

**2019 FOREST SURVEY RESULTS -
MARBLED MURRELETS IN THE SANTA CRUZ MOUNTAINS**

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Prepared for the California State Parks Department

*Murrelet AV surveys were conducted by Jason Antinora, Mike Duffy, Portia Halbert,
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December 2019

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SUMMARY OF KEY FINDINGS

- 1. Total detections and occupied behavior detections from the 3 sites with the best long-term data, when combined, fell within the range of previous reported values going back to 2014.**
- 2. Flight behaviors associated with nesting were markedly down at Butano this year, these included occupied behaviors and wing sound detections, the latter going from 64 in 2018 to 14 in 2019. However see #3 below.**
- 3. Physical evidence of successful nesting was found this year near the Butano site in the form of eggshell fragments found on the ground.**
- 4. Murrelet activity levels at Big Basin in the first 3 surveys were not dis-similar to 2018 values, but went to zero in the last two surveys. It is unknown whether or not any murrelets visited Big Basin after the third survey.**

Simultaneous A-V surveys were conducted at the Butano, Gazos (Gazos Camp), Big Basin, and Portola survey stations on 5 days in July 2019 using the PSG Forest Survey protocol. Data from these stations in 2019 is compared here with the data from prior years. Data for total detections and occupied behavior from the duration of the project are shown in Tables 1, 2, and 8 in Appendix 1. (*Note: All tables and graphs can be found in Appendix 1*).

Key results for all detection types observed at all four stations in 2019 are shown in Table 3. Total detections for the three most-regularly surveyed stations (Big Basin, Butano, and Gazos) when pooled for 2019 are generally similar to values in previous years (Table 4, Graph 1), although the distribution of detections among sites has changed.

As in previous years, all four stations had numerous observations of those types of detections that are associated with active nesting nearby, these include occupied behavior and birds seen flying below one canopy height (Table 3). Additionally, fragments of a murrelet eggshell (apparently from a successful hatching) were found near the Butano survey station. Also of interest is the apparent early cessation of murrelet activity at Big Basin. Total detections went from 91 on July 17 (which was the highest daily value for any station) to zero on July 23 and July 25. The other three stations continued to have detections through at least July 25 and no other station had a day with zero detections. It's possible that the nesting season may have ended early at Big Basin this year. Data from an acoustic recording unit in place at Big Basin for the duration of the normal breeding season, when analyzed, should reveal whether any murrelet activity occurred at Big Basin after July 23.

Because of the apparent cut-off of murrelet activity at Big Basin, we are unable to ascertain if the significant increasing trend in detection numbers documented in 2018 at Big Basin continued into 2019.

Note to the Readers: Whenever the text mentions “three sites combined” it refers to the pooled data from Big Basin, Butano, and Gazos. These 3 stations were surveyed each year from 2014 – 2019, with full data available.

INTRODUCTION

This report discusses the results of 2019 Marbled Murrelet audio-visual (A-V) surveys at four breeding areas in the Santa Cruz Mountains (see map in Appendix 2). The four stations are (1) Big Basin, which is located at the Redwood Meadow in Big Basin State Park; (2) Gazos, also known as Gazos Mountain Camp, which is located inside Butano State Park, (3) Butano, which is also known as Butano Service Road or Little Butano, and is located on a service road in Butano State Park, and (4) Portola which is located at the Old Tree Parking Area in Portola State Park. All four stations are located in different watersheds. These sites have been surveyed for many years, although full original data only exist for 2014 and subsequent years. Circumstantial evidence indicates that individual murrelets do not visit more than one of our sites in a given morning.

State Parks’ original long-term monitoring program began in 2003 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; surveys at Upper Pilarcitos Creek on land belonging to the San Francisco Public Utilities Commission; surveys in Pescadero Creek County Park by the San Mateo County Parks Department; and surveys by the Midpeninsula Regional Open Space District on several of their preserves. A complete review of the history and extent of inland marbled murrelet monitoring efforts in the Santa Cruz Mountains through 2017 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 have limited value 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 are usually very similar. However the close grouping of these two detection types did not occur in 2019 (Graph 1). 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). Unfortunately below one canopy detection data prior to 2014 have been lost by the previous project leader.

These occupied behavior flight behaviors are just some of the indications that there is an active or inactive nest nearby. In order of decreasing strength of prediction, the full complement of indicators are (1) grounded fledgling or chick 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 occupied behaviors (Evans et al 2003, Nelson and Peck 1995, and Singer et al 1995). It should be noted that only the first two items 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.

