Marbled Murrelet Effectiveness Monitoring
Northwest Forest Plan

2008 Summary Report

Northwest Forest Plan Interagency Regional Monitoring Program

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SUMMARY

This report summarizes activities of the Marbled Murrelet (*Brachyramphus marmoratus*) Effectiveness Monitoring Program in the area of the Northwest Forest Plan (NWFP), from the start of monitoring in 2000 through 2008. The purpose of the effectiveness monitoring is to assess status and trends of murrelet populations and nesting habitat. This report includes results of the annual at-sea population surveys including an initial trend analysis, and an update on modeling of nesting habitat.

The objectives of the murrelet population monitoring are to estimate (1) population trends and (2) population size during the breeding season within and across five murrelet conservation zones in coastal waters adjacent to the NWFP area. The 2008 estimated population of murrelets in the NWFP target (sampling) area is 17,800 (95 percent confidence interval = 14,600 to 21,000), with the largest Zone population estimate (about 6,200) occurring in Conservation Zone 3 (Columbia River to North Bend, Oregon). At the conservation zone scale, murrelet at-sea density estimates in 2008 ranged from 0.14/km^2 in Zone 5 (California coast, just south of Shelter Cove to San Francisco Bay) to 4.14 birds/km^2 in Zone 4 (North Bend, Oregon to just south of Shelter Cove, California).

For the 5-zone area combined, the population declined over the years 2000 to 2008. The estimated rate of annual decline for that period was 2.4 percent, which is equivalent to an average decline of about 488 (standard error = 241) birds per year. The estimated rate of decline from year 2001 to 2008 was greater, averaging 4.3 percent or 867 (standard error = 129) birds per year. Additional at-sea monitoring will be needed to test for population declines at the scale of individual conservation zones, and to evaluate whether the declines observed to date continue into the future, and if so, at what rate.

Under the habitat monitoring component of the Effectiveness Monitoring Program, the habitat team continued to develop modifications to the existing habitat models, and to evaluate model performance using the GNN-IMAP vegetation maps that are under development. The team decided to pursue resource selection function models as the preferred approach for modeling the amount and distribution of murrelet nest habitat, for Northwest Forest Plan's 15-year report cycle.

PREFACE

This report was prepared by Gary Falxa, Deanna Lynch, and the Marbled Murrelet Monitoring Team members.

ACKNOWLEDGMENTS

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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.

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INTRODUCTION

Managers responsible for resolving natural resource issues need resource trend information to develop sound management plans. Regional-scale trend information can provide insights into broad-scale patterns and processes, as well as help support management strategies to achieve desired goals and objectives and to formulate new strategies (i.e., adaptive process). Evaluating population trends requires a commitment to long-term monitoring (multiple years) and consistent data collection from a target population sampled without biases (Urquhart et al. 1998).

The marbled murrelet (*Brachyramphus marmoratus; hereafter* murrelet) and northern spotted owl (*Strix occidentalis*) were the only focal animal species selected to monitor and evaluate the effectiveness of the 1994 Northwest Forest Plan (NWFP). One NWFP goal is to maintain and restore marbled murrelet nesting habitat and populations throughout the range of the species within the NWFP area. A two-pronged approach is used to monitor murrelets and evaluate the success of the NWFP in meeting that goal (Madsen et al. 1999). The first approach uses annual at-sea surveys to assess murrelet population status and trends. For murrelets, at-sea surveys are an accurate and direct means to monitor population trends across the range of the NWFP. Because murrelets are secretive nesters, baseline reproductive information is difficult and expensive to collect at breeding locations. At-sea population surveys offer a cost-effective method for assessing the persistence and conservation status of this species. The methods used for the at-sea surveys were published in 2007 (Raphael et al. 2007). Status and trend information is used to assess the stability of murrelet populations within the NWFP area, and to help inform whether land based management actions are providing for the recovery of the species. The second approach for evaluating murrelet status within the NWFP area is to monitor the amount and trends of potential nesting habitat in the planning area. To accomplish this objective, murrelet habitat models were developed and the initial results published in 2006 (Huff et al. 2006).

The objectives of this report are to present the 2008 at-sea survey results, to present results of population trend analyses using the 2000-2008 population data, and to describe habitat modeling work.

EFFECTIVENESS MONITORING QUESTIONS

The broad objectives and approach to effectiveness monitoring of status and trends for the NWFP are described in Mulder et al. (1999). Effectiveness monitoring questions examine the extent to which measures of interest (e.g., strategy or initiative) have achieved intended objectives by evaluating the observed outcomes or impacts against expectations. Status questions evaluate the conditions of an indicator resource at a given moment in time, whereas trends follow changes in indicators over time and space.

The effectiveness monitoring goal for the marbled murrelet is to evaluate the success of the NWFP in maintaining and restoring murrelet populations and nesting habitat (Madsen et al. 1999). To meet that goal, the monitoring plan for murrelets identified questions to be addressed for the NWFP area, focused on (1) the predicted amount, distribution and spatial attributes of

murrelet nesting habitat, and trends in those characteristics, and (2) murrelet population status and trends. These questions are detailed in the murrelet effectiveness monitoring plan (Madsen et al. 1999).

Subsequently, Northwest Forest Plan managers identified a list of key management questions for the NWFP monitoring program. This list contains two questions directly related to murrelets:

1. What is the status and trend of Marbled Murrelet habitat and populations?
    - Identified by managers as best answered by monitoring

2. What are the relationships between marbled murrelet status and stressors, how does this affect nesting distribution, and can habitat models effectively predict where murrelets nest?
    - Identified by managers as best answered by research

METHODS

Methods for data collection and analysis of population and habitat information can be found in Huff et al. (2006) and Raphael et al. (2007). Deviations from the population survey protocol during 2008 are presented below.

