Marbled Murrelet Effectiveness Monitoring
Northwest Forest Plan

2001 Annual Summary Report

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EXECUTIVE SUMMARY

The purpose of the Marbled Murrelet Effectiveness Monitoring Plan is to assess trends in marbled murrelet (*Brachyramphus marmoratus*) populations and their nesting habitat throughout the range of the Northwest Forest Plan (NWFP). This report summarizes activities of the Marbled Murrelet Effectiveness Monitoring Program during fiscal year 2001 (FY01). This report serves as a follow-up to the 2000 Annual Report (Bentivoglio et al. 2002), although it is not as extensive in terms of detailing methodology and sampling designs. This report does, however, make note of any changes to the monitoring program since the 2000 field season. This program has two components: population monitoring, which occurs at sea, and monitoring of nesting habitat, which occurs at inland forest sites.

The objectives of the population monitoring component are to: (1) estimate the size of the marbled murrelets population that resides in the coastal waters adjacent to the land area covered by the NWFP, and (2) assess trends in population size over time. Each objective provides results within each of five murrelet conservation zones and also across the range of the NWFP (i.e., across all five conservation zones).

Murrelet population surveys were conducted from mid-May through late July in 2001 in all five of the murrelet conservation zones within the range of the NWFP. The population of marbled murrelets that resides within the range of the NWFP was estimated to be 21,268 and the 95% confidence interval ranged from 15,941 to 26,595. The density of marbled murrelets was highest in zone 3 (the Oregon Coast north of Coos Bay) while the population of murrelets was highest in zone 1 (Puget Sound and the Strait of Juan de Fuca in Washington). The 2001 population estimate does not appear to be dissimilar to the population estimate from 2000 (18,097 murrelets with a 95% confidence interval ranging from 12,991 – 23,202).

Survey data from 2001 represent only the second year of population monitoring data collected under the Effectiveness Monitoring Program. At this point in time it is still too early to try and detect biologically meaningful changes in estimates of either density or population size. For example, power analyses conducted at the conclusion of the 2000 survey season indicated that it may take at least 8 years to detect a decline in the population of 10% with a reasonable degree of statistical certainty. Limitations on the interpretation of these survey results are discussed in the section titled Monitoring Program Considerations.

The objectives of the habitat monitoring component of the Effectiveness Monitoring Program is to establish a credible nesting-habitat baseline as well as to assess status and trends of marbled murrelet nesting habitat in the NWFP area. Here, we discuss one type of predictive model being developed (referred to here as the habitat relationship (HR) model, referred to in previous documents as the nonmap model). The goal of the HR model process was to develop a single, statistically derived, NWFP-wide, predictive model of murrelet nesting habitat. Its specific objectives were to: (1) collect information on murrelet habitat characteristics from a random sample of occupied and unoccupied (or, in California, random) sites in each physiographic province of the NWFP area; (2) for each site, compile vegetation and fragmentation data from remote imagery developed by the Interagency Vegetation Mapping Project (IVMP); and (3) build

predictive statistical models of marbled murrelet habitat associations based on data sets developed in objectives 1 and 2 above.

As part of the habitat-monitoring program, we collected vegetation and habitat data (e.g., canopy cover, number of crown layers) from 51 sites and 428 plots during 2001. These sites were located in four of the 12 provinces located within the NWFP area (Olympic, Oregon Coast, Klamath, and California Coast). We also collected a suite of individual tree measurements (e.g., DBH, number of platforms, crown diameter) from ca. 10,500 trees across the four provinces. We have not conducted any analyses on these data because they are not yet complete. Data must still be collected from 126 sites in five additional provinces.

Population surveys and collection of nesting habitat data will continue in 2002. No major changes in methodology or sampling designs are scheduled. Annual reports are anticipated for the 2002 and 2003 field seasons. The full monitoring interpretive report is scheduled for completion in 2004, and it will include analyses of population and nesting habitat data.

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Introduction

The purpose of the Marbled Murrelet Effectiveness Monitoring Plan is to assess trends in marbled murrelet populations and their nesting habitat throughout the range of the Northwest Forest Plan (NWFP or Forest Plan). Madsen et al. (1999) developed a two-tiered approach to effectiveness monitoring for the murrelet under the Forest Plan that relies upon population monitoring at-sea and monitoring of nesting habitat inland. Ultimately, we will attempt to assess the relationship between murrelet populations and habitat via predictive models. This has yet to be initiated, however.

The goal of the population monitoring component is to estimate the size of the population of marbled murrelets that resides in the coastal waters adjacent to the land area covered by the NWFP and to assess trends in that population over time. The population team developed a sampling design and standardized survey methods that were implemented throughout the Forest Plan area beginning in the 2000-breeding season. Therefore, 2001 represents the second year of data collected under this standardized survey methodology. Trends in population abundance and nesting habitat will continue to be tracked annually.

