2019 Washington At-Sea Marbled Murrelet Population Monitoring:

Research Progress Report

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Abstract

In 1992, the marbled murrelet (*Brachyramphus marmoratus*) was listed as a Threatened species by U.S. Fish and Wildlife Service in California, Oregon, and Washington under the Endangered Species Act and as Threatened by Washington State. A federal recovery plan was published in 1997 that outlined recovery strategies including developing and conducting standardized at-sea surveys. In addition to meeting the requirements of the Endangered Species Act, marbled murrelet monitoring was designed to evaluate the effectiveness of the Northwest Forest Plan (Madsen et al. 1999), which is a large-scale ecosystem management plan for federal lands in the Pacific Northwest.

As part of the Effectiveness Monitoring Program of the Northwest Forest Plan, Washington Department of Fish and Wildlife, USDA Forest Service Pacific Northwest Research Station, U.S. Fish and Wildlife Service, Crescent Coastal Research, and other state, federal, and private researchers have participated in a program to estimate marbled murrelet population size and trends during the breeding season between San Francisco Bay and Washington state since 2000. The information derived from this effort is the only information available to assess population size and trends in this geographic area for this species. This monitoring program uses at-sea line transects within 8 km of the Washington, Oregon, and northern California coastline in the area covered by the Northwest Forest Plan. There are five monitoring zones or Conservation Zones throughout this range, two of which are located in Washington: (Zone 1) Strait of Juan de Fuca, Puget Sound, Hood Canal, and the San Juan Islands; and (Zone 2) the outer coast of Washington. Both zones are currently monitored by the Washington Department of Fish and Wildlife. The U.S. Forest Service monitored Zone 1 from 2000-2012.

Between 2000 and 2015 we conducted annual surveys of both of Washington's Conservation Zones. Starting in 2016 we implemented a reduced-sampling effort design, where Conservation Zone 1 is sampled in even years and Conservation Zone 2 is sampled in odd years. In Washington, this sampling design was implemented in 2016 with surveys conducted in Conservation 1 but not in Zone 2 and we have alternated between Zones since. This report focuses on monitoring results from Conservation Zone 2 during the 2019 monitoring season (15 May - 31 July).

The population estimate for the Washington outer coast for 2019 (Zone 2) was 1,657 birds (95% confidence interval = 745 – 2,752 birds). No trend was detected for Conservation Zone 2; while the trend was negative (-2.2%), the evidence for a trend was not conclusive because the estimate's 95% confidence interval overlapped zero (-5.8% to 1.5%).

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Introduction

In 1992, the marbled murrelet (*Brachyramphus marmoratus*) was listed as Threatened in California, Oregon, and Washington under the federal Endangered Species Act. A recovery plan was published in 1997 that outlined recovery strategies including developing and conducting standardized at-sea surveys (U.S. Fish and Wildlife Service 1997). Also, in the 1990s, controversy over harvest of old-growth forest led to sweeping changes in federal forest management and to the implementation of a large-scale ecosystem plan for federal forests, the Northwest Forest Plan (FEMAT 1993). In response to the recovery goal for the murrelet and the requirement for monitoring under the Northwest Forest Plan, the U.S. Fish and Wildlife Service, U.S. Forest Service, and state wildlife agencies initiated a marbled murrelet monitoring strategy in 2000 (Madsen et al. 1999; Raphael et al. 2007; Miller et al. 2012). The goal of this monitoring strategy is to estimate marbled murrelet population size and trends in each of five conservation zones between San Francisco and the Washington – Canada border. Results from this effort are used to evaluate: 1) effectiveness of the Northwest Forest Plan (Madsen et al. 1999); 2) effects of incidental take under the Endangered Species Act, and 3) marbled murrelet recovery.