Population Monitoring

Marbled murrelets are sampled from boat-based transects within 2 - 8 km of shore in Recovery Conservation Zones 1 through 5, adjacent to the NWFP area (USDI Fish and Wildlife Service 1997; Figure 1). We conducted surveys from mid-May through late-July, the peak activity period of the murrelet nesting season. We divided each conservation zone into two or three strata based on murrelet density patterns. A target number of sampling units was designated for each stratum; however, we estimate density and population size at the conservation zone and NWFP scales only. We used program DISTANCE to generate population density estimates (Buckland et al. 2001). The confidence intervals for individual zone population estimates were constructed using the bootstrap approach; this can result in asymmetric confidence intervals. For the population estimate for all zones combined, we constructed confidence intervals by first calculating the 5-zone standard error from the individual zone standard errors, weighting by zone area. We then constructed the 95 percent confidence intervals as plus/minus 1.96 times the 5-Zone standard error; these are symmetric. See Raphael et al. (2007) for additional details on methods.

We calculated a population estimate for the entire 5-zone area by summing the estimates from each zone, for a given year. For 2006, when Zone 5 was not surveyed, we used the mean of the 2005 and 2007 Zone 5 estimates to provide the Zone 5 population estimate. Because the counts from Zone 5 are so low with respect to the other zones, this use of interpolation to estimate such a relatively small number for 2006 had little effect on the overall estimated number of birds, or

on the trend analysis regressions. Zone 5 contributed an average of only 0.6 percent of the birds in the annual 5-zone population estimates for 2000 to 2008 (range 0.2 to 1.4 percent).

In most zones, most or all of the shoreline is sampled at least once each year. Zone 1 (Puget Sound, San Juan Islands, Straits of Juan de Fuca) has a long complex shoreline, with 98 Primary Sampling Units (PSUs) total. At the outset of the monitoring program, a one-time random sample of 30 of the 98 PSUs was selected from Zone 1, with different sampling effort distributed among the zone's 3 geographic strata, based on relative murrelet abundance. These 30 PSUs are sampled twice annually, for a total of 60 PSU samples from Zone 1 (Raphael et al. 2007). Stratum 3 of Zone 1 includes 47 PSUs and encompasses the Puget Sound, parts of Hood Canal and Whidbey Island, and the mainland between Puget Sound and the border with Canada. Data for this stratum indicated low murrelet densities; therefore the sampling design allocated relatively light effort, 5 PSUs sampled twice annually, to represent the stratum. This approach is robust with respect to detecting trends, and murrelet density and numbers are low for the stratum. However, estimates for this stratum can be influenced by high murrelet density in a single PSU sample.

Adjustments and other notes on survey methods for 2008

In Conservation Zone 2, the survey team collected 28 PSU samples in 2008, slightly under the target of 30 PSU samples. This should not bias the Zone 2 estimate, as the analyses are robust to such variations in sample size. Two additional samples collected prior to the May 15 survey start date were not included in the analyses.

Conservation Zone 3 experienced a 27-day period without sampling in the last half of June and early July, due to unfavorable weather conditions and logistical problems. Sampling gaps of a week are expected for the outer coast zones due to weather conditions, but the 2008 gap was longer than usual. The 2008 gap did not affect the Zone 3 sample size, as 30 PSU samples were obtained, but the gap resulted in the samples being more clustered temporally than normal.

Conservation Zone 5 surveys were all conducted in July in 2008, due to funding delays. Thirteen of the 15 target PSU samples were completed.

In 2008, the module lead accompanied teams on murrelet surveys, in part to check for consistency among crews and zones in implementing the survey protocol. We noted two differences in survey implementation among survey crews: 1) whether to count birds that are observed ahead of the survey boat at the time the end of a transect line is reached [they are to be counted]; and 2) whether to record murrelets that are beyond 200 meters perpendicular to the transect line [yes, record all murrelets detected, regardless of distance]. In the first case, the protocol had not been clear about sampling at ends of transects. As a result, observers in one zone (Zone 1) had not been including birds sighted ahead of the boat at the moment a transect ended; this could result in counting birds in a smaller area than assumed. The area affected, roughly a half-circle in front of the boat, represents about 0.9 percent of the total area surveyed in Zone 1, based on the average effective strip half-width of 86.4 meters (Buckland et al. 2001; calculated as 1/f(0)) for Zone 1 for 2000-2008 (range: 0.7 – 1.2 percent). This difference should result in a similarly small underestimation of density for the single zone. In the second case,

which occurred in only a portion of Stratum 2 in Zone 1, murrelets beyond 200 meters from the transect line were not recorded. Because very few murrelets occur at that distance, and because murrelets far from the transect line have negligible to no influence on density estimates in the program DISTANCE, which in our analyses discards (truncates) observations beyond a distance that is typically 200 meters or less ("Truncation Distance" column in Table 1). These differences should have minimal effect on density and population estimates, due to the limited area affected by the differences, and small effect size. The differences should have no measureable effect on trend results, because of the small effect size and consistency within zone or stratum of methods. Both survey aspects will be made consistent among all survey areas in 2009.

Trend Analysis

Because a declining trend has been predicted for murrelets by demographic models (USDI Fish and Wildlife Service 1997, McShane et al. 2004), we used annual population estimates for 2000 through 2008 to evaluate whether a declining trend exists. The statistical test for trends was conducted by fitting a regression line to the annual population estimates for each of the five individual zones within the NWFP area, and for the 5-zone area combined. The statistical tests for trends were conducted as one-tailed tests for declines; significance was tested at the level of $P \leq 0.05$. Thus, we tested the null hypothesis that the slope equals zero or greater (no change or an increase in murrelet numbers) against the alternative hypothesis of the slope being less than zero (murrelet numbers decreasing; Miller et al. 2006, page 46). Estimates for annual rates of decline were calculated by dividing the estimated annual decline for the period of analysis (the slope from the regression equation, in numbers of birds) by the mean population for the period of analysis (the average of the annual population estimates).

