MARBLED MURRELET INLAND MONITORING PROGRAM
SANTA CRUZ MOUNTAINS REGION
2020 PROGRESS REPORT

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2020 MARBLED MURRELET INLAND SURVEY RESULTS
SANTA CRUZ MOUNTANS REGION

OVERVIEW - KEY FINDINGS

- **From a regional perspective (i.e., Big Basin, Butano and Gazos combined), total detections were dramatically higher in 2020 than the long-term average, going back to 2014.**
- **Regionally, occupied behaviors also were higher than in previous years, but the increase was not as steep.**
- **Single-silent birds below canopy (SSBBC) detections did not mirror the rise in total detections and occupied behavior, and were slightly down from 2019. SSBBC detections have been gradually trending downward since reaching a peak in 2017.**
- **At the station level, Portola was recorded with the highest mean for total detections and SSBBC per survey, while Gazos was recorded with the highest mean of occupied behavior.**
- **Total detections, occupied behavior and SSBBC at Big Basin were lower in 2020 than 2019, continuing a downward trend for each category in recent years.**
- **The long-term pattern of total detections (2014-2020), between Big Basin, Butano and Gazos, appear to reflect murrelet use of different stands over the years.**

INTRODUCTION

This report presents the results of the 2020 marbled murrelet audio-visual (A-V) surveys at four breeding areas in the Santa Cruz Mountains[1] (Figure 1). 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 data from standardized survey methods 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 (Singer 2019).

The initial State Parks 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 include the Gazos Mountain Camp study, which began in 1998 (Singer 2017; Singer 2013), and is 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).

[1] For consistency, some sections of this report are derived from Singer 2019.

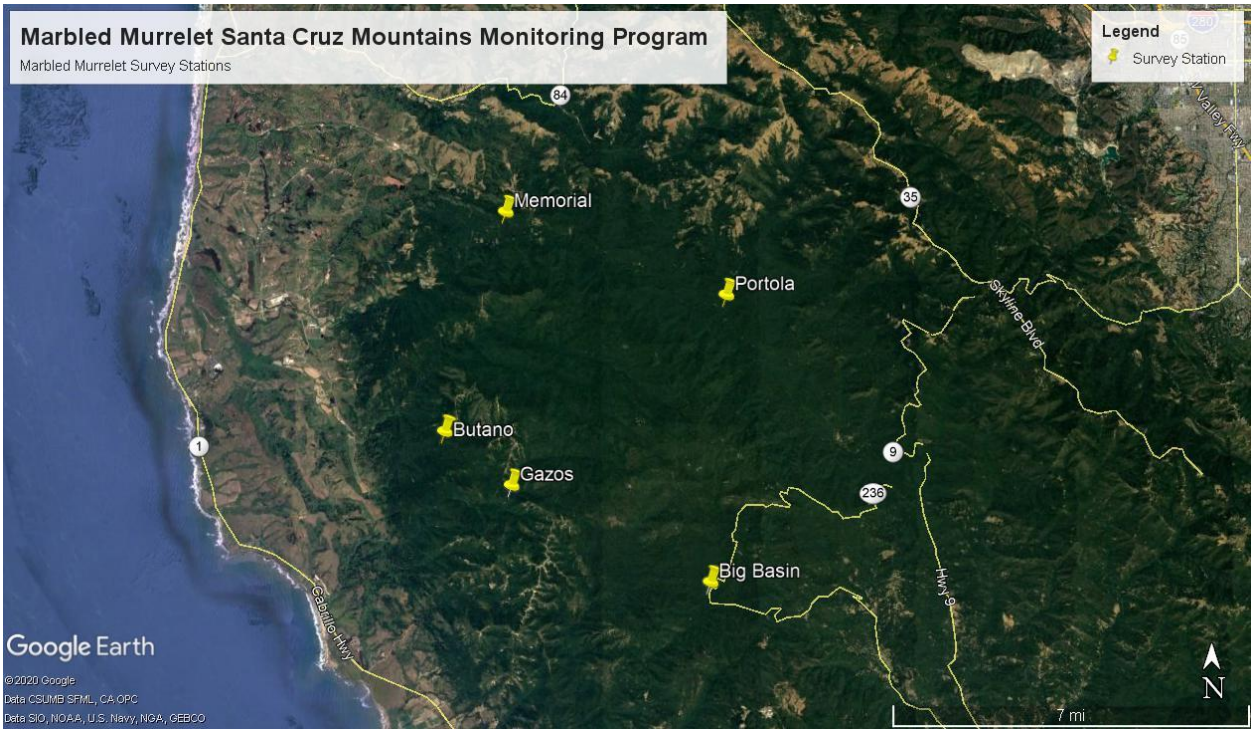


Figure 1. 2020 Marbled Murrelet survey stations discussed in this report.

