



**MARbled MURRELET INLAND MONITORING PROGRAM
SANTA CRUZ MOUNTAINS REGION
2022 PROGRESS REPORT**

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**2022 MARBLED MURRELET INLAND SURVEY RESULTS
SANTA CRUZ MOUNTAINS REGION**

SUMMARY OF FINDINGS

- From a regional perspective (i.e., Big Basin, Butano, Gazos and Portola combined), total detections, occupied behavior and single-silent birds-below-canopy dropped from 2021. While total detections were well within the range of previous years, occupied behaviors and single-silent-birds-below-canopy matched their lowest values.
- At the station level, all three detection categories fell at Big Basin from 2021 averages, although the drop was within the range of values from previous years.
- At Butano, all three detection categories rose from declines observed in 2021, and occupied and single-silent-birds-below-canopy were the highest of the survey stations in 2022.
- Gazos recorded the lowest average total detections (19.8) and occupied behavior (3.2), and the second lowest in single-silent-birds-below-canopy (1.4) of all stations in 2022. All three detection categories fell to their lowest values in nine years.
- Portola was recorded with the highest mean total detections (86.8) but the lowest mean single-silent-birds-below-canopy (1.2) in 2022.
- The general pattern of total detections diverging between Big Basin versus Butano, Gazos and Portola combined was not seen in 2022.

INTRODUCTION

This report presents the results of the 2022 marbled murrelet audio-visual (A-V) surveys from four breeding areas in the Santa Cruz Mountains (Figure 1). The four survey stations are: (1) Big Basin Redwood Meadow located in Big Basin State Park; (2) Gazos, also known as Gazos Mountain Camp, located inside Butano State Park, (3) Butano, which is also known as Butano Service Road or Little Butano, and is located 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.

The initial State Parks long-term monitoring program in Zone 6 of the marbled murrelet conservation area 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 at Memorial County Park and 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).

The 2020 CZU Lightning Fire

The 2020 CZU Lightning Fire presented a unique opportunity to collect survey data following the devastating event, which burned 86,500 acres and an estimated 62% of known nesting habitat in the Santa Cruz Mountains. The CZU Fire burn perimeter is shown on **Figure 1**. A detailed account of the CZU Fire can be reviewed on the Santa Cruz Mountains Bioregional Council website: <http://www.scmbc.org/news>. Obvious questions regarding the region's marbled murrelet population stem from the aftermath - How will the loss of habitat 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 stands of suitable 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 many years prior to the fire, establishing a pre-fire baseline from which continued monitoring hopefully can address some of these questions adequately.



Figure 1. Marbled murrelet survey stations. The CZU Fire burn perimeter is highlighted in orange.

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. In 2021, an additional survey station was established in Big Basin State Park, near the intersection of North Escape Road and Gazos Creek Road, approximately 500 meters northwest of the survey station at Big

Basin Redwood Meadows, to record MAMU activity at a MAMU nest site discovered earlier in the season. For practical reasons, the North Escape Road station was discarded in 2022, as the previous year's results strongly suggested a high degree of overlap in detections between the traditional and North Escape Road stations (Bryan Mori Biological Consulting 2022). The survey stations employed in 2022 included Big Basin, Butano, Gazos and Portola. Surveys were performed simultaneously at each station on 7, 12, 21, 25, and 28 July. The surveyors for this study were Alex Rinkert, Bryan Mori, Inger-Marie Laursen, Mike Duffy, each surveying the same station, as in previous years. This standardized approach allows for long-term comparisons between stations and the pooling of station data to provide a snapshot of murrelet activity on a regional level, with less variability due to observer bias. Survey data for 2022 also was obtained for Memorial County Park, for which survey data exist from as early as since 2003.

Terminology

Several detection categories are used to analyze the survey results and are consistent with previous studies dating back to 2014. These categories are explained, below.

Total Detections (TD)

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 (OB)

For the purposes of this study, occupied behaviors are categorized as follows:

Circling Above Canopy. These observations are of murrelets seen circling overhead at a height between one canopy and two canopy (Singer 2019).

Below-canopy Detections. Observations of murrelets flying at or below canopy level. 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).

Single-Silent Birds Below Canopy (SSBBC). This subcategory of 'below canopy detections' is defined by observations of non-vocalizing, solitary murrelets flying at or below one canopy and is a strong indicator of nesting activity. Even stronger is the subcategory of 'early single silent birds below canopy', 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 usually of birds flying below canopy and often are of unseen birds. 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 cataloged as 'occupied behavior'.

