001 .

Unlike last year, there were no instances of tree landings or birds seen carrying fish at Big Basin, or at any of the survey stations.

Butano -- Detection numbers at Butano moved in the reverse direction from those at Big Basin. Total detections, occupied behavior detections, and below-one-canopy detections have decreased over the last two years at Butano. However, the 2016 values are still above the lows that occurred from 2006 – 2008. The 2014 – 2016 decline in below-one-canopy detections was statistically significant (Boxplot B-8), but the decrease in total detections was not.

Also of interest was a large drop in wing sound detections – dropping from 52 in 2015 to 17 in 2016.

Gazos Camp – Gazos had the second highest number of total detections in 2016, and by far, the highest number of below-one-canopy detections. Gazos had a daily mean of 22.2 below-one-canopy detections and the closest other station to that was Butano which had only 7.2 mean daily detections. Gazos also led all other stations in the number of single silent birds below-one-canopy detections with a daily mean of 8.6 compared to 2.2 at Butano and Portola, 2.0 at Big Basin, and 0.6 at Pescadero Creek County Park (Boxplot B-9). These results suggest that more nesting activity was associated with Gazos Camp in 2016 than with any other station.

Pescadero Creek County Park – Surveys were conducted in Pescadero Creek County Park on the Old Haul Road at the crossing of Dark Gulch. Visibility is reported to be reasonably good (Arechiga, pers. comm.). This spot is approximately 4 km. downstream of the Portola survey station and is on the same murrelet flyway. It is about 3 km. upstream of the old Memorial survey station where detection numbers were always lower. The difference may be due to stream noise interference – this location has none whereas Memorial was right on the creek.

The daily mean for total detections here was 46.8 which is higher than Big Basin but lower than Gazos Camp and Portola. Few of these detections were of below-one-canopy birds with the daily mean value being 4.00 which is only 8.5% of the total detections. Heard-only detections were 39.2 which represented about 84% of the total detections.

Portola - In 2016 Portola had more total detections than any other station, a daily mean of 74.2. Last year Portola had only 27.8 total detections. But for a technical glitch, Portola would have had the highest one day value of total detections. On July 15, Portola recorded 101 detections, but 10 minutes of data were loss during the prime activity period, and likely 20 or so additional detections. If these detections would have been recorded, the number would have beaten the next-highest single day value of 109 at Butano on July 21.

This year's increase in total detections at Portola was the largest single year increase ever noted for Portola. Most of those detections (75%) were heard-only detections.

Even though the mean value of most detection types was the same or larger from year to year in the 2014 – 2016 period, the increases were not statistically significant.

Statistical Review of Year-to-Year Changes at the Same Station

Heard-only detections increased significantly at Big Basin from 2014 – 2016 (with the removal of one extreme value in 2015 from the data set). The Butano station had a statistically significant decline in below-one-canopy detections overall from 2014 to 2016, however the year-to-year changes were not statistically significant (Boxplot B-8).

For the other detection types, and all other stations, there were no statistically significant trends over the three year period – either increasing or decreasing over all three years.

Statistical Review of Differences Between Stations, 2014 – 2016

The statistical review found that: (1) Butano and Gazos Camp have similar detection levels (high levels), (2) Portola and Big Basin have similar detection levels (low levels), and (3) there is a significant difference between the high-level stations and the low-level stations. This is true for total detections, below-one-canopy detections, and SSBBC detections (Boxplots B-1, B-3, and B-5). The only detection type that does not fit this characterization is heard-only detections (Boxplot B-6). Portola had more heard-only detections, on average, than Gazos, but there was not a statistically significant difference. There is no statistical evidence for a difference in heard-only detections among the four stations.

Detection values from Pescadero Creek County Park were not used in this analysis, because it was only surveyed this year.

Statistical Review of Differences Between Stations, 2016 only

In 2016, Gazos Camp had significantly greater below-one-canopy detections and SSBBC detections than all other stations, including Pescadero Creek County Park (Boxplots B-4 and B-9). There were no significant differences between the other stations. No station had a significant difference with the others when looking at total detections (Boxplot B-2) and heard-only detections (Boxplot B-7).

Common Raven and Steller's Jay Numbers in 2016

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 9, which were detected at Pescadero Creek County Park on July 15. Ravens were detected on all five days at Big Basin and Pescadero Creek County Parks, on 3 days at Portola, and on 2 days at Gazos Camp. No ravens were detected on any of the 5 surveys at Butano this year.

The maximum number of jays detected simultaneously was 9 which was detected on one day at Portola. All stations had at least one jay present each day with the exception of Pescadero Creek County Park where jays were absent on two days.

RECOMMENDATIONS

1. If not all stations can be monitored in 2017, it is recommended that priority be given to monitoring Big Basin, Gazos Camp, and Pescadero Creek County Park.
2. Continue to do surveys at different sites simultaneously. This provides a clearer estimate of the relative levels of murrelet activity at each site.
3. Consider implementation of long-term, season-long acoustic monitoring effort at Gazos Mountain Camp, to co-exist with the A-V survey program there and not to replace it. The additional acoustic detection data would be helpful in the interpretation of the A-V survey results and vice-versa.
4. Park managers should continue to manage all survey sites in such a manner as to maintain the relatively high levels of murrelet activity therein.

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APPENDIX I – Tables, Graphs, and Boxplots

Table 1. 2016 Total Detections and (Below-one-canopy Detections)

Table 3 provides the number of total detections and below-one-canopy detections (shown in parentheses) on every 2016 survey at all sites and provides the Standard Deviation (STDEV) and Coefficient of Variation (CV) for each site. CV values were high for all sites except for Total Detections at Gazos Camp and the 4 Sites Combined. 2015 values are included on bottom line for comparison.

