

# Marbled Murrelet Effectiveness Monitoring, Northwest Forest Plan

## 2015 Summary Report

Northwest Forest Plan Interagency Regional Monitoring Program



Photo credits: M. Lance, WDFW (top), M.G. Shepard (bottom)

April 2016

## Marbled Murrelet Effectiveness Monitoring Team

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## SUMMARY OF 2015 RESULTS

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We report the 2015 monitoring results from the Northwest Forest Plan Effectiveness Monitoring Program for the Marbled Murrelet (*Brachyramphus marmoratus*). The purpose of this program is to assess status and trends of at-sea murrelet populations during the nesting season, and status and trends in their nesting habitat. Please refer to the 20-year report and past publications for more details on the program and methods (Madsen *et al.* 1999; Huff *et al.* 2006; Raphael *et al.* 2007; Raphael *et al.* 2011; Miller *et al.* 2012; Falxa *et al.* 2014; Falxa and Raphael *In press*).

In 2014 we implemented a reduced-sampling effort design, where Conservation Zones 1 and 3 are sampled in even years, Conservation Zones 2 and 4 are sampled in odd years, and Conservation Zone 5 is sampled every fourth year, in conjunction with Conservation Zone 4. We only partially implemented this design in 2015, as Conservation Zone 1 was also sampled in this “odd” year. The lack of 2015 data for Conservation Zones 3 and 5 means there are no 2015 population estimates or trend results for those zones, nor for the Plan-wide area (“All-Zones”) or at the state-scale for Oregon. Thus for Conservation Zone 3, All Zones, and Oregon, we present trend results through 2014.

The objectives of murrelet population monitoring are to estimate population size and trend during the breeding season in five murrelet conservation zones in coastal waters adjacent to the Northwest Forest Plan area, which extends from the United States border with British Columbia south to the Golden Gate of San Francisco Bay. We present detailed results through 2015 (where available) in the tables and figures below. At the conservation zone scale, the 2015 population estimates were about 4,300 murrelets in Conservation Zone 1 (Strait of Juan de Fuca, San Juan Islands, and Puget Sound, Washington), 3,200 in Conservation Zone 2 (outer coast of Washington), and 8,700 in Conservation Zone 4 (from Coos Bay, Oregon south to Shelter Cove, California) (see Table 1). At-sea murrelet density estimates for areas sampled in 2015 ranged from 1.23 birds per km<sup>2</sup> in Conservation Zone 1 to 7.54 birds per km<sup>2</sup> in Conservation Zone 4 (Table 1).

At the scale of individual conservation zones that we sampled in 2015, we continue to find evidence for population declines in Conservation Zone 1 (5.3% decline per year; 95% CI: -8.4 to -2.0%) (see Table 2 and Figures 2 and 4). While the data indicate there may continue to be a negative trend in Conservation Zone 2, the upper confidence interval overlaps zero; therefore, the trend for this Conservation Zone is uncertain. In 2015, we found evidence for a population increase in Conservation Zone 4 (3.0% increase per year; 95% CI: 0.04 to 5.6%) (see Table 2 and Figures 2 and 4 for details). In this summary report, as in the 20-year and 2014 summary reports, we have included population and trend estimates at the state scale (Tables 2 and 4, Figures 2, 3, and 4). In Washington, comprised of Conservation Zones 1 and 2, we found evidence for a population decline at the state scale for the 2001 to 2015 period (-4.4% decline per year; 95% CI: -6.8 to -1.9%). In California, as for Zone 4, the current results suggest a positive trend for the 2000 to 2015 period (3.8% increase per year; 95% CI: 0.9 to 6.8%) (see Table 2 and Figures 2 and 4). While the data indicate there may be a positive trend in Oregon, the lower confidence interval overlaps zero; therefore, the trend for this state is uncertain (see Table 2 and Figures 3 and 4). Because changes in murrelet population trends have occurred across different time periods and zones, we recommend continued monitoring to track these changes.

Due to the nature of sampling a sparsely and patchily distributed bird, our population and trend estimates tend to have fairly wide confidence intervals. We repeat here information from the 20-year report (Falxa et al. *In press*) on evaluating for evidence of a trend:

“For the purposes of evaluating 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 non-zero trend. Confidence intervals that are mainly above or below zero, but slightly overlap zero, can provide some evidence of a trend. “

For the nest habitat component of the Marbled Murrelet Effectiveness Monitoring Program, our work in 2015 focused on completing the assessment of status and trend for murrelet nest habitat and is documented in the 20-year report (Raphael et al. *In press a*).