Since 2000, Washington Department of Fish and Wildlife along with researchers from Pacific Northwest and Pacific Southwest Research Stations of the U.S. Forest Service, U.S. Fish and Wildlife Service, and Crescent Coastal Research, have been estimating marbled murrelet population size and trends using at-sea line transects within 8 km of the Washington, Oregon, and northern California coastline. Transects cover ~8,800 km^2. The range of the ESA listed population has been subdivided into six marbled murrelet Conservation Zones identified in the marbled murrelet Recovery Plan (Figure 1; U.S. Fish and Wildlife Service 1997). Five of these zones (Zones 1-5) fall within the scope of the Northwest Forest Plan and have been monitored from year 2000 to 2019. This report focuses on the methods and results from Zone 2 during the 2019 monitoring season.

Methods

Sampling Design.
We monitored Zone 2 marbled murrelets from 15 May - 26 July (protocol survey window = 15 May – 31 July), a time when the birds detected on the water are potentially nesting. Conservation Zone 2 on the outer coast of Washington (Cape Flattery to the south jetty of the Columbia River) is divided into two geographic strata (Figure 2). Stratum 1 (north coast) extends from the northwest tip of Washington south to Point Grenville and Stratum 2 (south coast) extends from Point Grenville south to the south jetty of the Columbia River. In an effort to reduce variability in the population estimates, more sampling effort is devoted to Stratum 1 because of higher murrelet density (Thompson 1999). Each stratum is divided into primary sampling units (PSUs), each of which is a roughly rectangular area along approximately 20 km of coastline. At-sea sampling followed the methods described in Raphael et al. (2007).

Observer Training.
The survey team consists of four permanent biologists that rotated through various roles including boat operator, two observers (one responsible for each side of the boat), and a data recorder. The team rotated among these positions at the beginning of each PSU (or as needed) to avoid survey fatigue.

Our team of biologists moved directly from fall and winter surveys for the US Navy to these spring surveys using the same protocols and methodology, therefore no dedicated training for this program was

needed. The team of biologists in 2019 had a minimum of 3 years and as many as 8 years of experience with this monitoring program and conduct year-round monitoring of murrelets. We conduct an annual boat safety training prior to the start of this field season.

Distance estimates from the transect line are a critical part of the data collected and substantial time was spent practicing and visually 'calibrating' before surveys began, followed by weekly distance-testing throughout the survey period. During distance trials, each individual's estimate of perpendicular distance was compared to a perpendicular distance recorded with a laser rangefinder. These trials were conducted using stationary buoys and bird decoys as targets, which were selected at a range of distances from the transect line and in locations in front of as well as to the sides of the boat where marbled murrelets would be encountered on real surveys (see Raphael et al. 2007 for details). Each observer completed 100 distance estimates prior to starting our 2019 sampling season and were tested weekly throughout the survey season. During weekly tests, each observer estimated five perpendicular distances to floating targets. If all five estimates were within 15% of the actual distance, the trial was complete. If any of the five estimates were not within 15% of actual, the observer continued to conduct estimates in sets of five until all five distances were within 15% of the actual distance. In addition, SFP conducted two audits of the survey team to evaluate their overall performance and ability to detect marbled murrelets during the survey season (Raphael et al. 2007, Huff et al. 2003).

Observer Methods.
Two observers (one on each side of the boat) scanned from 0^{o} off the bow to 90^{o} abeam of the vessel. Slightly more effort was spent watching for marbled murrelets forward of the boat and close to the transect line (within 45^{o} of line). Observers scanned continuously, not staring in one direction, with a complete scan taking about 4-8 seconds. Observers were instructed to scan far ahead of the boat for birds that flush in response to the boat and communicate between observers to minimize missed detections or double counting. Binoculars were used for species verification, but not for detecting birds.

Consistent with previous years, survey speed was maintained at 8-12 knots, and survey effort was ended if glare obstructed the view of observers, or if Beaufort wind scale was 3 or greater for more than 25% of a nearshore or offshore transect. Beaufort 3 is described as a gentle breeze, 7-10 knot winds, creating large wavelets, crests beginning to break, and scattered whitecaps. The crew surveyed in short stretches of Beaufort 3 associated with tidal rips, or other bathymetric features common in Puget Sound.

Equipment.
Surveys were conducted from a 26-foot Lee Shore (Fog Lark) with twin-outboard engines.