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 (AV) 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. Audible wing sounds from murrelets not seen were considered to be below-canopy flights by single birds.

As in 2018, AV surveys at all sites in 2019 were done simultaneously. Surveys were done at Big Basin, Butano, Gazos, and Portola on these dates: July 9, July 16, July 17, July 23, and July 25. A map showing survey station locations appears in Appendix 2. Surveys were done by the same observer at each site.

In 2011 and prior years AV surveys were not conducted simultaneously and the number of surveys per season (normally 3) was different at some stations. Memorial County Park was part of the original survey effort but has since been dropped, ending in 2014. Surveys were not done at Portola in 2017 or 2018, and were not done at any of the sites except for Gazos in 2012 and 2013.

Observations were recorded live into tape or digital recorders and later transcribed onto standard forest AV survey forms.

The maximum number of common ravens detected simultaneously (seen or heard) and the maximum number of Steller's Jays detected simultaneously (seen or heard) 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 a summary of those efforts can be found in Halbert and Singer (2017). In 2019, as in the previous three years, the maximum number of murrelets seen in the sky at the same time was also recorded.

RESULTS AND DISCUSSION

All Sites Combined or Compared

Table 3 shows the results of key detection types recorded in the 2019 surveys. Tables 1, 2, 4, and 8 show the 2019 results for total detections and occupied behaviors, and compares them with results from previous years.

The three stations that were surveyed most faithfully each year and had the highest murrelet activity levels were Big Basin, Butano, and Gazos. Combined data from these three stations reveal that total detections, occupied behavior detections, and below one canopy detections all show no trend since 2014, either decreasing or increasing (Table 4 and Graph 1). However statistical verification of this apparent stability is lacking due to the high day-to-day variation in detections and the small number of AV surveys (*Note: A statistical analysis of all detections from 2014 to 2018 was done last year and can be found in Comfort (2018) which is available from the author.*)

For the 3 sites combined on all the surveys done there was a total of 687 detections this year compared to 599 in 2018 and 740 in 2017. The highest single day in 2019 was July 17 with 273 detections. This day had the highest number of detections for all 3 stations. The next highest day for the stations combined was July 23 with 122 detections.

When comparing detection type results for all four stations, mean total detection numbers were greatest at Butano (56) and smallest at Big Basin (24.6, but two days with no detections). Mean occupied behaviors were highest at Gazos (23) and lowest at Portola (6.2). The highest mean number of single silent birds flying below one canopy (SSBBC) was 4.4 at Big Basin – this despite the fact that two days had zero detections there. The fewest mean SSBBC detections was at Portola where the mean value was 1.6. Mean number of wing sounds was highest at Big Basin (3.2) (again despite the fact that two days had zero detections) and lowest at Portola (0).

The results of other detection types (SSBBC, wing sounds, and heard-only detections) for 2019 are shown in Tables 4, 5, and 7 where they can be compared with results from previous years. SSBBC detections for the combined 3 sites have declined from 2017 to 2019 (Graph 4)and this bears watching in 2020.

Big Basin

The results from the first two surveys went as expected for this station. On the third survey (July 17) 91 total detections were recorded, which was the highest daily value for any station in 2019. Then, surprisingly, the last two surveys (July 23 and 25) went to zero detections. This suggests that the nesting season may have ended early at Big Basin. However the other 3 stations continued to report a normal number of detections on July 23 and July 25.

Data from an acoustic recording unit located at the Big Basin station, when it becomes available, should tell us whether or not the nesting season (and associated murrelet activity) ended before July 23. The recording unit was in place from March 24 to September 15, so should tell us the duration of the activity period at Big Basin and whether or not the two zero days were just flukes.

Results from the first three surveys had total detections ranging from 15 to 91 with a mean of 41. Occupied behaviors ranged from 10 to 46 with a mean of 22.7. Because of the uncertainty regarding the cause of the two surveys with no detections, it is not possible to say whether the statistically significant upward trend in total detections noted last year continued this year.

Butano

Total detections at Butano this year were slightly more than last years but occupied behaviors and below canopy detections were markedly lower. Occupied behaviors had a mean of 18 in 2018 but were only 7.2 in 2019. Below one canopy detections had a mean of 17.6 in 2018 but were only 6.2 in 2019. These declines may have been due to the sharp declines in wing sounds at Butano in 2019. In 2018 the mean was 12.5 but in 2019 the mean was only 2.8. For whatever reason, occupied behavior detections at Butano this year were the lowest reported since 2011. The reduced values of these behaviors indicative of nesting strongly suggests that the nesting effort at Butano was lower this year (however see below).

