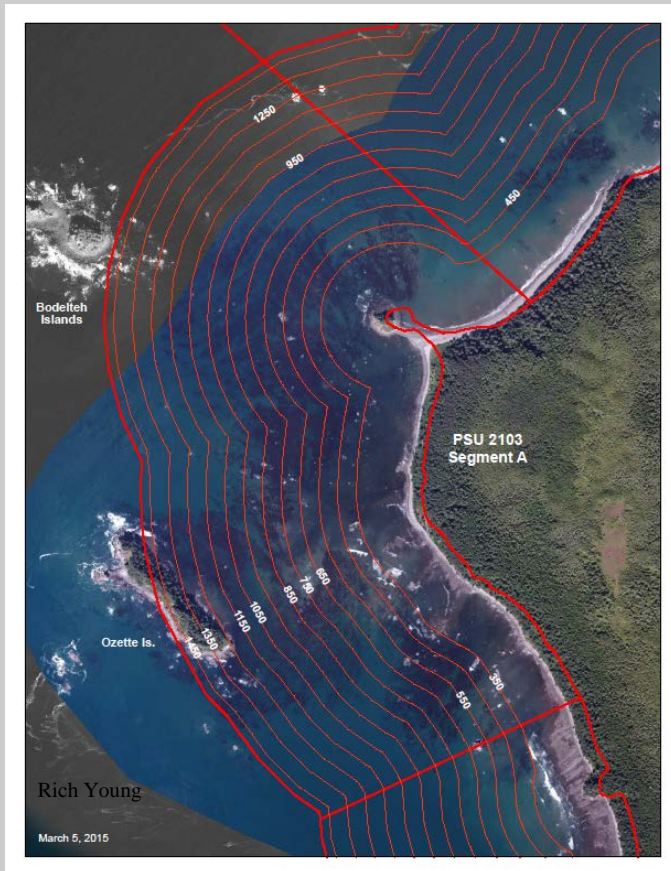


2015 Washington At-Sea Marbled Murrelet Population Monitoring: Research Progress Report

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Fish and Wildlife
Wildlife Program
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Olympia, Washington

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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, long-term 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, 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. This report focuses on monitoring results from Conservation Zones 1 and 2 during the 2015 monitoring season (15 May - 31 July).

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2015 (Zone 1) was 4,290 birds (95% confidence interval = 2,783 – 6,492 birds) with a -5.3% (95% CI = -8.4 to -2.1%) average annual rate of decline for the 2001-2015 period, assuming a constant rate of decline. The population estimate for the Washington outer coast for 2015 (Zone 2) was 3,204 birds (95% confidence interval = 1,883 – 5,609 birds). No trend was detected for Conservation Zone 2; while the trend was below zero (-2.8%), the evidence was not conclusive because the estimate's 95% confidence interval overlapped zero (-7.6% to 2.3%). For Washington State (Zones 1 and 2 combined) the estimate of annual rate of change in murrelet density was -4.4% (95% CI = -6.8 to -1.9) for the 2001-2015 period.

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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 km². 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 2015. This report focuses on the methods and results from the 2015 monitoring season and the two zones in Washington State, Conservation Zones 1 and 2.

Methods

Sampling Design.

We monitored marbled murrelets from 15 May - 31 July, a time when the birds detected on the water are potentially nesting. There are two murrelet conservation zones in Washington. Conservation Zone 1 includes the Strait of Juan de Fuca, Puget Sound, Hood Canal, and the San Juan Islands (Figure 2). Within this zone, there are three geographic strata based on murrelet density and ecological factors: Stratum 1: Strait of Juan de Fuca; Stratum 2: San Juan Islands, Whidbey and Camano islands, Port Townsend, Admiralty Inlet, and northern Hood Canal; Stratum 3: central/south Puget Sound. 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 3). 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 crews in Zone 1 and Zone 2 consisted of one dedicated boat operator and three observers/data recorders each. The data recorder and two observers (one responsible for each side of the boat) switched duties at the beginning of each PSU to avoid survey fatigue. The outer coast crew covered all of the sampling units in Zone 2 plus the Zone 1-Stratum 1 sampling units in the Strait of Juan de Fuca. The other crew covered the remainder of the sampling units in Zone 1.