Observers relayed data (species, number of birds, estimated perpendicular distance of the bird(s) from the trackline) via wireless headsets to a person in the boat cabin who entered data directly onto a laptop computer using DLOG2 software (developed by R.G. Ford, Inc., Portland, OR.) that is interfaced with a GPS unit that collected real time location data for each observation. Transect survey length was calculated from the GPS trackline and was also recorded in DLOG2. Additional data such as PSU identification, weather and sea conditions, on/off effort, and names of observers were recorded manually into the DLOG2 program.

The following data were collected for each murrelet detection: group size (a collection of birds separated by less than or equal to 2 m at first detection and moving together, or if greater than 2 m the birds are

exhibiting behavior reflective of birds together), plumage class (Strong 1998), and water depth (from boat depth finder).

Survey Effort

Primary Sampling Units (PSUs) were accessed from four ports along the Washington coast: Neah Bay (PSUs 1-3), La Push (PSUs 4-7), Westport (PSUs 8-11), and Ilwaco (PSUs 12-14). PSUs in Stratum 1 (PSUs 1-8) were sampled three times. To sample Stratum 1, a port (Neah Bay or La Push) was randomly selected during each 18-day period and the order of PSU sampling from a given port was also randomly selected. Within each PSU, a coin flip determined whether to conduct the nearshore or offshore segment of the PSU first. After all PSUs were completed from that port, the same protocol of random selection of PSUs was completed from the other port. PSUs in Stratum 2 were sampled once. To sample Stratum 2 (PSUs 9-14), a port (Westport or Ilwaco) was randomly selected and two PSUs were surveyed during each 18-day period. Within each PSU, a coin flip determined whether to conduct the nearshore or offshore segment of the PSU first. Grays Harbor and Columbia River bar conditions, which are heavily influenced by tide, swell, and wind, dictated when surveys were completed in Stratum 2.

Data Analysis

Transect distances, murrelet group size, and perpendicular distances for each marbled murrelet observation were sent to U.S. Forest Service statistician Jim Baldwin for analysis. Jim Baldwin used the programs DISTANCE in the program R to calculate densities and 95% confidence intervals (CI) as described in Miller et al. 2006 and Raphael et al. 2007. For population trends, we used a linear regression to the natural logarithm of annual density estimates to test for declining trends. For our analysis, the natural logarithm best fits and tests existing demographic models (USFWS 1997; McShane et al. 2004) that predict the murrelet population is declining by a constant percentage each year. We tested the null hypothesis that the slope equals zero or greater (no change or increase in murrelet numbers) against the alternative hypothesis of the slope being less than zero (i.e., a one-tailed test for decreasing murrelet densities).

Results

Population Estimates and Trends – Washington Coast

In 2019, all 30 surveys in Conservation Zone 2 were conducted to protocol including three replicates of 8 PSUs in Stratum 1 and a single survey of each of the 6 PSUs in Stratum 2. Throughout the 12-week season, high winds and rough seas precluded surveying during week 2 (19-25 May), week 4 (2-8 June), and week 10 (14-20 July), which was an unprecedented number of days that surveys were either not attempted due to forecasted high swell and wind, or the team went out and were not able to start or complete a survey and stay within protocol for weather conditions.

Navigation was influenced by physical features of the shoreline and open ocean weather conditions on the outer coast of Washington. In some instances, physical features were permanent obstructions such as submerged groups of rocks or larger rocky islands (e.g. Cape Alava, Tatoosh Island). In other cases, features were less permanent such as kelp beds. Swell height, tidal fluctuations, and breaking waves also affected navigation especially in the near-shore transects. For Conservation Zone 2, the nearshore boundary was 350 m. In 2019, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed for 6 subunits in Stratum 1 and 8 subunits in Stratum 2. In these cases, the subunit was moved out from shore in 100 m increments until 75% or greater of the transect line could be

surveyed. The reason for moving the subunit and the new distance from shore was documented (e.g. shallow water, breaking waves, or rocks). The team made every effort to follow the predetermined random schedule of nearshore and offshore surveys, but there were instances where the survey order had to be switched for safety and navigation reasons due to tide or swell height and breaking waves.