METHODS

Audio-visual (AV) Survey

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. Surveys were performed at Big Basin, Butano, Gazos, and Portola on 2, 9, 14, 23, and 27 July. The AV surveys were performed simultaneously at each site, as has been the case since 2014. The surveyors for this study were Alex Rinkart, Bryan Mori, Inger-Marie Laursen, Matt Duffy and Portia Halbert, each surveying the same station throughout the study period. This standardized approach allows for long-term comparisons between stations and the pooling of station data to provide a snapshot of murrelet activity at a regional perspective. A map of the survey station locations is shown on Figure 1 and includes Memorial County Park, for which supplemental data for 2020 was obtained from San Mateo County Parks.

Prior to 2014, AV surveys were not conducted simultaneously and the number of surveys per season differed at some stations (Singer 2019). Due to the high variability of detections that are inherent with AV surveys, data prior to 2014 are not used for station to station comparisons or pooled for obtaining a regional perspective. Data prior to 2014 were used, however, to look at general long-term patterns for the stations individually.

Observations were recorded live on tape or digital recorders and later transcribed onto standard forest AV survey forms. In addition to murrelet detections, ancillary information on the maximum number of common ravens detected simultaneously (seen or heard) and the maximum number of Steller's Jays detected simultaneously (seen or heard) also were recorded. 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 2020, as in previous years, the maximum number of murrelets seen in the sky at the same time also was recorded.

Terminology

There are several detection categories used to analyze the monitoring results collected for this study and are consistent with previous reports. These categories are explained, below.

Total Detections
These consist of any detection of a murrelet by either sight or sound and can include detections of murrelet vocalizations that are more than 400 meters away from the observer.

Occupied Behaviors
For the purposes of this study, occupied behaviors are observations of murrelets seen circling overhead at a height between one canopy and two canopy or flying below one-canopy height (Singer 2019). "*Below-canopy detections*" are observations of murrelets flying at or below the tree top level. Since the vast majority of occupied behaviors are made by below-canopy birds, this detection type and overhead circling (within 1-2 canopy) usually correspond strongly with each other. Studies have shown that below-canopy detections are made by birds with active nests or nests active earlier in the season, in the near vicinity (Plissner et al. 2015). Unfortunately below one canopy detection data, prior to 2014, are unavailable.

Circling within two-canopy and below-canopy flight behaviors are just some of the indicators that an active or inactive nest is nearby. In order of decreasing strength of prediction, the full complement of nesting 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) single-silent birds below canopy (SSBBC) detections early during the survey period, (6) wing sounds, (7) other SSBBC detections, and (8) other below-one-canopy 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 may indicate a nest platform or simply be a bird practicing tree landings. Information not widely publicized but made available in Plissner (2015) indicate 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). This subcategory of occupied behavior is defined by observations of non-vocalizing, solitary murrelets flying below one canopy and is a strong indicator of nesting activity. Even stronger is the subcategory of "*early single silent birds below canopy*", those observations 8 minutes or more prior to sunrise. Although the cutoff time of 8 minutes is somewhat arbitrary, it does represent the approximate time limit for the earliest nest visits, as recorded during observations at 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. Wing sounds are non-vocal detections of murrelets and believed to be agnostic in nature. The detections usually are of birds flying below canopy and often are not seen by the observer. For this study, wing sound detections of birds not seen are presumed to be below-canopy detections and are believed to be strong indicators of nesting nearby. Thus, audible wing sounds from unseen murrelets were classified as occupied behavior.

RESULTS

The results of the 2020 monitoring program are presented for the study region as a whole and for the individual survey stations. As discussed earlier, surveys were performed at four stations simultaneously throughout the monitoring period. Together, these survey stations are representative of the core of marbled

murrelet breeding habitat in the Santa Cruz Mountains. Thus, combining the data provides a snapshot of their activity level, from a regional perspective. However, data from Portola were excluded from the regional analysis, since monitoring at this station was not performed in 2017 and 2018 and the absence of data would have skewed the trend. Nonetheless, data from Portola were analyzed for the individual stations.

Due to high day-to-day variability of detections inherent with AV surveys, and the small number of surveys performed at each station under the monitoring program, care must be taken when evaluating trends of activity levels at any one station and comparing differences of murrelet activity levels between stations.

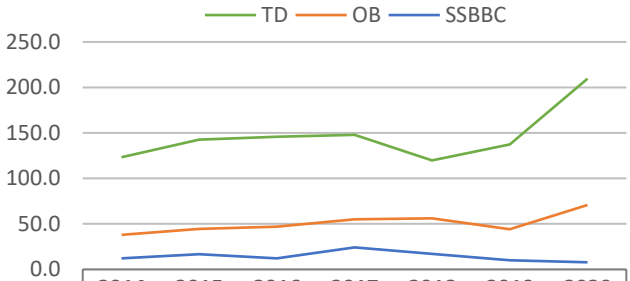
Regional Perspective - Survey Stations Combined

The mean number of total observations per day was 209.6, ranging from a low of 101 on July 2 and a high of 311 on July 27. The mean occupied behavior detections was 70.8, with a low of 40 detections on July 9 and a high of 112 on July 23. Single-silent birds below canopy observations averaged 7.8 per survey and ranged from 3 on July 9 to 13 on July 27. The coefficient of variation (CV) values for all detection categories show a high level of variation per day. These results are summarized on **Table 1.** When compared to monitoring results from 2014-2019, the mean number of total detections increased sharply in 2020 (**Figure 2**). An increase also was observed for occupied behavior detections, but less abruptly. On the other hand, observations of single-silent birds below canopy was slightly lower and has been gradually decreasing since 2017 **(Figure 2**).