Although nesting effort seems likely to have been reduced at Butano this year, we know for a fact that nesting did occur. Eggshell fragments representing about one-third of a murrelet egg were found on the service road near the Butano station on July 9. There were no signs of predation on the eggshell fragments and it was assumed to be from a successful hatching as there was a potentially suitable nest tree nearby. A dawn stake-out was conducted focusing on this tree, an old-growth Douglas-fir, but no murrelets were seen associating with it. However only one side of the tree could be observed. A full description of the eggshell fragments and this discovery can be found in a written report that is available elsewhere (Singer 2019).

Raven numbers at Butano were somewhat higher than the other stations and the number of detections at Butano were up in 2019. The maximum raven group size in 2019 was 9 compared to 2 in 2018; and 4 of the 5 surveys in 2019 had raven present, whereas in 2018, ravens were present in 3 of 5 surveys.

Gazos

Total detections and occupied behaviors bounced back to the near normal range of historic values in 2019, after extremely low values were recorded in 2018. The mean number of total detections was 47.4 (with a range of 37 to 77) and the mean number of occupied behaviors was 23 (with a range of 12 to 43). This was the highest mean value of occupied behaviors for any station in 2019. Gazos also had the highest number of visual detections, with a mean of 30.2. Next highest was Big Basin with a mean of 16.8.

Portola

A full complement of 5 AV surveys was completed at Portola this year, for the first time since 2016. Individual values for total detections ranged from 27 to 56 with a mean of 37.8. Occupied behavior detections ranged from 2 to 11, with a mean of 6.2. These values are similar to those of historic surveys and are lower than values from all other stations with the exception of Big Basin.

Common Raven and Steller's Jay Numbers at All Sites

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) during the AV survey was recorded. Ravens and jays were present at all survey stations. Steller's Jays saturate all forest areas in the Santa Cruz Mountains and were present on every individual AV survey. The distribution of ravens is more variable. The maximum number of individual ravens present at each station in 2019 and the previous four years is shown in Table 9. In 2019, the highest number of ravens detected on a morning survey was 9 on July 17 at Butano. The second highest value was 5 at Butano on July 9. Ravens were detected most often on surveys at Big Basin.

RECOMMENDATIONS

1. Closely monitor AV survey results from Big Basin and Butano in 2020. Check to see if murrelet detections end early in Big Basin again and whether or not flight behaviors associated with nesting remain low at Butano.
2. Continue to do full-season morning ARU recording at Big Basin and Gazos. Work with Conservation Metrics to devise a monitoring scheme that utilizes both ARU and AV surveys to produce results with greater statistical power.
3. Work with all agencies doing AV surveys in the Santa Cruz Mountains to standardize methodologies and survey dates, and strongly encourage them to archive their full data spreadsheets with the State Parks Department in the developing Zone 6 data archive site.

ACKNOWLEDGEMENTS

Thanks to Jason Antinora, Mike Duffy, Portia Halbert, Bryan Mori, and Alex Rinkert for conducting AV surveys or doing other field work. This work was funded by the California State Parks Department.

Thanks to California State Parks Department staff at Big Basin, Butano, Portola, and the District office for their assistance and especially to Jason Antinora and Portia Halbert.

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APPENDIX I – Tables and Graphs

Table 1. Mean Number of Total Detections 2003 - 2019

Mean Number of Murrelet Total Detections 2003 – 2019						
(Empty boxes are years where no surveys were done or results were not available)						
Year	Big Basin	Portola	Gazos Mtn. Camp	Butano	Memorial	3 Sites Combined (Big Basin, Gazos, and Butano)
2003	16.3	33.2	59.7	34	4.3	110
2004	17	35.6	44.7	68.3	1	130
2005	14	18		26.7	1.3	
2006	18.3	18.6	79.7	48	4.7	146
2007	16.3	30.6	31.2	46.3	0.7	93.8
2008	12	19	71.8	20.7	0.7	104.5
2009	1.3	5.4	6.8	17.7	0.7	25.8
2010	15.3	33	66	62	11	143.3
2011	22	55	44.3	32	4.7	98.3
2012			53.1			
2013			28.1			
2014	8.3	27.7	37	78	10.3	123.3
2015	18	27.8	62.2	62.6		142.8
2016	36.4	74.2	61.2	48.2		145.8
2017	38		55.2	54.8		148
2018	50.4		22.8	46.6		119.8
2019	24.6	37.8	47.4	56		137.4