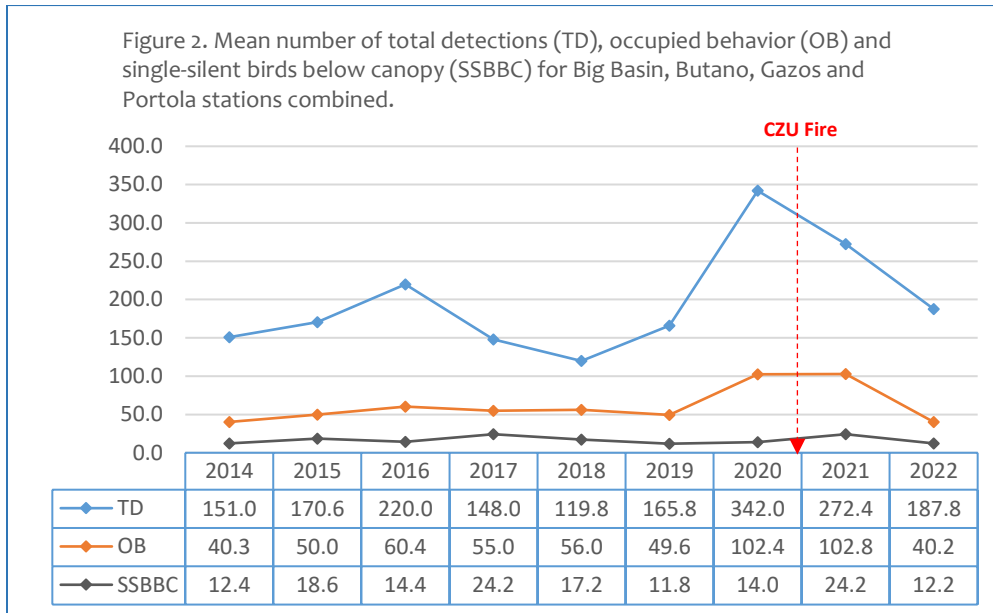
RESULTS

The results of the 2022 monitoring program are presented for the individual survey stations and for the study region as a whole. 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 current monitoring program, caution must be taken when evaluating trends of activity levels at any given station or when comparing differences of murrelet activity between stations.

Regional Perspective - Survey Stations Combined

As the survey stations are representative of core marbled murrelet breeding habitat in the Santa Cruz Mountains, combining the data from the various stations provides a snapshot of their activity level from a regional perspective.

The mean number of total detections per day was 187.8, the mean occupied behavior detections was 40.2, and SSBBC observations averaged 12.2 per survey in 2022 (**Figure 2**). When compared to monitoring results from 2014-2021, each category fell in 2022 values, with total detections dropping for the second consecutive year. While the numbers of TD and SSBBC detections in 2022 are within the averages from previous years, the number of OB detections decreased to the lowest value since 2014.



Individual Stations

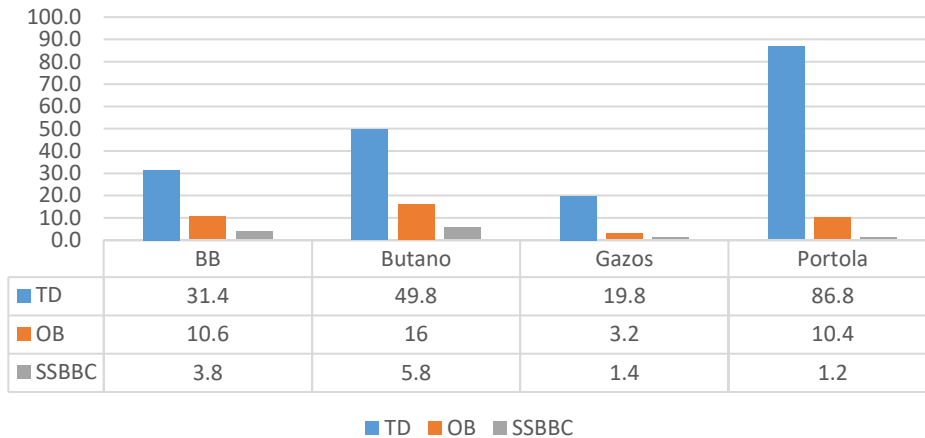
The 2022 results for all survey stations are summarized on **Table 1** and **Figure 3**. Data from prior to 2014 also were evaluated for each station, however, as the data prior to 2014 were not collected in a standardized manner consistent with the current monitoring program, their presentations are meant to provide generalized long-term patterns and should be interpreted with care.

In 2022, Portola was recorded with the highest mean total detections, with 86.8. Butano recorded the highest mean occupied and SSBBC detections. In contrast, Gazos was recorded with the lowest mean total and occupied detections, with 19.8 and 3.2 per survey. Gazos and Portola both recorded low SSBBC detections with 1.4 and 1.2 per survey, respectively.

Table 1. Summary of daily MAMU observations from all survey stations – Big Basin Redwood Meadow (BB), Butano (BU), Gazos (GA) and Portola (PO).