Table 1. Daily total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) for Big Basin, Butano and Gazos combined.

Date	TD	OB	SSBBC
7/2/2020	101	51	11
7/9/2020	130	40	3
7/14/2020	197	45	4
7/23/2020	309	112	8
7/27/2020	311	106	13
$\bar{x}$	**209.6**	**70.8**	**7.8**
SD	**98.04**	**35.15**	**4.32**
CV	**0.47**	**0.50**	**0.55**

Figure 2. **Big Basin, Butano and Gazos Combined** - Mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) from 2014-2020. Data table of the mean observations for each category included



	2014	2015	2016	2017	2018	2019	2020
TD	123.3	142.8	145.8	148.0	119.8	137.4	209.6
OB	38.0	44.4	47.0	55.0	56.0	44.2	70.8
SSBBC	12.3	16.6	12.2	24.2	17.2	10.2	7.8

Individual Stations

The 2020 results for all survey stations (i.e., Big Basin, Butano, Gazos and Portola) are summarized on **Table 2** and **Figures 2, 4, 6 and 8.** Data from prior to 2014 also were evaluated for each station and are summarized on **Figures 3, 5 and 7**. As the data prior to 2014 were not collected in a standardized manner (e.g., consistent number of surveys between stations and stations simultaneously surveyed), their presentations are meant to provide generalized long-term patterns, and should be interpreted with caution.

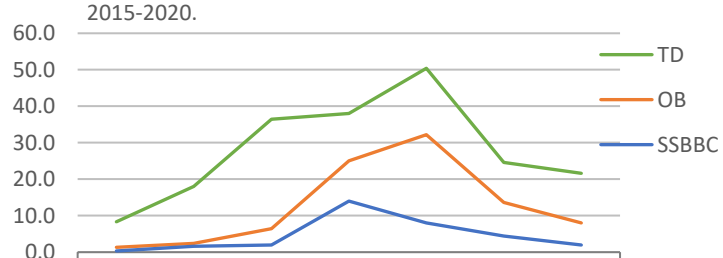
Big Basin

In 2020, Big Basin recorded the lowest daily mean number of total detections at 21.6, with observations ranging from a low of 9 on July 9 and a high of 34 on July 27 (**Table 2**). Unlike 2019 when no detections were recorded on the final two surveys, murrelets were detected on all surveys. The lowest daily mean for occupied behavior behaviors also was recorded at this station with 8.0, with observations ranging from a low of 1 on July 9 and a high of 16 on July 2. Single-silent birds below canopy observations averaged 2.0 per survey, ranging from 0 on July 14 to a high of 4 on July 2. The CV values for all detection categories indicate high daily variation (**Table 2**). When compared with the results from 2014-2019, the mean number of total detections, occupied behaviors and single-silent birds below canopy in 2020 were not out of the range of the variation seen from previous years. However, the numbers for each category decrease, from 2017 and 2018 (**Figure 3**). Including data from prior to 2014, the mean number of total detections have been trending downward since 1995 (**Figure 4**).

Table 2. Daily total detections, occupied behavior and single-silent birds below canopy from each survey station.

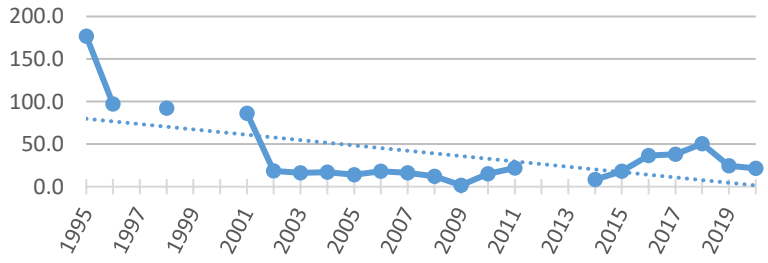
Date	Total Detections				Occupied Behavior				Single-Silent Birds Below Canopy			
	Big Basin	Butano	Gazos	Portola	Big Basin	Butano	Gazos	Portola	Big Basin	Butano	Gazos	Portola
7/2/2020	28	45	28	85	16	13	22	7	4	0	7	0
7/9/2020	9	55	66	148	1	16	23	34	1	1	1	14
7/14/2020	19	107	71	85	7	8	30	15	0	0	4	2
7/23/2020	18	103	188	159	5	14	93	40	2	1	5	2
7/27/2020	34	116	161	185	11	29	66	62	3	3	7	13
x̄	**21.6**	**85.2**	**102.8**	**132.4**	**8.0**	**16.0**	**46.8**	**31.6**	**2.0**	**1.0**	**4.8**	**6.2**
SD	**9.66**	**32.67**	**68.20**	**45.31**	**5.74**	**7.84**	**31.49**	**21.69**	**1.58**	**1.22**	**2.49**	**6.72**
CV	**0.45**	**0.38**	**0.66**	**0.34**	**0.72**	**0.49**	**0.67**	**0.69**	**0.79**	**1.22**	**0.52**	**1.08**

Figure 3. **Big Basin** - Mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) from 2014-2020. N=3 surveys in 2014, N=5 surveys 2015-2020.