Date	Big Basin	Butano	Gazos Camp	Portola	Pescadero Creek Co Pk	4 Sites Combined*
July 1	31 (6)	48 (2)	58 (5)	89 (7)	39 (1)	226 (20)
July 14	52 (5)	25 (4)	61 (25)	71 (1)	27 (2)	209 (35)
July 15	30 (1)	25 (3)	56 (20)	101 (10)	92 (14)	212 (34)
July 21	30 (1)	109 (23)	70 (25)	82 (2)	61 (3)	291 (51)
July 22	39 (5)	34 (4)	61 (36)	28 (1)	15 (0)	162 (46)
2016 TOTAL	182 (18)	241 (36)	311 (111)	371 (21)	234 (20)	1100 (186)
MEAN	36.4 (3.6)	48.2 (7.20)	61.2 (22.2)	74.20 (4.20)	46.80 (4.00)	220.00 (37.2)
STDEV	9.50 (2.41)	35.27 (8.87)	5.36 (11.26)	28.03 (4.09)	30.45 (5.70)	46.44 (12.0)
CV	0.26 (0.27)	0.73 (1.23)	0.09 (0.51)	0.38 (0.97)	0.65 (1.43)	0.21 (0.32)
2015 TOTAL	90 (12)	313 (108)	311 (102)	139 (28)	—	853 (250)

* Excludes values from Pescadero Creek County Park.

**Table 2. Frequency of Detection Types in 2016, 2015, and 2014
– Four Stations Combined***

Type of Detection	Total 2016 - Combined Daily Mean (of 20 survey-days)	Total 2015- Combined Daily Mean (of 20 survey-days)	Total 2014 Combined Daily Mean (of 12 survey-days)
Total Detections	55	42.7	37.8
Total Visual Detections	19.5	14.9	16.7
Below 1 Canopy Detections	9.3	9.8	8.6
Single Silent Birds Below 1-Canopy	3.6	4.7	3.3

Notes: * Excludes values from Pescadero Creek County Park and Memorial County Park.

Table 3. 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 have a strong predictive value of an active or inactive nest site nearby, especially when detected on multiple days. 2015 total included at bottom for comparison.

Date	Big Basin	Butano	Gazos Camp	Portola	Pescadero Creek Co Pk	4 Sites Combined*
July 1	4 (4)	2 (3)	1 (0)	2 (3)	0 (0)	9 (10)
July 14	2 (0)	0 (2)	12 (0)	0 (2)	0 (0)	14 (2)
July 15	1 (0)	7 (3)	14 (0)	7 (3)	1 (0)	29 (6)
July 21	0 (0)	1 (1)	8 (4)	1 (1)	2 (0)	12 (6)
July 22	3 (3)	1 (0)	8 (0)	1 (0)	0 (0)	13 (3)
2016 TOTAL	10 (7)	11 (9)	43 (4)	11 (9)	3 (0)	77 (27)
MEAN	2.00 (1.4)	2.20 (1.80)	8.6 (0.8)	2.20 (1.80)	0.60 (0)	15.4 (5.4)
STDEV	1.58 (1.95)	2.77 (1.30)	4.98 (1.79)	2.77 (1.30)	0.89 (0)	7.83 (3.13)
CV	0.79 (1.39)	1.26 (0.72)	0.58 (2.24)	1.26 (0.72)	1.49 (0)	0.58 (0.58)
2015 TOTAL	4 (8)	33 (52)	42 (9)	10 (9)	--	89 (78)

Note: * Excludes Pescadero Creek Co. Pk.

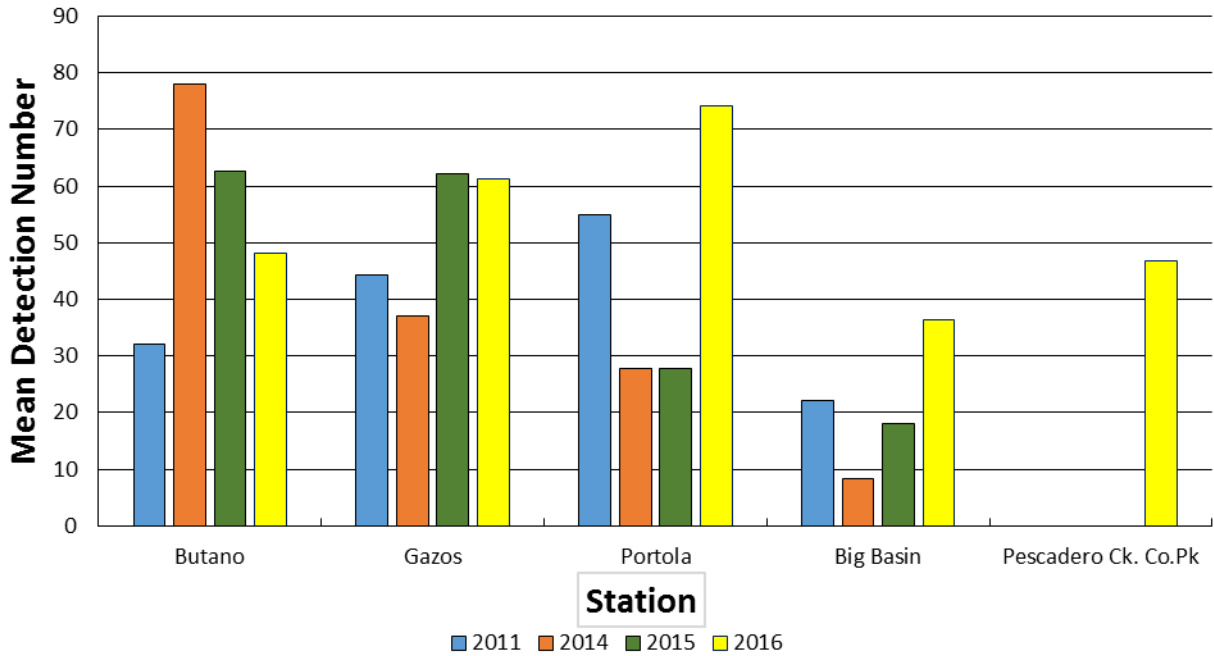
Table 4. Comparison of Murrelet Activity Levels at Each Park for All Data Years.

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. Note that only since 2014 were different station surveys conducted on the same day.