Publications that include recent population and habitat monitoring results in detail include the three chapters in the 20-year murrelet report: 1) population (Falxa et al. *In press*), 2) nesting habitat (Raphael et al. *In press a*), and 3) an integrative chapter (Raphael et al., *In press b*), as well as a related study of relationships between the at-sea murrelet distribution observed by this program and terrestrial habitat and marine factors (Raphael et al. 2015). These and other reports, publications, and information relevant to the Marbled Murrelet Effectiveness Monitoring Program (and for other NW Forest Plan Effectiveness Monitoring programs) can be found at <http://www.reo.gov/monitoring>.

#### *Additional Notes on 2015 surveys*

Zones 1 and 2: Washington Department of Fish and Wildlife (WDFW) crews conducted these surveys. WDFW surveyed Strata 2 and 3 of Conservation Zone 1 with one boat and survey team, and a second boat and crew surveyed Conservation Zone 2 and Stratum 1 of Zone 1. This division of effort by WDFW provided a comparable survey effort for each crew and was effective for logistical and geographic reasons. There were no significant survey issues to report for 2015. Of interest, only one murrelet was counted in Stratum 3 of Zone 1, while in primary sampling unit (PSU) 10 of Zone 2 Stratum 2 we observed the highest number of murrelets ever observed in that PSU (observed on May 28).

Zone 4: A team from Crescent Coastal Research conducted these surveys. There were no significant survey issues to report for 2015 but the team did experience bad weather in early June. As a result, while the sampling target of 30 primary sample unit (PSU) samples was met, seven PSUs were sampled only once. One note, some surveys were conducted under high swell conditions that may have affected the detectability of murrelets.

Zones 3 and 5: We did not conduct surveys in 2015 in these zones, as discussed above.

## **Adjustments to Trend Analysis Method to Account for Reduced Effort Sampling Design**

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 combined, and states). Now, with most zones to be sampled only every-other 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:

1. At the conservation zone scale, trend estimates will be generated through the most recent year with population surveys and density estimates, using only data from those years with actual surveys for a conservation zone.
2. At the All-Zones and state scales, trend estimates will be 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 will not be used for components from these zones. This means that All-Zones and state-scale estimates will be one year “behind” (except for the California estimate; see below).
  - For example, for 2016, we would provide All-Zones and state trend estimates through 2015 only, because Zones 2 and 4 will not have been surveyed in 2016, and these zones contribute to all three state-scale analyses. The 2001-2015 All-Zones and state trend estimates will use the actual 2015 density estimates for Zones 1, 2 and 4 (which were all surveyed in 2015), and an interpolated 2015 density estimate for Zone 3 (based on density estimates for 2014 and 2016—survey years for Zone 3).
3. Interpolations will only be 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 will be 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).
5. For the Zone 5 component of the California and All-Zones trend estimates, we will use the density estimate from the most recent year with Zone 5 surveys (currently, this is 2013). With Zone 5 scheduled to be surveyed only every fourth year, this extrapolation of Zone 5 data allows updating of the California and All-Zone trend estimates more frequently than every fourth year. Because Zone 5 has so few birds, this extrapolation has a negligible effect on these trend estimates.

### **ACKNOWLEDGMENTS**

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We thank the many crew members who have conducted the at-sea population surveys over the years, often under difficult conditions. Funding and other support for this work in 2015 was provided by several offices and programs of the U.S. Fish and Wildlife Service, by the U.S. Forest Service Pacific Northwest Research Station, the U.S. Forest Service Pacific Southwest Forest Research Station, and the Washington Department of Fish and Wildlife.

We also want to thank our monitoring team leader, Gary Falxa. His last year with the teams was 2015. He did a great job of keeping us on point and moving forward.

### **CONTACT INFORMATION**

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**Web Site:** Additional information, reports, publications, and program updates relevant to the Marbled Murrelet Effectiveness Monitoring Program (as well all other modules from the Interagency Regional Monitoring Program) can be found at <http://www.reo.gov/monitoring>.

### **RECOMMENDED CITATION:**

Lynch, D. Falxa, G., J. Baldwin, M. M. Lance, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2016. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2015 summary report. 19 pp.

# **TABLES AND FIGURES**

**Table 1.** Summary of 2001-2015 marbled murrelet density and population size estimates (rounded to nearest 100 birds) for all conservation zones combined. Numbers may differ slightly from those in previous summary reports, as a result of additional data quality reviews performed in 2014.