Table 2. Mean Number of Occupied Behavior Detections 2003 -2019

Mean Number of Murrelet Occupied Behavior Detections 2003 – 2019						
(Empty boxes are years where no surveys were done or results were not available)						
Year	Big Basin	Portola	Gazos Mtn. Camp	Butano	Memorial	3 Sites Combined (Big Basin, Gazos, and Butano)
2003	1.3	6	9.7	6	0	17
2004	2.3	4.4	9.5	22	0	33.8
2005	1.3	0.2		4	0	
2006	9	2.4	19.8	4.3	0.3	33.1
2007	2.7	0.8	9.2	5.7	0	17.6
2008	0	0.6	27.2	3	0	30.2
2009	0	0	0.8	2	0	2.8
2010	3	5.8	25.7	19.7	1	48.4
2011	3	16.7	7.4	6.7	0.3	17.1
2012			15.1			
2013			2.1			
2014	1.33	2.33	8	28.7	7.7	38
2015	2.4	5.6	20.4	21.6		44.4
2016	6.4	13.4	29.8	10.8		47
2017	25		10.8	19.6		55.4
2018	32.2		5.8	17.6		55.6
2019	13.6	6.2	23	7.2		44.2

Table 3. Mean values of 5 Simultaneous Surveys in July, 2019
(values following in parenthesis are the range for each site)

Station	Total Detects (& Range)	BC Detects (& Range)	OB Detects (& Range)	Visual Detects (& Range)	SSBBC Detects (& Range)
Big Basin	24.6* (0 – 91)	7.4* (0-20)	13.6* (0-46)	16.8* (0-60)	4.4* (0-9)
Butano	56 (20-85)	6.2 (2-9)	7.2 (2-11)	13.6 (5-20)	1.6 (0-3)
Gazos	47.4 (37-77)	9.4 (6-14)	23 (12-43)	30.2 (16-53)	4.2 (1-10)
Portola	37.8 (27-45)	2.6 (0-6)	6.2 (2-11)	12.4 (6-19)	1.6 (0-5)
3 Sites Combined	137.4 77-273	23.2 (14-40)	44.2 (23-96)	60.6 (33-128)	10.2 (2-14)

* Unusually low values because the last two surveys had zero detections.

Table 4. Frequency of Detection Types in 2019, 2018, 2017, and 2016
– Three Most Surveyed Stations Combined (Big Basin, Butano, Gazos)

Type of Detection	Total 2019 Daily Mean Per Survey Site (of 15 survey-days)	Total 2018 Daily Mean Per Survey Site (of 15 survey-days)	Total 2017 Daily Mean Per Survey Site (of 15 survey-days)	Total 2016 Daily Mean Per Survey Site (of 15 survey-days)
Total Detections	45.8	39.9	49.3	48.6
Occupied Behaviors	14.7	18.7	18.3	22.3
Total Visual Detections	20.2	18.9	18.9	28.5
Below Canopy Detections	7.7	16.9	15.9	11
Single Silent Birds Below Canopy	3.4	5.7	8.1	5

Table 5. 2019, 2018 and 2017 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 active nesting effort nearby. The 2018 total is included at the bottom for comparison with 2019.

Date	Big Basin 2019	Butano 2019	Gazos 2019	2019 3 Sites Combined	2018 3 Sites Combined	2017 3 Sites Combined
Day 1	9 (7)	0 (0)	4 (7)	13 (14)	18 (6)	26 (5)
Day 2	7 (2)	2 (1)	4 (1)	13 (4)	17 (11)	35 (11)
Day 3	6 (7)	3 (1)	10 (0)	19 (8)	23 (28)	13 (7)
Day 4	0 (0)	2 (4)	2 (0)	4 (4)	20 (39)	44 (22)
Day 5	0 (0)	1 (8)	1 (0)	2 (8)	8 (4)	3 (5)
TOTAL	22 (16)	8 (14)	21 (8)	51 (38)	86 (88)	121 (50)
MEAN	4.4 (3.2)	1.6 (2.8)	4.2 (1.6)	10.2 (7.6)	17.2 (17.6)	24.2 (10)
STDEV	4.16 (3.56)	1.14 (3.27)	3.49 (3.05)	7.05 (4.10)	5.63 (15.24)	16.5 (7.1)
CV	0.95 (1.11)	0.71 (1.17)	0.83 (1.91)	0.69 (0.54)	0.33 (0.87)	0.6 (0.71)
2018 TOTAL	65 (20)	10 (64)	11 (4)		--	--