Date	Total Detections				Occupied Behavior				Single-Silent Birds Below Canopy			
	BB	BU	GA	PO	BB	BU	GA	PO	BB	BU	GA	PO
7/7/2022	42	67	11	54	26	8	0	9	16	3	0	0
7/12/2022	31	76	24	78	3	22	8	15	0	13	4	2
7/21/2022	16	31	18	153	6	7	0	8	1	6	0	3
7/25/2022	58	46	42	110	14	27	8	17	1	7	3	1
7/28/2022	10	29	4	39	4	16	0	3	1	0	0	0
\bar{x}	31.4	49.8	19.8	86.8	10.6	16.0	3.2	10.4	3.8	5.8	1.4	1.2
SD	19.46	21.11	14.50	45.71	9.63	8.69	4.38	5.64	6.83	4.87	1.95	1.30
CV	0.62	0.42	0.73	0.53	0.91	0.54	1.37	0.54	1.80	0.84	1.39	1.09

Figure 3. Mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) recorded at the survey stations. N = 5 for each station.



Big Basin Redwood Meadow (Big Basin)

Big Basin recorded a mean number of total detections at 31.4, a mean of 10.6 for occupied behaviors and a mean of 3.8 for SSBBC, with each category peaking on 25 July (**Table 1**). Total detections ranged from 10 to 42; occupied behavior from 3 to 26; and SSBBC from 0 to 16. The averages from all three detection categories in 2022 fell from the previous year (**Figure 4**). The CV values indicate high daily variation for all detection categories (**Table 1**). When incorporating data previous to the current monitoring program, the mean number of total detections have been trending downward since 1995 (**Figure 5**).

Figure 4. **Big Basin** - Mean total detections (TD), occupied behavior (OB) and single-silent birds below canopy (SSBBC) from 2014-2022

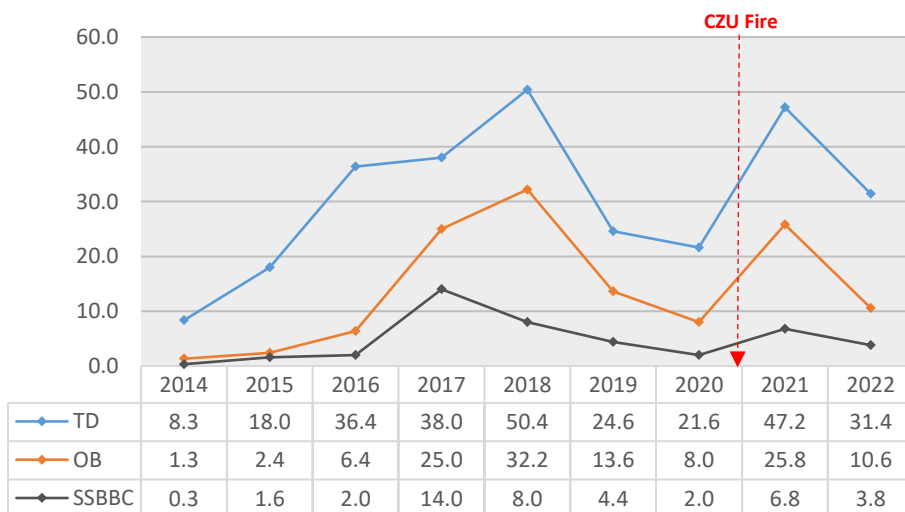
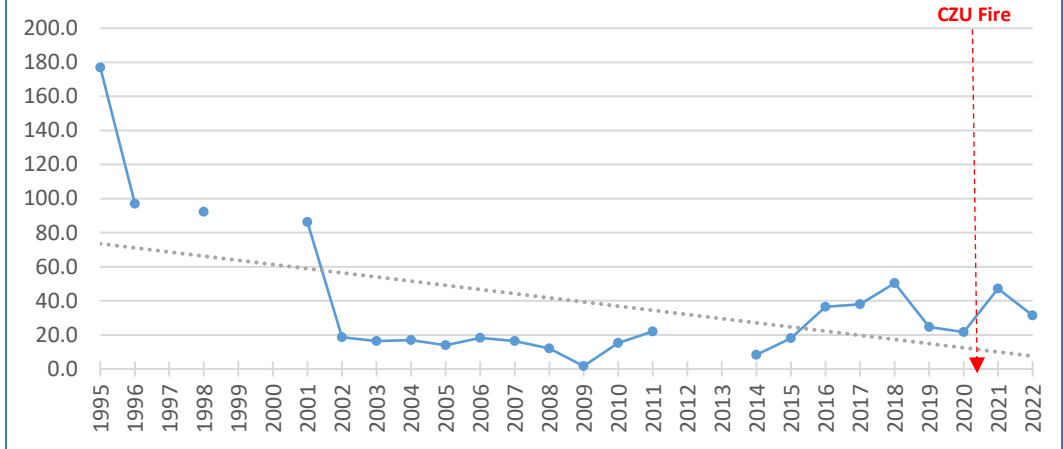


Figure 5. The long-term trend of mean total detections from 1995 - 2022 at Big Basin when combining the data set from this study with data from previous years. N=4 1995-98; N=3 2001-2014; N=5 2015-2022.