Inland, the goal is to establish a credible nesting-habitat baseline and assess trends in nesting habitat over time. We are developing a habitat relationship model (previously referred to as nonmap model; Bentivoglio et al. 2002) that will be used to quantify availability of murrelet habitat throughout the range of the NWFP. Here, we present preliminary results from initiation of the habitat relationship model, which focuses on collection of site-based vegetation data. The development of a second type of model that relies on satellite imagery (the map model; Bentivoglio et al. 2002) is only in the early stages of development and hence will not be discussed in this report.

This report, therefore, summarizes activities of the Marbled Murrelet Effectiveness Monitoring Program during fiscal year 2001 (FY01). Each of the following sections will address both population and habitat monitoring.

METHODS

Population Monitoring

In general, the methodology for assessing the population of marbled murrelets consists of a series of boat-based transects conducted in the nearshore environment from mid-May through mid-July. A basic description of the survey methods appears herein, while a more detailed account is available in the 2000 annual report (Bentivoglio et al. 2002). Here, we also note any changes that were made to the survey protocol between 2000 and 2001.

We subdivided the target population into the Conservation Zones identified in the Marbled Murrelet Recovery Plan (USFWS 1997; Fig. 1). Within this region, we conducted boat-based surveys in waters within 2 - 8 km of shore. Surveys were conducted from mid-May through late-July, the period when breeding birds at sea are likely to be associated with inland nesting habitat in the Forest Plan area. In each zone, researchers identified two or three areas along the coast (hereafter referred to as strata) where densities of murrelets appeared to be similar within the area

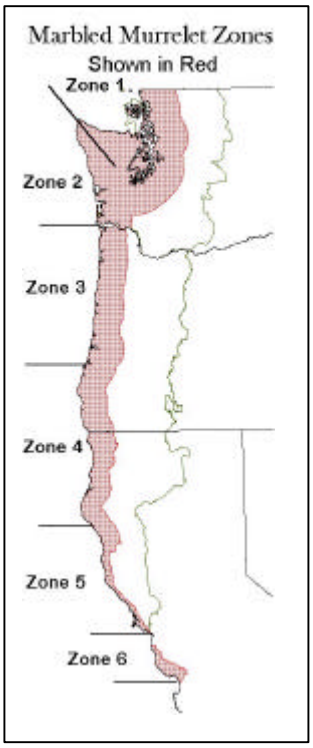

Fig. 1. Marbled Murrelet Conservation Zones.

but substantially different from adjoining areas. We sampled in each stratum, but did not estimate murrelet density or population separately for each stratum. This sampling design was implemented to reduce error rates associated with density and population estimates.

These surveys and the associated analytical approach produced statistically defensible estimates of average marbled murrelet densities (average numbers of birds per square km for the target period) for the target population, with associated defensible estimates of precision. This was done for each zone, separately, and also for the entire target population consisting of all zones combined. We produced total population and density estimates of murrelets from standard methods for stratified sampling. We produced estimates of precision by using a complex application of bootstrap resampling methods. A far more detailed description of analytical methods is available in the 2000 Annual Report (Bentivolgio et al. 2002).

Changes in methodology for population monitoring.-- We instituted one major change in sampling methodology between 2000 and 2001 and this was restricted to zone 2 and stratum 1 of zone 1. Due to a computer software problem that occurred while data were being recorded during surveys in zone 2 and zone 1 stratum 1 in 2000, we lost many of the distance measures (i.e., distance from the surveyor vessel to the observed murrelet) that are required in DISTANCE sampling. Therefore, the line transect estimation method (using Distance 3.5) could not be used to estimate the necessary parameter $f(0)$. In zone 2, we instead used a fixed-width transect of width 200 m (100 m on each side of the boat) for estimating density and the total number of birds. Population and density estimates derived from fixed-width samples are expected to be biased low compared to estimates that would have been derived from distance sampling. The degree of this bias is, however, unknown. In 2001 all distance measurements were available in zone 2 and the line transect estimation method (using Distance 3.5) was used in the same manner as all other zones.

Different methods of estimation for Zone 1 also were performed in 2000 and 2001. Details of the estimation procedure used in 2000 are available in the 2000 annual report. In 2001 all distance measurements were available throughout all strata within zone 1 and the line transect estimation method (using Distance 3.5) was used in the same manner as all other zones.