The population estimate for the Washington outer coast for 2019 was 1,657 birds (95% confidence interval = 745 – 2,752 birds). There was a negative slope for the trendline in Zone 2 in 2019 (Figure 5, Table 1). While the trend was below zero (-2.2%), the evidence for a negative trend was weak because the estimate's 95% confidence interval overlapped zero (-5.8% to 1.5%) (Table 1, Figure 5). The results reported here are the same as reported in McIver et al. (2020). As in all previous years, higher densities of marbled murrelets were observed in Stratum 1 than Stratum 2 (only 1 murrelet was observed in Stratum 2 and 863 were observed in Stratum 1). In 2019, the highest murrelet detections occurred in the northerly PSU 2 (187 murrelets on 25 June). Murrelet detections in the same PSU on 22 July was lower (68 birds), but there were increases in murrelet detections in nearby PSUs (e.g., PSUs 1 and 3 – with 170 detected on 9 July in PSU 1). There was an increase in the detections in PSU 8 late in the season, like what we observed in 2017 during replicates 2 and 3 (n = 121, 121, respectively).

We observed an unusually high number of juvenile (hatch year) murrelets this year: 8 were detected on July 9, 2 on July 11, and 14 on July 22 and 23. All of these birds were observed in PSU 1-5 of Stratum 1. And, most were observed in PSU 2 (n = 8) and 3 (n = 8) between Makah Bay to the north and Carroll Island to the south (Figure 2).

Table 1. Estimate of average annual rate of population change (linear) for Zone 2, 2001-2019. This same information is reported in McIver et al. (2020).

Zone	Annual Rate (%)	95% Lower CL	95% Upper CL	Adjusted R^2	P-value
2	-2.2	-5.8	1.5	0.040	0.216

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Figure 1. Marbled murrelet Recovery Plan Conservation Zones (from Raphael et al. 2007).