Table 6. Ratio of Occupied Behaviors to Total Detections (OB/TD) By Station

Survey Station	2014	2015	2016	2017	2018	2019
Big Basin	0.16 (1.3/8.3)	0.13 (2.4/18.0)	0.18 (6.4/36.4)	0.65 (24.6/38.0)	0.64 (32.2/50.4)	0.55 (13.6/24.6)
Gazos	0.22 (8/37)	0.33 (20.4/62.2)	0.49 (30.0/61.2)	0.20 (10.8/55.2)	0.25 (5.8/22.8)	0.49 (23/47.4)
Butano	0.37 (28.7/78.0)	0.34 (21.6/62.6)	0.22 (10.6/48.2)	0.36 (19.6/54.8)	0.39 (18.0/46.6)	0.13 (7.2/56)
All Sites Combined*	0.30 (48/161.3)	0.29 (48.8/170.6)	0.25 (67/266.8)	0.37 (91.7/246.7)	0.47 (280/599)	0.32 (44.2/137.4)

* Number of sites: 2014=5, 2015=4, 2016=5, 2017=3, 2018=3, 2019=3

Table 7. Ratio of Heard-only Detections to Total Detections (Means)

Survey Station	2014	2015	2016	2017	2018	2019
Big Basin	0.76 (1.3/8.3)	0.86 (15.4/18)	0.75 (27.2/36.4)	0.43 (16.2/38)	0.34 (17.2/50.4)	0.32 (7.8/24.6)
Gazos	0.57 (21/37)	0.62 (38.8/62.2)	0.44 (26.8/61.2)	0.72 (39.8/55.2)	0.56 (12.8/22.8)	0.36 (17/47.4)
Butano	0.51 (40/78)	0.59 (37.2/62.6)	0.68 (33/48.2)	0.64 (35/54.8)	0.71 (33/46.6)	0.72 (40.2/56)
All Sites Combined*	0.53 (86/161.3)	0.61 (112.8/170.6)	0.53 (142.6/266.8)	0.21 (151.7/246.7)	0.53 (63/119.8)	0.49 (67.8/137.4)

* Number of sites: 2014=5, 2015=4, 2016=5, 2017=3, 2018=3, 2019=3

Table 8. 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
“ “	2018	5	50.4	32.2
“ “	2019	5	24.6	13.6

Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
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
“ “ – near Peters Creek Bridge	2019	5	37.8	6.2
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
“ “	2018	5	46.6	18.0
“ “	2019	5	56.0	7.2
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