We tested for trends for two periods: 1) 2000 through 2008, and 2) 2001 through 2008. The latter was evaluated because inspection of the data set (Figure 2) suggested that the 2000 estimate may have been unusually low, considering the pattern of estimates from subsequent years. The cause for the low 2000 estimate is not known; it may represent the true abundance that year, or it may simply represent natural or sampling variation. In addition, departures from the sampling protocol did occur in 2000, the first year under the sampling design, in Zone 2 and in Stratum 1 of Zone 1. These departures, which were corrected in subsequent years, may have contributed to the low estimate for 2000, but it is not known if those departures actually biased the estimate downwards. We discuss this further below under trend results. The trend analysis for 2001-2008 provides an estimate of rate of decline without the influence of the 2000 data.

Habitat Modeling

In 2008, the team continued work begun in 2007 to explore modifications to the existing habitat models (Huff et al. 2006), to evaluate model performance using a new vegetation map under development, to develop new data for use in habitat modeling, and to examine resource selection function models.

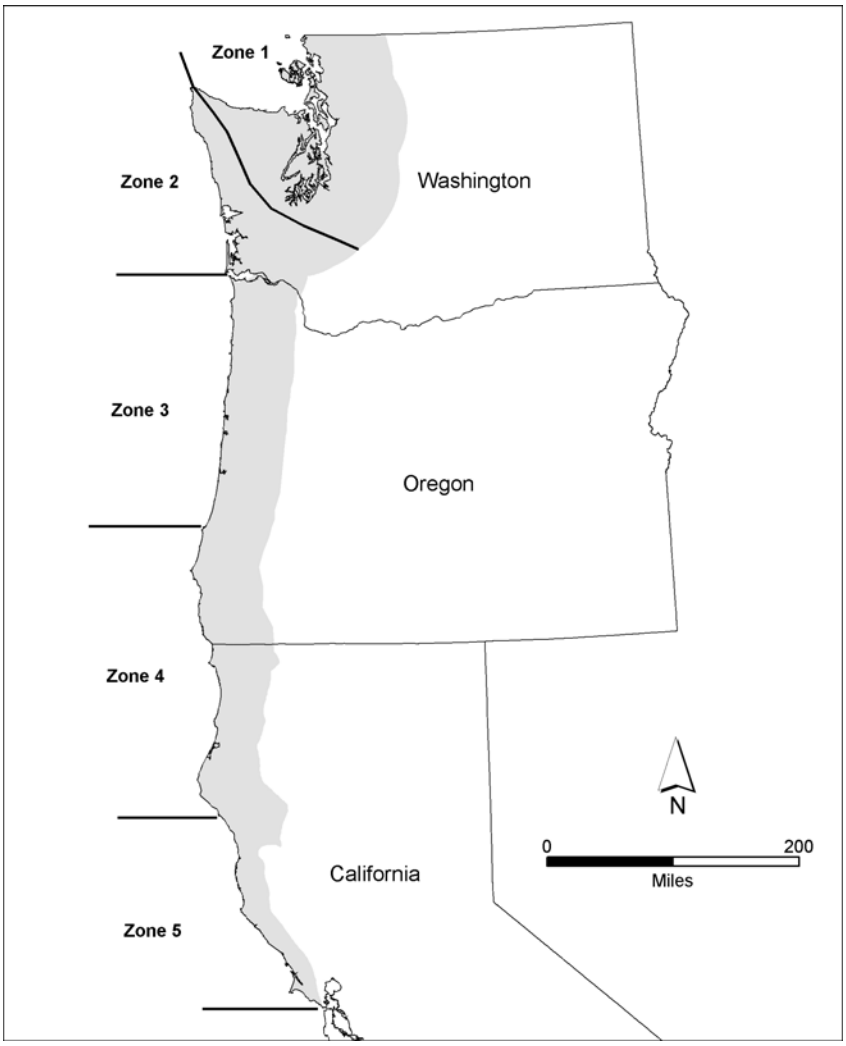


Figure 1. The five at-sea marbled murrelet survey zones adjacent to the NWFP area. Inland breeding distribution is shaded (adapted from USDI Fish and Wildlife Service 1997).

RESULTS AND DISCUSSION

Population Monitoring

The 2008 estimated murrelet population size in Conservation Zones 1 through 5 was 17,800 birds (Table 1). Among conservation zones, Zone 3 had the highest population estimate in 2008 (about 6,200) and Zone 4 the highest density (4.18 birds/km^2). A summary of results for Conservation Zones 1 through 5 combined is provided in Table 1 and Figure 2. Table 2 provides the 2008 density and population estimates for each conservation zone and includes related estimation parameters generated by the program DISTANCE. Figure 3 provides a comparison of yearly population estimates by conservation zone, while Figure 4 provides murrelet density (birds/km^2) by zone.

The area of coastal waters sampled by the NWFP at-sea surveys in 2008 was approximately 8,785 km^2; sampled areas vary by zone, as indicated in Table 2.

The relative variation in density estimates can be measured by the coefficient of variation (CV; the standard error divided by the mean, and then multiplied by 100). For the combined 5-zone density estimate, the CV has ranged from ~8 to 13 percent since 2000 (Table 1), with 2008 at the lower end of this range at 9 percent. At the scale of individual zones, CVs are typically larger, and ranged from ~15 to 51 percent in 2008 (Table 2), comparable to results in previous years (Falxa et al. 2008). As expected, variation tended to be largest in zones and strata with low densities.