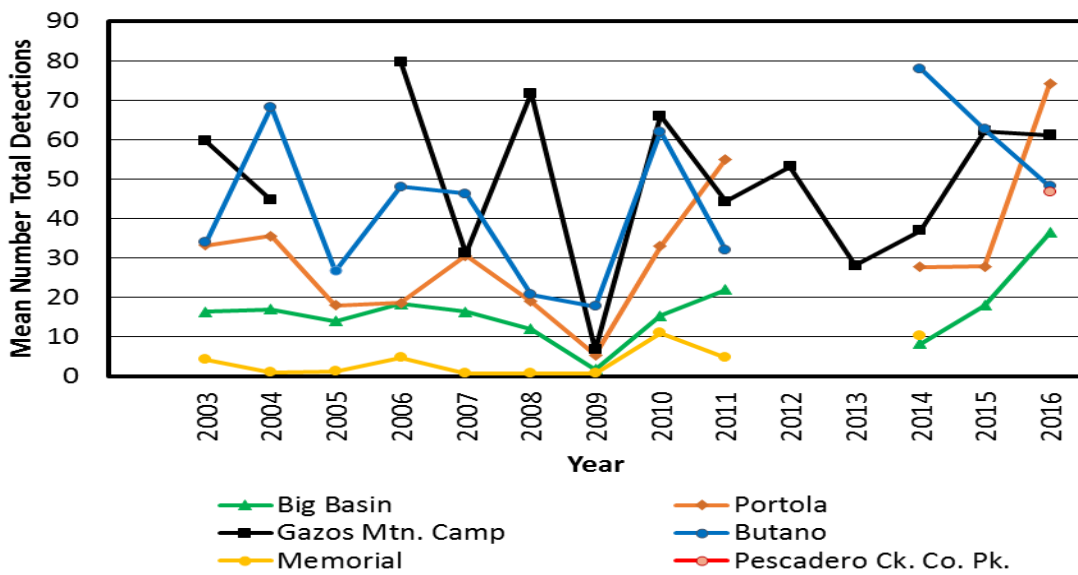
Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
Big Basin – Redwood Meadow	1995	4	177.0	64.0
“ “	1996	4	97.0	27.5
“ “	1998	4	92.3	33.5
“ “	2001	3	86.3	8.0
“ “	2002	3	18.7	1.3
“ “	2003	3	16.3	1.3
“ “	2004	3	17.0	2.3
“ “	2005	3	14.0	1.3
“ “	2006	3	18.3	9.0
“ “	2007	3	16.3	2.7
“ “	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
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
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

Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
Butano – Little Butano Creek	2007	3	46.3	5.7
“ “	2008	3	20.7	3.0
“ “	2009	3	17.7	2.0
“ “	2011	3	32.0	6.7
“ “	2014	3	78.0	27.7
“ “	2015	5	62.6	21.6
“ “	2016	5	48.2	10.6
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
“ “	2013	7	28.1	2.1
“ “	2014	3	37.0	3.3
“ “	2015	5	62.2	20.4
“ “	2016	5	61.2	30.0
Pescadero Creek County Park	2016	5	46.8	6.6

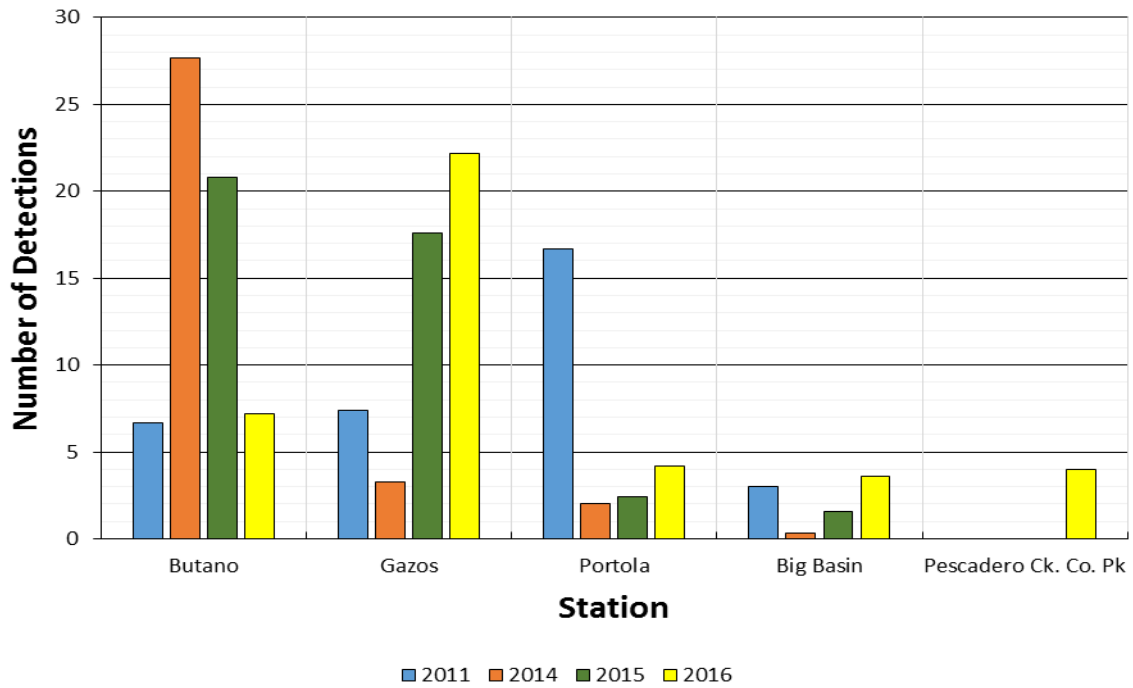
Graph 1. Mean Total Murrelet A-V Detections
2011, 2014, 2015, and 2016



