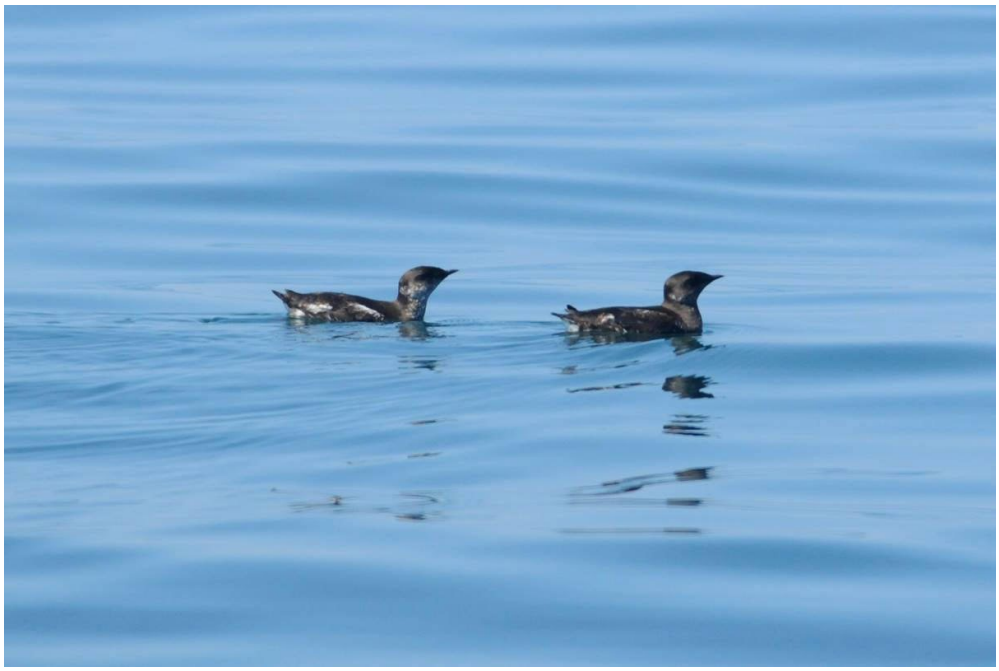
Marbled Murrelet Effectiveness Monitoring, Northwest Forest Plan

2023 Summary Report

Northwest Forest Plan Interagency Regional Monitoring Program



Marbled murrelets at sea. Photo credit: Ryan Merrill.

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Final Report

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Marbled Murrelet Effectiveness Monitoring Module

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Adult marbled murrelet on nest. Photo credit: Nick Hatch, U.S. Forest Service

SUMMARY OF 2023 WORK

The Northwest Forest Plan (NWFP), established in 1994, is an ecosystem management plan for Federal forest lands in the Pacific Northwest of the United States (U.S. Forest Service and Bureau of Land Management 1994). Mulder et al. (1999) described programs to monitor the effectiveness of the NWFP in meeting various objectives, including supporting populations of species associated with late-successional and old-growth forests. One of those species, the marbled murrelet (*Brachyramphus marmoratus*), occurs from Alaska to California and is federally listed as threatened in Washington, Oregon and California (U.S. Fish and Wildlife Service 1992). Madsen et al. (1999) described an effectiveness monitoring approach for the marbled murrelet under the NWFP designed to estimate status and trends of murrelet populations and nesting habitat. Population abundance and trend monitoring is accomplished with annual at-sea surveys of marbled murrelets during the nesting season in coastal waters adjacent to the NWFP area (Figure 1) (Raphael et al. 2007). Habitat monitoring has been accomplished through the development of various habitat models, utilizing regularly updated information on nest locations and spatial data on forest attributes to estimate amount and trend of nesting habitat (Huff et al. 2006; Raphael et al. 2011, 2016; Lorenz et al. 2021). Population and habitat assessments included in-depth evaluations at approximately 5-year intervals, beginning in 2006 (Huff et al. 2006; Raphael et al. 2011; Miller et al. 2012; Falxa and Raphael 2016; Lorenz et al. 2021; McIver et al. 2021), and periodic annual summary reports that primarily summarized at-sea survey results (e.g., Bentivoglio et al. 2002; Huff et al. 2003; Falxa et al. 2008; Lynch et al. 2017; McIver et al. 2022). Past publications provide details on the monitoring program and methods (e.g., Madsen et al. 1999; Huff et al. 2006; Raphael et al. 2007; Falxa and Raphael 2016).

In preparation of the "30-year report" under the NWFP's Effectiveness Monitoring Program, initial nesting habitat modeling was conducted in 2023 and will continue in 2024. The remainder of this report summarizes the 2023 population monitoring results from at-sea surveys of marbled murrelets in the NWFP area.

The population monitoring strategy was designed to estimate at-sea abundance and trend during the breeding season in five of the six marbled murrelet conservation zones established in the Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997, see Figure 1). At-sea abundance monitoring was implemented in 2000 (Bentivoglio et al. 2002). Details of survey design, sampling protocol, and analytic methods are given in Raphael et al. (2007). In short, the coastline of the entire Plan Area was divided into contiguous 20-km sections, termed Primary Sampling Units (PSU), and a stratified-random sampling survey was conducted within all selected PSUs, using Distance sampling methods. We present detailed results through 2023 in the tables and figures below. We conducted annual surveys in Conservation Zones 1-5 in years 2000-2013 (see Figure 1 for locations of conservation zones). Beginning in 2014, due to budgetary constraints, we implemented a reduced sampling effort design, where Conservation Zones 1 and 3 are sampled in even years (e.g., 2014, 2016, etc.), Conservation Zones 2 and 4 are sampled in odd years (e.g., 2015, 2017, etc.), and Conservation Zone 5 is sampled every fourth year, in conjunction with Conservation Zone 4 (Table 1). Conservation Zone 5 is sampled less frequently due to very low murrelet density estimates in this region; consequently, this region has little influence on range-wide population trend estimates, and so surveys here provide less information relative to the survey effort.

Conservation Zone 6 (Santa Cruz Mountains), in central California, is not in the NWFP area and is not sampled by this program. The U.S. Geological Survey currently conducts abundance monitoring in Conservation Zone 6 (Felis et al. 2023).

At-sea Abundance Estimates

Due to the reduced sampling effort, we were not able to provide a Plan-wide area ("All-Zones") or state-scale abundance estimate for 2023; this will be provided in our 2024 summary report. For 2022, we estimated 19,000 murrelets for All Zones (95% Confidence Interval "CI" = 15,000-23,200; all numbers rounded to nearest '100'; Table 2). In 2023, we sampled Conservation Zone 2 (Western Washington Coast [Cape Flattery to Columbia River mouth]) and Conservation Zone 4 (Siskiyou Coast [Coos Bay to southern boundary of Humboldt County, California]). At the conservation zone scale, the 2023 population estimates were approximately 1,100 murrelets (CI = 700-1,400) in Conservation Zone 2 and approximately 6,400 murrelets (CI = 4,500-9,400) in Conservation Zone 4 (Table 3). At the state scale, the population estimates were approximately 4,900 murrelets (CI = 3,700-6,000) in Washington (through year 2022); approximately 9,600 murrelets (CI = 6,400-12,900) in Oregon (through year 2022); and approximately 5,000 murrelets (CI = 3,500-6,600) in California (through year 2023) (Table 4).

At-sea Abundance Trends

The estimated All-Zones annual rate of change (or "linear trend") for years 2001 through 2022 was 0.0% per year (95% CI: -0.8 to 0.8%) and because the CI is small, includes zero, and there was no obvious departure from a straight line, we conclude there is no evidence of trend over that time period. At the conservation zone scale, Conservation Zone 2 showed a 3.5% decrease per year (95% CI: -5.8% to -1.0%) for years 2001 through 2023. Conservation Zone 4 showed a 2.9% increase per year (95% CI: 1.3% to 4.4%) for years 2000 through 2023. These results are summarized in Table 5, and Figures 2 and 3. Conservation Zones 1, 3 and 5 were not surveyed in 2023. At the state scale, all three states showed significant trends (95% CIs did not overlap zero): the Washington trend was declining between 2001 and 2022 (-4.1% per year; 95% CI: -5.3% to -3.0%); the Oregon trend was increasing between 2000 and 2022 (1.7% per year; 95% CI: 0.8% to 2.7%); and, the California trend was increasing between 2000 and 2023 (3.6% per year; 95% CI: 2.2% to 5.1% (Table 5).

Recalculated Zone 4 Estimate

The shoreline of Conservation Zone 4 contains 22 PSUs (Raphael et al. 2007; Falxa et al. 2016). Due to persistent winds throughout the survey season, the southern four PSUs in Conservation Zone 4, Stratum 2 (PSUs 19 through 22, near Cape Mendocino) were not sampled in 2023. Because this southern portion of Conservation Zone 4 has had very low murrelet densities throughout its survey history, it was not biologically justified to extrapolate from the densities farther north in Stratum 2 of Conservation Zone 4 to derive a zone-level estimate. To derive stratum and Conservation Zone 4 density estimates for 2023, we used the following approach:

- The standard bootstrap approach was run assuming the PSUs 19, 20, 21, and 22 did not exist. From this analysis the estimates for Stratum 1 and the surveyed PSU's in Stratum 2 (PSU's 15, 16, 17, and 18) were obtained.