Year	Density (birds/km <sup>2</sup> )	Bootstrap Standard Error (birds/km <sup>2</sup> )	Coefficient of Variation of Density (%)	Birds	Birds Lower 95% CL	Birds Upper 95% CL
2001	2.47	0.25	10.1%	21,800	17,500	26,100
2002	2.56	0.31	11.9%	22,500	17,300	27,800
2003	2.60	0.25	9.6%	22,800	18,500	27,100
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	2.08	0.17	8.2%	18,300	15,300	21,200
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%	17,300	13,700	20,900
2010	1.89	0.21	11.1%	16,600	13,000	20,300
2011	2.50	0.31	12.6%	22,000	16,600	27,400
2012	2.40	0.27	11.4%	21,100	16,400	25,700
2013	2.24	0.25	11.1%	19,700	15,400	23,900
2014	2.425	0.221	9.1%	21,305	17,492	25,118
2015	No estimates are available for "All Zones" in 2015, due to implementation of reduced-effort survey design.					



**Table 2.** Estimates of average annual rate of change based on the at-sea population surveys. Results that included 2015 data are presented first, at scales of conservation zone and state. Confidence limits are for the estimates of percent annual change. The *P*-value is based on a 1-tailed test for whether the annual rate of change is less than zero. Based on updated population estimates reported in Tables 1 and 3. For guidance on interpretation of rates of change and confidence intervals, please refer to Falxa et al. (*In press*), and the excerpt from that report in the summary text above.

Zone or State	Period of Analysis	Annual Rate of Change (%)	95% Conf. Limits		Adjusted $R^2$	<i>P</i> -value
			Lower	Upper		
Zone 1	2001-2015	-5.3	-8.4	-2.0	0.444	0.004
Zone 2	2001-2015	-2.8	-7.6	2.3	0.029	0.256
Zone 4	2000-2015	3.0	0.4	5.6	0.270	0.027
WA	2001-2015	-4.4	-6.8	-1.9	0.493	0.002
CA	2000-2015	3.8	0.9	6.8	0.321	0.013
Zone 3	2000-2014	1.3	-1.2	3.8	0.021	0.274
Zone 5	2000-2013	-2.5	-12.9	9.1	0.000	0.619
OR	2000-2014	1.2	-0.9	3.4	0.030	0.252
All Zones	2001-2014	-0.7	-2.3	0.8	0.006	0.319

**Table 3.** Murrelet population estimates for conservation zones and sampling strata within zones, 2000-2015, 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. See text for details on use of interpolated or extrapolated values for 2015 estimates.

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	-	260	883	0.0097	1.730	180
2000	5	1	0.179	80.6%	79	-	260	441			
2000	5	2	0.000	-	-	-	-	441			
2001	All	All	2.466	10.1%	21,763	17,472	26,053	8,826			
2001	1	All	2.553	18.0%	8,936	5,740	11,896	3,501	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	1,196			
2001	1	3	2.067	37.2%	3,016	404	5,003	1,459			
2001	2	All	0.899	41.9%	1,518	524	2,942	1,688	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	1,595	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	1,159	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	0.0101	1.749	170
2001	5	1	0.198	39.1%	87	-	138	441			
2001	5	2	0.043	231.6%	19	-	129	441			
2002	All	All	2.563	11.9%	22,521	17,264	27,777	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	1.233	29.2%	2,031	800	3,132	1,650	0.0195	1.400	70
2002	2	1	2.448	32.1%	1,774	559	2,840	724			
2002	2	2	0.278	41.2%	258	-	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	0.0108	1.724	175
2002	5	1	0.510	46.1%	225	8	371	441			
2002	5	2	0.054	71.1%	24	-	54	441			
2003	All	All	2.596	9.6%	22,808	18,525	27,091	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	-	85	883	0.0086	1.704	180
2003	5	1	0.109	61.1%	48	-	85	441			
2003	5	2	0.000	-	-	-	-	441			