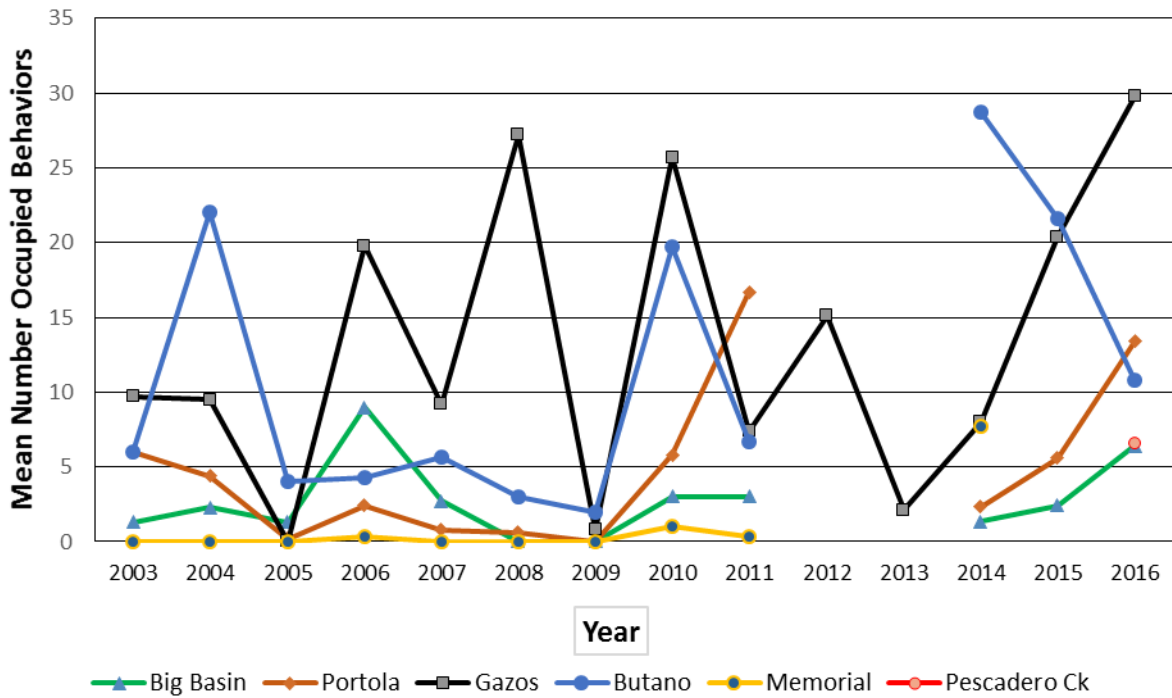
Graph 2. Mean Number of Total Murrelet Detections
2003 - 2016

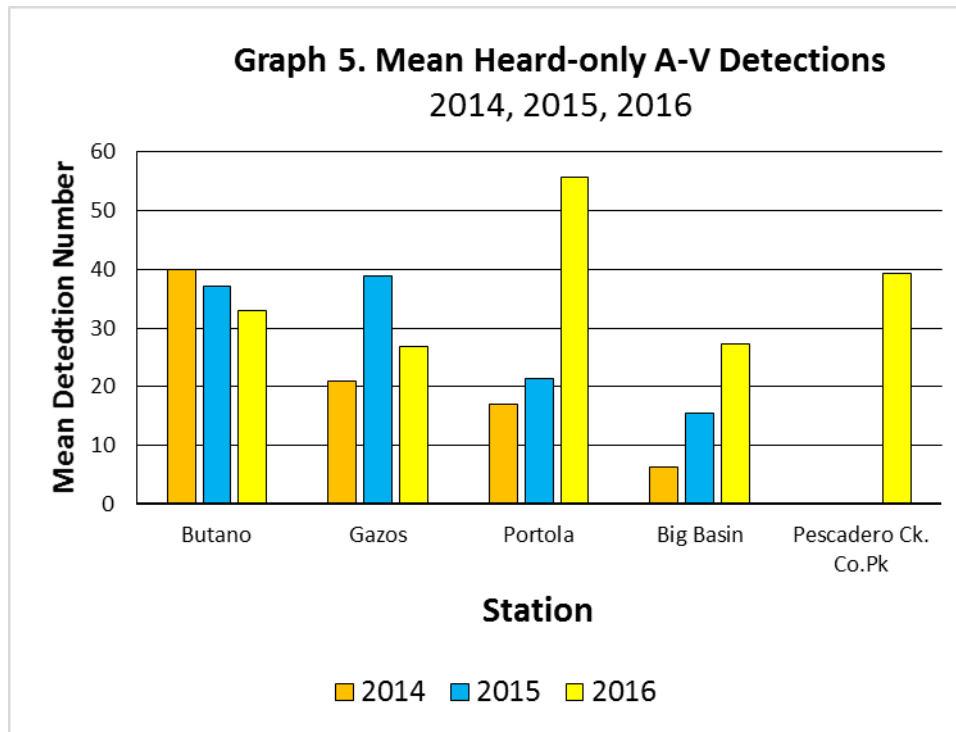


**Graph 3. Mean Below-1-Canopy Murrelet A-V Detections:
2011, 2014, 2015, and 2016**



**Graph 4. Mean Number Occupied Behaviors
2003 - 2016**





BOXPLOTS

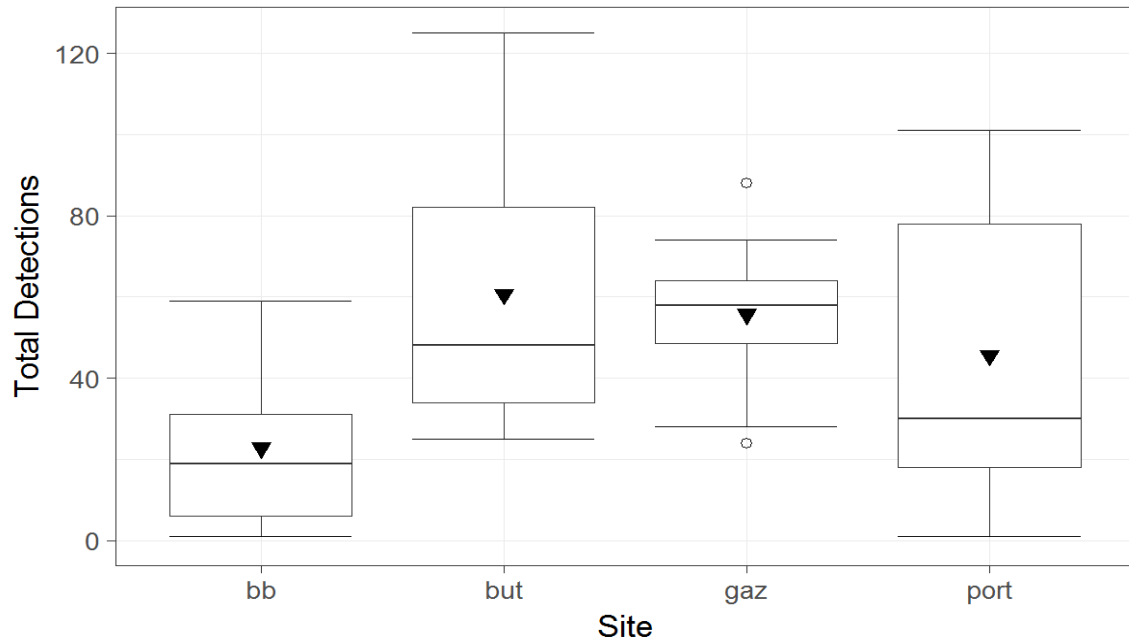
Explanation for Interpretation of the Following Boxplots

The following boxplots show the mean value (black triangle), median (bold line), 1st and 3rd quartiles (box), the value of the largest observation that is less than or equal to the upper quartile plus 1.5 the length of the interquartile range (upper whisker), the value of the smallest observation that is greater than or equal to the lower quartile less 1.5 times the length of interquartile range (lower whiskers), and extreme values (circles) of detections by station. Stations are abbreviated as bb (= Big Basin), but (= Butano), gaz (= Gazos Camp), port (= Portola), and pccp (= Pescadero Creek County Park). All boxplots are from Comfort (2016).