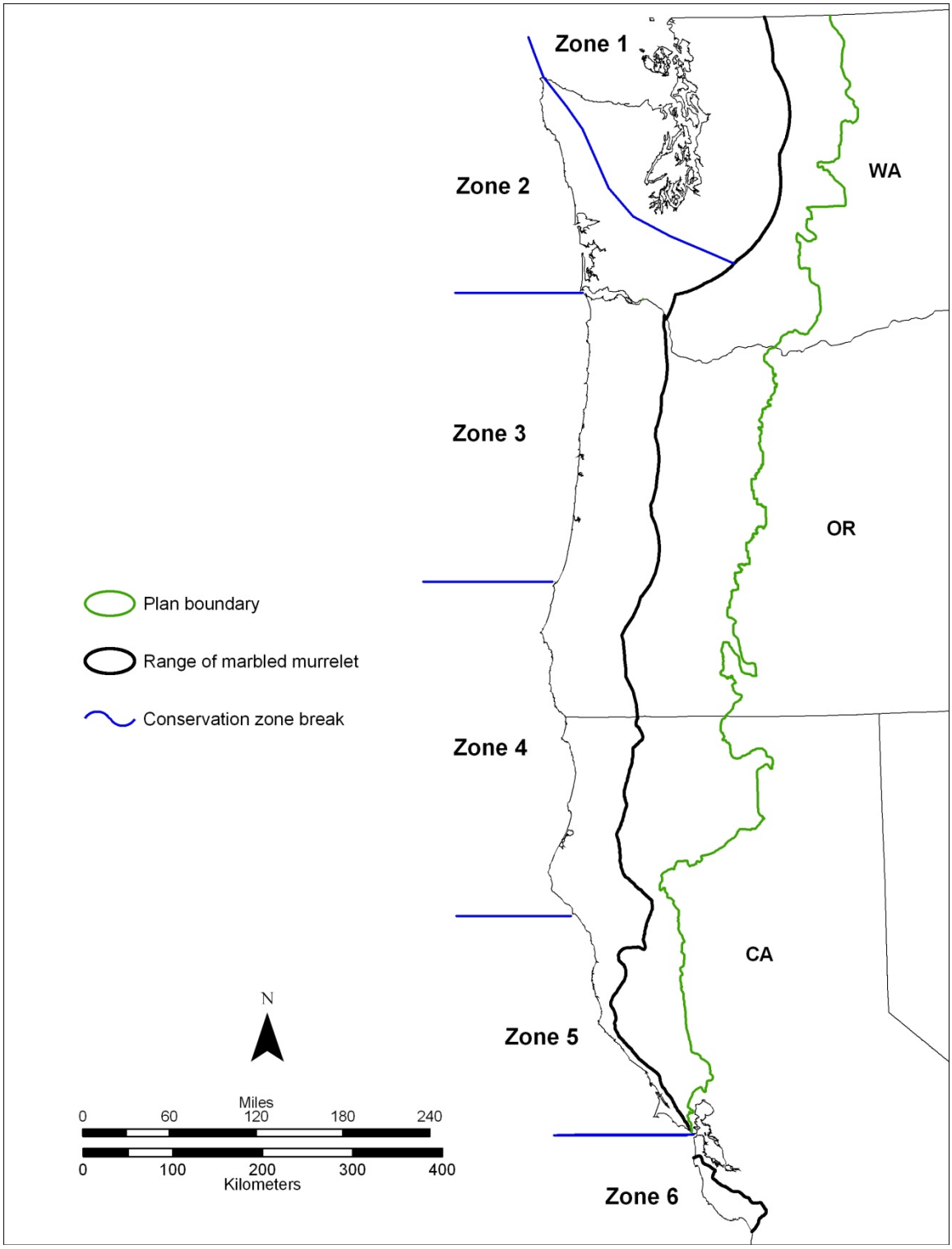


Figure 2. Strata 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2.

Figure 3. Marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore). One bin is selected (without replacement) for each segment of transect (from Raphael et al. 2007).