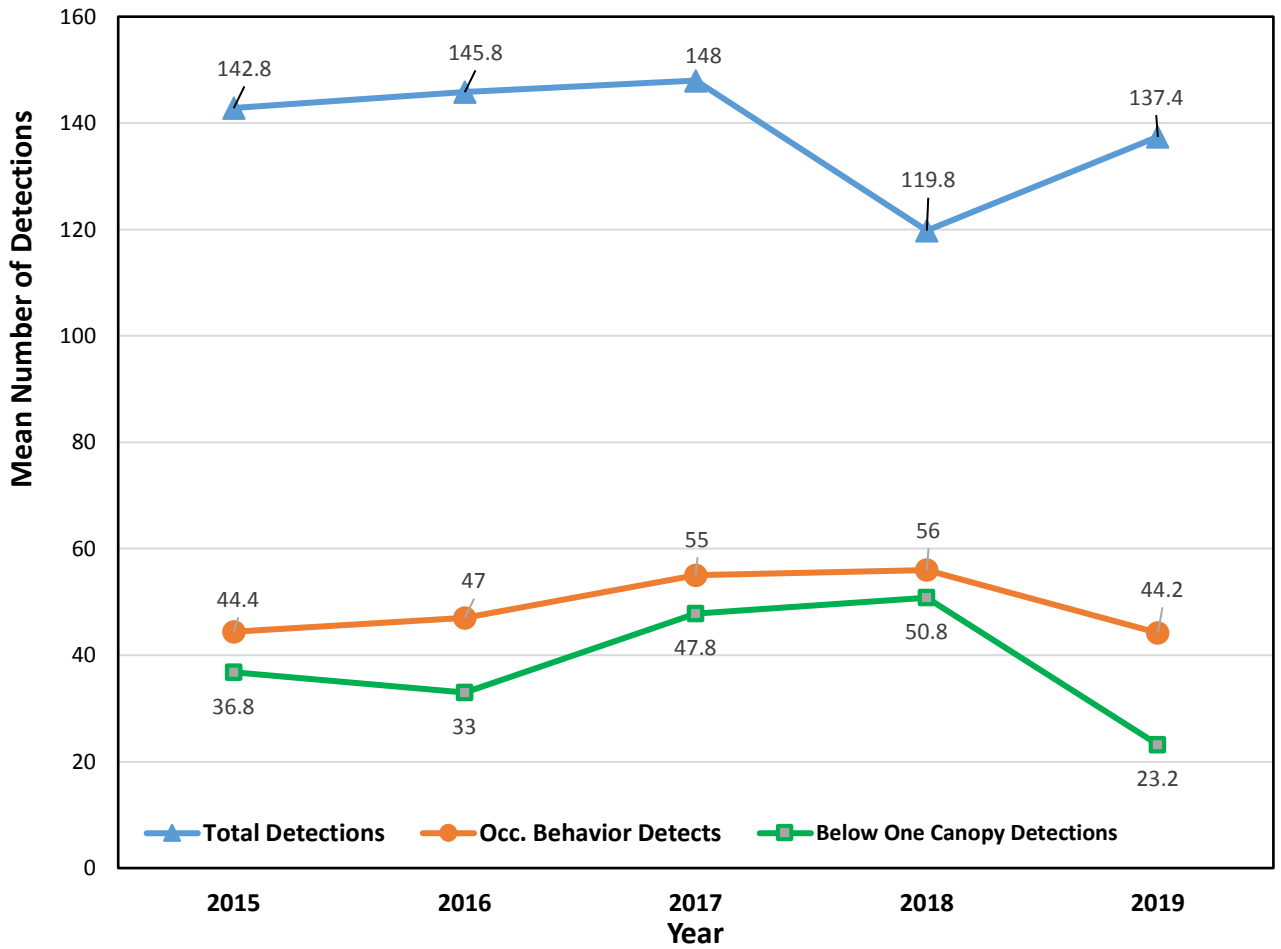
Station	Year	N	Average Total Detections	Average Occupied Beh. Detections
" "	2010	3	11.0	1.0
" "	2011	3	4.7	0.3
" "	2014	3	10.3	7.7
Gazos – Gazos Mtn. Camp	1998	6	36.0	10.7
" "	2000	6	57.3	15.0
" "	2001	6	64.7	17.8
" "	2002	6	52.0	9.2
" "	2003	6	59.7	9.7
" "	2004	6	44.7	9.5
" "	2006	6	79.7	19.8
" "	2007	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
" "	2017	5	55.2	10.8
" "	2018	5	22.8	5.8
" "	2019	5	47.4	23.0

Table 9. Number of Surveys with Ravens Present at Each Station

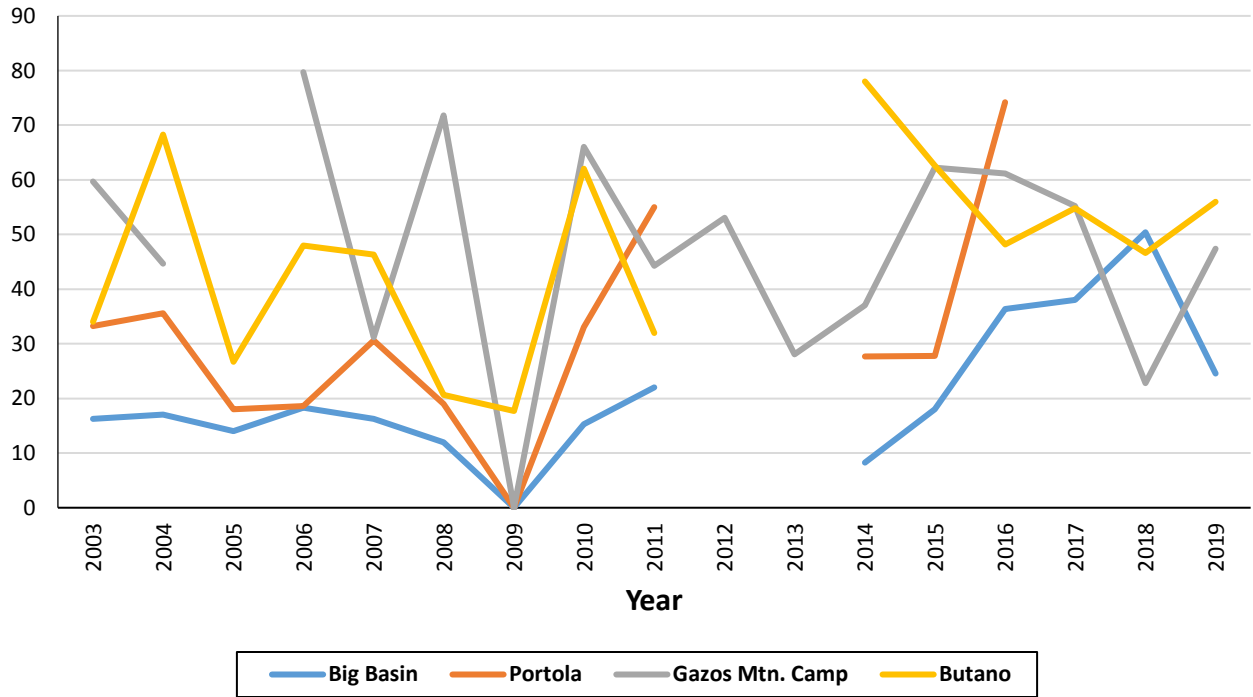
(Note: 5 surveys were conducted at each survey station)