	2014	2015	2016	2017	2018	2019	2020
TD	8.3	18.0	36.4	38.0	50.4	24.6	21.6
OB	1.3	2.4	6.4	25.0	32.2	13.6	8.0
SSBBC	0.3	1.6	2.0	14.0	8.0	4.4	2.0

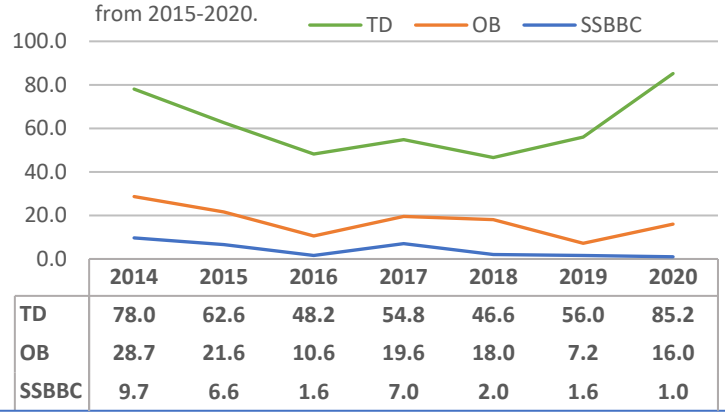
Figure 4. **Big Basin** - Long-term trend of annual x̄ total detections from 1995 to 2020, when data from this monitoring program is pooled with data from previous years. N=4 surveys from 1995-98; N=3 surveys from 2001-14; N=5 surveys from 2015-2020.



Butano

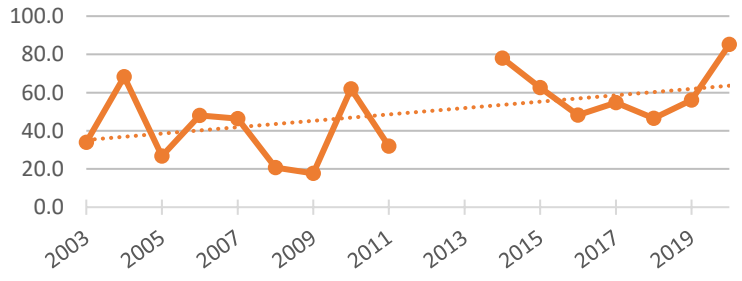
The mean number of total detections per day was 85.2 and ranged from a low of 45 on July 9 to a high of 116 on July 27 (**Table 2**). The mean occupied behavior detections per survey was 16.0, with a low of 8 observations on July 14 and a high of 29 on July 27. The lowest mean of single-silent birds below canopy was recorded at this station with 1.0 observations per survey, with a range from 0 on July 2 to 3 on July 27. The mean number of single-silent birds below canopy was the lowest recorded since 2014, but similar to lows of 1.6 recorded in 2019 and 2016. The CV values for all detection categories indicate high to very high variability per day **(Table 2)**. Compared to the results from 2014-2019, the mean number of total detections and occupied behaviors in 2020 increased from 2019, but were comparable with the observed variability since 2014 (**Figure 5**). Looking at the mean total detections prior to 2014, the numbers of total detections seem to be trending upward since 2003, despite high annual variability (**Figure 6**).

Figure 5. **Butano** - Mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) from 2014-2020. N=3 surveys in 2014, N=5 surveys from 2015-2020.



	2014	2015	2016	2017	2018	2019	2020
TD	78.0	62.6	48.2	54.8	46.6	56.0	85.2
OB	28.7	21.6	10.6	19.6	18.0	7.2	16.0
SSBBC	9.7	6.6	1.6	7.0	2.0	1.6	1.0

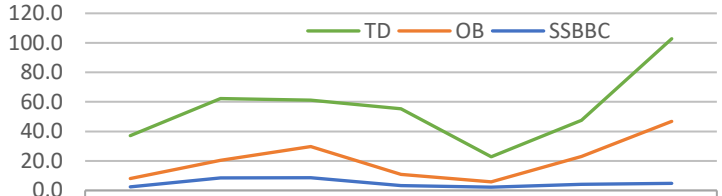
Figure 6. **Butano** - Long-term trend of annual $\bar{x}$ total detections from 2003 - 2020, when data from this monitoring program is pooled with data from previous years. N=3 surveys from 2003-2014; N=5 surveys from 2014-2020.