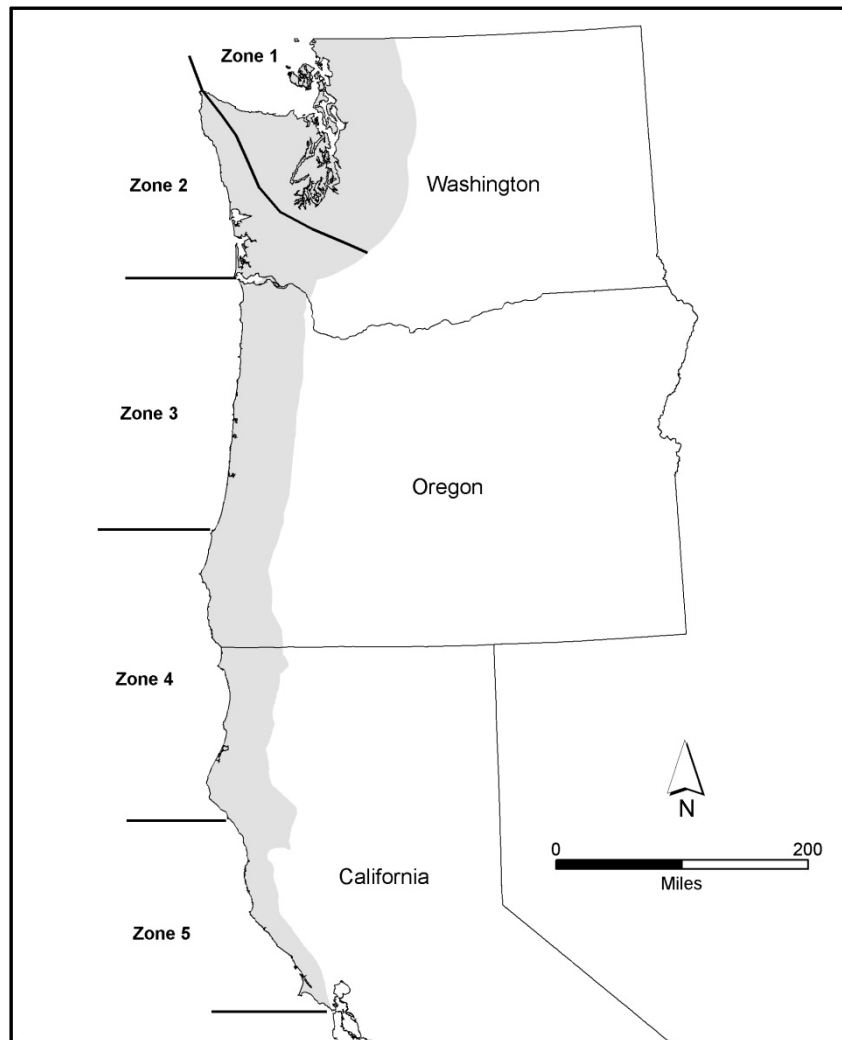
Table 3 (continued)											
Year	Zone	Stratum	Density	CV	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	E(s)	Truncation Distance (m)
2004	All	All	2.455	10.5%	21,572	17,144	26,000	8,786			
2004	1	All	1.562	22.0%	5,465	2,921	7,527	3,498	0.0108	1.789	280
2004	1	1	3.833	30.0%	3,241	1,365	4,845	845			
2004	1	2	1.513	25.4%	1,807	1,042	2,777	1,195			
2004	1	3	0.286	60.0%	417	-	727	1,458			
2004	2	All	1.823	27.0%	3,009	1,669	4,634	1,650	0.0116	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	0.0143	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	0.0093	1.700	200
2004	5	1	0.091	64.5%	40	-	104	441			
2004	5	2	0.107	93.6%	47	-	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			
2005	4	2	0.895	42.1%	381	243	901	425			
2005	5	All	0.169	31.8%	149	69	251	883	0.0108	1.518	170
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	2.080	8.2%	18,275	15,336	21,214	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	1.455	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	<i>Not surveyed. Interpolated estimate used for All Zone calculation</i>									
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	-	49	883	0.0106	1.607	180
2007	5	1	0.067	37.7%	30	-	49	441			
2007	5	2	0.000		-	-	-	441			

Table 3 (continued)											
Year	Zone	Stratum	Density	CV	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	E(s)	Truncation Distance (m)
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	-	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	0.0100	1.705	200
2008	5	1	0.065	60.1%	29	-	81	441			
2008	5	2	0.087	70.3%	38	-	68	441			
2009	All	All	1.965	10.6%	17,260	13,670	20,851	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	-	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	<i>Not surveyed. Interpolated estimate used for All Zone calculation</i>									
2010	All	All	1.894	11.1%	16,641	13,015	20,268	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	-	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	<i>Not surveyed. Interpolated estimate used for All Zone calculation</i>									
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	0.0122	1.644	145
2011	5	1	0.243	64.8%	107	5	259	441			
2011	5	2	0.068	78.8%	30	-	66	441			
2012	All	All	2.396	11.4%	21,052	16,369	25,736	8,785			