- Estimates for Stratum 2 PSUs 19, 20, 21, and 22 were taken from the average and standard deviation from the previous 6 surveys (2012, 2013, 2015, 2017, 2019, and 2021) when all 4 of the PSU's (19, 20, 21, and 22) were surveyed. In 2009, 2010, and 2011 not all of the 4 PSU's were surveyed.

- The two sets of estimates were then combined and weighted by the associated areas of the PSUs.

Some of our abundance and trend estimates have wide confidence intervals because we are sampling a seabird that is sparsely and patchily distributed while at sea, and because there is high variability in murrelet abundance and distribution among years. We repeat here our criteria for evaluating evidence of a trend, from our 25-year report (McIver et al. 2021):

> "To evaluate the evidence for a linear trend, we considered (1) the magnitude of the annual trend estimate, particularly in relation to zero, where zero represents a stable population; and (2) the width and location of the 95 percent confidence intervals surrounding that trend estimate, also in relation to zero. The evidence for a population trend, versus a stable population, is stronger when the trend estimate and its 95 percent confidence interval do not overlap zero, and when the trend estimate is farther from zero. When the confidence interval of a trend estimate is tight around zero, then we would conclude that there is no evidence of a trend. Finally, when the confidence interval of a trend estimate broadly overlaps zero and the trend estimate is not close to zero, this indicates evidence that is not conclusive for or against a nonzero trend. Confidence intervals that are mainly above or below zero, but slightly overlap zero, provide evidence of a trend. "

Publications providing recent detailed population and habitat monitoring results include (as part of the Effectiveness Monitoring Program's 25-year reporting): 1) for population, McIver et al. (2021) and, 2) for habitat, Lorenz et al. (2021). Three chapters comprised the 20-year murrelet report, as follows: 1) population (Falxa et al. 2016), 2) nesting habitat (Raphael et al. (2016a), and 3) an integrative chapter (Raphael et al., 2016b). In addition, Raphael et al. (2015) examined the relative influence of terrestrial and marine factors on at-sea distribution and abundance.

All reports relevant to the Marbled Murrelet Effectiveness Monitoring Program can be found at https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php.

Additional Notes on 2023 surveys

Conservation Zone 2. A team from Washington Department of Fish and Wildlife conducted these surveys. There were no significant survey issues to report for 2023. Specific details from these surveys are described in Pearson et al. (2024).

Conservation Zone 4. A team from Crescent Coastal Research conducted these surveys. As described earlier, persistent winds throughout the season in the southern four PSUs in Conservation Zone 4 (PSUs 19 through 22, near Cape Mendocino) prevented sampling of these PSUs in 2023. Specific details from these surveys are described in Strong et al. (2024).

Conservation Zones 1, 3 and 5. These zones were not surveyed in 2023. Conservation Zone 1 (Strait of Juan de Fuca, San Juan Islands and Puget Sound) and Conservation Zone 3 (Oregon Coast [Columbia River mouth to Coos Bay]) will be surveyed in 2024. Conservation Zone 5 (Mendocino [northern boundary Mendocino County to San Francisco Bay, California]) will be surveyed in 2025, in conjunction with Conservation Zone 4 (Table 1).

Reduced Effort Sampling Design and Adjustments to Analyses

Prior to implementing the reduced-effort sampling design, the program was able to generate population trend estimates annually for inference units (individual Conservation Zones, All-Zones, and states). Now, with Conservation Zones 1-4 sampled only every other year, and Conservation Zone 5 sampled every fourth year, trend analyses must account for years without population estimates.

In 2015, the population monitoring team developed the following adjustments to the trend analyses method to take into account this new population data structure. These methods are reflected in the estimates provided in the Tables and Figures.

1. At the Conservation Zone scale, at-sea abundance trend estimates are generated through the most recent year of surveys.
2. At the All-Zones and state scales, trend estimates are generated through the most recent year with either (a) population surveys and density estimates, or (b) an interpolated value, for the input density components from Conservation Zones 1 through 4. Extrapolations are not used for components from these Zones. This means that All-Zones and state-scale annual population estimates are one year "behind" (except for the California estimate; see below).
    - For example, the 2016 All-Zones estimate uses the actual 2016 density estimates for Conservation Zones 1 and 3 and interpolated 2016 values for Conservation Zones 2 and 4 (which were all surveyed in 2015 and 2017).
3. Interpolations are only used to generate zone density estimates for the last year of a trend analysis period, and only for generating All-Zones and state-scale trend estimates, as described above.
4. For California, trend estimates are generated only through the most recent year with population surveys and density estimates for Conservation Zone 4 (which provides the primary component to the California estimate). For the Conservation Zone 5 component of the California and All-Zones trend estimates, we use the density estimate from the most recent year with Conservation Zone 5 surveys. With Conservation Zone 5 scheduled to be

surveyed only every fourth year, this extrapolation of Conservation Zone 5 data allows updating of the California and All-Zones trend estimates more frequently than every fourth year. Prior to 2017, Conservation Zone 5 has typically contained few birds (see Pearson *et al*. 2018), and this extrapolation has a negligible effect on these trend and population estimates. In the "25-year report" for population trend (McIver et al. 2021) we evaluated the 2017 results from Conservation Zone 5 with respect to trend and annual rate of change in California.

ACKNOWLEDGMENTS

We thank the many team members who have conducted the at-sea population surveys over the years, often under difficult conditions. For surveys conducted in 2023, in Conservation Zone 2 we thank the excellent survey biologists Kelly Beach, Kristin Saksa, Sarah Tanedo and Jackson Winn for unwavering work ethic and resilience. In Conservation Zone 4, surveys were supervised by Craig Strong, with Darell Warnock as team lead, and the following crew members conducting surveys: Dawn Barlow, Teresa Bird, Alex Cook, Rob Fowler, Jeff Jacobsen, Deborah Jacques, and Mark Marks. Funding and other support for this work in 2023 was provided by several offices and programs of the U.S. Fish and Wildlife Service, U.S. Forest Service Pacific Northwest Research Station, U.S. Forest Service Pacific Southwest Forest Research Station, Washington Department of Fish and Wildlife and the Makah and Quileute Tribes.

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Web Site: Additional information, reports, publications, and program updates relevant to the Marbled Murrelet Effectiveness Monitoring Program (as well as links to all other modules from the Interagency Regional Monitoring Program) can be found at https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

TABLES AND FIGURES

Table 1. Survey years by conservation zone, under the reduced sampling design implemented in 2014, for years 2014-2025[1]. See text in report for description of reduced sampling design.

Conservation Zone	Survey years[2]
1 – Puget Sound (Strait of Juan de Fuca, San Juan Islands and Puget Sound)[2]	2014, 2015, 2016, 2018, 2020, 2022, 2024
2 – Western Washington Coast (Cape Flattery to Columbia River mouth)[2]	2014, 2015, 2017, 2019, 2021, 2023, 2025
3 – Oregon Coast (Columbia River mouth to Coos Bay)	2014, 2016, 2018, 2020, 2022, 2024
4 – Siskiyou Coast (Coos Bay to southern boundary of Humboldt County, California)	2015, 2017, 2019, 2021, 2023, 2025
5 – Mendocino (northern boundary Mendocino County to San Francisco Bay)	2017, 2021, 2025

Footnotes –

[1] Survey years listed only to 2025 in this table, but surveys are planned after 2025, presumably under the current reduced sampling design.

[2] Surveys were conducted in Conservation Zone 1 in 2015 and Conservation Zone 2 in 2014 due to availability of funds.

Table 2. Summary of 2001-2022 marbled murrelet density and abundance estimates (rounded to nearest 100 birds) for all Conservation Zones combined. Note that the most recent range-wide estimate is always one year behind the current sampling year because it takes two years to derive estimates when sampling units every other year. See figures 2 and 3 (p. 22-23).