Gazos

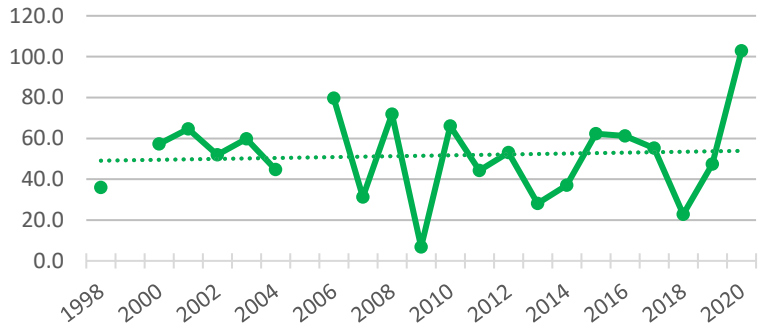
The mean number of total detections per day was 102.8, ranging from a low of 28 on July 2 and a high of 188 on July 23 (**Table 2);** the 188[2] total detections was the highest recorded for any station in 2020. The mean occupied behavior observations per survey was 46.8, the highest mean of all stations, with detections ranging from a high of 93 observations on July 23 and a low of 22 on July 2. The mean single-silent birds below canopy was 4.8 observations per survey, with a range from 1 on July 9 to 7 on both July 2 and 27. The CV values for all detection categories indicate a high level of daily variation **(Table 2)**. When compared to the results from 2014-2019, the mean number of total detections was sharply higher than in previous years, and occupied behaviors showed a similar increase (**Figure 7**). The mean number of single-silent birds below canopy in 2020 was comparable with variations observed in previous years. From prior to 2014, the mean total detections are highly variable but seem to be stable or slightly trending upward since 1998 (**Figure 8**).

Figure 7. **Gazos** - Mean numbers of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC). N=3 surveys m 2014, N=5 surveys from 2015-2020.



	2014	2015	2016	2017	2018	2019	2020
TD	37.0	62.2	61.2	55.2	22.8	47.4	102.8
OB	8.0	20.4	29.8	10.8	5.8	23.0	46.8
SSBBC	2.3	8.4	8.6	3.2	2.2	4.2	4.8

Figure 8. **Gazos -** Long-term trend of annual $\bar{x}$ total detections from 1998 - 2020, when data from this monitoring program is pooled with data from years. N=6 from 1998-2010, N=7 surveys from 2011-2013, N=4 surveys in 2014.

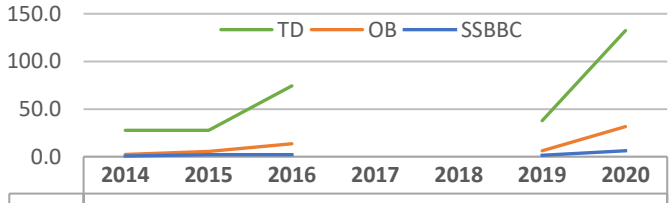


[2] 188 represents a conservative total, as the survey was ended after 1-hr beyond the standard survey period, before 15 minutes had not elapsed since the last detection was recorded, due to scheduling conflicts.

Portola

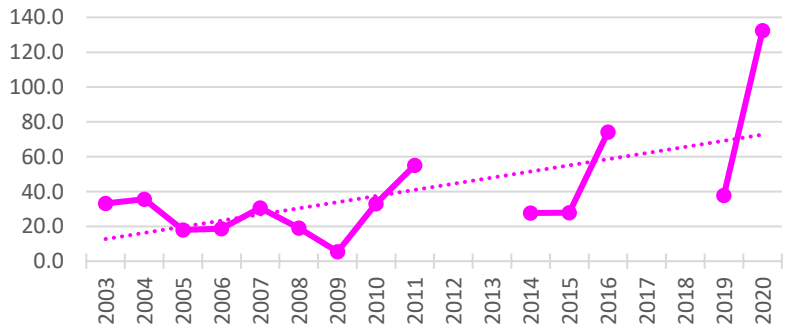
The Portola station was recorded with the highest daily mean number of total detections of all the stations at 132.4[3], with lows of 85 on July 2 and 14 and a high of 185 on July 27 (**Table 2);** the 185 total detections was the second highest recorded for any station in 2020. The mean occupied behavior per survey was 31.6, the second highest mean of all stations, with detections ranging from a high of 62 observations on July 27 to a low of 7 on July 2. The mean of single-silent birds below canopy was 6.2 observations per survey and was the highest of all stations, with a range from 0 on July 2 to 14 on July 9. The CV values for all detection categories show moderate to very high daily variation **(Table 2).** When compared with the results from 2014-2019, the mean number of total detections was sharply higher than recorded in previous years, and occupied behaviors showed a similar, but less abrupt increase (**Figure 9**). The mean number of single-silent birds below canopy also increased in 2020, but only slightly above previous year averages. Combining the data from prior to 2014, the mean total detections trends upward since 2003, despite high annual variability (**Figure 10**).