Station	2019	2018	2017	2016	2015
Big Basin	5	5	4	5	4
Butano	4	3	2	0	1
Gazos	3	1	0	2	2
Portola	2	-	-	2	2

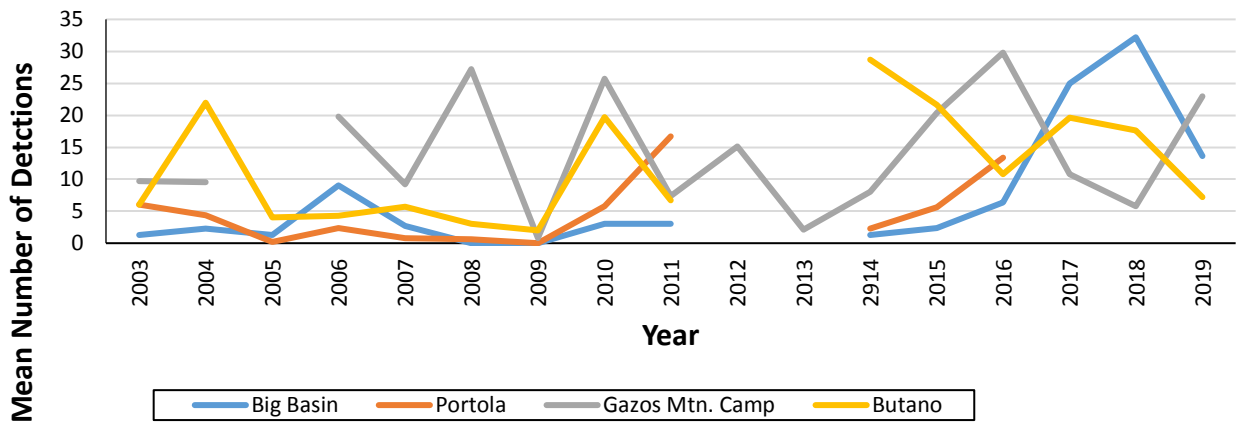
Graph 1. 3 Sites Combined - Total Detections, Occupied Behavior Detections and Below One Canopy Detections



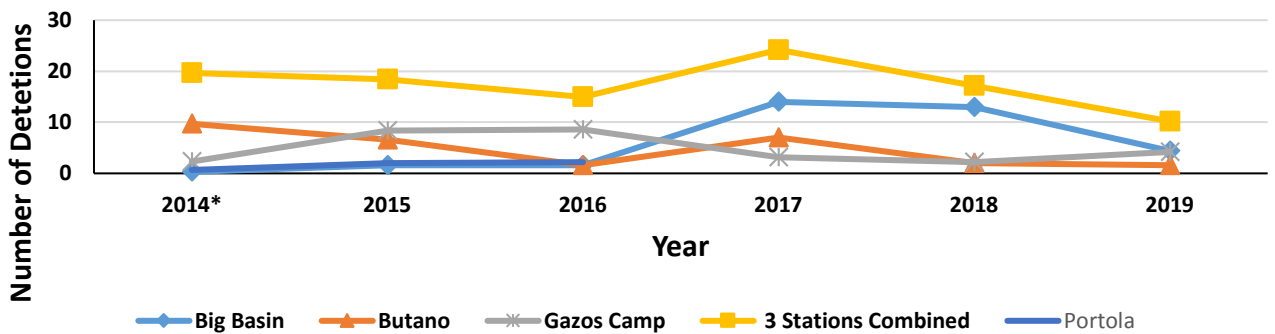
Graph 2. Mean Total Detections 2003 - 2019



Graph 3. Occupied Behavior Detections, 2003 - 2019.