Year	Density (birds/km^2)	Bootstrap Standard Error (birds/km^2)	Coefficient of Variation of Density (%)	Birds	Birds Lower 95% CL	Birds Upper 95% CL
2001*	2.53	0.25	9.9	22,300	18,000	26,700
2002*	2.58	0.30	11.8	22,700	17,400	27,900
2003*	2.53	0.23	9.1	22,200	18,300	26,200
2004	2.46	0.26	10.5	21,600	17,100	26,000
2005	2.30	0.25	10.7	20,200	16,000	24,400
2006	2.09	0.17	8.2	18,300	15,400	21,300
2007	1.97	0.27	13.7	17,300	12,700	22,000
2008	2.06	0.18	8.9	18,100	15,000	21,300
2009	1.96	0.21	10.6	17,200	13,700	20,800
2010	1.89	0.21	11.1	16,600	13,000	20,200
2011	2.50	0.31	12.6	22,000	16,600	27,400
2012	2.40	0.27	11.3	21,100	16,400	25,800
2013	2.24	0.25	11.1	19,600	15,400	23,900
2014*	2.42	0.22	9.2	21,300	17,500	25,100
2015	2.75	0.26	9.5	24,100	19,700	28,600
2016	2.58	0.26	10.0	22,600	18,200	27,100
2017	2.62	0.26	10.0	23,000	18,500	27,600
2018	2.56	0.29	11.4	22,500	17,500	27,600
2019	2.42	0.28	11.5	21,200	16,400	26,000
2020	2.24	0.24	10.9	19,700	15,500	23,900
2021	2.05	0.23	11.3	18,000	14,000	21,900
2022	2.19	0.24	11.1	19,000	14,900	23,200

[1] Numbers in some years may differ slightly from those in previous summary reports (as indicated by an asterisk (*), as a result of additional data quality reviews performed in 2019 (see McIver *et al*. 2019 [2018 Annual Summary Report]).

Table 3. Marbled murrelet population estimates for Conservation Zones and sampling strata within Zones, 2000-2023, with parameter values (right 3 columns) used in the Distance Sampling method used to estimate population size. Based on at-sea surveys. The Zone 5 and "All Zone" estimates use interpolated values in years when Zone 5 was not surveyed. Numbers in some years may differ slightly from those in previous summary reports, as a result of additional data quality reviews performed in 2019 (see McIver *et al.* 2019 [2018 Annual Summary Report]). See text for details on use of interpolated or extrapolated values for estimates[1].

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2000	3	All	4.129	18.6	6,587	3,987	8,756	1,595	0.0165	1.623	100
2000	3	1	1.336	32.2	883	357	1,350	661			
2000	3	2	6.104	19.6	5,704	3,296	7,608	935			
2000	4	All	4.216	30.9	4,887	3,417	9,398	1,159	0.0097	1.730	180
2000	4	1	6.024	34.0	4,420	2,931	8,784	734			
2000	4	2	1.097	32.1	467	297	881	425			
2000	5	All	0.090	80.6	79	0	260	883			
2000	5	1	0.179	80.6	79	0	260	441			
2000	5	2	0.000	0.00	0	0	0	441			
2001	All	All	2.531	9.9	22,339	17,986	26,693	8,826			
2001	1	All	2.553	18.0	8,936	5,740	11,896	3501	0.0133	1.594	142
2001	1	1	4.506	23.1	3,809	2,432	5,689	845			
2001	1	2	1.764	21.4	2,111	948	2,816	1196			
2001	1	3	2.067	37.2	3,016	404	5,003	1459			
2001	2	All	0.899	41.9	1,518	524	2,942	1688	0.0125	1.444	80
2001	2	1	1.430	55.7	1,040	91	2,364	727			
2001	2	2	0.497	72.5	478	106	1,317	961			
2001	3	All	4.636	13.2	7,396	5,230	9,075	1595	0.0166	1.735	140
2001	3	1	1.724	23.0	1,140	657	1,700	661			
2001	3	2	6.695	14.1	6,257	4,241	7,814	935			
2001	4	All	3.284	24.0	3,807	2,983	6,425	1159	0.0101	1.749	170
2001	4	1	4.567	27.2	3,351	2,436	5,880	734			
2001	4	2	1.072	30.1	456	313	854	425			
2001	5	All	0.121	52.5	106	27	244	883			
2001	5	1	0.198	39.1	87	0	138	441			
2001	5	2	0.043	231.6	19	0	129	441			
2002	All	All	2.581	11.8	22,683	17,440	27,926	8,788			
2002	1	All	2.788	21.5	9,758	5,954	14,149	3,501	0.0103	1.761	194
2002	1	1	7.207	32.8	6,092	2,716	9,782	845			
2002	1	2	1.879	26.9	2,248	909	3,309	1,196			
2002	1	3	0.972	34.7	1,419	580	2,515	1,459			
2002	2	All	1.329	29.2	2,031	800	3,132	1,650	0.0195	1.400	70
2002	2	1	2.660	32.1	1,774	559	2,840	724			
2002	2	2	0.288	41.2	258	0	417	926			
2002	3	All	3.583	24.1	5,716	3,674	9,563	1,595	0.0118	1.892	150
2002	3	1	0.696	34.1	460	258	886	661			
2002	3	2	5.624	24.7	5,256	3,301	8,732	935			
2002	4	All	4.112	15.1	4,766	3,272	6,106	1,159	0.0108	1.724	175
2002	4	1	5.186	15.9	3,805	2,501	4,892	734			
2002	4	2	2.260	33.1	961	437	1,665	425			
2002	5	All	0.282	42.3	249	27	400	883			
2002	5	1	0.510	46.1	225	8	371	441			
2002	5	2	0.054	71.1	24	0	54	441			

Table 3. (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2003	All	All	2.531	9.1	22,234	18,275	26,194	8,786			
2003	1	All	2.428	16.6	8,495	5,795	11,211	3,498	0.0087	1.817	300
2003	1	1	6.644	22.1	5,617	3,372	7,795	845			
2003	1	2	1.441	32.9	1,721	911	2,794	1,195			
2003	1	3	0.793	32.8	1,156	252	1,912	1,458			
2003	2	All	2.407	28.8	3,972	2,384	6,589	1,650	0.0171	1.399	80
2003	2	1	2.639	26.0	1,912	1,132	3,048	724			
2003	2	2	2.225	48.4	2,061	1,019	4,229	926			
2003	3	All	3.686	16.1	5,881	3,992	7,542	1,595	0.0132	1.664	130
2003	3	1	1.192	23.8	788	499	1,212	661			
2003	3	2	5.450	17.8	5,093	3,244	6,680	935			
2003	4	All	3.806	17.3	4,412	3,488	6,495	1,159	0.0086	1.704	180
2003	4	1	4.960	19.7	3,640	2,622	5,392	734			
2003	4	2	1.816	27.2	773	557	1,424	425			
2003	5	All	0.055	61.1	48	0	85	883			
2003	5	1	0.109	61.1	48	0	85	441			
2003	5	2	0.000	0.0	0	0	0	441			
2004	All	All	2.455	10.5	21,572	17,144	26,000	8,786			
2004	1	All	1.562	22.0	5,465	2,921	7,527	3,498	0.0108	1.789	280
2004	1	1	3.833	30.0	3,241	1,365	4,845	845			
2004	1	2	1.513	25.4	1,807	1,042	2,777	1,195			
2004	1	3	0.286	60.0	417	0	727	1,458			
2004	2	All	1.823	27.0	3,009	1,669	4,634	1,650	0.0115	1.411	115
2004	2	1	3.373	33.4	2,444	1,217	4,093	724			
2004	2	2	0.611	25.0	565	314	841	926			
2004	3	All	5.051	13.7	8,058	5,369	9,819	1,595	0.0141	1.697	110
2004	3	1	1.721	20.7	1,137	707	1,732	661			
2004	3	2	7.405	15.1	6,921	4,278	8,564	935			
2004	4	All	4.272	26.9	4,952	3,791	9,021	1,159	0.0093	1.700	200
2004	4	1	5.331	32.2	3,911	2,729	7,732	734			
2004	4	2	2.447	43.5	1,041	608	2,421	425			
2004	5	All	0.099	60.5	88	18	214	883			
2004	5	1	0.091	64.5	40	0	104	441			
2004	5	2	0.107	93.6	47	0	137	441			
2005	All	All	2.300	10.7	20,209	15,976	24,442	8,785			
2005	1	All	2.275	20.5	7,956	4,900	11,288	3,497	0.0156	1.758	150
2005	1	1	2.501	37.7	2,114	698	3,661	845			
2005	1	2	2.426	25.4	2,895	1,186	4,210	1,194			
2005	1	3	2.021	30.1	2,947	1,198	5,019	1,458			
2005	2	All	1.561	20.4	2,576	1,675	3,729	1,650	0.0136	1.418	130
2005	2	1	2.785	19.1	2,018	1,233	2,764	724			
2005	2	2	0.603	56.7	558	166	1,461	926			
2005	3	All	3.669	16.9	5,854	3,580	7,447	1,595	0.0127	1.841	150
2005	3	1	0.808	32.2	534	269	962	661			
2005	3	2	5.693	17.8	5,320	3,156	6,760	935			
2005	4	All	3.169	23.6	3,673	2,740	6,095	1,159	0.0108	1.518	170
2005	4	1	4.487	25.5	3,292	2,329	5,562	734			