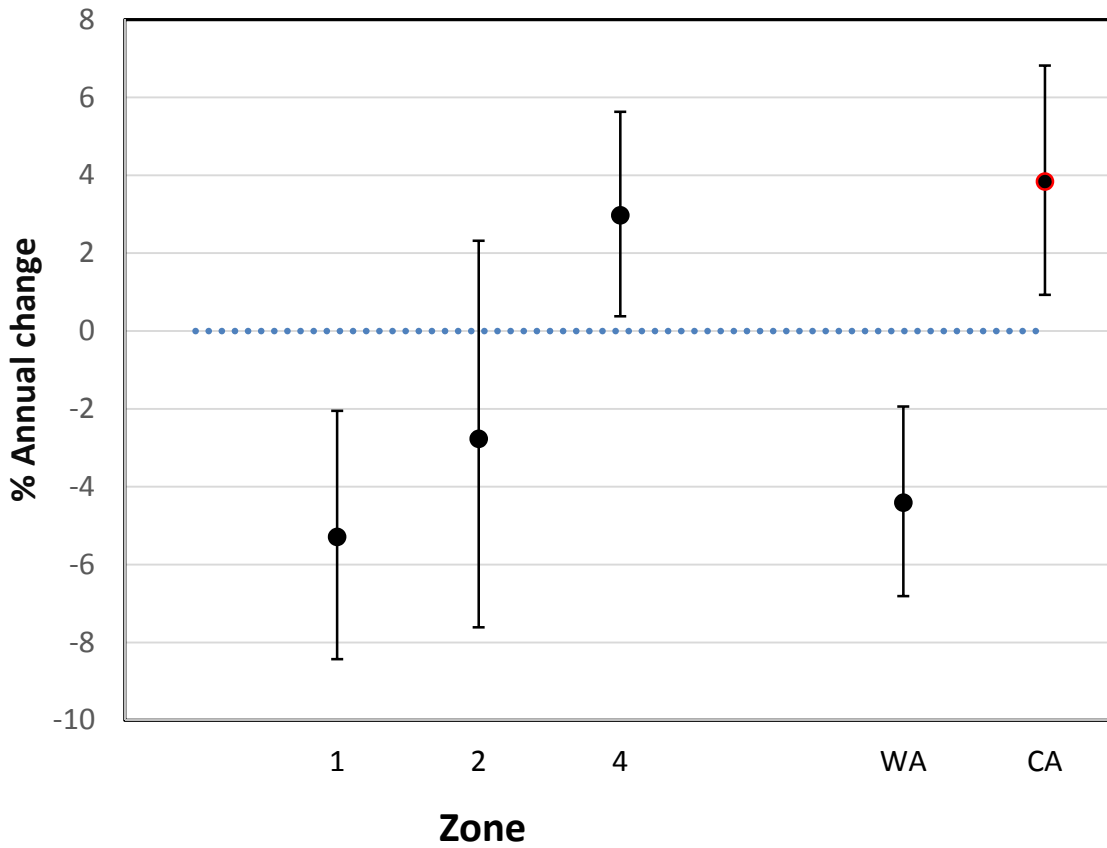
Table 3 (continued)											
Year	Zone	Stratum	Density	CV	Birds	Lower 95% CI	Upper 95% CI	Area	f(0)	E(s)	Truncation Distance (m)
2012	1	All	2.414	20.7%	8,442	5,090	12,006	3,497	0.0109	1.847	164
2012	1	1	7.166	24.4%	6,056	3,289	8,823	845			
2012	1	2	1.507	30.4%	1,799	812	2,892	1,194			
2012	1	3	0.402	48.1%	587	168	1,227	1,458			
2012	2	All	0.719	33.5%	1,186	564	2,360	1,650	0.0132	1.485	106
2012	2	1	1.178	29.2%	853	325	1,289	724			
2012	2	2	0.360	89.9%	333	-	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	<i>Not surveyed. Interpolated estimate used for All Zone calculation</i>									
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	-	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	0.0128	1.607	146
2013	5	1	0.160	45.4%	71	5	118	441			
2013	5	2	0.000	-	-	-	-	441			
2014	All	All	2.425	9.1%	21,305	17,492	25,118	8,785			
2014	1	All	0.807	19.3%	2,822	1688	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	-	-	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	-	-	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	<i>Not Surveyed. Interpolated value used for All-Zone estimate</i>									
2014	5	<i>Not Surveyed. Extrapolated value used for All-Zone estimate</i>									
2015	All	<i>Zones 3 and 5 were not surveyed; therefore, do not have an All Zones estimate</i>									
2015	1	All	1.227	22.8%	4,290	2,783	6,492	3,497	0.01111	1.786	191
2015	1	1	2.218	33.5%	1,875	956	3,334	845			
2015	1	2	1.945	28.2%	2,321	1,250	3,683	1,194			
2015	1	3	0.064	91.7%	94	-	261	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	725			
2015	2	2	1.231	71.2%	1,140	144	3,290	926			
2015	3	<i>Not Surveyed</i>									
2015	4	All	7.542	16.8%	8,743	7,409	13,125	1,159	0.01183	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	<i>Not Surveyed</i>									