SSBBC is the abbreviation for Single Silent Birds Below One Canopy.

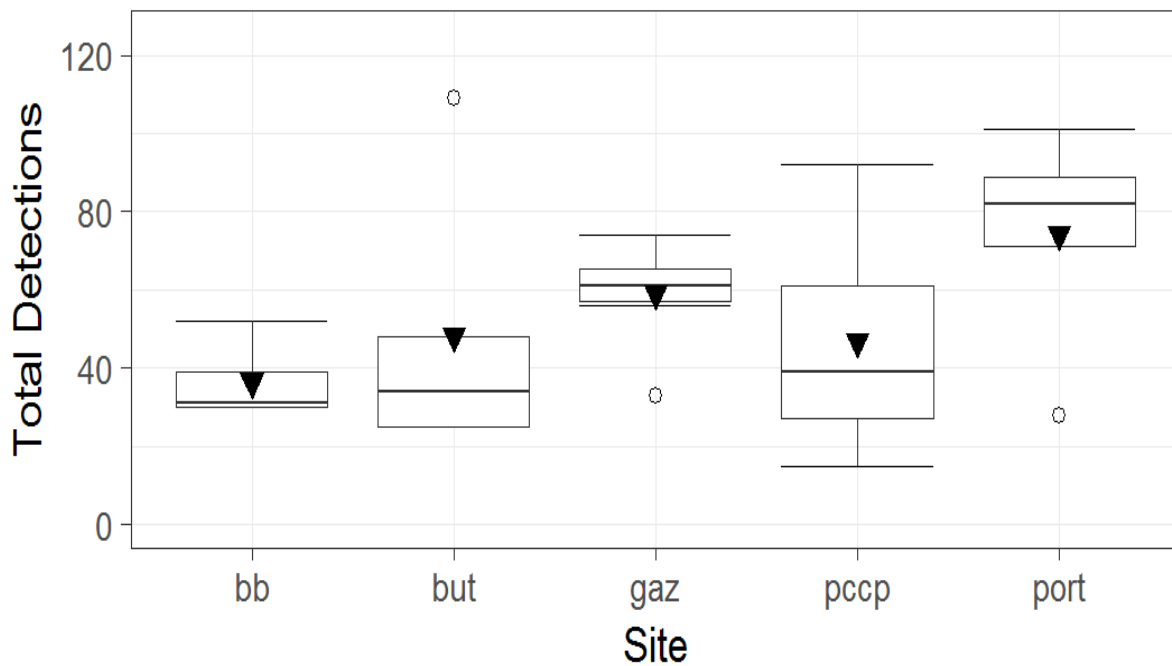
Boxplot B-1. Total Detections at 4 Sites, 2014 - 2016

Boxplot of Total Detections by Site



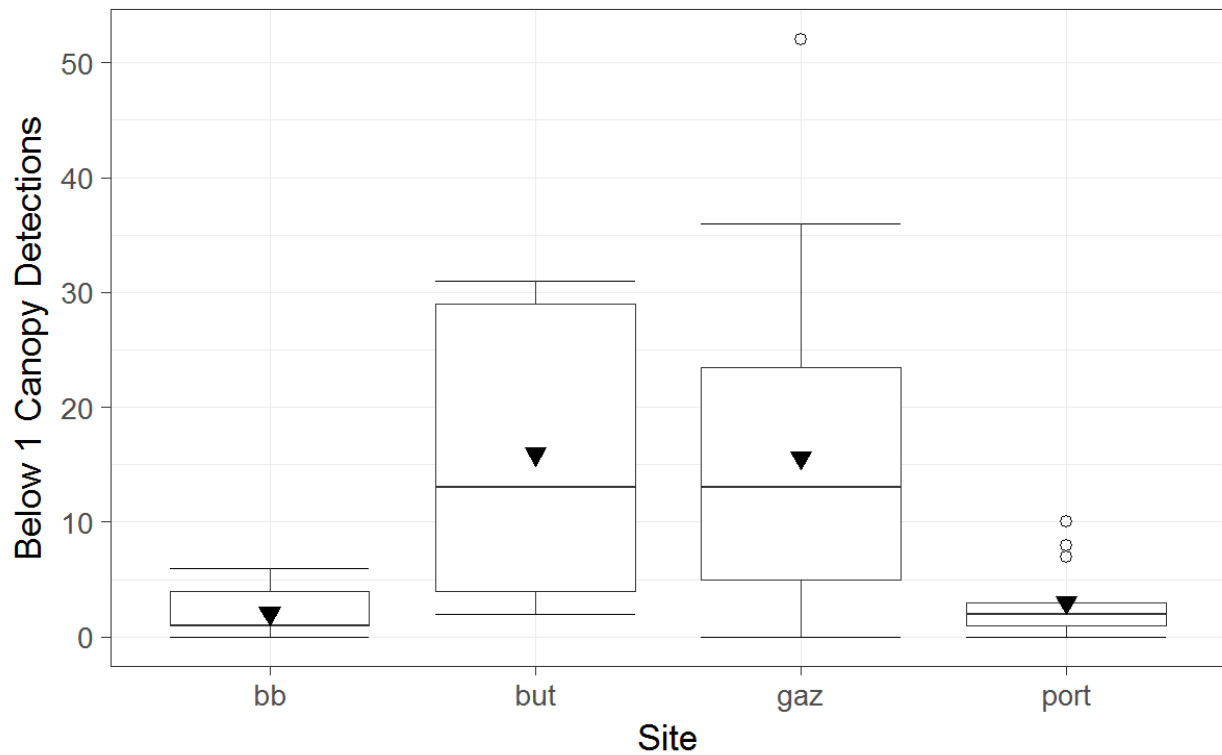
Boxplot B-2. Total Detections by Site, 2016 Only