One further difference in sampling design occurred in zone 1 stratum 3. In 2000 this stratum was sampled via transects that were oriented parallel to the shoreline, whereas in 2001 this stratum was sampled with transects that were oriented in a zigzag pattern relative to the shoreline (see the methods section in the 2000 Annual Report for a description of this transect layout).

Habitat Monitoring

A sample of occupied (n = 20) and unoccupied or random sites (n = 20) were selected from each of the six physiographic provinces located within the NWFP area that encompasses the range of the murrelet: the Olympic Peninsula, Washington Cascades, and Western Washington Lowlands provinces in Washington; the Coast Range and Klamath Mountain provinces in Oregon; and the California Coastal Province in California. Survey sites were considered for collection of habitat data only if they met the criteria of the Pacific Seabird Group's Marbled Murrelet Forest Survey Protocol (Ralph et al. 1994 and subsequent revisions, Evans et al. 2000). Therefore, we only included data from sites that were surveyed in or after 1994 (i.e. year of protocol inception) and that also met the requirements of having eight station visits during two years with a minimum of three visits in one year.

For our monitoring purposes, a site was considered "occupied" if surveys conducted in that site ever yielded a detection of a murrelet that was classified as "occupied". Sites with murrelet "presence" only (i.e., birds detected but not with behaviors that indicate occupation) were omitted from all analyses, as birds detected during such surveys cannot be positively associated with a particular forest stand (Cooper and Blaha in review). If murrelets were not detected, the station's status was defined as "unoccupied". For provinces without a large sample of unoccupied sites (primarily those in California), random sites were chosen from state and federal lands with stands of old growth and mature forests, and younger stands with a residual component (i.e., areas that would need to be surveyed in advance of any activities that might alter habitat). In all cases, site boundaries were identified by using information provided by the agency that conducted the original murrelet survey and/or by digitizing the station locations into GIS coverages. Each site was then assigned the appropriate murrelet status based on survey results.

Vegetation data were collected from nested 13- and 25-m radius plots randomly located in each of the randomly selected murrelet survey sites. We established 8 – 10 plots within each site, irrespective of the size of the site. We collected data on tree species and tree diameter (dbh, cm) on all trees 25-50 cm dbh in the 13-m plots but only on trees >50 cm dbh in the 25-m plots. Within the 25-m plot we also collected the following data: number of trees with platforms (where a platform was defined as any structure $\geq$10 cm in diameter and $\geq$10 m above the ground) and number of platforms, diameter of each platform, moss coverage, crown diameter, canopy cover (%), and number of canopy layers.

Each vegetation survey was overlaid on remotely-sensed data from the IVMP maps and aerial photos and information obtained on slope, aspect, elevation, distance to ocean, distance to nearest stream, and distance to openings (natural and man-made). We also derived a variety of landscape variables using program FRAGSTATS (McGarigal and Marks 1995). These steps are in the early stages of development and so are not reported herein.

Although we have not yet initialized analyses, a short description of the planned approach follows. A set of *a priori* nesting-habitat models will be developed and then analyzed using logistic regression. The binary dependent variable will indicate murrelet status at the site (i.e., occupied or not occupied). The independent variables available for use in the modeling exercise

will include data from our ground plots, satellite imagery, GIS layers, and spatial variables derived using the program FRAGSTATS. Final model suitability will be evaluated based on: (1) Akaike Information Criterion [AIC]), and (2) biological significance and practical application. We will assess the predictive ability of the models by either reserving a number of sites from the modeling exercise to be used for validation purposes or by using cross validation techniques.

RESULTS

Population Monitoring

Zone-specific results.-- At-sea surveys were conducted in zone 1 (Puget Sound and the Strait of Juan de Fuca, Washington; Fig. 1) from 21 May through 31 July in 2001. A total of 60 primary sampling units (PSUs) were sampled, resulting in 2,158 km of transects covering an area of 3,494 km^2 (Table 1). We estimated that the density of murrelets in zone 1 was 2.41 $\pm$ 0.45 birds/ km^2 (Table 2). Murrelet density was greater in stratum one than in strata two or three. The population estimate for zone 1 was 8,421 murrelets and the 95% confidence interval ranged from 5,506 to 11, 882.

Table 1. Summary of analysis statistics from marbled murrelet marine surveys in conservation zone 1, 21 May – 31 July 2001.

Analysis parameter	Entire zone	Stratum 1	Stratum 2	Stratum 3
Number of km surveyed	2,158	354.9	1603.2	200.0
Number of Sampling Units sampled	60	10	40	10
Number of murrelets	1,086	463	583	40
Number of murrelet groups	649	272	348	29
Area of zone (km^2)	3,494	840	1,196	1,459
Truncation point (m)	142	--[a]	--	--
Probability of detection on the line–f(0)	0.012	--	--	--
Average cluster size–E(S)	1.620	--	--	--
Encounter rate (number of birds/km)[b]	0.487	1.241	0.352	0.324

[a]Dashes indicate that estimates were not available by stratum.
[b]Encounter rate = (no. murrelet groups observed within (i.e., $\leq$) truncation zone / total transect length) * E(S). These two footnotes also apply to Tables 3, 5, 7, and 9.