Table 1. Summary of 2000-2008 murrelet density and population size estimates (rounded to nearest 100 birds) in Conservation Zones 1 through 5 in the area of the Northwest Forest Plan.

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
2000	2.11	0.30	14.2	18,600	13,400	23,700
2001	2.52	0.27	10.5	22,200	17,600	26,800
2002	2.69	0.31	11.5	23,700	18,300	29,000
2003	2.53	0.24	9.5	22,200	18,000	26,400
2004	2.34	0.27	11.5	20,600	16,000	25,200
2005	2.30	0.25	10.8	20,200	16,000	24,500
2006	2.14	0.17	8.0	18,795	15,900	21,700
2007	1.98	0.26	13.4	17,400	12,800	21,900
2008	2.03	0.18	9.1	17,800	14,600	21,000

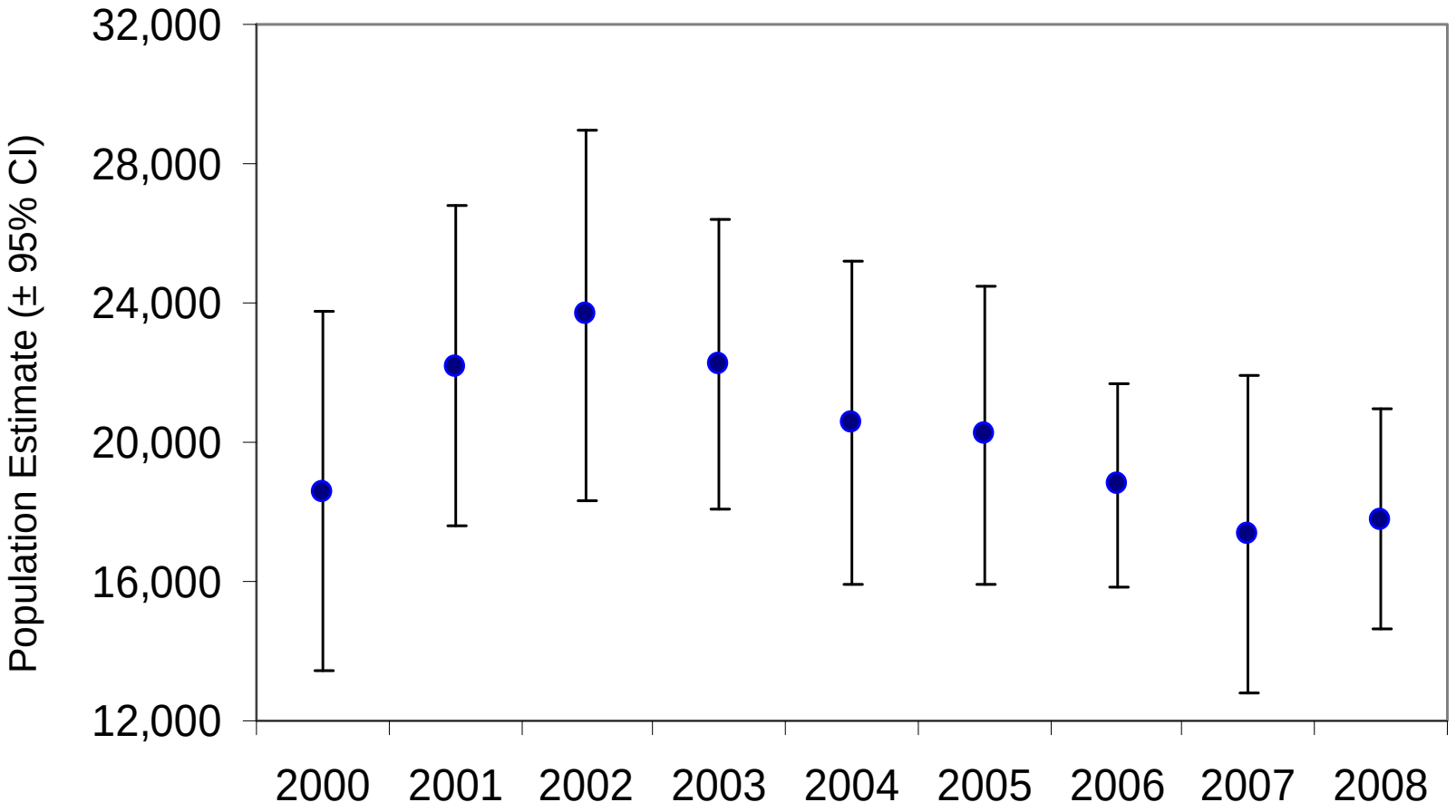
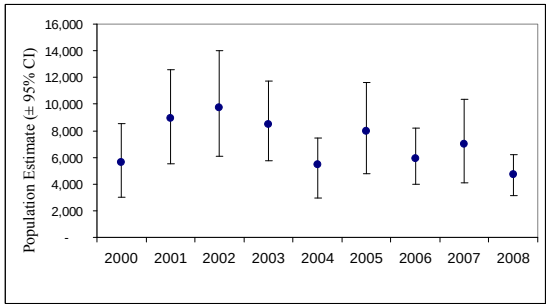


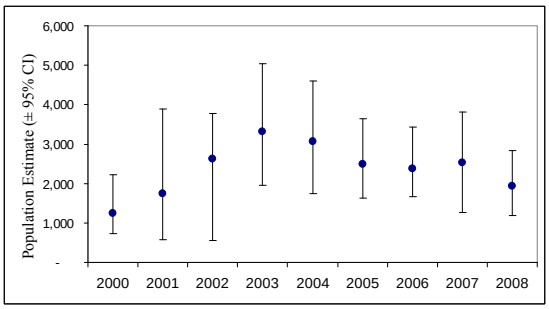
Figure 2. Annual marbled murrelet population estimates and 95 percent confidence intervals, for Conservation Zones 1 - 5 combined.