Table 3 (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2005	4	2	0.895	42.1	381	243	901	425			
2005	5	All	0.169	31.8	149	69	251	883			
2005	5	1	0.141	48.1	62	8	121	441			
2005	5	2	0.197	39.7	87	36	156	441			
2006	All	All	2.087	8.2	18,335	15,395	21,275	8,785			
2006	1	All	1.687	18.1	5,899	4,211	8,242	3,497	0.0138	1.765	139
2006	1	1	2.760	16.3	2,333	1,628	3,182	845			
2006	1	2	1.418	24.9	1,693	777	2,551	1,194			
2006	1	3	1.284	40.4	1,873	595	3,440	1,458			
2006	2	All	1.443	18.0	2,381	1,702	3,433	1,650	0.0130	1.567	107
2006	2	1	2.261	19.9	1,638	1,038	2,372	724			
2006	2	2	0.802	34.0	743	380	1,344	926			
2006	3	All	3.731	12.7	5,953	4,546	7,617	1,595	0.0114	1.814	145
2006	3	1	1.034	29.6	684	352	1,070	661			
2006	3	2	5.638	14.1	5,269	3,886	6,827	935			
2006	4	All	3.410	14.9	3,953	3,164	5,525	1,159	0.0106	1.622	150
2006	4	1	4.821	15.5	3,538	2,698	4,894	734			
2006	4	2	0.977	47.8	416	209	981	425			
2006	5	*Not surveyed.*									
2007	All	All	1.971	13.7	17,317	12,654	21,980	8,785			
2007	1	All	1.997	24.2	6,985	4,148	10,639	3,497	0.0117	1.642	378
2007	1	1	3.445	27.6	2,912	1,025	4,392	845			
2007	1	2	1.218	21.9	1,453	708	1,993	1,194			
2007	1	3	1.796	51.3	2,620	206	5,629	1,458			
2007	2	All	1.536	26.7	2,535	1,318	3,867	1,650	0.0135	1.496	126
2007	2	1	2.851	32.0	2,065	964	3,336	724			
2007	2	2	0.508	25.5	470	234	666	926			
2007	3	All	2.518	19.8	4,018	2,730	5,782	1,595	0.0106	1.653	150
2007	3	1	0.526	58.5	348	26	744	661			
2007	3	2	3.927	20.4	3,670	2,525	5,378	935			
2007	4	All	3.234	34.8	3,749	2,659	7,400	1,159	0.0106	1.607	180
2007	4	1	4.730	37.5	3,470	2,329	7,025	734			
2007	4	2	0.655	36.9	279	146	549	425			
2007	5	All	0.033	37.7	30	0	49	883			
2007	5	1	0.067	37.7	30	0	49	441			
2007	5	2	0.000	0.0	0	0	0	441			
2008	All	All	2.064	8.9	18,134	14,983	21,284	8,785			
2008	1	All	1.344	17.6	4,699	3,000	6,314	3,497	0.0109	1.739	206
2008	1	1	3.572	25.1	3,019	1,439	4,472	845			
2008	1	2	0.899	27.6	1,073	580	1,640	1,194			
2008	1	3	0.416	30.8	607	288	970	1,458			
2008	2	All	1.169	22.1	1,929	1,164	2,868	1,650	0.0112	1.535	187
2008	2	1	2.584	22.4	1,872	1,132	2,801	724			
2008	2	2	0.062	49.1	57	0	116	926			
2008	3	All	3.857	14.7	6,153	4,485	8,066	1,595	0.0113	1.750	130
2008	3	1	0.337	28.4	223	107	353	661			
2008	3	2	6.345	15.3	5,930	4,233	7,816	935			
2008	4	All	4.560	17.9	5,285	3,809	7,503	1,159	0.0100	1.705	200
2008	4	1	6.386	19.5	4,685	3,167	6,687	734			
2008	4	2	1.410	39.0	600	302	1,195	425			
2008	5	All	0.076	48.1	67	9	132	883			

Table 3 (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2008	5	1	0.065	60.1	29	0	81	441			
2008	5	2	0.087	70.3	38	0	68	441			
2009	All	All	1.962	10.6	17,237	13,647	20,827	8,785			
2009	1	All	1.608	21.2	5,623	3,786	8,497	3,497	0.0094	1.694	254
2009	1	1	3.811	27.7	3,221	1,777	5,107	845			
2009	1	2	0.689	26.3	822	489	1,302	1,194			
2009	1	3	1.083	42.9	1,580	410	3,299	1,458			
2009	2	All	0.765	21.9	1,263	776	1,874	1,650	0.0092	1.475	191
2009	2	1	1.609	23.3	1,166	693	1,766	724			
2009	2	2	0.105	61.0	97	0	209	926			
2009	3	All	3.696	17.7	5,896	3,898	7,794	1,595	0.0131	1.696	120
2009	3	1	0.650	42.5	430	187	893	661			
2009	3	2	5.849	19.0	5,467	3,339	7,250	935			
2009	4	All	3.786	19.9	4,388	3,599	6,952	1,159	0.0100	1.661	150
2009	4	1	5.304	20.9	3,892	3,031	6,170	734			
2009	4	2	1.167	67.3	497	244	1,390	425			
2009	5	*Not surveyed.*									
2010	All	All	1.889	11.1	16,595	12,969	20,220	8,785			
2010	1	All	1.256	20.0	4,393	2,719	6,207	3,497	0.0100	1.717	200
2010	1	1	2.004	26.8	1,694	957	2,712	845			
2010	1	2	1.783	23.6	2,128	1,021	3,052	1,194			
2010	1	3	0.391	43.1	571	62	1,142	1,458			
2010	2	All	0.779	25.5	1,286	688	1,961	1,650	0.0114	1.582	145
2010	2	1	1.336	23.8	968	552	1,439	724			
2010	2	2	0.343	71.9	318	0	784	926			
2010	3	All	4.503	16.7	7,184	4,453	9,425	1,595	0.0138	1.770	160
2010	3	1	1.071	50.1	708	239	1,354	661			
2010	3	2	6.930	17.7	6,476	3,691	8,468	935			
2010	4	All	3.162	28.5	3,665	2,248	6,309	1,159	0.0120	1.624	165
2010	4	1	3.774	34.3	2,769	1,463	5,087	734			
2010	4	2	2.106	36.3	896	431	1,700	425			
2010	5	*Not surveyed.*									
2011	All	All	2.501	12.6	21,972	16,566	27,378	8,785			
2011	1	All	2.055	17.4	7,187	4,807	9,595	3,497	0.0089	1.666	289
2011	1	1	5.580	20.3	4,717	2,621	6,399	845			
2011	1	2	1.243	23.7	1,484	790	2,147	1,194			
2011	1	3	0.676	65.8	986	206	2,384	1,458			
2011	2	All	0.721	33.4	1,189	571	2,106	1,650	0.0110	1.496	161
2011	2	1	1.314	30.8	952	400	1,572	724			
2011	2	2	0.256	102.0	237	38	772	926			
2011	3	All	4.661	16.3	7,436	5,067	9,746	1,595	0.0126	1.678	120
2011	3	1	0.980	38.6	648	343	1,455	661			
2011	3	2	7.264	17.4	6,788	4,304	9,054	935			
2011	4	All	5.196	34.9	6,023	2,782	10,263	1,159	0.0122	1.644	145
2011	4	1	6.724	42.2	4,933	1,643	8,767	734			
2011	4	2	2.561	47.3	1,090	592	2,472	425			
2011	5	All	0.155	53.0	137	16	295	883			
2011	5	1	0.243	64.8	107	5	259	441			
2011	5	2	0.068	78.8	30	0	66	441			
2012	All	All	2.400	11.3	21,086	16,401	25,770	8,785			
2012	1	All	2.414	20.7	8,442	5,090	12,006	3,497	0.0109	1.847	164