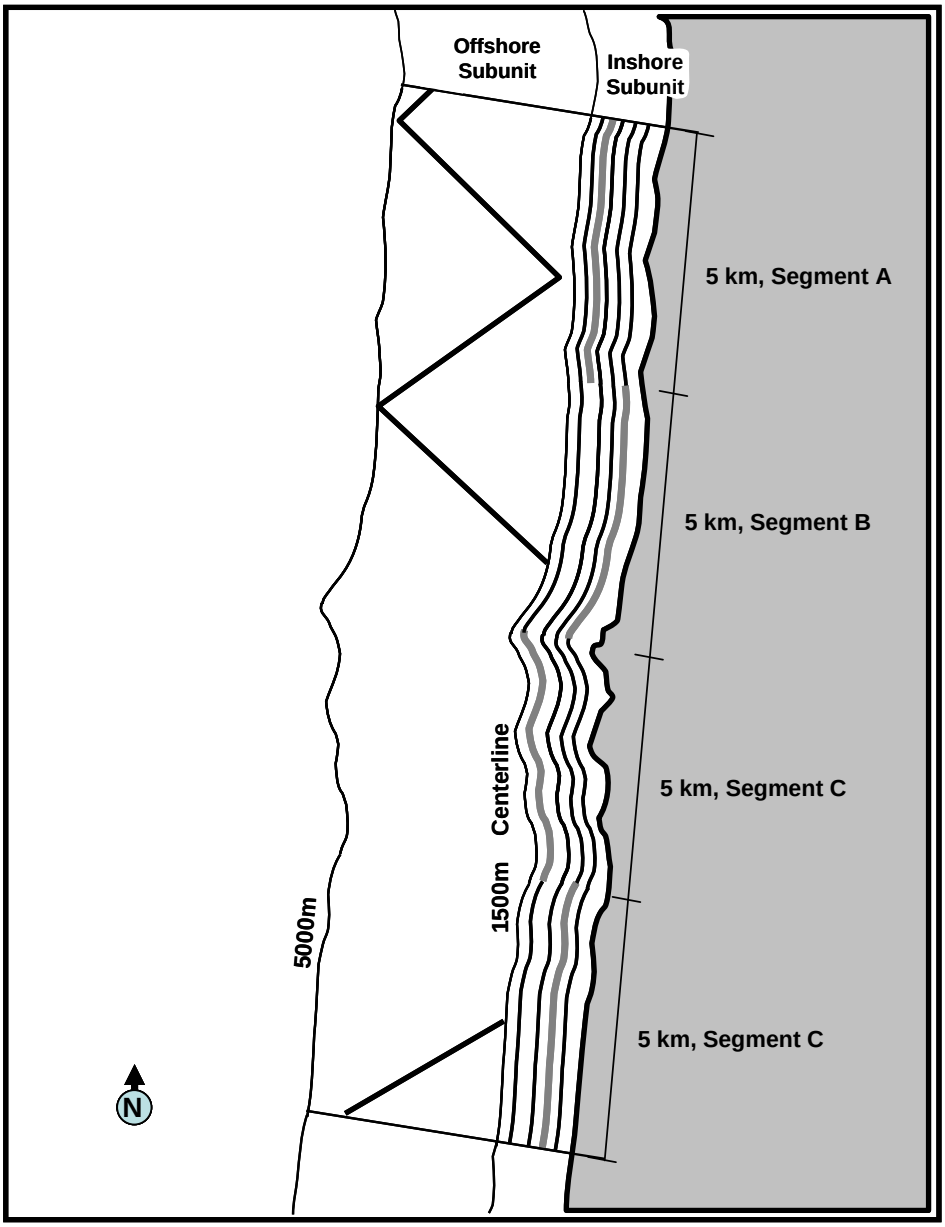


Figure 4. 2001-2019 marbled murrelet population densities (birds/km2) with 95% confidence intervals for the Washington coast (Zone 2) and for the northern (Stratum 1) and southern (Stratum 2) portions of this Zone. Note the Y axis scale differences among graphs. The information here for this zone is identical to that reported in McIver et al. (2020; Table 3).