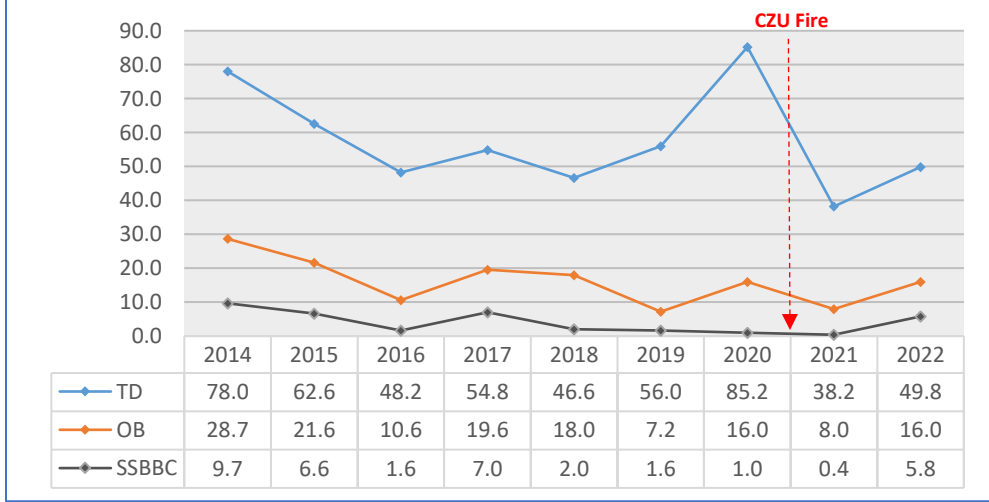


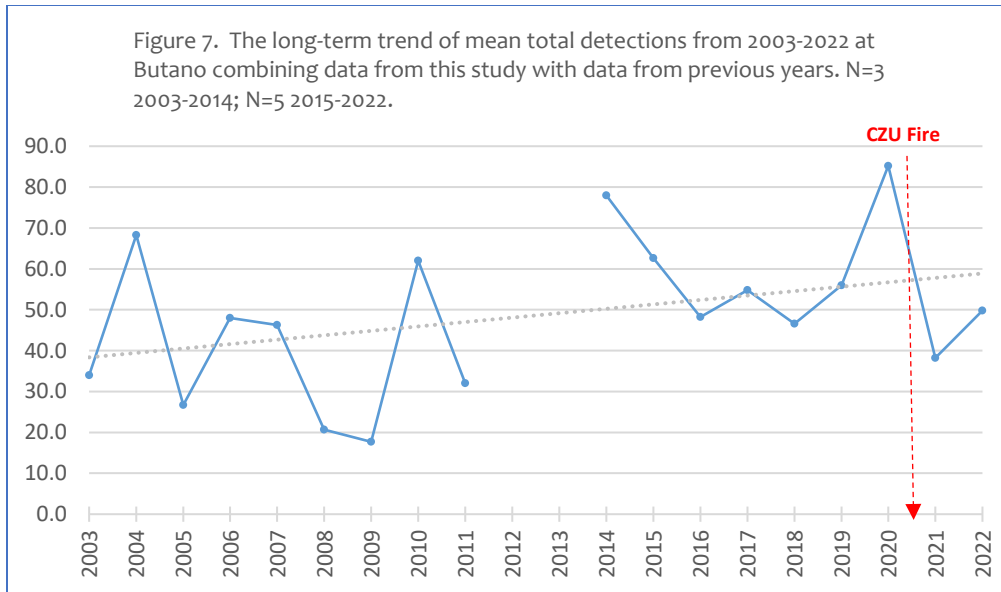
Butano

The mean number of total detections per day was 49.8, with detections ranging from a low of 10 on 28 July to a high of 58 on 25 July (**Table 1**). The mean occupied behavior per survey was 16.0, with the observations ranging from a low of 7 on 21 July to a high of 27 on 25 July. The mean of SSBBC was recorded at 5.8 per survey, ranging from 0 on 28 July to 13 on 12 July. The mean of all three detection categories in 2022 rebounded from the previous year (**Figure 6**). The CV values indicate moderate to very high variability per day for all detection categories (**Table 1**). Looking at the long-term trend of mean total detections from 2003, total detections appear to be trending upward, despite high annual variability (**Figure 7**).

Of special interest were observations of possible aborted landings on 12 and 14 July, the latter a stake-out survey. Nesting evidence was not confirmed during the stake-out and aborted landings were not recorded thereafter, for the remainder of surveys in 2022.