Table 2. Summary of marbled murrelet population statistics for conservation zone 1, 21 May – 31 July 2001.

Population parameter	Entire zone	Stratum 1	Stratum 2	Stratum 3
Density (number of birds/km^2)	2.408	4.259	1.665	1.955
Coefficient of variation of density (%)	18.9	25.1	22.5	36.9
Population estimate	8,421	3,579	1,991	2,852
95% confidence interval on population estimate	5,506 – 11,882	2,354 – 5,677	944 – 2,790	383 – 4,870

At-sea surveys were conducted in zone 2 (outer coast of Washington; Fig. 1) from 16 May through 26 July in 2001. A total of 28 PSUs were sampled, resulting in 938 km of transects covering an area of 1,688 km^2 (Table 3). We estimated that the density of murrelets in zone 2 was 1.14 $\pm$ 0.35 birds/ km^2 (Table 4). Murrelet density was greater in stratum one than in stratum two. The population estimate for zone 2 was 1,918 murrelets and the 95% confidence interval ranged from 957 to 3,173.

Table 3. Summary of analysis statistics from marbled murrelet marine surveys in conservation zone 2, 16 May – 26 July, 2001.

Analysis parameter	Entire zone	Stratum 1	Stratum 2
Number of km surveyed	937.8	688.1	351.2
Number of Sampling Units sampled	28	16	12
Number of murrelets	230	205	25
Number of murrelet groups	154	136	18
Area of zone (km^2)	1,688	727	961
Truncation point (m)	80		
Probability of detection on the line–f(0)	0.014		
Average cluster size–E(S)	1.466		
Encounter rate (number of birds/km)	0.241	0.290	0.075

Table 4. Summary of marbled murrelet population statistics for conservation zone 2, 16 may – 26 July 2001.

Population parameter	Entire zone	Stratum 1	Stratum 2
Density (number of birds/km^2)	1.136	2.051	0.444
Coefficient of variation of density (%)	30.5	33.5	77.9
Population estimate	1,918	1,491	427
95% confidence interval on population estimate	957 – 3,173	579 –2,380	145 – 1,432

At-sea surveys were conducted in zone 3 (Oregon coast north of Coos Bay; Fig. 1) from 6 June through 29 July in 2001. A total of 32 PSUs were sampled, resulting in 1,067 km of transects covering an area of 1,580 km^2 (Table 5). We estimated that the density of murrelets in zone 3 was 4.36 $\pm$ 0.64 birds/ km^2 (Table 6). Murrelet density was greater in stratum two than in stratum one. The population estimate for zone 3 was 6,879 murrelets and the 95% confidence interval ranged from 5,389 to 9,423.

Table 5. Summary of analysis statistics from marbled murrelet marine surveys in conservation zone 3, 6 June – 29 July 2001.

Analysis parameter	Entire zone	Stratum 1	Stratum 2
Number of km surveyed	1,066.8	397.3	669.5
Number of Sampling Units sampled	32	12	20
Number of murrelets	1,282	129	1,153
Number of murrelet groups	716	77	639
Area of zone (km^2)	1,578.5	645	934
Truncation point (m)	140		
Probability of detection on the line–f(0)	0.015		
Average cluster size–E(S)	1.749		
Encounter rate (number of birds/km)	1.174	0.339	1.669

Table 6. Summary of marbled murrelet population statistics for conservation zone 3, 6 June – 29 July 2001.

Population parameter	Entire zone	Stratum 1	Stratum 2
Density (number of birds/km^2)	4.358	1.629	6.241
Coefficient of variation of density (%)	14.8	26.7	16.0
Population estimate	6,879	1,133	5,829
95% confidence interval on population estimate	5,389 – 9,243	554 –1,676	4,420 – 7,962

At-sea surveys were conducted in zone 4 (Oregon coast south of Coos Bay to California coast just south of Cape Mendocino; Fig. 1) from 25 may through 31 July in 2001. A total of 40 PSUs were sampled, resulting in 1,421 km of transects covering an area of 1,165 km^2 (Table 7). We estimated that the density of murrelets in zone 4 was 3.33 $\pm$ 1.52 birds/ km^2 (Table 8). Murrelet density was greater in stratum one than in stratum two. The population estimate for zone 4 was 3,888 murrelets and the 95% confidence interval ranged from 2,901 to 6,567.