**Table 4.** Summary of 2000 to 2015 marbled murrelet density and population size estimates at the State scale. 2015 estimates are available for Washington and California only, due to Conservation Zone 3 not being sampled in 2015.

Year	State	Density (murrelets per km <sup>2</sup> )	Murrelets	Murrelets 95% CL Lower	Murrelets 95% CL Upper	Area (km <sup>2</sup> )
2001	WA	2.01	10,453	7,057	13,849	5,188
2002	WA	2.29	11,789	7,507	16,071	5,151
2003	WA	2.42	12,467	8,906	16,028	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	6,886	4,486	9,285	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	5,665	3,217	8,114	5,148
2014	WA	0.97	4,998	3,311	6,686	5,148
2015	WA	1.46	7,494	3,667	11,320	5,148
2000	OR	3.85	7,983	4,095	11,870	2,071
2001	OR	4.43	9,168	5,935	12,402	2,071
2002	OR	3.64	7,530	4,473	10,586	2,071
2003	OR	3.56	7,380	4,547	10,213	2,075
2004	OR	4.40	9,112	5,532	12,692	2,071
2005	OR	3.36	6,966	4,589	9,344	2,071
2006	OR	3.68	7,617	5,779	9,455	2,071
2007	OR	2.59	5,357	3,009	7,704	2,071
2008	OR	3.64	7,541	4,893	10,189	2,071
2009	OR	3.58	7,423	4,454	10,393	2,071
2010	OR	3.95	8,182	4,678	11,686	2,071
2011	OR	4.05	8,379	2,209	14,550	2,071
2012	OR	3.76	7,780	4,183	11,377	2,071
2013	OR	4.74	9,819	6,158	13,480	2,071
2014	OR	5.50	11,384	5,104	17,664	2,071
2000	CA	2.28	3,571	2,556	4,585	1,566
2001	CA	1.31	2,051	1,030	3,073	1,566
2002	CA	2.04	3,202	2,425	3,980	1,566
2003	CA	1.91	2,985	2,392	3,579	1,569
2004	CA	2.55	3,986	3,009	4,964	1,566
2005	CA	1.73	2,710	2,106	3,313	1,566
2006	CA	1.52	2,378	1,781	2,976	1,566
2007	CA	1.56	2,440	1,709	3,170	1,566
2008	CA	2.53	3,964	3,414	4,515	1,566
2009	CA	1.88	2,952	2,148	3,755	1,566
2010	CA	1.72	2,691	1,959	3,424	1,566
2011	CA	3.33	5,217	4,155	6,279	1,566
2012	CA	2.22	3,481	2,795	4,167	1,566
2013	CA	2.67	4,178	3,561	4,795	1,566
2014	CA	3.14	4,922	3,411	6,433	1,566
2015	CA	3.62	5,666	3,970	7,362	1,566