Table 2. Estimates of murrelet density and population size during the 2008 breeding season in the area of the Northwest Forest Plan. E(s), f(0), and truncation distance are parameters used by the program DISTANCE; see Raphael et al. (2007) for details.

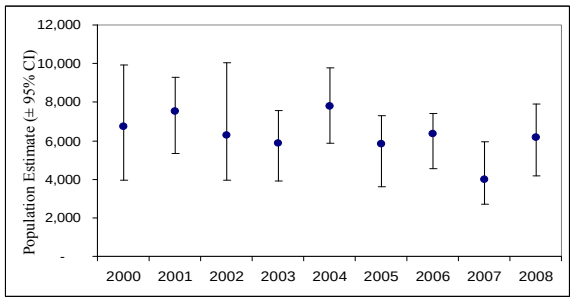
Zone	Stratum	Density (birds/km^2)	Bootstrap Standard Error (birds/km^2)	Coefficient of Variation of Density (%)	Birds	Birds Lower 95% CL	Birds Upper 95% CL	Survey Area (km^2)	Total Length of Survey Transects (km)	f(0)	Std. err. of f(0)	E(s)	Std. err. of E(s)	Truncation Distance (m)	Std. err. of Truncation Distance
1	1	3.57	0.86	24.1	3,019	1,586	4,339	845							
1	2	0.90	0.24	27.2	1,073	571	1,631	1,194							
1	3	0.42	0.13	31.1	607	227	953	1,458							
1	**All**	**1.34**	**0.23**	**17.0**	**4,699**	**3,132**	**6,201**	**3,497**	**2235**	**0.011**	**0.001**	**1.74**	**0.10**	**206**	**8.9**
2	1	2.60	0.56	21.5	1,887	1,146	2,781	724							
2	2	0.063	0.03	47.0	58	-	118	926							
2	**All**	**1.18**	**0.25**	**21.1**	**1,944**	**1,187**	**2,843**	**1,650**	**1528**	**0.011**	**0.003**	**1.54**	**0.08**	**187**	**33.9**
3	1	0.35	0.10	27.7	229	106	350	661							
3	2	6.36	1.02	15.9	5,948	3,876	7,658	935							
3	**All**	**3.87**	**0.60**	**15.4**	**6,176**	**4,175**	**7,903**	**1,595**	**1122**	**0.011**	**0.001**	**1.75**	**0.07**	**130**	**10.8**
4	1	5.87	1.25	21.4	4,306	3,115	6,600	734							
4	2	1.28	0.54	41.8	544	304	1,165	425							
4	**All**	**4.18**	**0.81**	**19.4**	**4,850**	**3,688**	**7,325**	**1,159**	**802**	**0.009**	**0.001**	**1.71**	**0.05**	**190**	**10.9**
5	1	0.12	0.08	65.3	52	-	159	441							
5	2	0.16	0.12	73.6	69	-	127	441							
5	**All**	**0.14**	**0.07**	**50.5**	**121**	**-**	**242**	**883**	**385**	**0.009**	**0.001**	**1.71**	**0.05**	**190**	**10.9**
ALL	**ALL**	**2.03**	**0.18**	**9.1**	**17,791**	**14,631**	**20,952**	**8,785**	**6,071**						



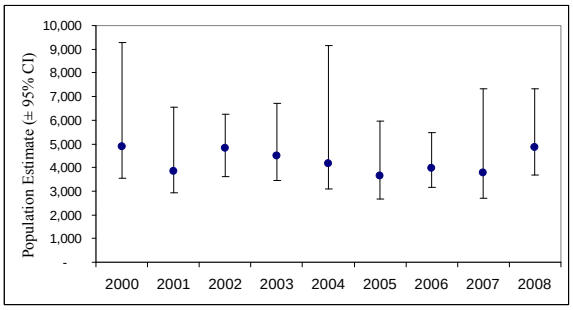
Zone 1



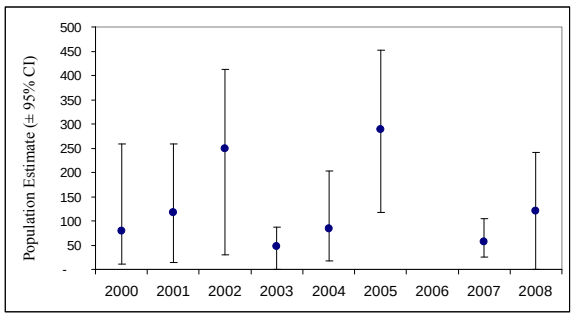
Zone 2



Zone 3



Zone 4



Zone 5

Figure 3. Annual marbled murrelet population estimates and 95 percent confidence intervals for each Conservation Zone, 2000 through 2008. Note that the scale of the vertical axes differs among graphs, most notably for Zone 5.