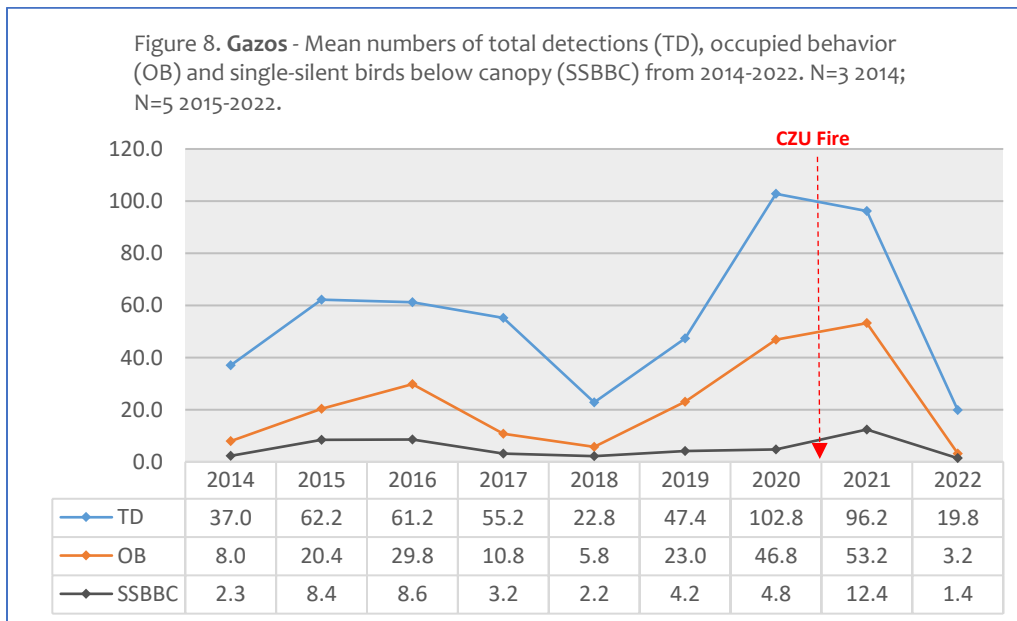
Figure 6. **Butano** - The mean number of total detections (TD), occupied behavior (OB) and single-silent birds below canopy from 2014-2022.