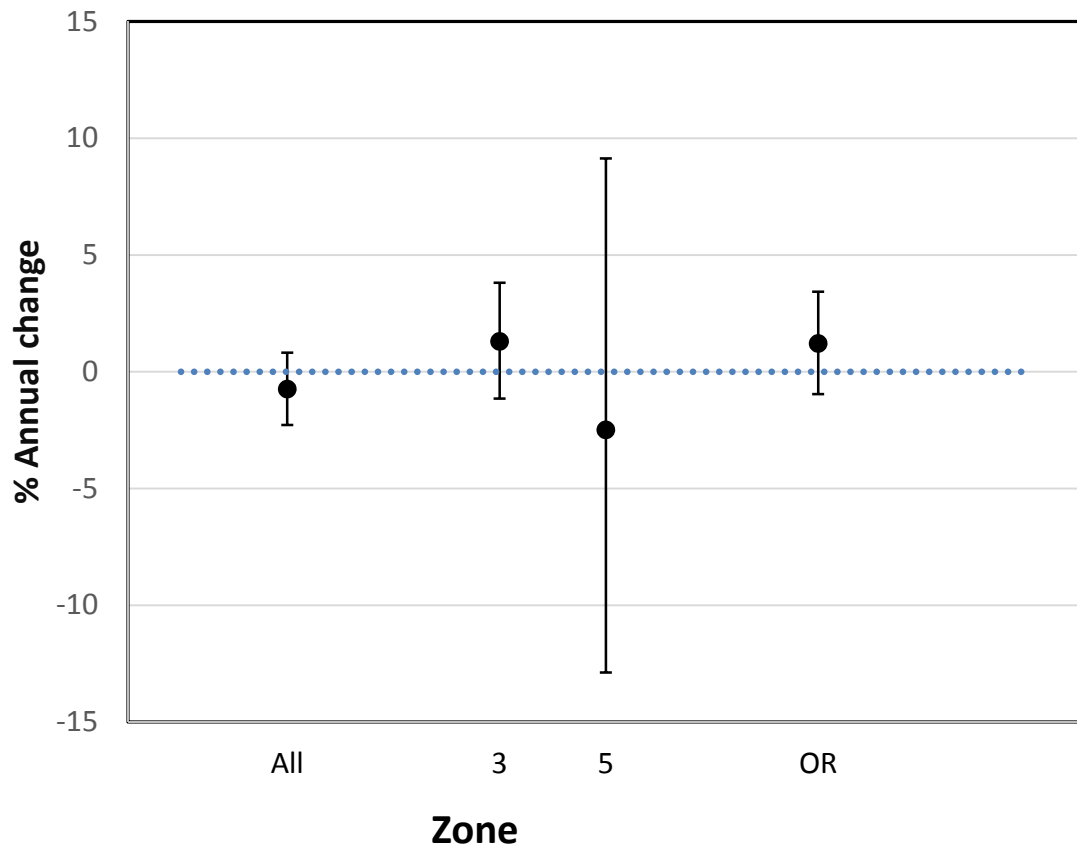


**Figure 1.** The five at-sea marbled murrelet conservation zones adjacent to the Northwest Forest Plan area. Approximate inland breeding distribution is shaded (adapted from U.S. Fish and Wildlife Service 1997).