Table 7. Summary of analysis statistics from marbled murrelet marine surveys in conservation zone 4, 25 May – 31 July 2001.

Analysis parameter	Entire zone	Stratum 1	Stratum 2
Number of km surveyed	1,421.3	547.5	873.8
Number of Sampling Units sampled	40	24	16
Number of murrelets	1,051	749	302
Number of murrelet groups	585	404	181
Area of zone (km^2)	1,165.3	738.6	426.7
Truncation point (m)	170		
Probability of detection on the line–f(0)	0.010		
Average cluster size–E(S)	1.748		
Encounter rate (number of birds/km)	0.719	1.290	0.362

Table 8. Summary of marbled murrelet population statistics for conservation zone 4, 25 May – 31 July 2001.

Population parameter	Entire zone	Stratum 1	Stratum 2
Density (number of birds/km^2)	3.335	4.648	1.062
Coefficient of variation of density (%)	45.5	46.8	53.3
Population estimate	3,888	3,435	453
95% confidence interval on population estimate	2,901 – 6,567	2,375 – 5,980	304 – 886

At-sea surveys were conducted in zone 5 (California coast just south of Cape Mendocino to California Coast just north of San Francisco Bay; Fig. 1) from 15 may through 22 July in 2001. A total of 24 PSUs were sampled, resulting in 602 km of transects covering an area of 885 km^2 (Table 9). We estimated that the density of murrelets in zone 5 was 0.13 $\pm$ 0.09 birds/ km^2 (Table 10). Murrelet density was greater in stratum one than in stratum two. The population estimate for zone 5 was 117 murrelets and the 95% confidence interval ranged from 30 to 276.

Table 9. Summary of analysis statistics from marbled murrelet marine surveys in conservation zone 5, 15 May – 22 July, 2001.

Analysis parameter	Entire zone	Stratum 1	Stratum 2
Number of km surveyed	601.7	433.7	168.0
Number of Sampling Units sampled	24	16	8
Number of murrelets	20	16	4
Number of murrelet groups	13	10	3
Area of zone (km^2)	884.7	442.4	442.3
Truncation point (m)	170		
Probability of detection on the line–f(0)	0.010		
Average cluster size–E(S)	1.748		
Encounter rate (number of birds/km)	0.038	0.040	0.031

Table 10. Summary of marbled murrelet population statistics for the 2001 breeding season in conservation zone 5.

Population parameter	Entire zone	Stratum 1	Stratum 2
Density (number of birds/km^2)	0.132	0.167	0.099
Coefficient of variation of density (%)	67.8	48.4	149.1
Population estimate	117	74	44
95% confidence interval on population estimate	30 – 276	11 – 122	0 – 184

Range-wide results.--We surveyed 184 PSUs across all five conservation zones, resulting in 6,287 km of transects covering an area of 8,811 km^2 (Table 11). We estimated that the density of murrelets across the range of the NWFP was 2.41 $\pm$ 0.30 birds/ km^2 (Table 11). The population estimate for the range of the NWFP was 21,223 murrelets and the 95% confidence interval ranged from 16,021 to 26,425.

Table 11. Summary of marbled murrelet population statistics for the 2001 breeding season across conservation zones 1-5.

Population parameter	Estimate
Area (km^2)	8,810.8
Density (number of birds/km^2)	2.408
Coefficient of variation of density (%)	12.5
Population estimate	21,223
95% confidence interval on population estimate	16,021 – 26,425

Habitat Monitoring

We collected vegetation and habitat data (e.g., canopy cover, number of crown layers; see Bentivoglio et al. 2002 for complete list) from 51 sites and 428 plots during 2001 (Table 12). These sites were located in four of the target provinces. Because data collection in each plot required much more time than expected, we decreased the number of plots in each site from 10 to eight early in the data collection process. We surveyed slightly more occupied sites and plots compared to unoccupied or random sites and plots (Table 12). We also collected a suite of individual tree measurements (e.g., DBH, number of platforms, crown diameter; see Bentivoglio et al. 2002 for complete list) from ca. 10,500 trees across the four provinces. We have not conducted any analyses on these data because they are not yet complete. We do present summary statistics for a select group of variables, however.

Table 12. Number, occupancy status, and province location of sites and plots for which vegetation surveys were completed in Washington, Oregon, and California, 2001.

Province (state)	No. occupied sites	No. unoccupied or random sites [a]	No. plots in occupied sites	No. plots in unoccupied or random sites [a]
Olympic Peninsula (WA)	8	7	64	56
Oregon Coast (OR)	11	8	92	70
Klamath Mountains (OR)	7	4	56	32
California Coast (CA)	2	4	18	32
Total	28	23	230	198

[a] Sites in WA and OR were classified as "murrelets absent" based on surveys; sites in CA were random sites and thus murrelet status is unknown.