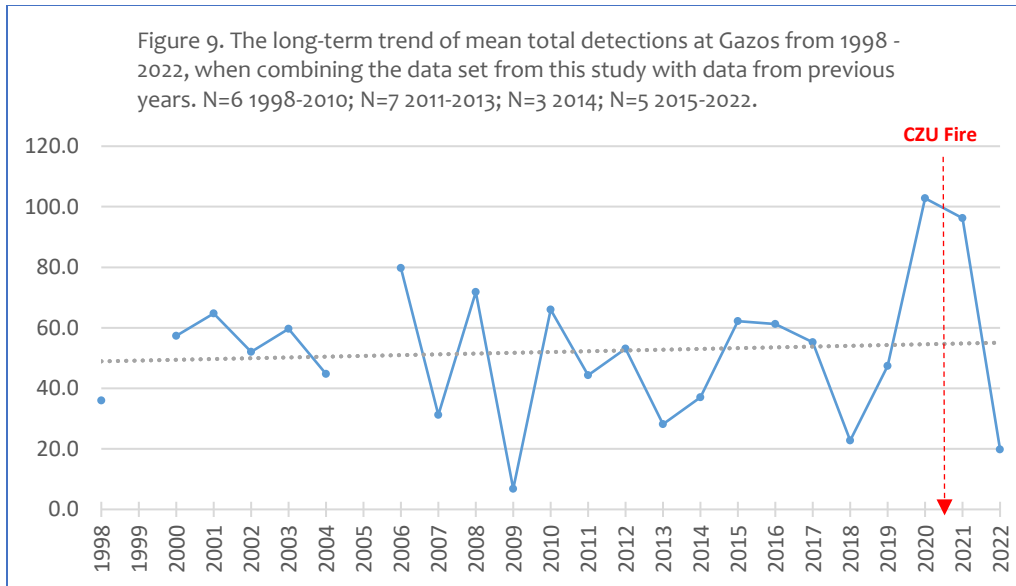




Gazos

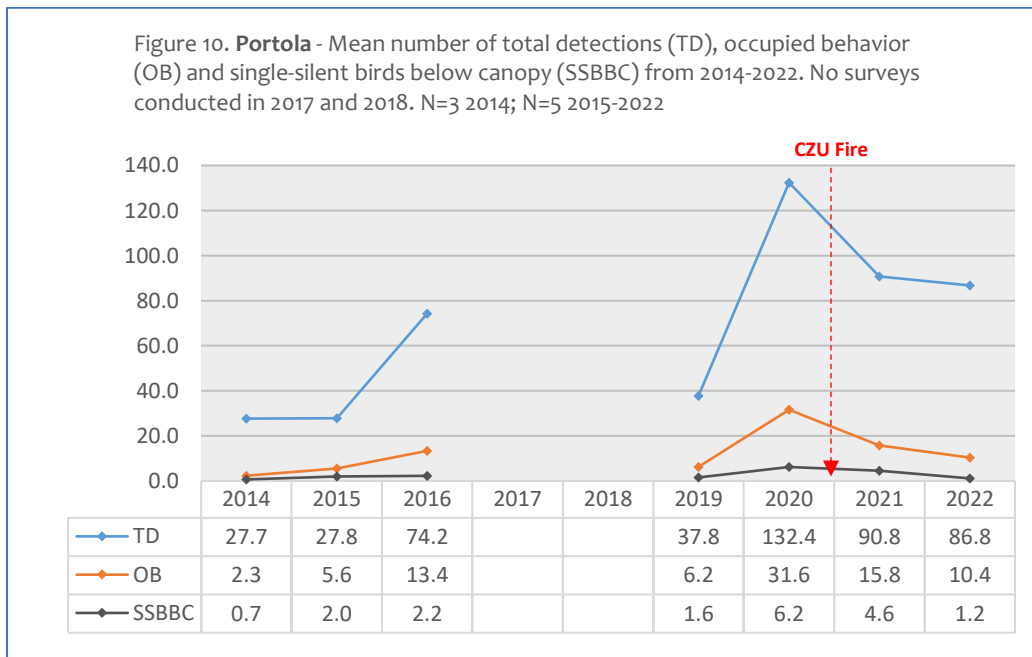
Of all the survey stations, Gazos recorded the lowest average of total detections and occupied behavior, and the second lowest in SSBBC in 2022, with 19.8, 3.2 and 1.4, respectively. All three detection categories fell considerably from the previous year, with averages recorded at their lowest in nine years (**Figure 8**). The CV values indicate a high level of daily variation for all detection categories. Looking at the long-term trend since 1998, the mean total detections in 2022 was the second lowest recorded since 2009. Although highly variable, the trend appears to be level or slightly increasing since 1998 (**Figure 9**).