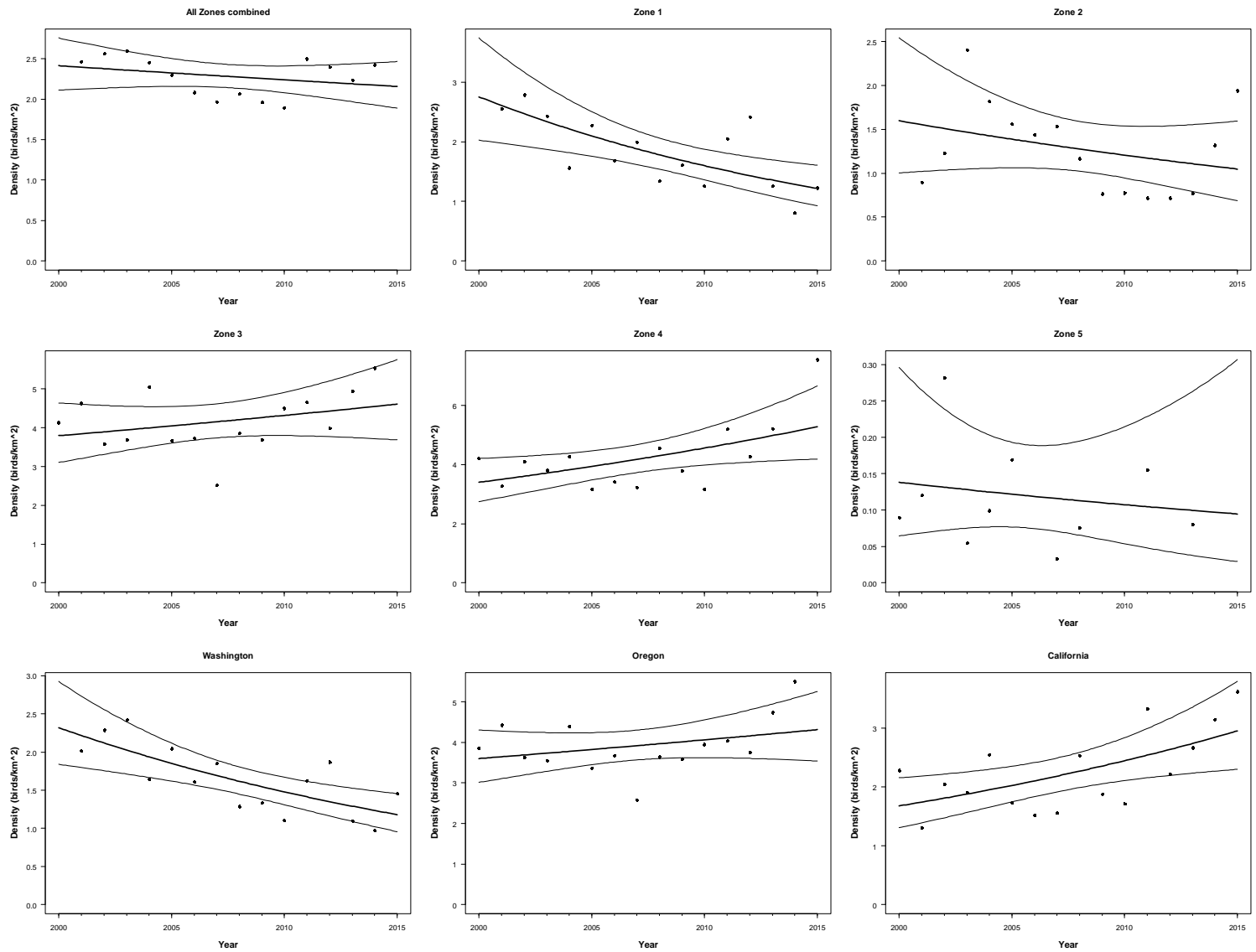


**Figure 2.** Trend results for units with population estimates through 2015: average rate of annual change with 95 percent confidence intervals. Refer to Table 1 for periods of analysis for each unit. For guidance on interpretation of rates of change and confidence intervals, please refer to Falxa et al. (*In press*), and the excerpt from that report in the summary text above. See Figure 3 for trend results for units which lack 2015 estimates.





**Figure 3.** Trend results for units with population estimates through 2014 only: average rate of annual change with 95 percent confidence. Refer to Table 1 for periods of analysis for each unit. For guidance on interpretation of rates of change and confidence intervals, please refer to Falxa et al. (*In press*), and the excerpt from that report in the summary text above. See Figure 2 for trend results for units for which we have 2015 population estimates.



**Figure 4.** Results of trend analyses at All-Zones, Conservation Zones, and State scales. Graphs show fitted regression lines through the annual population estimates for the period of analysis, with 95 percent confidence limits.

## LITERATURE CITED

Program products are available at: <http://www.reo.gov/monitoring/reports/marbled-murrelet-reports-publications.shtml>

- Falxa, G.A.; and M.G. Raphael, tech. eds. *In press*. 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. xx p.
- Falxa, G.A.; M.G. Raphael; C. Strong; J. Baldwin; M. Lance; D. Lynch; S.F. Pearson; and R.D. Young. *In press*. Status and Trend of Marbled Murrelet Populations in the Northwest Forest Plan Area. Chapter 1 in Falxa and Raphael (*In press*; full citation above).
- Falxa, G.; J. Baldwin; M. Lance; D. Lynch; S.K. Nelson; S.F. Pearson; M.G. Raphael; C. Strong; and R. Young. 2014. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2013 summary report. 20 pp.
- 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: [http://www.fs.fed.us/pnw/pubs/pnw\\_gtr650.pdf](http://www.fs.fed.us/pnw/pubs/pnw_gtr650.pdf)
- 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.
- 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.
- Raphael, M.G.; G.A. Falxa; D. Lynch; S.K. Nelson; S.F. Pearson; A.J. Shirk, R.D. Young. *In press a*. Status and trend of nesting habitat for the Marbled Murrelet under the Northwest Forest Plan. Chapter 2 in Falxa and Raphael (*In press*; 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. *In press b*. Factors Influencing Status and Trend of Marbled Murrelet Populations: An Integrated Perspective. Chapter 3 in Falxa and Raphael (*In press*; 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: [http://www.fs.fed.us/pnw/pubs/pnw\\_gtr716.pdf](http://www.fs.fed.us/pnw/pubs/pnw_gtr716.pdf)
- 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: <http://www.reo.gov/monitoring/reports/15yr-report/marbled-murrelet/index.shtml>
- 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.
- 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.