Table 3 (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2012	1	1	7.166	24.4	6,056	3,289	8,823	845			
2012	1	2	1.507	30.4	1,799	812	2,892	1,194			
2012	1	3	0.402	48.1	587	168	1,227	1,458			
2012	2	All	0.719	33.5	1,186	564	2,360	1,650	0.0131	1.485	106
2012	2	1	1.178	29.2	853	325	1,289	724			
2012	2	2	0.360	89.9	333	0	1,459	926			
2012	3	All	3.986	15.5	6,359	4,136	8,058	1,595	0.0112	1.765	186
2012	3	1	0.895	34.9	591	227	1,042	661			
2012	3	2	6.172	15.9	5,768	3,775	7,330	935			
2012	4	All	4.279	24.9	4,960	3,414	8,011	1,159	0.0107	1.652	140
2012	4	1	6.050	27.6	4,439	2,916	7,497	734			
2012	4	2	1.225	39.6	521	166	940	425			
2012	5	*Not surveyed.*									
2013	All	All	2.238	11.1	19,662	15,398	23,927	8,785			
2013	1	All	1.257	27.9	4,395	2,298	6,954	3,497	0.0109	1.695	137
2013	1	1	2.379	31.4	2,010	861	3,253	845			
2013	1	2	0.657	20.1	784	508	1,124	1,194			
2013	1	3	1.097	64.4	1,600	381	3,717	1,458			
2013	2	All	0.770	18.5	1,271	950	1,858	1,650	0.0117	1.569	132
2013	2	1	1.605	19.0	1,163	854	1,722	724			
2013	2	2	0.117	59.3	108	0	274	926			
2013	3	All	4.939	16.3	7,880	5,450	10,361	1,595	0.0112	1.637	160
2013	3	1	0.991	43.8	655	151	1,226	661			
2013	3	2	7.731	17.8	7,225	4,707	9,667	935			
2013	4	All	5.216	20.5	6,046	4,531	9,282	1,159	0.0128	1.607	146
2013	4	1	7.384	21.8	5,418	3,939	8,516	734			
2013	4	2	1.477	36.7	629	279	1,184	425			
2013	5	All	0.080	45.4	71	5	118	883			
2013	5	1	0.160	45.4	71	5	118	441			
2013	5	2	0.000	0.0	0	0	0	441			
2014	All	All	2.425	9.1	21,305	17,492	25,117	8,785			
2014	1	All	0.807	19.3	2,822	1,668	3,836	3,497	0.0102	1.664	172
2014	1	1	1.258	26.7	1,063	580	1,631	845			
2014	1	2	1.274	26.4	1,521	570	2,176	1,194			
2014	1	3	0.163	69.6	238	0	533	1,458			
2014	2	All	1.318	30.7	2,176	1,038	3,574	1,650	0.0131	1.508	122
2014	2	1	2.879	31.5	2,086	925	3,466	724			
2014	2	2	0.098	65.6	90	0	214	926			
2014	3	All	5.541	12.4	8,841	6,819	11,276	1,595	0.0108	1.720	140
2014	3	1	1.477	34.1	976	286	1,587	661			
2014	3	2	8.415	13.1	7,864	6,156	10,240	935			
2014	4	*Not surveyed.*									
2014	5	*Not surveyed.*									
2015	All	All	2.747	9.5	24,134	19,658	28,610	8,785			
2015	1	All	1.227	24.1	4,290	2,640	6,565	3,497	0.0111	1.786	191
2015	1	1	2.218	35.8	1,875	829	3,383	845			
2015	1	2	1.945	29.9	2,321	1,148	3,863	1,194			
2015	1	3	0.064	92.6	94	0	267	1,458			
2015	2	All	1.941	30.4	3,204	1,883	5,609	1,650	0.0093	1.866	175
2015	2	1	2.849	27.9	2,064	1,176	3,316	724			
2015	2	2	1.231	71.2	1,140	144	3,290	926			

Table 3 (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2015	3	*Not surveyed.*									
2015	4	All	7.542	16.8	8,743	7,409	13,125	1,159	0.0118	1.701	159
2015	4	1	9.897	17.3	7,262	5,906	10,692	734			
2015	4	2	3.480	48.9	1,481	859	3,713	425			
2015	5	*Not surveyed.*									
2016	All	All	2.575	10.0	22,624	18,173	27,075	8,785			
2016	1	All	1.319	30.0	4,614	2,298	7,571	3,497	0.0112	1.675	224
2016	1	1	2.693	36.6	2,276	969	4,062	845			
2016	1	2	1.655	51.7	1,975	617	4,075	1,194			
2016	1	3	0.249	37.7	362	106	621	1,458			
2016	2	*Not surveyed.*									
2016	3	All	4.271	13.8	6,813	5,389	8,821	1,595	0.0116	1.661	130
2016	3	1	0.862	27.9	570	346	944	661			
2016	3	2	6.681	14.8	6,244	4,760	8,195	935			
2016	4	*Not surveyed.*									
2016	5	*Not surveyed.*									
2017	All	All	2.620	10.1	23,019	18,477	27,561	8,785			
2017	1	*Not surveyed.*									
2017	2	All	1.065	23.2	1,758	1,041	2,623	1,650	0.0097	1.648	154
2017	2	1	2.127	25.8	1,541	820	2,353	724			
2017	2	2	0.235	36.5	218	56	363	926			
2017	3	*Not surveyed.*									
2017	4	All	7.373	14.9	8,546	6,277	11,331	1,159	0.0118	1.660	170
2017	4	1	9.185	15.7	6,740	4,677	8,890	734			
2017	4	2	4.248	11.7	1,807	813	3,223	425			
2017	5	All	0.988	39.0	872	467	1,698	883			
2017	5	1	0.768	188.0	339	63	736	441			
2017	5	2	1.207	48.8	533	321	1,208	441			
2018	All	All	2.564	11.4	22,521	17,482	27,559	8,785			
2018	1	All	1.099	34.6	3,843	1,937	6,901	3,497	0.0080	1.744	242
2018	1	1	1.402	44.8	1,185	339	2,367	845			
2018	1	2	1.034	29.6	1,234	543	1,947	1,194			
2018	1	3	0.977	87.4	1,425	0	4,246	1,458			
2018	2	*Not surveyed.*									
2018	3	All	5.274	18.6	8,414	6,026	12,033	1,595	0.0123	1.640	120
2018	3	1	1.026	43.0	678	286	1,408	661			
2018	3	2	8.277	19.9	7,736	5,258	11,164	935			
2018	4	*Not surveyed.*									
2018	5	*Not surveyed.*									
2019	All	All	2.417	11.5	21,230	16,446	26,015	8,875			
2019	1	*Not surveyed.*									
2019	2	All	1.004	30.7	1,657	745	2,752	1,650	0.0078	1.817	179
2019	2	1	2.276	30.8	1,649	738	2,741	724			
2019	2	2	0.009	102.2	9	0	28	926			
2019	3	*Not surveyed.*									
2019	4	All	5.885	21.9	6,822	5,576	11,063	1,159	0.0115	1.696	118
2019	4	1	8.091	22.8	5,936	4,588	9,921	734			
2019	4	2	2.081	47.1	885	481	2,076	425			
2019	5	*Not surveyed.*									
2020	All	All	2.24	10.9	19,685	15,493	23,877	8,785			
2020	1	All	0.899	21.1	3,143	2,030	4,585	3,497	0.0067	1.656	226

Table 3 (continued)

Year	Zone	Stratum	Density	CV (%)	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	*E(s)*	Truncation Distance (m)
2020	1	1	1.831	30.8	1,548	803	2,269	845			
2020	1	2	0.825	29.6	985	296	1,420	1,194			
2020	1	3	0.419	37.4	611	39	1,060	1,458			
2020	2	*Not surveyed.*									
2020	3	All	5.239	17.5	8,359	5,560	11,323	1,595	0.0131	1.692	140
2020	3	1	0.701	27.8	464	233	731	660			
2020	3	2	8.449	18.2	7,896	5,243	10,881	935			
2020	4	*Not surveyed.*									
2020	5	*Not surveyed.*									
2021	All	All	2.045	11.3	17,966	13,982	21,949	8,875			
2021	1	*Not surveyed.*									
2021	2	All	0.617	21.5	1,018	564	1,428	1,650	0.0006	1.790	144
2021	2	1	1.332	29.8	965	512	1,352	724			
2021	2	2	0.057	48.1	53	0	102	926			
2021	3	*Not surveyed.*									
2021	4	All	4.427	22.5	5,132	3,739	8,243	1,159	0.0112	1.652	146
2021	4	1	6.099	23.9	4,476	3,147	7,267	734			
2021	4	2	1.543	0.94	657	90	1,521	425			
2021	5	All	0.473	59.6	42	0	79	883			
2021	5	1	0.021	40.0	9	0	17				
2021	5	2	0.073	74.7	32	0	69				
2022	All	All	2.193	11.1	19,033	14,877	23,190	8,680			
2022	1	All	1.086	14.0	3,797	2,781	4,829	3,497	0.0067	1.871	211
2022	1	1	3.552	16.3	3,002	2,066	3,948	845			
2022	1	2	0.543	21.6	648	355	916	1,194			
2022	1	3	0.101	53.3	147	21	313	1,458			
2022	2	*Not surveyed.*									
2022	3	All	5.170	19.8	8,249	5,405	11,901	1,595	0.0119	1.879	100
2022	3	1	1.073	30.7	709	301	1,172	661			
2022	3	2	8.068	21.3	7,540	4,796	11,132	935			
2022	4	*Not surveyed.*									
2022	5	*Not surveyed.*									
2023	All	All	*2023 All-Zones estimate will be available in 2024 Summary Report.*								
2023	1	*Not surveyed.*									
2023	2	All	0.659	17.9	1,088	651	1,401	1,650	0.0087	1.769	155
2023	2	1	1.142	18.5	1,027	594	1,320	724			
2023	2	2	0.065	52.5	60	0	127	926			
2023	3	*Not surveyed.*									
2023	4	All	6.752	19.6	6,411	4,472	9,367	949	0.0111	1.675	118
2023	4	1	7.871	21.8	5,775	3,890	8,751	734			
2023	4	2	2.947	21.4	636	348	875	216			
2023	5	*Not surveyed.*									

[1] Due to persistent winds throughout the survey season in 2023, the southern four PSUs in Conservation Zone 4, Stratum 2 (PSUs 19 through 22, near Cape Mendocino) were not sampled in 2023. So, for Conservation Zone 4, Stratum 2, estimates of density and numbers of marbled murrelets were used, as described on p. 4-5 of this report.