2016 Total Detections by Site



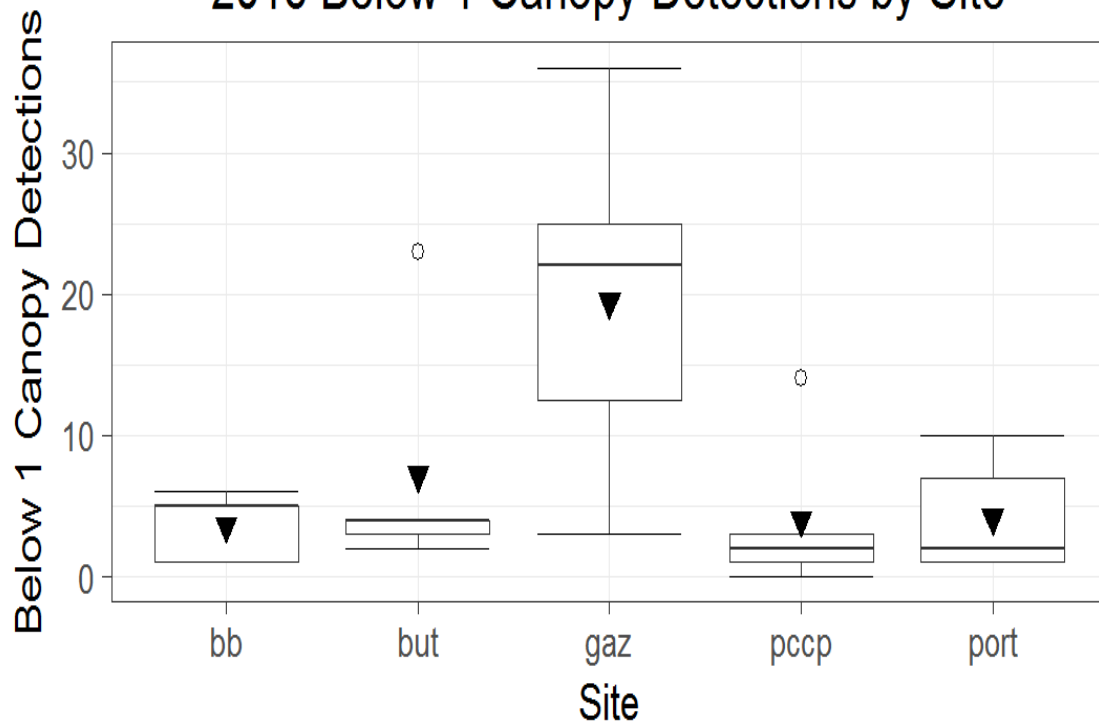
Boxplot B-3. Below-one-canopy Detections, 4 sites, 2014 - 2016

Boxplot of Below 1 Canopy Detections by Site



Boxplot B-4. Below-one-canopy Detections by Site, 2016 Only

2016 Below 1 Canopy Detections by Site



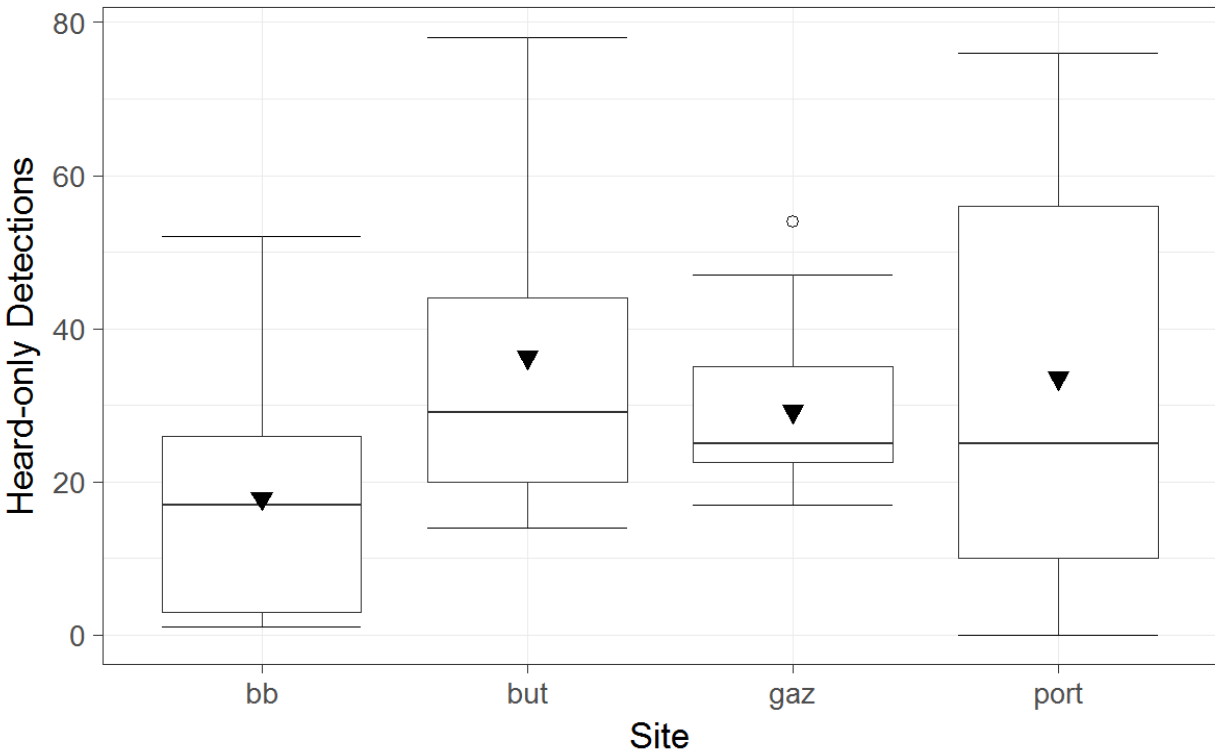
Boxplot B-5. SSBBC Detections at 4 Sites, 2014 – 2016