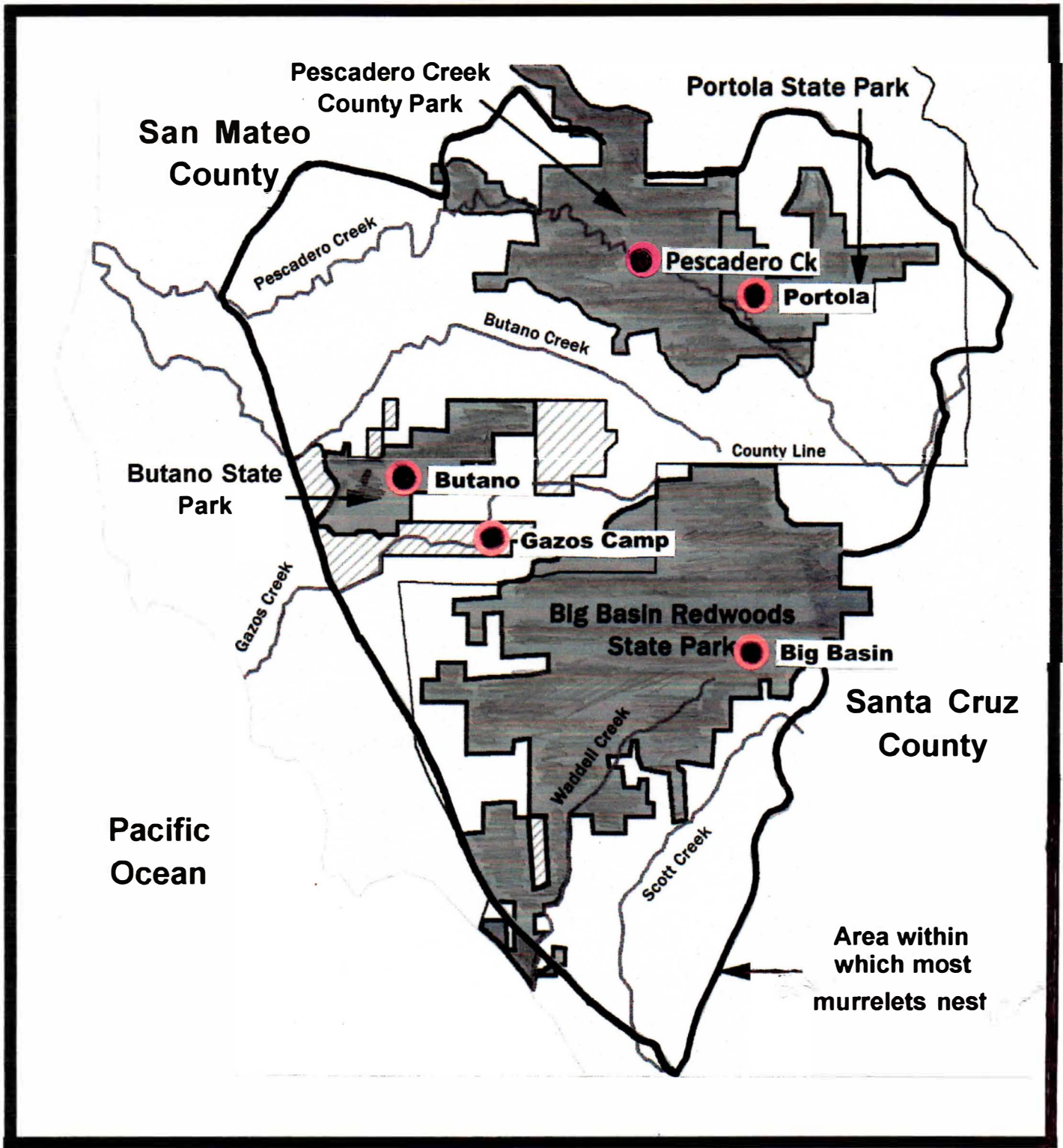
Graph 4. Mean Single Silent Birds Below Canopy Detections



APPENDIX 2 – Station Location Map
(on following page)

[Note: The map shows the location of Big Basin, Butano, Gazos and Portola stations plus an additional station used in previous years]

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



Map by L. Robinson. modified by S. Singer