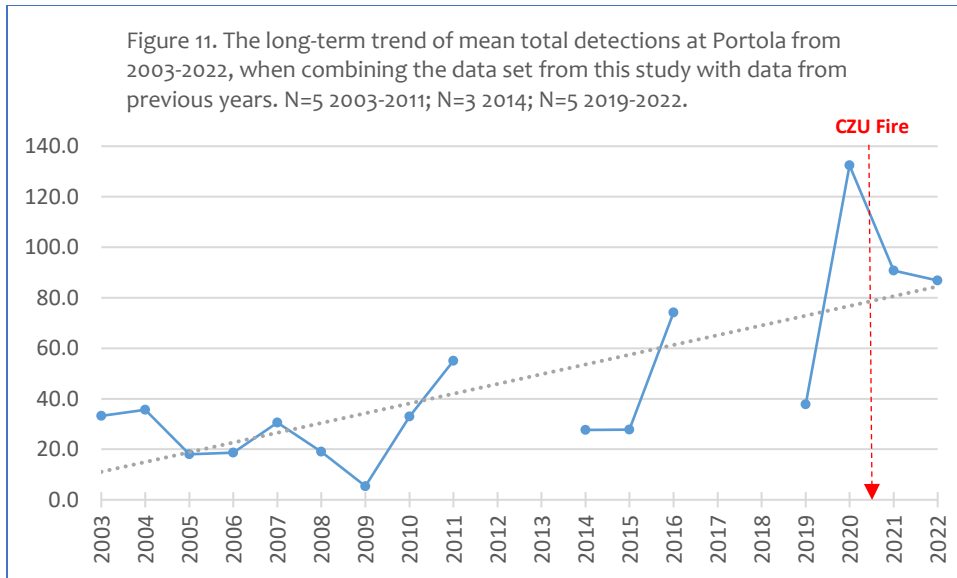




Portola

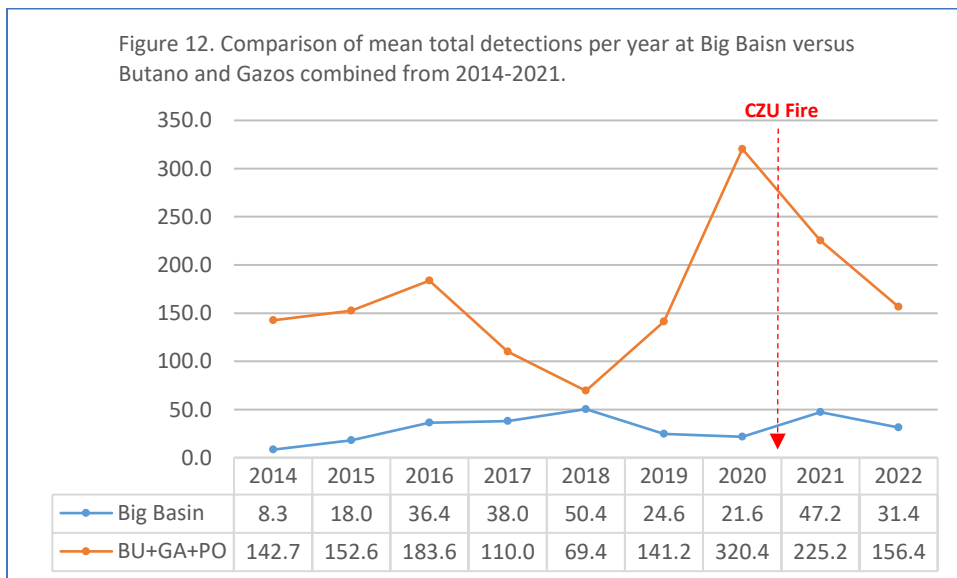
The Portola station was recorded with a mean of 86.8 total detections, 10.4 occupied behavior detections, and 1.2 SSBBC detections (**Table 1; Figure 10**). The mean total detections was the highest of all survey stations and similar to the results from 2021. The CV values for all detection categories show moderate to very high daily variation. All three detection categories were recorded with lower means than in 2021, but within the variability observed over previous years (**Figure 10**). Despite the slight drop in mean total detections in 2022, the trend is upward, since 2003 (**Figure 11**).





Landscape Level Patterns: A Closer Look

In general, the mean total detections at Big Basin appeared to diverge with results from Butano, Gazos and Portola combined between 2014 - 2022, perhaps reflecting interannual changes in stand use among the three state parks (Bryan Mori Biological Consulting 2021 and 2022). However, this pattern was not observed in 2022, as both groups decreased (**Figure 12**).



Other Studies

The following discussion is based on preliminary information obtained from San Mateo County Parks (SMCP) and Midpeninsula Regional Open Space District (Midpen) staff and is subject to change.

SMCP resumed MAMU monitoring at Memorial County Park (MCP) in 2020, as part of a separate study (E. Cole, SMCP, Natural Resource Specialist, pers. com.). MCP was included in the original Zone 6 monitoring program from 2003 – 2014, but was discontinued following the 2014 survey season (Singer 2019). The data from 2022 and previous years are presented here only to make general comparisons over the years. From 2003 – 2014,

Portola) or low to moderately burned forests (e.g., Butano), presuming that birds from severely burned forests might seek unburned pockets of mature forests in search of suitable nesting habitat.

Post-Fire Year 1

The results from 2021 were contrary to the above expectations. For instance, although there was a drop in mean total detections on a regional level, the drop was consistent with the variability observed in past years. Additionally, occupied behavior detections remained the same as the 2020 seven-year high, while SSBBC detections slightly rose from 2020 and matched the high in 2017 (see **Figure 2**).

At the station level, the results also were contrary to expectations at 3 out of 4 survey stations. First, Big Basin total detections and occupied behavior rose sharply to near 2018 highs, while SSBBC detections also were up, but less markedly. The Big Basin results were surprising, given the severity of burn and the downward trend in these categories since 2018. However, it was presumed that the close proximity of a confirmed nest site 500 m north of the traditional survey station likely influenced the 2021 results (Bryan Mori Biological Consulting 2022). Second, there was only a slight decrease of mean total detections at Gazos, while both occupied behaviors and SSBBC rose from 2020 (see **Figure 8**). Finally, all three observation categories were down at Portola (see **Figure 10**), inconsistent with the idea that detections might increase in unburned stands, due to MAMU inhabiting severely burned stands seeking suitable habitat elsewhere. Only at Butano (low to moderate burn severity) were the results consistent with expectations following the CZU Fire, as mean total detections dropped sharply to an eight year low and occupied behavior and SSBBC also were down, but less abruptly (see **Figure 6**). Strong site fidelity likely influenced the post-fire year 1 results by moderating the response of MAMU to the effects of the CZU Fire.

Post-Fire Year 2

On a regional level, all three detection categories dropped in 2022. Although total detections were within the variability seen in previous years, occupied behavior and SSBBC matched lows not seen since 2014 (see **Figure 2**) and are consistent with expectations following a severe burn. Looking closely at the station level, the results at Big Basin and Gazos were down for each detection category in 2022 (see **Figures 4 and 8**), especially at Gazos where overall detections fell to the lowest recorded during the monitoring program. The results at Gazos are consistent with expectations following loss of suitable nesting habitat due to the CZU Fire, since parts of Gazos experienced severe burns. With regards to Butano and Portola, the results did not show an obvious pattern that could be attributed to the CZU Fire.