Figure 9. **Portola** - Mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC). N= 3 surveys in 2014. No surveys were conducted in 2017 and 2018, N=5 surveys from 2019-2020.



	2014	2015	2016	2017	2018	2019	2020
TD	27.7	27.8	74.2			37.8	132.4
OB	2.3	5.6	13.4			6.2	31.6
SSBBC	0.7	2.0	2.2			1.6	6.2

Figure 10. **Portola** - Long-term trend of annual $\bar{x}$ total detections from 2003 - 2020 when data from this monitoring program is pooled with data from previous years. N=5 surveys for all years except 2014 where N=3. No surveys were performed from 2012-13 and



[3] The mean represents a conservative value, as some data on 23 July were lost through recorder malfunction.

A Closer Look at Big Basin, Butano and Portola

An interesting pattern is revealed, when the annual mean total detections for Big Basin, Butano, and Gazos from 2014-2020 are compared. The mean total detections for Big Basin increases from 2014 to 2018, then decreases from 2018 to 2020, while the patterns generally move in opposite directions for Butano and Gazos (**Figure 11**). This pattern is especially pronounced when the data for Butano and Gazos are combined (**Figure 12**). Perhaps this pattern reflects interannual changes in stand use among the three state parks.

Figure 11. Comparison of mean number of total detections at Big Basin, Butano and Gazos from 2014-2020.

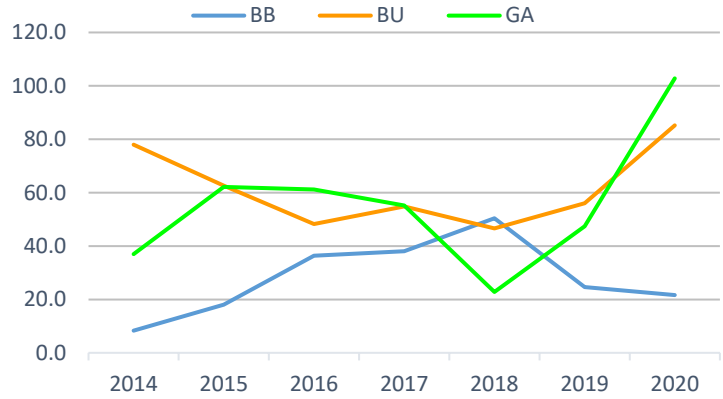
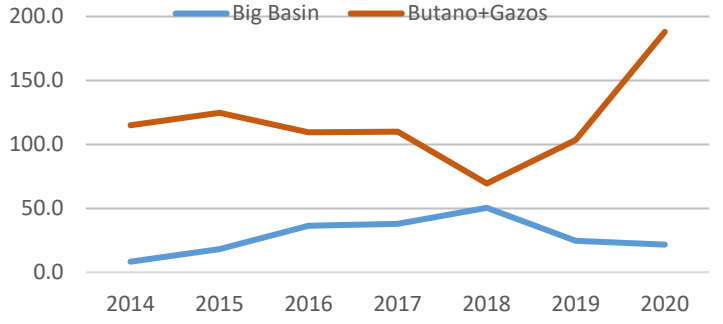


Figure 12. Comparison of mean total detections per year at Big Baisn versus Butano and Gazos combined, from 2014-2020.

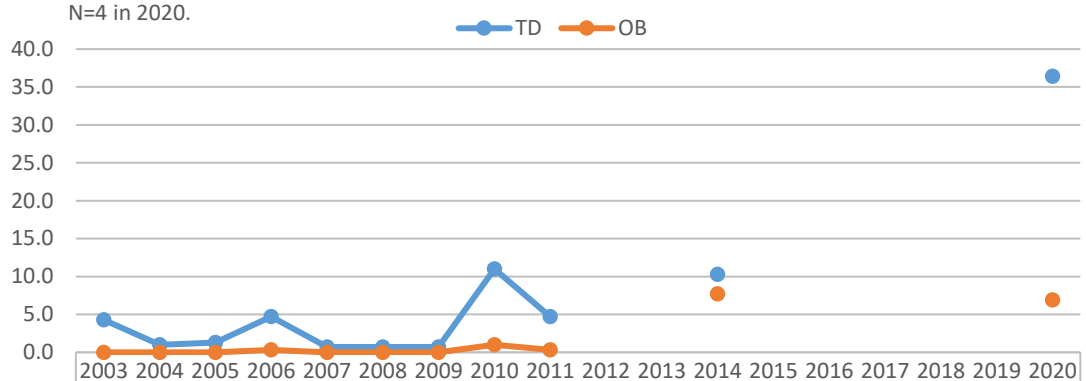


Other Studies

Memorial County Park was part of the original monitoring program from 2003 – 2014, but was discontinued, following the 2014 survey season (Singer 2019). In 2020, however, murrelet surveys were conducted at Memorial County Park independent of this study (Hannah Ormshaw, pers. com.). The data from 2020 and previous years are presented here only to make generalized comparisons over the years. Mostly, detection levels were relatively low from 2003 - 2014, with a high mean of 11 total detections per survey recorded in 2010 (**Figure 13**). In 2020, however, the mean jumps sharply to 36.4 per survey, the highest level recorded at

Memorial, and corresponds to the overall increase in total detections observed regionally (i.e, Butano, Gazos and Portola). Surveys also were performed at Pescadero Creek County Park, where the mean total detections was 98.8, also the highest recorded for that site, where previous detections ranged from 30 – 50 (H. Ormshaw, pers. comm.).