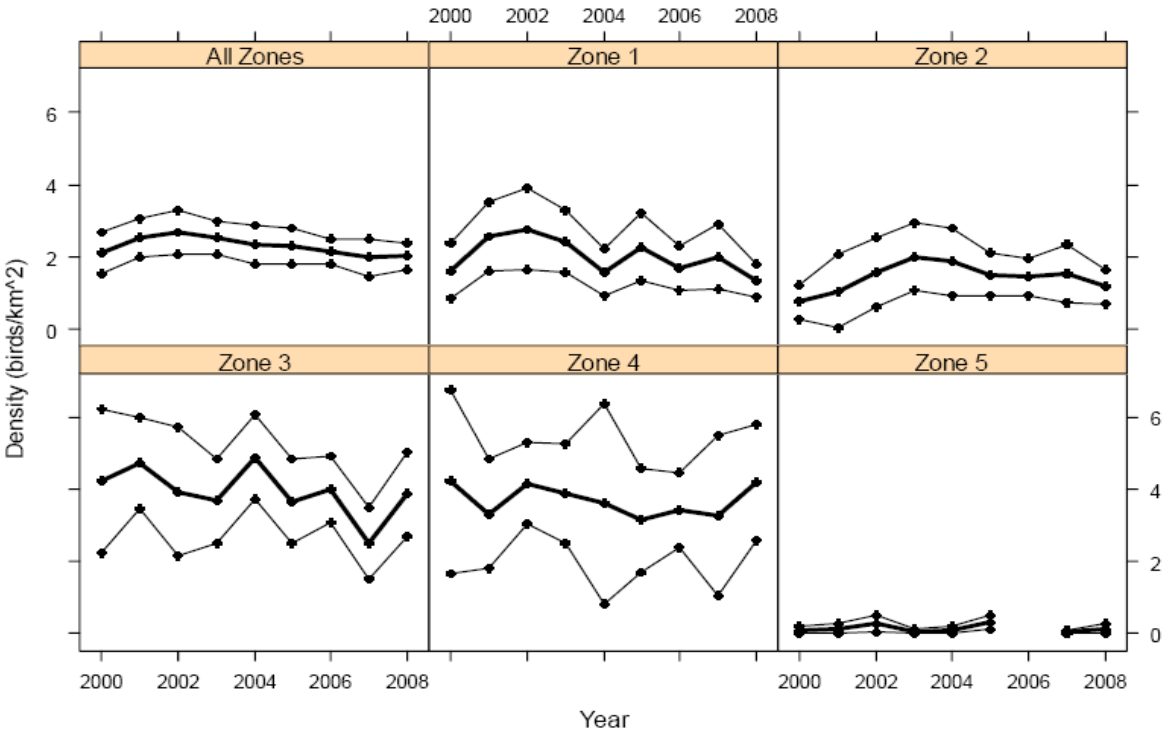


Figure 4. Estimated marbled murrelet densities (birds per square kilometer) for each Conservation Zone along with approximate 95 percent confidence intervals for years 2000 through 2008.

Trend Analysis

For the population of the 5 conservation zones combined, power analyses based on data collected from 2000 to 2003 estimated that with 9 years of annual sampling (the current sampling effort), an annual decrease of 5 percent could be detected with 95 percent power or greater, and that an annual decrease of 4 percent could be detected with lower (80 percent) power (Table 3a; Huff et al. 2006). More years of sampling are required to detect smaller rates of decline, or to achieve greater certainty (power) of detecting an actual decline of any given magnitude (avoiding a false negative, and thus incorrectly accepting the null hypothesis of no change in murrelet numbers when there actually was a decline). For individual zones, power to detect trends is often less. For only 2 zones (Zones 2 and 3) were 9 years of sampling adequate to detect an annual decline of less than 7 percent with high confidence (Table 3b, 95 percent power).

Population demographic models have predicted population declines in the range of 3 to 7 percent per year for this area (USDI Fish and Wildlife Service 1997; McShane et al. 2004). In 2007, we conducted a preliminary analysis for population trends using the 2000 through 2007 data, and detected no trend (Falxa et al. 2008). We repeated this analysis with the addition of the 2008 population data. As discussed in the Methods section, inspection of the data suggested that the 2000 estimate may have been unusually low, therefore we tested for trends for two periods: 1) 2000 through 2008, and 2) 2001 through 2008.

With the addition of 2008 data we detected a significant population decline for the combined 5-zone area, both for the 2000-to-2008 and 2001-2008 periods (Figure 5, Tables 4 and 5). For the analysis based on the 2000-2008 data, we estimate that there was a loss of 490 (SE of 241) birds per year. For the analysis based on the shorter 2001-2008 period, the estimated loss was 870 (SE of 129) birds per year; note that the losses are rounded to the nearest 10 birds. The estimated rate of decline is greater for the shorter period, because of the effect of the relatively low population estimate for 2000 on the 2000-2008 analysis.

The finding of a declining murrelet population for the combined five-zone area is consistent with declines as predicted by demographic models (USDI Fish and Wildlife Service 1997, McShane et al. 2004). Those models estimated rates of annual decline of about 3-to-7 percent based on the data available at the time. The slope of the regression line for the 2000-2008 data represents a 2.4 percent annual decline, and the regression slope for 2001-2008 represents an annual decline of about 4.3 percent (Tables 4 and 5, Figure 5).

The *P*-value provides a test of whether the population trend (regression slope) is stable (slope equals zero) or declining (slope less than zero). With *P*-values of 0.04 (2000-2008) and 0.0003 (2001-2008), this means that if there was in fact no trend, we had a 4 percent (0.03 percent for 2001-2008) probability of observing an average annual decline as large or larger than what we observed. While the estimated rate of decline has some uncertainty as indicated by the standard errors (Tables 4 and 5), these low *P*-values indicate a relatively high level of confidence that a declining trend exists, with our 2 estimates of the rate of decline ranging from 2.3 to 4.3 percent per year.

We can conclude that a declining trend exists, but do not know which analysis period, 2000-2008 or 2001-2008, best represents the magnitude of the decline during the sampling period. As noted earlier, the cause for the lower estimate in 2000 is not known. Departures from the sampling protocol did occur in 2000. The geographic area where the departures occurred (Zone 2 and stratum 1 of Zone 1) did have low estimates in 2000 compared to subsequent years (Figures 3 and 4), and these low estimates contributed substantially to the low 5-zone population estimate for 2000. We do not know if those departures from protocol biased the estimate downwards, or if the 2000 estimate was an unbiased estimate of abundance. However, the departures were not of a nature expected to systematically result in underestimates.