While the results at Gazos are concerning, continued monitoring is needed to determine if 2022 marks the beginning of a downward trend related to the CZU Fire. Also, further annual monitoring may reveal significant changes in inland activity at other stations, if MAMU productivity decreases as a whole and the influence of site fidelity wanes. Although inland surveys are not ideal for monitoring the population status of murrelets (i.e. numbers of individuals), dynamic fluctuations in occupied behavior and SSBBC detections may reveal changes in nesting behavior.

San Mateo County Parks (SMCP) and Midpeninsula (Midpen) Regional Open Space

The parallel murrelet monitoring programs being conducted on lands managed by SMCP and Midpen are in areas not directly impacted by the CZU Fire, which caused extensive damage generally south of Pescadero Creek. As such, these study sites offer opportunities to monitor changes of murrelet activity in unburned stands, similar to the Portola station used for the State Parks study. The expectation is that murrelet detections would increase over time in unburned stands, as murrelets seek suitable nesting habitat outside of traditional, natal stands. Over the past two years following the CZU Fire, the results from SMCP and Midpen have been mixed. As seen on **Figure 13** and reported, above, the results from MCP two years following the fire did not support this concept, as detections dropped from unprecedented highs to values consistent with previous years, while detections remained low at the Midpen Purisima Creek site. Site fidelity may have played a role in the 2021 findings. In 2022, however, total detections and occupied behaviors at Purisima Creek were up sharply from previous years. Along with the decreases at Gazos over the past two seasons, these observations

perhaps signal shifts in the regional distribution of MAMU occupancy at inland sites and/or nesting success. Such changes may become more evident in subsequent years, presuming the influence of site fidelity diminishes.

Potential Nesting

In 2021, MAMU nesting was confirmed at Big Basin, 500m north of the traditional Redwood Meadows survey station. No confirmed nesting was recorded at any survey station in 2022. However, evidence of potential nesting was observed at Butano, where aborted landings and SSBBC were observed concentrated around Douglas fir trees south of the survey station on 12 July. A follow-up stake-out on 14 July recorded similar detections as well as a colliding-with-branches sound, but no confirmations of landings were seen and such behaviors were not recorded in surveys thereafter. Interestingly, the aborted landings were recorded during the peak of seasonal activity at Butano on 12 July. Since peak detections in July are widely assumed to represent post-breeding behavior (Nelson 2020), perhaps a nesting attempt occurred earlier in the vicinity of the station. This conclusion is supported by results from nest monitoring at Big Basin in 2021, when the peak of detections was recorded following successful fledging (Bryan Mori Biological Consulting 2022). Also, occupied behavior and single-silent-birds-below-canopy detections at Butano were the highest of all survey stations in 2022, offering further support of potential nesting.

Potential nesting may have occurred at Pescadero Creek County Park, as well, based on inland activity levels on 7 July, when 103 total detections and 38 occupied behaviors were recorded. In general, total detections were between 0 - 25 and occupied behavior ranged from 0 – 5 before and after 7 July. Given this marked difference, it is reasonable to speculate that nesting occurred in the vicinity of the survey station.

RECOMMENDATIONS

Because of the importance of collecting long-term data for robust analyses, it is presumed that the MAMU monitoring program will continue in forthcoming years, as funding allows. Continuous monitoring will be critical to reveal changes in inland activity, following the CZU Fire.

A prior recommendation to consider the implementation of satellite tracking studies has been tabled, in light of the Northrup et al 2018 study, which highlighted the short-comings of the technology to record fine-scale movements and to efficiently locate stationary tags in the field, and the mortality level associated with tagged individuals. The latter issue is of great concern, especially since the Santa Cruz Mountains Zone 6 MAMU population is extremely vulnerable due to its small size. The use of satellite tags can be reconsidered when appropriate technology is available.

In addition to past recommendations (Singer 2019; Bryan Mori Biological Consulting 2021 and 2022), this report presents only one new recommendation, below.

- Perhaps consider using broadcast calls to encourage MAMU into areas of suitable habitat not known to be occupied or in previously occupied habitat, where MAMU are presently presumed absent. This recommendation is based on the 2016-2017 experimental study which showed that the use of broadcast calls resulted in increased detections in areas not known to support MAMU (Valente *et al* 2021). However, proposed broadcast sites should be carefully vetted to exclude sites where predation pressures or disturbances from human activities could be high, possibly attracting MAMU to sink habitats (e.g., Fall Creek Unit Henry Cowell State Park). Potential broadcast call sites could include Middle Ridge Big Basin State Park, San Lorenzo River gorge/Eagle Creek area, Laguna Creek, and Midpen holdings.

Acknowledgments

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