Figure 13. **Memorial** - Annual $\bar{x}$ total detections and occupied behavior observations from 2003 - 2020. No surveys were performed in 2012-2013 and 2015 - 2019. N=3 surveys from 2003-2014, N=4 in 2020.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
TD	4.3	1.0	1.3	4.7	0.7	0.7	0.7	11.0	4.7			10.3						36.4
OB	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.0	0.3			7.7						6.9

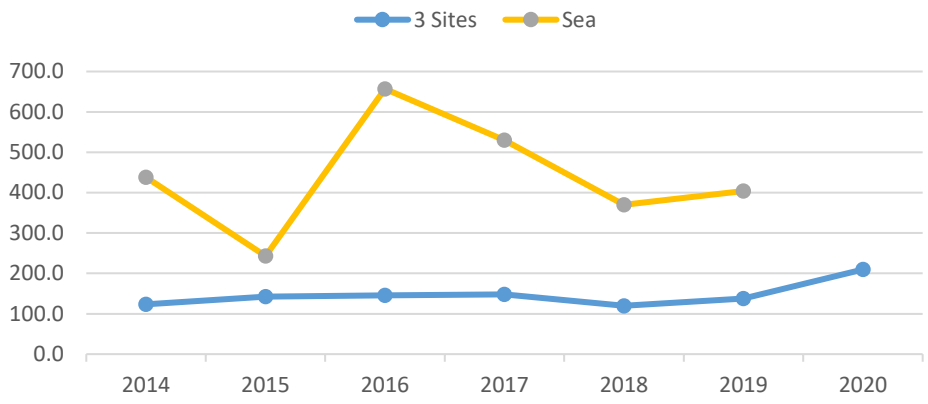
DISCUSSION

Regional Murrelet Activity

In 2020, the level of murrelet activity was noticeably higher than over the previous 6 years of the monitoring program. Mean total detections were up significantly, for the region (e.g., Big Basin, Butano and Gazos combined) and for Butano, Gazos and Portola individually. This increase also was mirrored at Memorial County Park and Pescadero Creek County Park (H. Ormshaw, pers. comm.). While the results recorded at Big Basin were contrary to the overall regional trend, it should be noted that this station has been experiencing a decline in detections since 2018 (**Figure 3**), and overall since 1995 (**Figure 4**), while total detections for the region have remained somewhat stable from 2014 - 2019 (**Figure 2**).

Whether this sharp increase in murrelet activity reflects an actual increase in the number of murrelets in the region is uncertain, as data from at-seas counts for 2020 were not available for this report and AV surveys do not allow for estimates of actual numbers (Paton 1995). A cursory comparison of at-sea abundance estimates derived from Felis *et al* (2020) with the results from this monitoring program over the same period does not appear to show a positive relationship between at-sea numbers and inland activity levels recorded from AV surveys (**Figure 14**). While a positive relationship between at-sea numbers and inland detections was observed in one study in British Columbia (Rodway *et al* 1995), the researchers also found contrary results at another site, and they caution that at-sea numbers may not correspond to inland activity. If, then, this apparent lack of relationship applies to this study, what caused the significant increase in murrelet detections throughout the study region in 2020?

Figure 14. A cursory comparison of mean number of detections from Big Basin, Butano and Gazos combined versus at-sea abundance estimates during the study period (Felis *et al* 2020). Note: at-sea estimates for 2020 were not available for this report.



One possible explanation for the increase in total detections could be that feeding conditions may have been more favorable in 2020, when compared with past years, resulting in a greater number of nesting attempts. The corresponding increase in occupied behaviors recorded in 2020 would seem to support this idea (**Figure 2**). While the increase in total detections did not result in a corresponding increase in SSBBC detections (a strong indicator of nesting), such detections likely only would increase, if previously unoccupied potential nest platforms near a survey station were used for nesting in 2020. The lack of an increase in SSBBC detections in 2020 doesn't preclude the possibility of increased nesting elsewhere in the stand, beyond the detection from survey stations. Unfortunately, information on murrelet prey distribution and abundance is lacking (Betts *et al* 2020) and further studies are needed to address the complex relationship between ocean temperatures and prey abundance (Lorenz *et al* 2017).