We also conducted preliminary trend analyses for each zone (Table 4). No trends were detected at the scale of individual zones for the 2000-2008 analysis, as would be expected based on the generally low power to detect trends at the single-zone scale with 9 years of sampling. However, the 2001-2008 analysis showed a significant decline in Zone 1. As noted earlier, the variability in population estimates generally increases at smaller spatial scales such as zone, compared to estimates for all zones combined, and with 9 years of data, the regression analysis can be sensitive to a single year of data that is above or below the regression line. Also, in Zone 3 the trend was not significant at the $P \leq 0.05$ level, but the low *P*-value (0.07 for 2000-2008) is consistent with a decline.

Table 3a. Estimate of the number of years of survey needed to detect various percentages of annual decrease in the NWFP murrelet population with 80 percent power or greater, in all Conservation Zones combined or by individual zone. Based on power analysis in Huff et al. (2006; Chapter 3).

Annual Decrease Rate (%)	Zone					
	All	1	2	3	4	5
2	13	21	11	13	16	52
3	10	16	8	10	12	39
4	8	14	7	8	10	33
5	7	12	6	7	9	28
6	7	11	6	7	8	25
7	6	10	5	6	7	23
8	6	9	5	6	7	21
9	6	8	5	6	7	19
10	5	8	5	5	6	18

Table 3b. Estimate of the number of years of survey needed to detect various percentages of annual decrease in the NWFP murrelet population with 95 percent power or greater, in all Conservation Zones combined or by individual zone. Based on power analysis in Huff et al. (2006; Chapter 3).

Annual Decrease Rate (%)	Zone					
	All	1	2	3	4	5
2	15	25	12	15	19	62
3	12	19	10	12	15	47
4	10	16	8	10	12	39
5	9	14	7	9	11	34
6	8	13	7	8	10	30
7	7	11	6	7	9	27
8	7	11	6	7	8	25
9	6	10	6	6	8	23
10	6	9	5	6	7	21

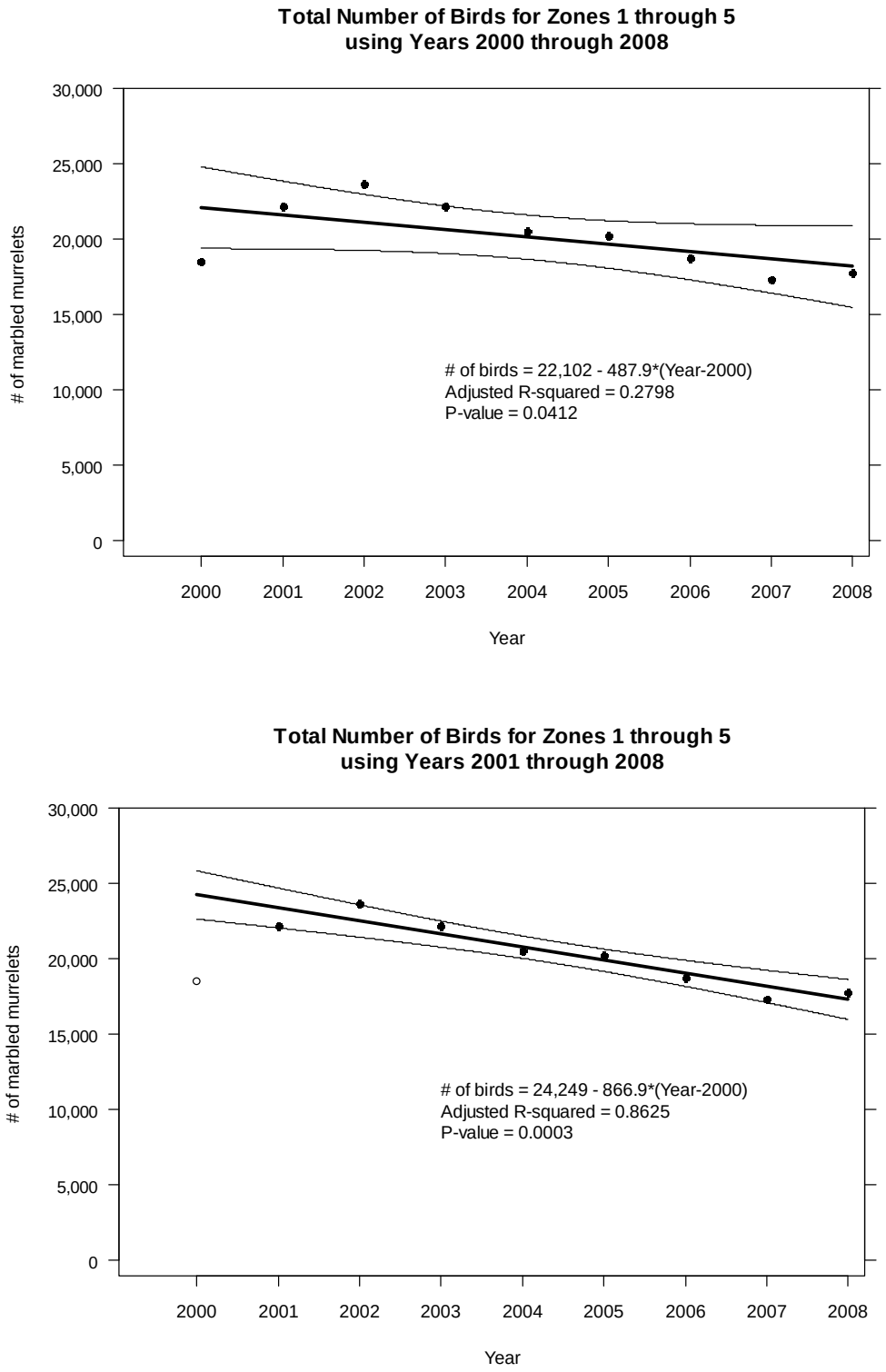


Figure 5. Results of trend analysis for Conservation Zones 1 through 5 combined, for the 2000 to 2008 (top) and 2001-2008 (bottom) periods. Graphs show regression lines through the annual population estimates for the period of analysis, with 95 percent confidence limits for line, and the regression equation and associated statistics.