Boxplot of SSBBC Detections by Site

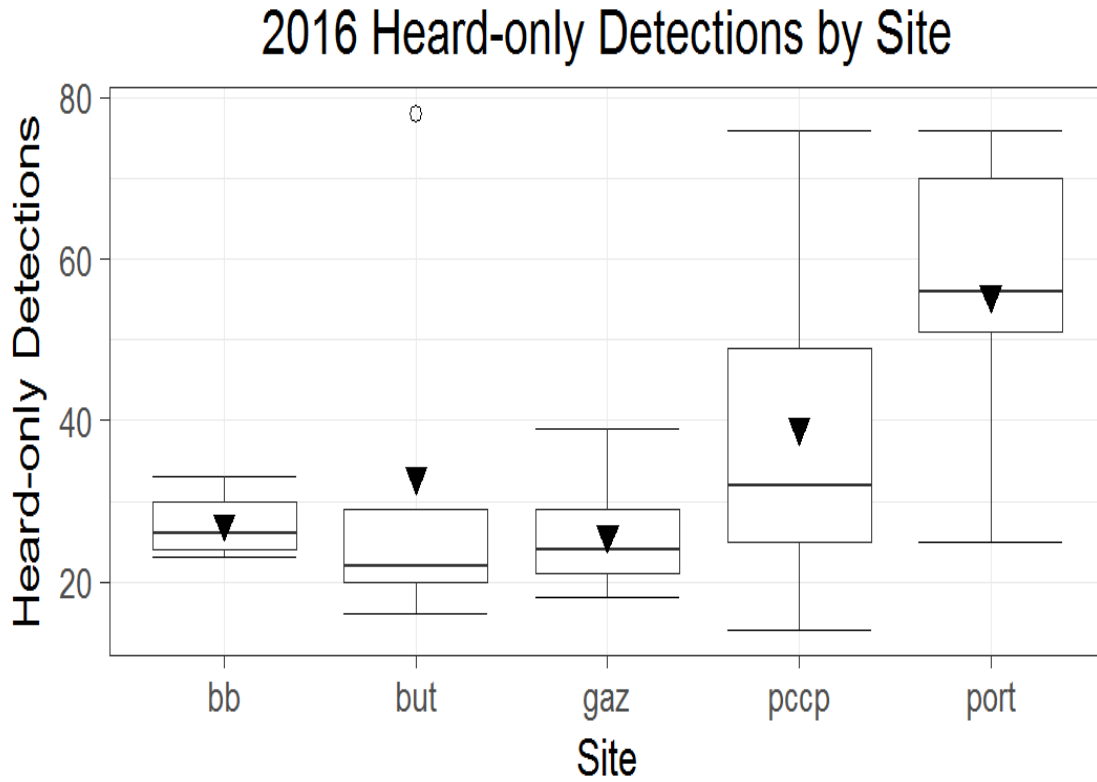


Boxplot B-6. Heard-only Detections at 4 Sites

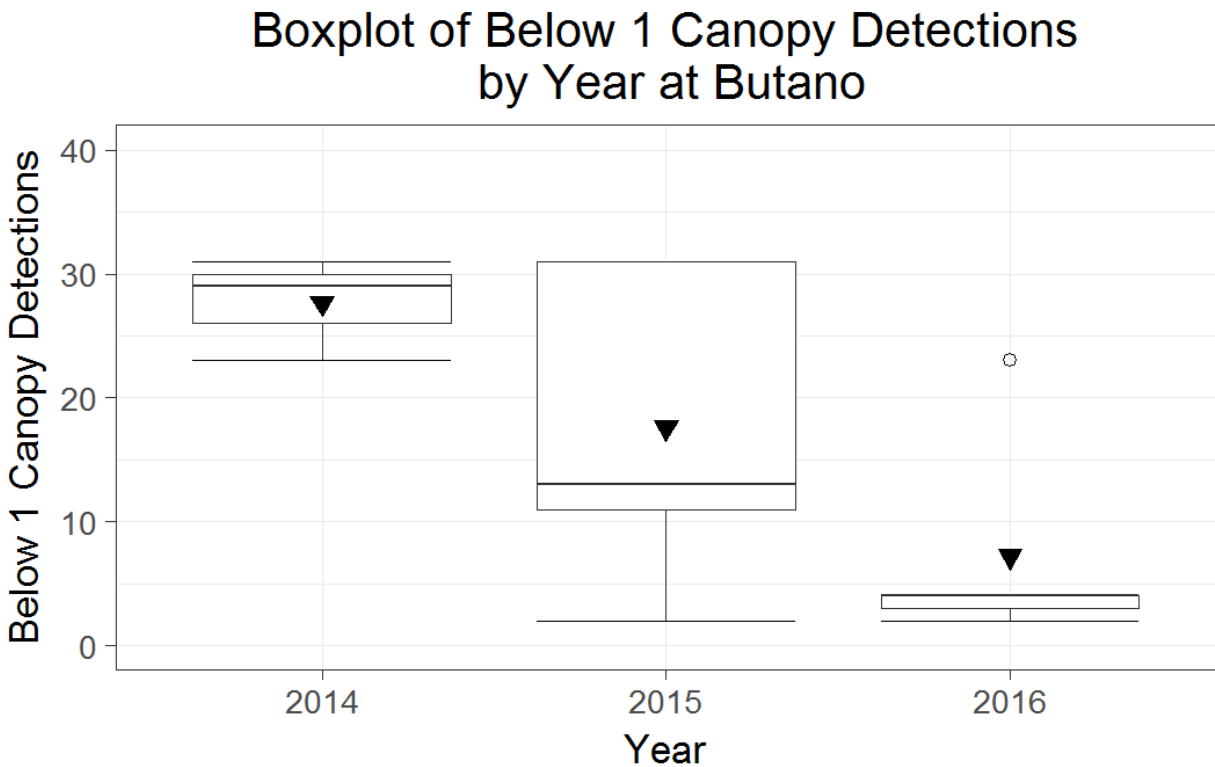
Boxplot of Heard-only Detections by Site