Table 4. Summary of 2000 to 2023[1] marbled murrelet density and abundance estimates at the State scale. Numbers in some years may differ slightly from those in previous summary reports, as a result of additional data quality reviews performed in 2019 (see McIver et al. 2019). These data are represented in Figure 3 (see p. 23).

Year	State	Density (murrelets per km2)	Murrelets	Murrelets 95% CL Lower	Murrelets 95% CL Upper	Area (km2)
2001	WA	2.13	11,030	7,554	14,505	5,188
2002	WA	2.32	11,951	7,687	16,216	5,151
2003	WA	2.31	11,894	8,729	15,058	5,149
2004	WA	1.65	8,474	5,625	11,322	5,149
2005	WA	2.05	10,533	7,179	13,887	5,148
2006	WA	1.61	8,280	6,024	10,536	5,148
2007	WA	1.85	9,520	5,946	13,095	5,148
2008	WA	1.29	6,628	4,808	8,448	5,148
2009	WA	1.34	6,894	4,495	9,294	5,148
2010	WA	1.10	5,679	3,840	7,518	5,148
2011	WA	1.63	8,376	5,802	10,950	5,148
2012	WA	1.87	9,629	6,116	13,142	5,148
2013	WA	1.10	5,646	3,195	8,097	5,148
2014	WA	0.97	4,977	3,248	6,706	5,148
2015	WA	1.46	7,494	4,711	10,276	5,148
2016	WA	1.38	7,095	4,060	10,130	5,148
2017	WA	1.16	5,984	3,204	8,764	5,148
2018	WA	1.08	5,545	2,785	8,305	5,148
2019	WA	1.00	5,148	2,953	7,343	5,148
2020	WA	0.87	4,481	2,997	5,965	5,148
2021	WA	0.87	4,488	3,240	5,736	5,148
2022	WA	0.94	4,850	3,732	5,968	5,148
2000	OR	3.85	7,983	4,992	10,974	2,071
2001	OR	4.43	9,168	6,537	11,800	2,071
2002	OR	3.64	7,530	4,727	10,332	2,071
2003	OR	3.56	7,380	5,370	9,390	2,075
2004	OR	4.40	9,112	6,833	11,391	2,071
2005	OR	3.36	6,966	4,812	9,121	2,071
2006	OR	3.68	7,617	5,916	9,318	2,071
2007	OR	2.59	5,357	3,332	7,381	2,071
2008	OR	3.64	7,541	5,682	9,400	2,071
2009	OR	3.58	7,423	5,208	9,638	2,071
2010	OR	3.95	8,182	5,743	10,622	2,071
2011	OR	4.05	8,379	5,943	10,816	2,071
2012	OR	3.76	7,780	5,605	9,956	2,071
2013	OR	4.74	9,819	7,195	12,443	2,071
2014	OR	5.50	11,384	8,839	13,930	2,071
2015	OR	5.30	10,975	8,188	13,762	2,071
2016	OR	4.85	10,053	7,527	12,580	2,071
2017	OR	5.28	10,945	8,018	13,872	2,071

Table 4. (continued)

Year	State	Density (murrelets per km2)	Murrelets	Murrelets 95% CL Lower	Murrelets 95% CL Upper	Area (km2)
2018	OR	5.36	12,281	8,516	16,045	2,071
2019	OR	4.84	12,149	8,271	16,027	2,071
2020	OR	4.69	10,742	7,565	13,919	2,071
2021	OR	4.64	9,607	6,511	12,704	2,071
2022	OR	4.64	9,603	6,339	12,868	2,071
2000	CA	2.28	3,571	1,884	5,258	1,566
2001	CA	1.31	2,051	608	3,495	1,566
2002	CA	2.04	3,202	2,181	4,224	1,566
2003	CA	1.90	2,985	1,753	4,217	1,567
2004	CA	2.55	3,986	2,197	5,775	1,566
2005	CA	1.73	2,710	1,896	3,523	1,566
2006	CA	1.56	2,438	1,727	3,149	1,566
2007	CA	1.56	2,440	1,465	3,415	1,566
2008	CA	2.53	3,964	2,802	5,126	1,566
2009	CA	1.87	2,928	1,589	4,268	1,566
2010	CA	1.69	2,644	1,098	4,191	1,566
2011	CA	3.33	5,217	1,962	8,472	1,566
2012	CA	2.24	3,514	1,812	5,216	1,566
2013	CA	2.67	4,178	2,662	5,694	1,566
2014	CA	3.14	4,922	3,410	6,433	1,566
2015	CA	3.62	5,666	3,970	7,361	1,566
2016	CA	3.51	5,489	3,995	6,984	1,566
2017	CA	3.90	6,111	4,473	7,749	1,566
2018	CA	3.78	5,924	4,189	7,659	1,566
2019	CA	3.66	5,738	3,887	7,588	1,566
2020	CA	3.33	5,217	3,669	6,765	1,566
2021	CA	2.47	3,870	2,727	5,014	1,566
2022	CA	3.10	4,532	3,179	5,885	1,461
2023	CA	3.72	5,047	3,492	6,602	1,356

[1] Periods of analysis: 2001-2022 for Washington, 2000-2022 for Oregon and 2000-2023 for California.

Table 5. Estimates of average annual rate of marbled murrelet population change based on at-sea abundance surveys, by Conservation Zone (Zone, All Zones) and State, based on updated population estimates reported in Tables 2 and 3. Confidence limits are for the estimates of percent annual change. The *P*-value is based on a 2-tailed test for whether the annual rate of change differs from zero, and significant values (*P*-value ≤ 0.05) are shaded in gray. For guidance on interpretation of rates of change and confidence intervals, please refer to McIver et al. (2021), and the excerpt from that report in the summary text above. Numbers in some years may differ slightly from those in previous summary reports, as a result of additional data quality reviews performed in 2019 (see McIver *et al.* 2019). Please note that periods of analysis vary by sampling unit, depending on years sampling units were first and last surveyed. These data are represented in Figures 2 and 3 (see pp. 22-23).

Zone or State	Period of Analysis	Annual Rate of Change (%)	95% Conf. Limits		Adjusted R^2	*P*-value
			Lower	Upper		
Zone 1[1]	2001-2022	-4.6	-6.4	-2.7	0.585	<0.001
Zone 2[2]	2001-2023	-3.5	-5.8	-1.0	0.305	0.008
Zone 3[1]	2000-2022	1.6	0.3	2.9	0.228	0.022
Zone 4[2]	2000-2023	2.8	1.3	4.4	0.446	0.001
Zone 5[3]	2000-2021	1.5	−7.7	11.7	0.000	0.726
WA	2001-2022	-4.1	-5.2	-3.0	0.729	<0.001
OR	2000-2022	1.7	0.8	2.7	0.366	0.001
CA	2000-2023	3.6	2.2	5.1	0.544	<0.001
All Zones	2001-2022	0.0	−0.8	0.8	0.000	0.987