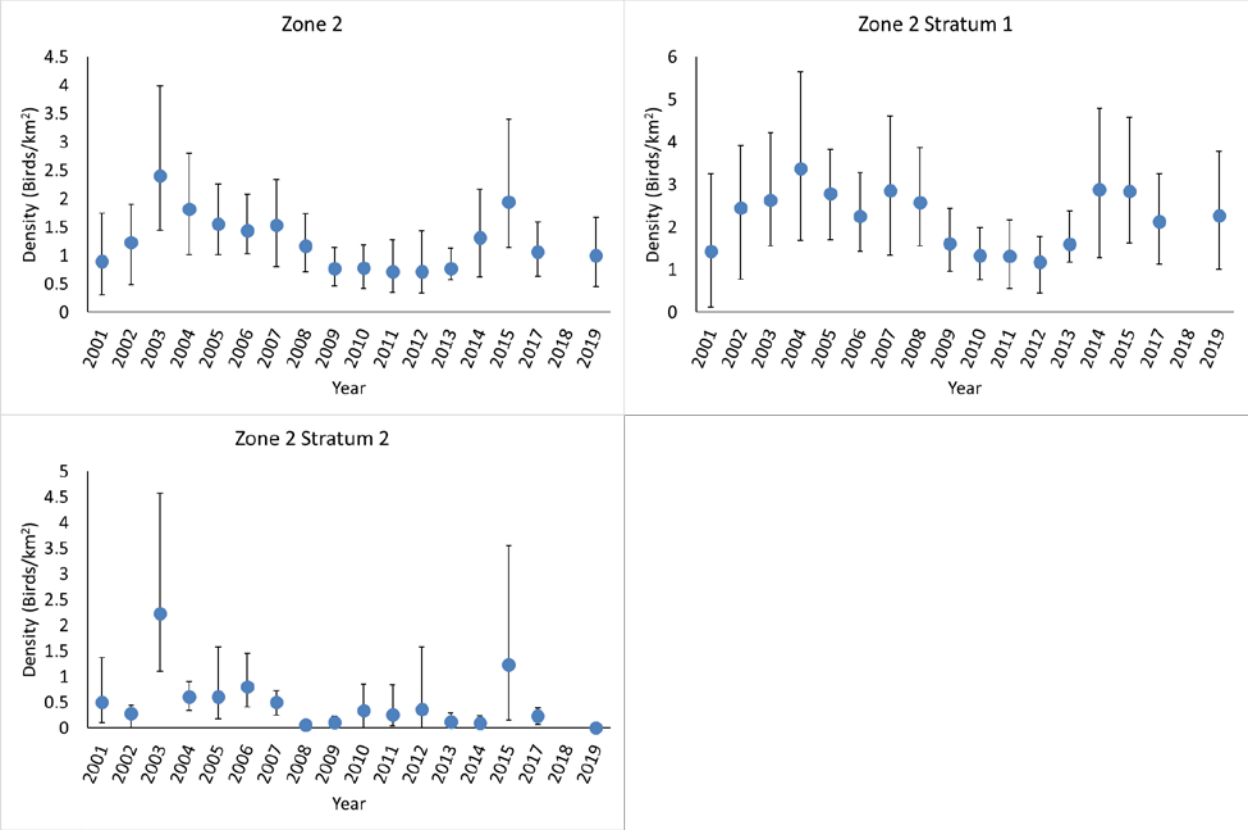
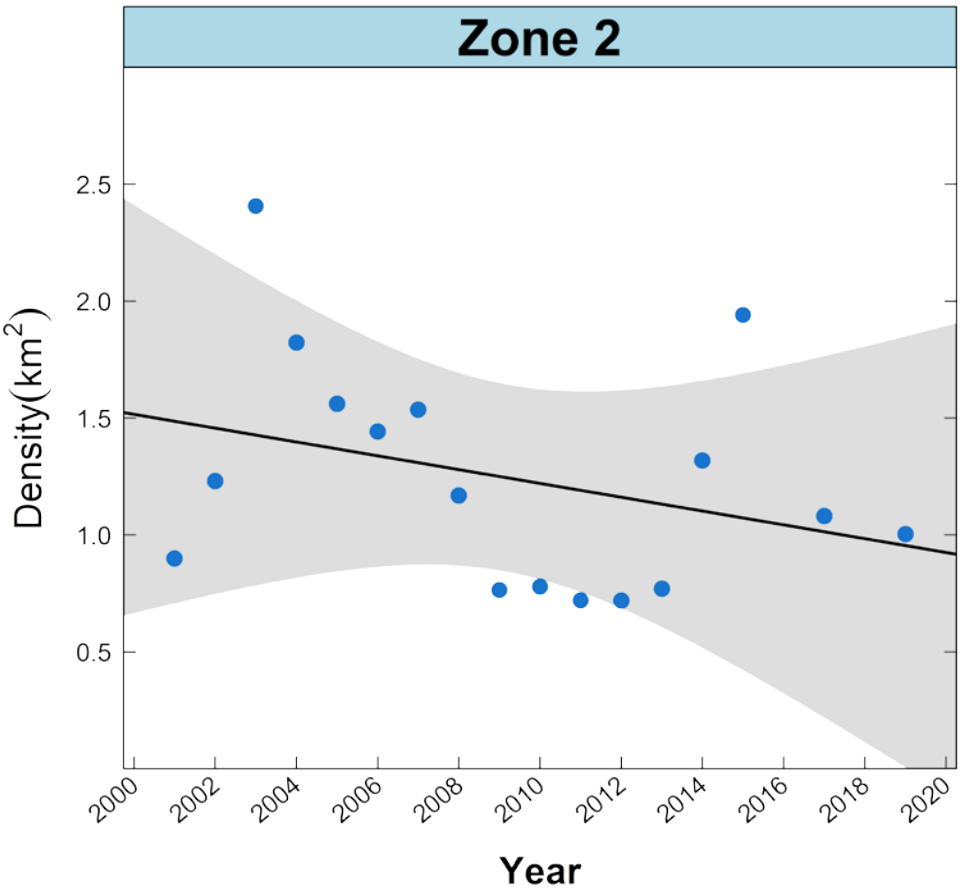


Figure 5. Washington marbled murrelet population density trend for 2001-2019 with 95% confidence band for Zone 2 (outer coast of Washington). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1. Grey shaded area is the 95% Confidence Interval.



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