Boxplot B-7. Heard-only Detections by Site, 2016 Only

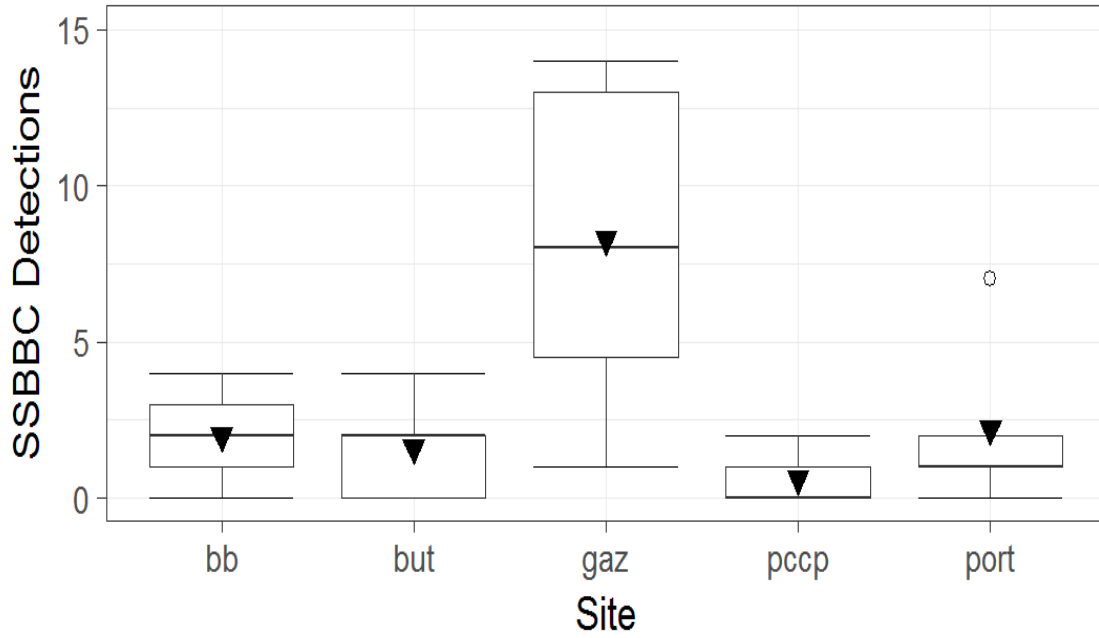


Boxplot B-8. Below-one-canopy Detections By Year at Butano



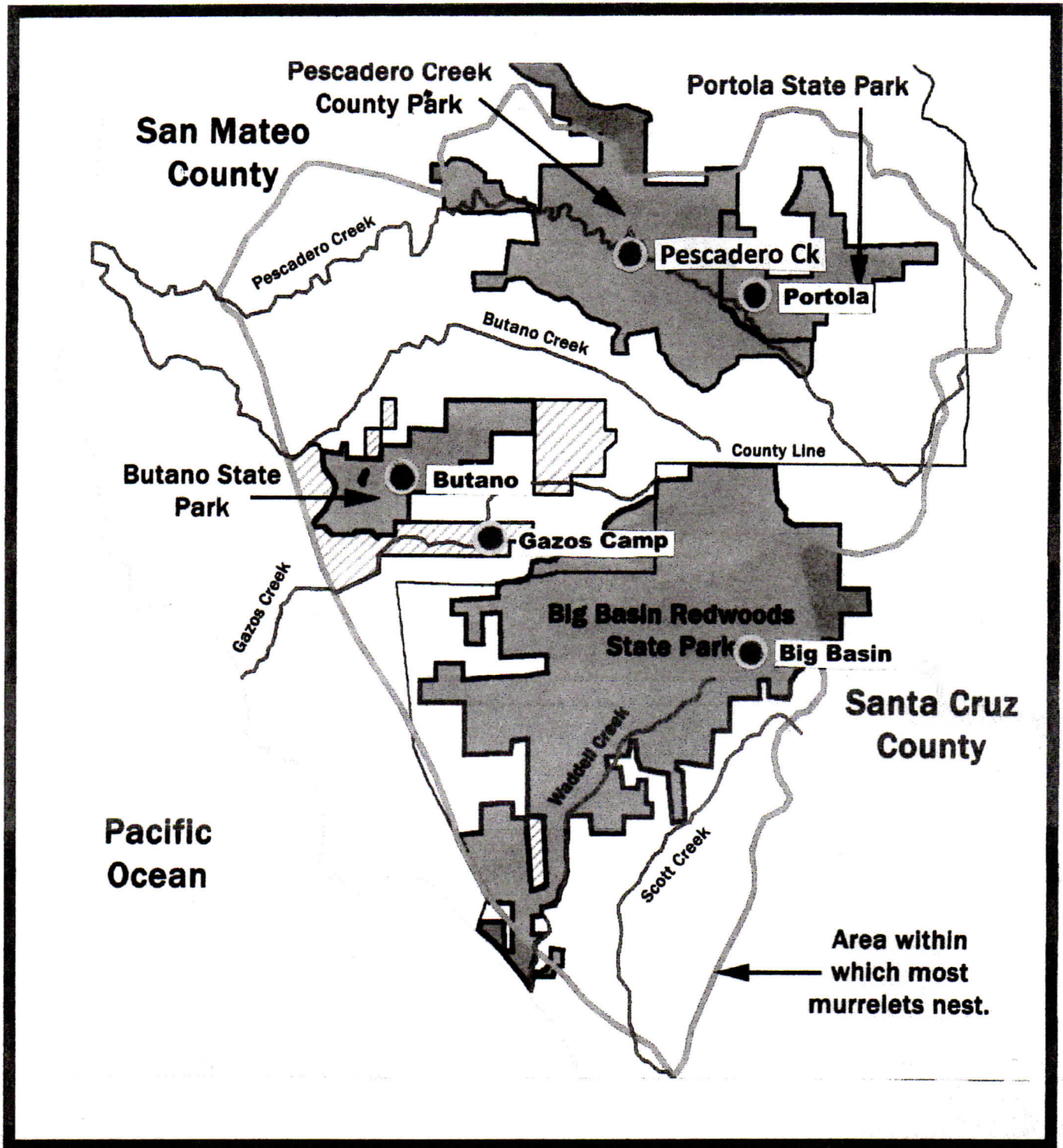
Boxplot B-9. SSBBC Detections by Site, 2016 Only

2016 SSBBC Detections by Site



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