[1] Last surveyed in 2022
[2] Last surveyed in 2023
[3] Last surveyed in 2021

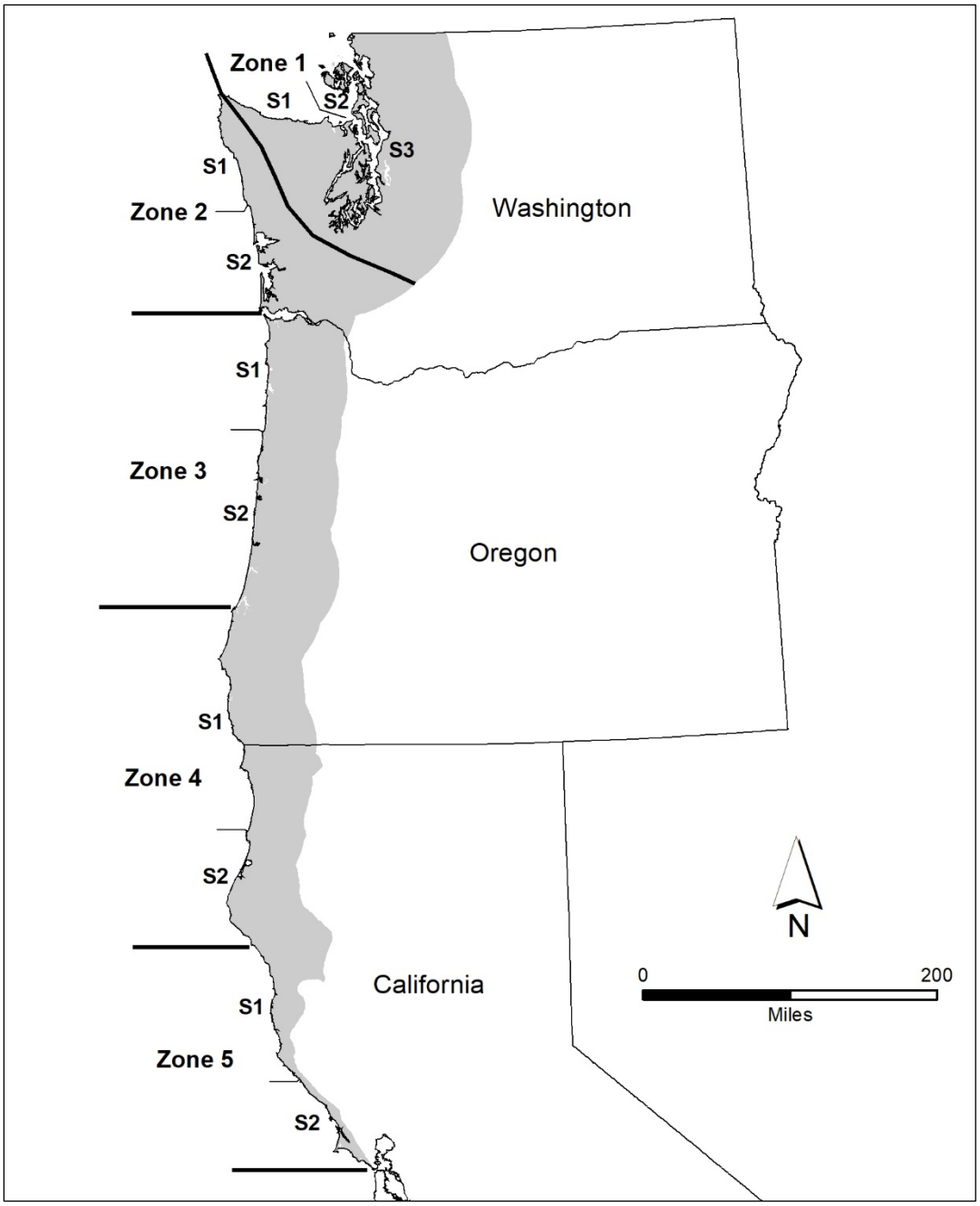

Figure 1. The five at-sea marbled murrelet Conservation Zones (in figure, Zone) and strata (in figure, S1, S2, or S3) within each conservation zone adjacent to the Northwest Forest Plan area. Approximate inland breeding distribution is shaded (adapted from U.S. Fish and Wildlife Service 1997).

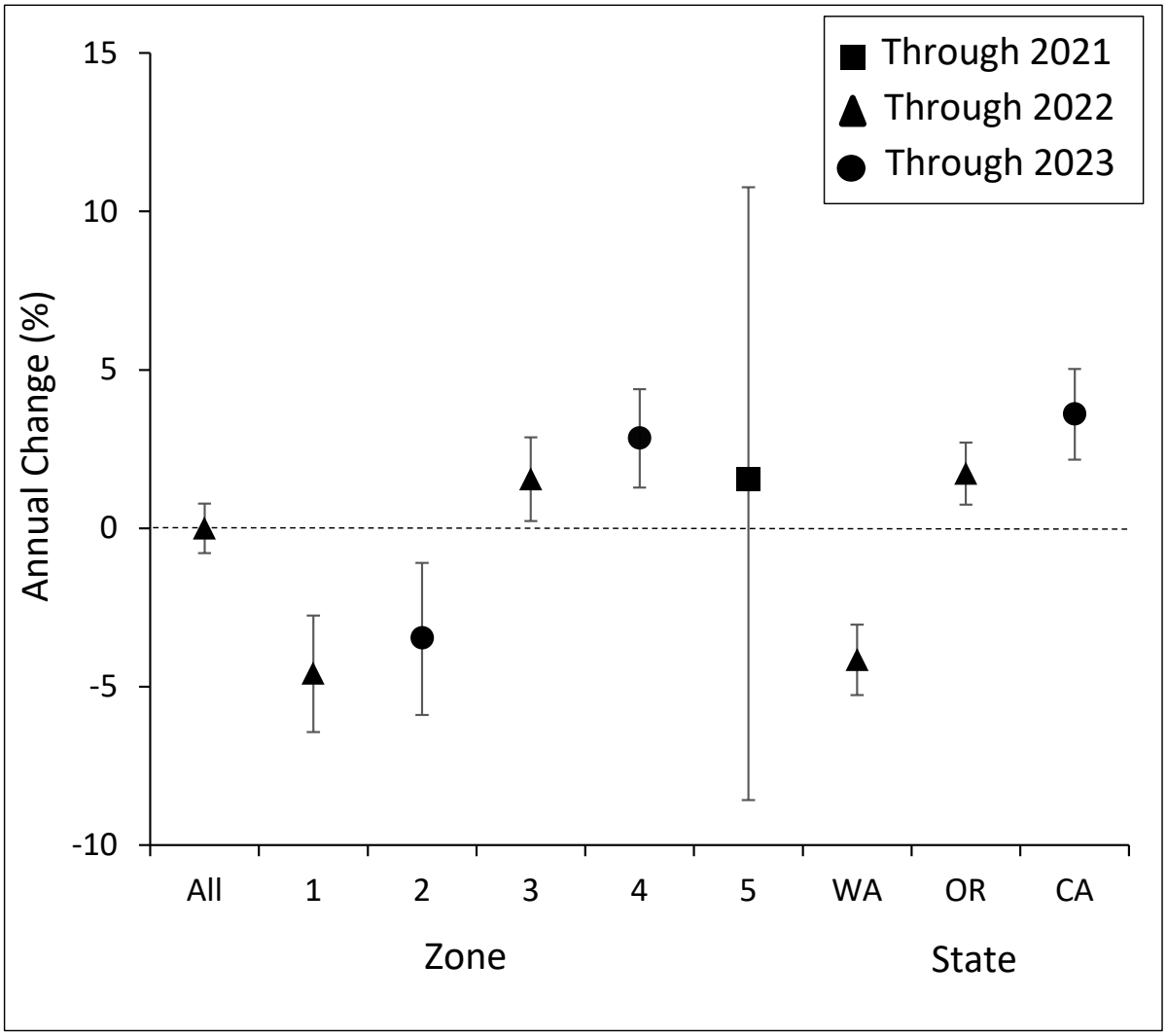

Figure 2. Percent annual change (95% Confidence interval) by Conservation Zone, "All"-Zones combined and by State. Trends are through 2021 for the square, through 2022 for the triangles and through 2023 for the circles. If the confidence intervals do not overlap zero (see dotted line), then there is support for either a positive (e.g., Zone 4) or a negative (e.g., Zone 1) trend. Statistics and periods of analysis for these results are provided in Table 5 (see p. 20).