Table 4. Estimates of average annual change, in terms of birds and percent of the mean number of birds, based on the 2000 to 2008 at-sea population surveys. Standard errors are for the estimates of annual change in terms of numbers of birds. The *P*-value is for testing whether the annual change is zero or a negative value less than zero.

Zone	Mean # of birds	Estimate of Annual change			*P*-value for a decline
		Birds	% of mean	Std. Err.	
1	7,089	-295	-4.2%	216	0.1071
2	2,371	64	2.7%	85	0.7605
3	6,286	-211	-3.3%	129	0.0731
4	4,273	-47	-1.1%	66	0.2473
5	135	1	1.0%	12	0.5427
All	**20,154**	**-488**	**-2.4%**	**241**	**0.0412**

Table 5. Estimates of average annual change, in terms of birds and percent of the mean number of birds, based on the 2001 to 2008 at-sea population surveys. Standard errors are for the estimates of annual change in terms of numbers of birds. See Table 4 for additional information.

Zone	Mean # Of birds	Estimate of Annual change			*P*-value for a decline
		Birds	% of mean	Std. Err.	
1	7,270	-577	-7.9%	183	0.0099
2	2,511	-29	-1.1%	86	0.3756
3	6,231	-254	-4.1%	163	0.0854
4	4,198	-3	-0.1%	78	0.4862
5	142	-4	-2.9%	15	0.3924
All	**20,351**	**-867**	**-4.3%**	**129**	**0.0003**

Habitat Monitoring

In 2008, the murrelet habitat monitoring team continued work to prepare for the upcoming reanalysis of the amount and distribution of nesting habitat. The team worked on modifications to the habitat models used for the initial 1994-2003 analyses, taking advantage of improved data sources and modeling approaches. The team continued testing of the Interagency Mapping and Assessment Project (IMAP) data, a key new data source which maps vegetation structure and composition for the Plan area. IMAP uses Gradient Nearest Neighbor (GNN) methods to combine satellite imagery data with on-the-ground vegetation plot data to create vegetation maps. The team also continued work to compare the performance of the BioMapper/ENFA and Resource Selection Function (RSF) models for predicting the location and quality of potential nest habitat, and has tentatively decided to use RSF models. Another new source is location data for all known murrelet nest sites in the Plan area. Team members assembled location data on known murrelet nests, found eggshells, and grounded downy chicks from across the NWFP area. This set of nest locations will be used to develop and test models of nesting habitat suitability.

MONITORING PROGRAM CONSIDERATIONS

Funding to maintain annual at-sea surveys continues to be a challenge. The U.S Fish and Wildlife Service has committed to fund the at-sea surveys for the near future, and surveys will be conducted in 2009. Testing and selection for models of murrelet nesting habitat are being conducted in 2009, with final results for publication in the 15-year update on the NWFP, which is expected to be completed in mid-2010. In early 2009, the murrelet monitoring team was honored with a Wings Across the Americas award for "Bird Research and Management Partnership"; Wings Across the Americas is a U.S. Forest Service program to conserve birds, bats and butterflies. In late 2008, Katie Dugger joined the monitoring effort to assist the 15-year nesting habitat analyses in habitat modeling, biometrics and other aspects. Dr. Dugger is a researcher on the faculty in the Department of Fisheries and Wildlife at Oregon State University.

RECENT PROGRAM PRODUCTS

Earlier program products are listed in previous reports, which are available at: http://www.reo.gov/monitoring/reports/marbled-murrelet-reports-publications.shtml. The following recent publications and reports were published in association or collaboration with the Marbled Murrelet Effectiveness Monitoring Program in the last 2 years:

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. Available at: http://www.reo.gov/monitoring/reports/marbled-murrelet-reports-publications.shtml

Lance, M.M.; Pearson, S.F.; Raphael, M.G.; Bloxton, T.D. 2009. 2008 at-sea marbled murrelet population monitoring: Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, WA. 17 pp.

Long, L.L; Miller, S.L; Ralph, C.J.; Elias, E.A. 2008. Marbled murrelet abundance, distribution, and productivity along the coasts of northern California and southern Oregon, 2005-2007. Report to U.S. Fish and Wildlife Service and Bureau of Land Management, Arcata, CA. U.S. Department of Agriculture, Forest Service, Redwood Sciences Laboratory, Arcata, CA. 44 p.

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 online at: http://www.fs.fed.us/pnw/pubs/pnw_gtr716.pdf

Raphael, M.G., and R. Molina, editors. 2007. Conservation of rare or little-known species: biological, social, and economic considerations. Island Press, CA. 392 p.

Strong, C.S. 2009. Population and productivity monitoring of marbled murrelets in Oregon during 2008. Report to the U.S. Fish and Wildlife Service, Portland, Oregon. Crescent Coastal Research, Crescent City, CA. 13 p.

Strong, C.S. 2009. Seabird abundance and distribution during summer off the Oregon and southern Washington coast. Report to National Fish & Wildlife Foundation and USFWS Columbia River Estuarine Fund. Crescent Coastal Research, Crescent City, CA. 46 p.

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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.

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.

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