We measured the canopy cover of conifers in each quadrant of each plot and took the average of these to represent the mean canopy cover of conifers for each plot. Preliminary results suggest that there were moderate differences in canopy cover between occupied and unoccupied sites in each province except the Klamath, although the direction of the difference varied among provinces (Table 13).

Table 13. Mean canopy cover (%) of conifers (dominants and co-dominants) in occupied and unoccupied or random plots from four provinces within the range of the NWFP. Data collection is incomplete and so results are preliminary.

	Occupied			Unoccupied or random		
Province	Mean	SE	n	Mean	SD	n
Olympic	53.3	2.7	64	65.7	2.2	56
Oregon Coast	45.7	2.1	100	56.5	2.1	70
Klamath	40.5	2.7	55	40.8	2.9	32
California Coast	58.7	3.9	18	35.2	1.9	31

We measured the crown diameter of each tree with $\geq$ 1 platform in each plot. There appeared to be moderate differences in mean crown diameter between occupied and unoccupied plots in each province except the Klamath, although the direction of the difference was inconsistent among provinces (table 14).

Table 14. Mean crown diameter (CDA; m) in occupied and unoccupied or random plots from four provinces within the range of the NWFP. Data collection is incomplete and so results are preliminary. Sampling unit is at the plot scale, so the mean CDA represents the mean of the plot means and n = number of plots.

	Occupied			Unoccupied or random		
Province	Mean	SE	n	Mean	SE	n
Olympic	11.1	0.2	64	9.7	0.2	56
Oregon Coast	8.4	0.3	84	9.7	0.4	46
Klamath	12.4	0.3	49	12.8	0.4	27
California Coast	13.9	0.5	18	11.7	0.3	30

We also measured availability of platforms in each tree. The proportion of trees within plots with platforms was 30.8% in the California Coast, 21.6% in the Klamath, 30.3% in the Olympic Peninsula, and 18.3% in the Oregon Coast Range. We estimated the number of available platforms in each tree (Table 15). There appeared to be more platforms in occupied stands compared to unoccupied stands in the Olympic and Oregon Coast provinces.

Table 15. Mean number of platforms/tree in occupied and unoccupied or random plots from four provinces within the range of the NWFP. Data collection is incomplete and so results are preliminary. Sampling unit is at the plot scale, so the mean platform count represents the mean of the plot means and n = number of plots.

	Occupied			Unoccupied or random		
Province	Mean	SE	n	Mean	SE	n
Olympic	2.4	0.3	64	1.4	0.2	56
Oregon Coast	2.3	0.2	100	0.7	0.1	70
Klamath	1.6	0.2	55	1.6	0.2	32
California Coast	2.3	0.3	18	2.0	0.4	31

We also estimated the percentage of moss coverage on platform trees (Table 16). There appeared to be more moss on platform trees in occupied stands compared to unoccupied or random stands in the Klamath and California Coast provinces, but little to no difference in the moss coverage between stand types in the Olympic or Oregon Coast provinces.

Table 16. Mean moss coverage (%) on platform trees in occupied and unoccupied or random plots from four provinces within the range of the NWFP. Data collection is incomplete and so results are preliminary. Sampling unit is at the plot scale, so the mean moss coverage represents the mean of the plot means and n = number of plots.

	Occupied			Unoccupied or random		
Province	Mean	SE	n	Mean	SE	n
Olympic	60.9	3.7	58	67.7	2.5	48
Oregon Coast	47.8	3.3	84	49.3	4.5	47
Klamath	25.0	3.8	49	2.6	0.8	27
California Coast	38.2	3.6	18	2.6	1.4	30

DISCUSSION

Population Monitoring

Inter-annual comparisons.-- Survey data from 2001 represent only the second year of population monitoring data collected under the Effectiveness Monitoring Program. Zone-by-zone comparisons of murrelet density estimates in 2000 and 2001 are shown in Figure 2. The overlap in SE bars within each zone but zone 2 suggest that the zone-specific estimates of murrelet density did not differ between years. In zone 2, the change in survey methodology that occurred between years makes it difficult to determine if the apparent increase in murrelet density was biologically meaningful. Similarly, the overlap in SE bars for the range-wide density estimate also suggests murrelet densities did not differ substantially between years (Fig. 3).