Patterns of Regional Distribution

When the data for Big Basin, Butano and Gazos survey stations are compared, a pattern appears that seems to reflect shifting use of regional habitats over time. **Figures 11 and 12** show high interannual variability for each station, which is expected (Smith and Harke 2001, Jodice and Collopy 2000), however, the trends seem to move in opposing directions between Big Basin versus Butano and Gazos combined. While the patterns may simply be a coincidental artifact of sampling, perhaps they could reflect a strategy to minimize the effects of chronic corvid predation, despite the presumed strong site fidelity for this species. Unfortunately, data derived from AV surveys alone cannot provide definitive results to support this idea.

Studies on site fidelity over different scales (e.g., nest tree, stand, watershed) are challenging to perform, due to the species' secretive nature and the difficulties in tracking the same birds over time (Plissner *et al* 2015). In general, the overall evidence points to strong site fidelity, based on the behavior of other alcids, documented repeated use of nest platforms and nest trees, and consistent occupancy of forest patches and watersheds. However, the sample size is small for direct evidence of consecutive use of habitat over different scales by the same birds (Plissner *et al* 2015), thus, use of nesting habitat across different watersheds by the same bird(s) is largely speculative. For example, the farthest distance documented between nest trees is 200 meters, for recaptured birds of inland forests, across different years (Burger *et al* 2009).

On the other hand, other factors, such as forest patch size, availability of nest platforms and habitat continuity may influence the degree of site fidelity observed. For example, in the Gulf of Alaska, where suitable habitat is extensive, murrelets seem to show lower rates of site fidelity than birds from the species' southern range (Plissner *et al* 2015). Also, marbled murrelets appear to possess the capacity for extensive dispersal and may exhibit a higher tendency to prospect and occupy non-natal breeding sites (Divoky and Horton 1995). Lower rates of nest site fidelity may benefit the species, in areas where logging and persistent degradation of nesting habitat (e.g., predation pressure) have reduced the extent of suitable habitat.

The CZU Lighting Fire

On the heels of dramatic increases in regional murrelet activity in 2020, tragedy struck the heart of the Santa Cruz Mountains, the core of marbled murrelet habitat. A dry-lightning storm passed through the region on August 16 and ignited the CZU fire, which wasn't fully contained until September 22. In the end, 86,500 acres burned, making this the largest fire in the Santa Cruz Mountains Bioregion since at least 1940, the first year with accurate records of fire size (http://www.scmbc.org/news).

A preliminary assessment of the fire damage indicated that 62% of the known murrelet nesting habitat was burned, including the forests of Big Basin, Butano and Gazos State Parks (http://www.scmbc.org/news). Specifically at Big Basin, 48% of the suitable murrelet nest trees on Middle Ridge and 45% in the Slippery Rock – Huckleberry Campground area were lost to the fire (Singer 2021). In addition, murrelet nesting habitat in burned areas likely will be unavailable for many years to come. For example, "old-growth trees that survived the last major crown fire to burn a portion of the park [Big Basin], which was in 1904, still have not produced branches large enough to support a murrelet nest" (http://www.scmbc.org/news).

Besides the damage to murrelet nesting habitat, the fire likely resulted in the loss of some murrelet nestlings, as the fire occurred before the end of the typical nesting season. Since the estimated total of at-sea birds in 2019 only was 400 individuals (Felis *et al* 2020), the loss of even a few birds to the fire would be significant to this at-risk population.

In the aftermath of the tragic fire, certain questions arise regarding the region's marbled murrelet population. How will this impact the already vulnerable Santa Cruz Mountains marbled murrelet population? Will individuals remain in traditional stands, due to presumed strong site fidelity, or disperse from natal sites and attempt to occupy remaining pockets of habitat? If murrelets remain in natal stands, will they be subjected to higher levels of predation, due to fire-generated marginal conditions? How many years of recovery will be necessary to reestablish suitable murrelet nesting habitat? Fortunately, at-sea and inland monitoring programs have been in place for several years, establishing a pre-fire baseline from which continued monitoring hopefully can address some of these questions.

RECOMMENDATIONS

The recommendations, below, are taken, in part, from Singer 2019.

- In light of the devastating CZU fire, continuation of the murrelet monitoring program is crucial, in order to detect possible changes in activity levels, stand or watershed occupancy (presence/absence), and nesting behaviors.
- Continue with full-season morning ARU recordings at Big Basin and Gazos, and work with Conservation Metrics to develop a monitoring scheme that utilizes both ARU and AV surveys to produce results with strong statistical power.

- Collaborate with the USGS to develop a monitoring scheme that utilizes both at-sea and AV surveys to identify relationships between at-sea numbers and inland detections.
- Consider revisiting a tracking study of at-seas birds, using GPS/satellite tags to collect fine scale inland flight behavior, especially flight duration and areal extent of individual birds, to help shed light on the relationship between detections and numbers of birds.
- Collaborate with all agencies doing AV surveys in the Santa Cruz Mountains to standardize survey methods and archive data with the State Parks Department Zone 6 database.

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