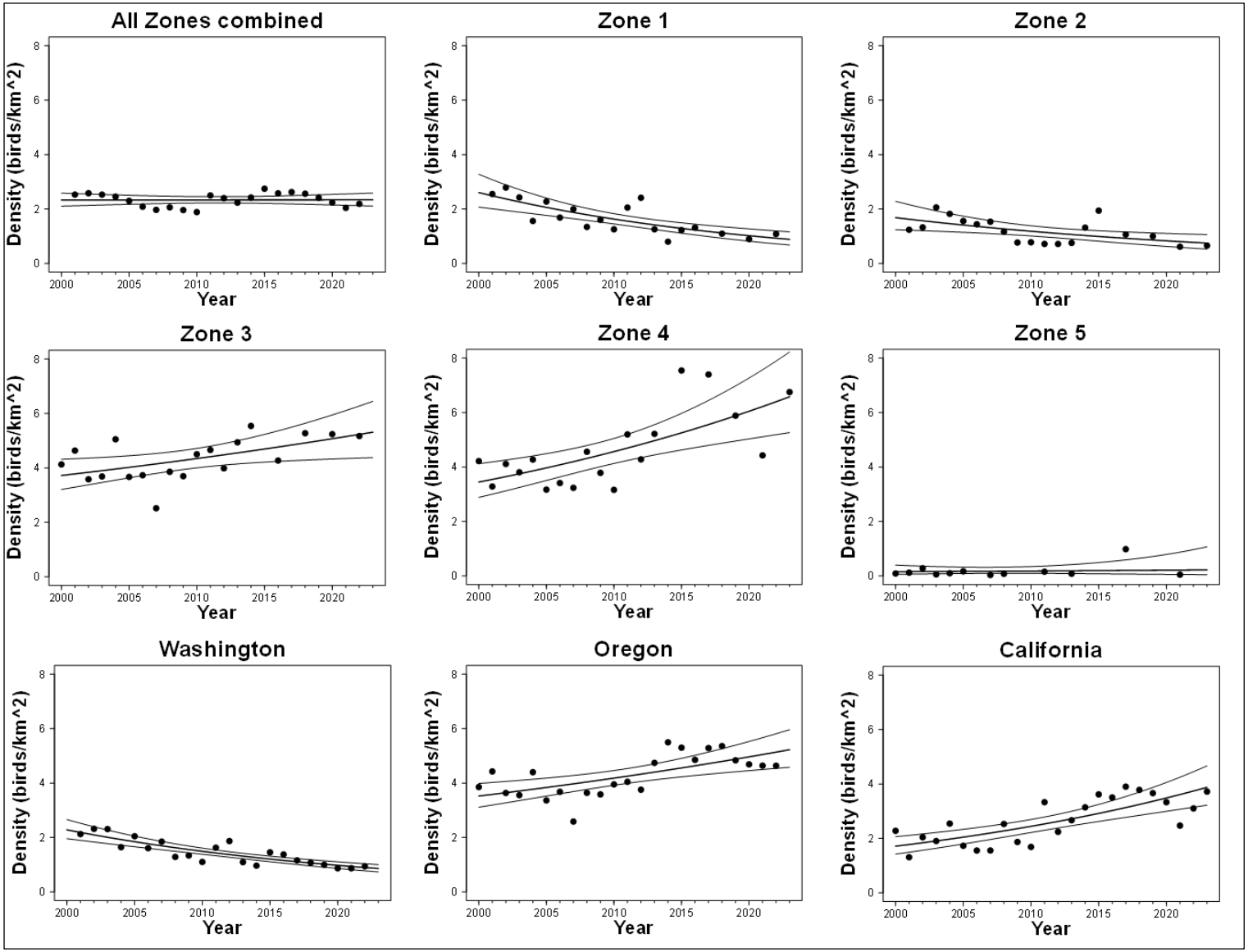

Figure 3. Marbled murrelet density trend analyses for All-Zones, individual Conservation Zones, and State scales. Graphs show fitted regression lines through the annual density estimates for the period of analysis (through 2021 for Conservation Zone 5; through 2022 for Conservation Zones 1 and 3, and for Oregon & Washington; through 2023 for Conservation Zones 2 and 4, and California) with 95 percent confidence limits. For comparative purposes, data are shown on a common scale. Data are represented in Table 2 (see p. 10).

LITERATURE CITED

Program products are available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Bentivoglio, N.; J. Baldwin; P.G.R. Jodice; D. Evans-Mack; T. Max, T; S, Miller; S.K. Nelson; K. Ostrom; C.J. Ralph; M. Raphael; C. Strong; C. Thompson; R. Wilk. 2002. Northwest Forest Plan Marbled Murrelet effectiveness monitoring 2000 annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Portland, OR. 72 p. Available at: http://www.reo.gov/monitoring/reports/murrelet/MAMU_EM_00report.pdf

Falxa, G., J. Baldwin, D. Lynch, S.K. Nelson, S.L. Miller, S.F. Pearson, C.J. Ralph, M.G. Raphael, C. Strong, T. Bloxton, B. Galleher, B. Hogoboom, M. Lance, R. Young, and M.H. Huff. 2008. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2004-2007 summary report. 25 pp.

Falxa, G.A.; and M.G. Raphael, tech. eds. 2016. Northwest Forest Plan—The first 20 years (1994–2013): status and trend of marbled murrelet populations and nesting habitat. Gen. Tech. Rep. PNW-GTR-933. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 148 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Falxa, G.A.; M.G. Raphael; C. Strong; J. Baldwin; M. Lance; D. Lynch; S.F. Pearson; and R.D. Young. 2016. Status and Trend of Marbled Murrelet Populations in the Northwest Forest Plan Area. Chapter 1 in Falxa and Raphael (2016; full citation above).

Felis JJ, White LM, Adams J, Kelsey EC, and Becker B. 2023. Abundance of marbled murrelets (*Brachyramphus marmoratus*) off central California during the 2023 breeding season: Summary provisional data report to Luckenbach Trustee Council and California State Parks, 21 pp.

Huff, M; Jodice, P.; Baldwin, J.; Miller, S.; Young, R.; Ostrom, K.; Ralph, C.J.; Raphael, M.G.; Strong, C. Thompson, C.; Falxa, G.; Evans Mack, D.; Nelson, K. 2003. Marbled Murrelet Effectiveness Monitoring Northwest Forest Plan, 2002 Annual Summary Report (Version 2). Northwest Forest Plan Interagency Regional Monitoring Program. 27p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Huff, M.H.; M.G. Raphael; S.L. Miller; S.K. Nelson; and J. Baldwin, tech coords. 2006. Northwest Forest Plan – The first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 149 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Lynch, D., J. Baldwin, M.M. Lance, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2017. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2016 summary report. 19 pp.

Lorenz, T.J.; Raphael, M.G.; Young, R.D. [et al.]. 2021. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan, 1993 to 2017. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 64 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Madsen, S.; D. Evans; T. Hamer; P. Henson; S. Miller; S.K. Nelson; D. Roby; and M. Stapanian. 1999. Marbled murrelet effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-439. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 51 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

McIver, W., Baldwin, J; Lance, M.M.; Pearson, S.F.; Strong, C.; Johnson, N.; Lynch, D.; Raphael, M.G.; Young, R.; Lorenz, T.; Nelson, K. 2019. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2018 summary report. 22 p.

McIver, W.R.; Pearson, S.F.; Strong, C. [et al.]. 2021. Gen. Tech. Rep. PNW-GTR-996. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

McIver, W.R.; Baldwin, J.; Lance, M.M.; Pearson, S.F.; Strong, C.; Raphael, M.G.; Duarte, A; Fitzgerald, K.

2022. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: At-sea Monitoring - 2021 summary report. 25 p.

Miller, S.L.; M.G. Raphael; G.A. Falxa; C. Strong; J. Baldwin; T. Bloxton; B.M. Galleher; M. Lance; D. Lynch; S.F. Pearson; C.J. Ralph; and R.D. Young. 2012. Recent population decline of the marbled murrelet in the Pacific Northwest. Condor 114:771-781.

Mulder, B.S.; Noon, B.R.; Spies, T.A.; Raphael, M.G.; Palmer, C.J.; Olsen, A.R.; Reeves, G.H.; Welsh, H.H. 1999. The strategy and design of the effectiveness monitoring program for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-437. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 138 p.

Pearson, S.F., B. McIver, D. Lynch, N. Johnson, J. Baldwin, M.M. Lance, M.G. Raphael, C. Strong, and R. Young, T. Lorenz, and K Nelson. 2018. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2017 summary report. 19 pp.

Pearson, S.F., M.M. Lance, K. Beach, K. Saksa, S. Tanedo, and J. Winn. 2024. Washington 2023 at-sea marbled murrelet population monitoring: Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, Washington.

R Core Team. 2017. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Raphael, M.G.; G.A. Falxa; D. Lynch; S.K. Nelson; S.F. Pearson; A.J. Shirk, R.D. Young. 2016a. Status and trend of nesting habitat for the Marbled Murrelet under the Northwest Forest Plan. Chapter 2 *in* Falxa and Raphael (2016; full citation above).

Raphael, M.G.; A.J. Shirk; G.A. Falxa; D. Lynch; S.K. Nelson; S.F. Pearson; C. Strong; R.D. Young. 2016b. Factors Influencing Status and Trend of Marbled Murrelet Populations: An Integrated Perspective. Chapter 3 *in* Falxa and Raphael (2016; full citation above).

Raphael, M.G.; J. Baldwin; G.A. Falxa; M.H. Huff; M. Lance; S.L. Miller; S.F. Pearson; C.J. Ralph; C. Strong; and C. Thompson. 2007. Regional population monitoring of the marbled murrelet: field and analytical methods. Gen. Tech. Rep. PNW-GTR-716. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Raphael, M.G.; G.A. Falxa; K.M. Dugger; B.M. Galleher; D. Lynch; S.L. Miller; S.K. Nelson and R.D. Young. 2011. Northwest Forest Plan—the first 15 years (1994-2008): Status and trend of nesting habitat for the Marbled Murrelet. Gen. Tech. Rep. PNW-GTR-848. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Available at: https://www.fs.usda.gov/r6/reo/monitoring/marbled-murrelet.php

Raphael, M.G., A. Shirk, G.A. Falxa, and S.F. Pearson. 2015. Habitat associations of marbled murrelets during the nesting season in nearshore waters along the Washington to California coast. Journal of Marine Systems 146:17-25.

Strong, C.S. 2024. Marbled Murrelet population monitoring in Conservation Zone 4 during 2023: results from southern Oregon and northern California. Unpublished report, Crescent Coastal Research. Crescent City, CA. 22 p

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; Determination of threatened status for the Washington, Oregon, and California population of the murrelet. Final rule. Fish and Wildlife Service. 57 Federal Register 45328; October 1, 1992.

U.S. Fish and Wildlife Service. 1997. Recovery plan for the threatened marbled murrelet *(Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, OR. 203 p.

U.S. Forest Service and Bureau of Land Management. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl; standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Portland, Oregon. 74 p.