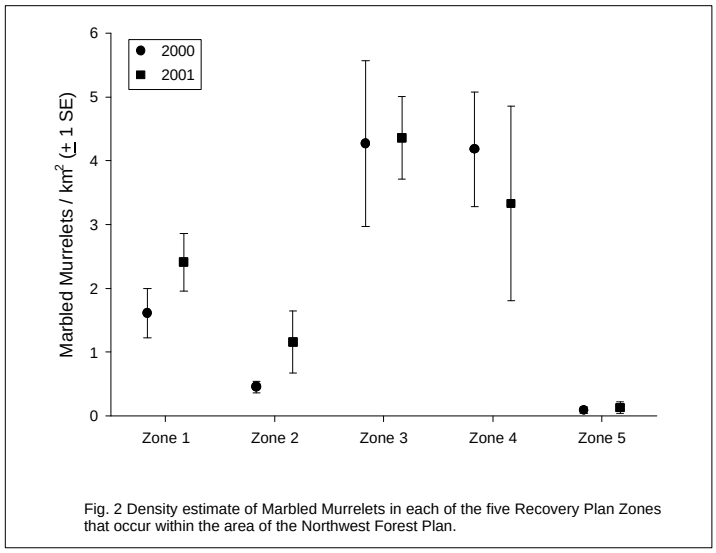

Fig. 2 Density estimate of Marbled Murrelets in each of the five Recovery Plan Zones that occur within the area of the Northwest Forest Plan.

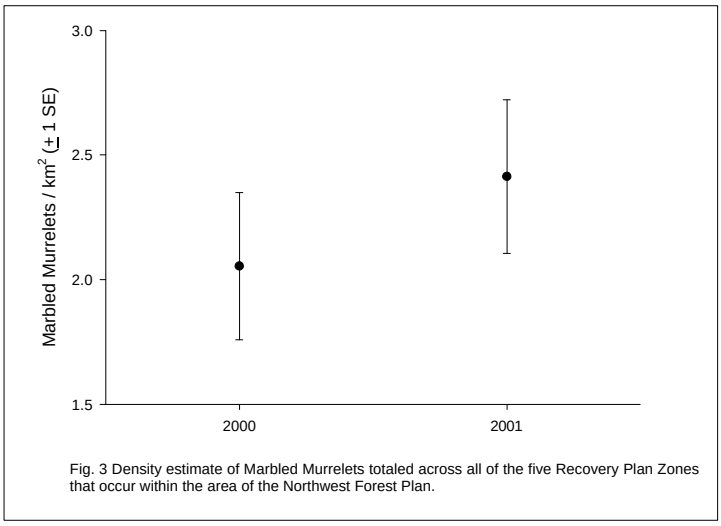

Fig. 3 Density estimate of Marbled Murrelets totaled across all of the five Recovery Plan Zones that occur within the area of the Northwest Forest Plan.

A comparison of the zone-specific population estimates yields similar results to comparison of the density estimates (Fig. 4). An overlap in 95% CI bars in each zone suggests that the population estimate within each zone in 2001 was within the range of possible values for 2000. The degree of overlap did vary, however, being least in zones 1 and 2. The region-wide population estimates in 2001 and 2000 also overlapped substantially (Table 17).

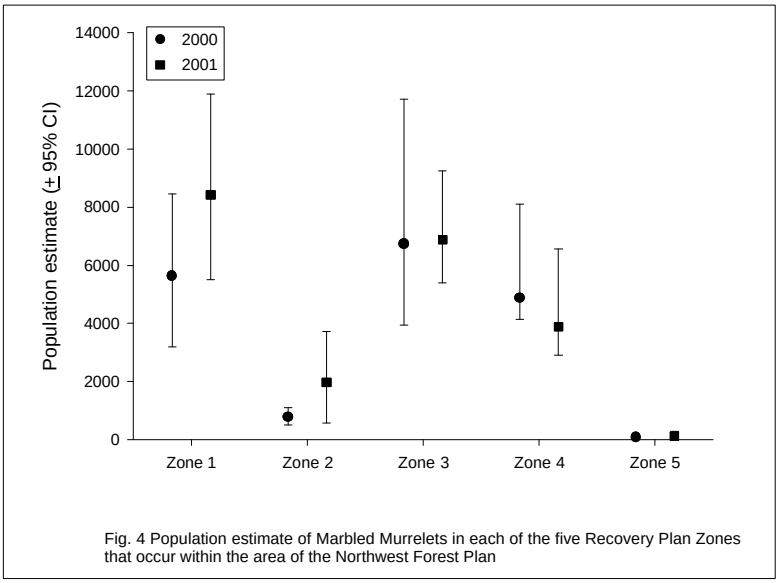

Fig. 4 Population estimate of Marbled Murrelets in each of the five Recovery Plan Zones that occur within the area of the Northwest Forest Plan

Table 17. Comparison of marbled murrelet population statistics between the 2000 and 2001 breeding seasons across conservation zones 1-5.

Population parameter	2000 estimate	2001 estimate
Population estimate	18,097	21,223
95% confidence interval on population estimate	12,991 – 23,202	16,021 – 26,425

Habitat Monitoring

The work effort required to collect habitat data was greater than we anticipated when we originally designed this portion of the monitoring program. This has led us to decrease the number of plots sampled within each site and to increase the time required and budget expenditure to collect these data. Data has been collected from 51 sites, but must still be collected from 126 sites (Olympic = 25, Washington Cascades = 40, Oregon Coast = 21, Klamath = 29, and California Coast = 36) or ca. 1,000 plots. This work is scheduled to be completed by August 2002.

Given that the data sets are currently incomplete, it is difficult to assess the biological significance of any of the summary statistics presented. Nonetheless, one pattern that appears to be consistent among the four variables examined herein is the inconsistency with which differences exist between occupied and unoccupied stands among the provinces. How this might affect the construction of a single, logistic regression model (i.e., one model for all provinces) remains to be seen.

MONITORING PROGRAM CONSIDERATIONS

There is a great deal of anticipation surrounding the release of the annual population estimates from the Marbled Murrelet Effectiveness Monitoring Program. This is not only because this program represents the first effort to produce a population estimate for this species across the range within which it is considered threatened, but also because this program represents the first survey effort to be conducted throughout this range under a unified design. This results in statistically defensible population estimates and their associated error measurements. Therefore, it is critical to explicitly state the scope of inference from these estimates and the assumptions inherent in them.

Results from 2001 represent only the second year of data collected under this unified sampling scheme. While 2000 has often been referred to as the baseline year from which future estimates will be assessed, it is critical to acknowledge that our understanding of the population estimates from 2000 is limited by our lack of comparative data. It likely will take multiple years of population estimates to truly understand what our baseline population estimate truly is. This is because we will need to understand the range of annual variation that exists in our survey data before we can begin to seek interpret any trends in the data we may find. At this point in time it is still too early to try and detect biologically meaningful changes in estimates of either density or population size. For example, power analyses conducted at the conclusion of the 2000 survey season indicated that it may take at least 8 years to detect a decline in the population of 10% with a reasonable degree of statistical certainty.

Therefore, we caution the reader against two particular issues. First, population estimates derived from our surveys should not be directly compared with those of alternate surveys. This is because our surveys were conducted under a specific sampling scheme that may or may not yield comparable results to those produced by other sampling schemes. For example, the manner in which transects are laid out in relation to the coastline may vary among various survey programs. This could result in a different area of the sea being surveyed by two different programs and thus could result in different populations of marbled murrelets being surveyed. Such a discrepancy would invalidate any comparisons of the population estimates.

Second, although we currently have two years of survey data, we believe it would be premature to seek a difference in population estimates between years. While doing so would not be statistically difficult, we believe it would result in data that lacked ecological significance. Our understanding of the annual fluctuations in marbled murrelet population estimates will only increase as the number of survey years increases, and until we have a more complete understanding of the range of that interannual fluctuation, we are hesitant to make such comparisons. We are, however, exploring opportunities to make use of alternate marbled murrelet survey data sets that may improve our understanding of how our survey results compare with other, longer-term, murrelet survey data sets.

RECOMMENDATIONS FOR UPCOMING FIELD SEASON

Work in FY 2002 will continue to focus on population monitoring at sea and habitat assessment inland. No major revisions have been made to the population monitoring sampling design or schedule. Surveys will be conducted in all five conservation zones that fall within the range of the NWFP and results should be available early in 2003. Data will continue to be collected on vegetation and habitat attributes at inland sites. The western Washington lowlands province will not be sampled, however, due to budget restrictions. Development of the logistic regression habitat models will commence once the data collected during the FY02 field season are entered and checked.

PROGRAM AND PRODUCTS

The Marbled Murrelet Effectiveness Monitoring Program underwent some staffing and team member changes in FY01. Naomi Bentivoglio departed as Module Lead and was replaced by Patrick Jodice. Ken Ostrom also resigned his position with the FWS and so no longer will be involved with the EM program.

Products (presentations at meetings, reports, publications) stemming from the EM program can be found at our web page (see below).

LITERATURE CITED

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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 Monitoring Program) can be found at www.reo.gov/monitoring.

Budget

	BLM	R-5	USFWS	PNW	PSW	WA DNR	TOTAL
Program Mgmt.			100				100
Population Monitoring	40		251	157	90	75	613
Habitat Modeling		70	15	92	89		266
Vegetation Plots	160						160
MODULE TOTAL	200	70	366	249	179	75	1,139