The Zone 2 boat captain and our crew leaders in both zones had previous years of experience with this monitoring program. The Zone 1 boat captain had extensive experience operating similar boats throughout Puget Sound and the remaining four observers had knowledge of Washington's seabirds and on-water data collection and observation skills. New observers surveyed with experienced observers for the first two weeks to ensure consistency and accuracy in data collection. Observers in both crews had one week of training that consisted of both office and on-water training. Office training included a presentation of background information, survey design, and protocols including line transect distance sampling methodology, and measurement quality objectives. On-water training included boat safety orientation, seabird identification, specific training on correctly assigning marbled murrelet plumages (Strong 1998), practice survey transects, and distance estimation testing using laser rangefinders. Boat safety training included instructions and reminders for weather and sea condition assessment, use of the VHF marine radio, boat handling, proper boat maintenance, safety gear, rescue techniques, and emergency procedures. Observer training was designed to be consistent with training conducted by other groups within the marbled murrelet Effectiveness Monitoring program (Huff et al. 2003, Mack et al. 2003, Raphael et al. 2007).

During practice transects, observers were taught how to scan, where to focus their eyes, and which portions of the scan area are most important. 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 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 during pre-survey training. Distance estimate tests were repeated weekly throughout the entire survey season. During the weekly tests, each observer estimated five perpendicular distances to floating targets. After the first set of five, if all five estimates were within 15% of the actual distance, the trial was complete for that observer. 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, one of the project leads accompanied the survey crew and observed their overall performance and ability to detect marbled murrelets during the survey season and completed an audit form created by the Murrelet Monitoring Program (Raphael et al. 2007, Huff et al. 2003). The results of the audit were shared with the observers after the survey day was completed for feedback and discussion.

Observer Methods.

Two observers (one on each side of the boat) scanned from 0° off the bow to 90° 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° 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. 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 the 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 Zone 1 crew surveyed in short stretches of Beaufort 3 associated with tidal rips, or other bathymetric features common in Puget Sound.

Equipment.

The Zone 1 crew surveyed from a 24-foot Almar boat with twin-outboard engines. This was the third year that we used this boat and a change from previous years (2000-2012) where 17 or 20 foot Boston Whaler boats were used. The Zone 2 crew surveyed from a 26-foot Almar boat with twin-outboard engines. This is the same boat that has been used for all previous years.

In both zones, observers relayed data (species, number of birds, estimated perpendicular distance of the bird(s) from the trackline) via 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 calculated from the GPS trackline 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.

In both zones and for each marbled murrelet sighted, the following data were collected: 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

Zone 1.— Zone 1 contains a total of 98 PSUs, of which 30 were randomly selected prior to starting the sampling program in 2000. These same 30 PSUs are sampled every year since. Consistent with this approach, we sampled 5 Primary Sampling Units (PSUs) in Stratum 1, 20 PSUs in Stratum 2, and 5 PSUs in Stratum 3. The same PSUs are sampled each year, but the order of sampling varies randomly. Each PSU was sampled twice during the survey season with replicate one completed by 20 June. A random sampling unit selection approach was used to spread the survey effort out both spatially and temporally. We accomplished this by first selecting a Stratum randomly and then randomly selecting PSUs within that Stratum to build a survey week. During each week, a single crew moved nearly every day and typically started in the south and worked their way north, or the opposite. Within each PSU, a coin flip determined whether to conduct the nearshore or offshore segment of the PSU first. PSUs in Stratum 2 are located in the San Juan Islands, Whidbey and Camano Islands, Port Townsend, Admiralty Inlet, and northern Hood Canal and accessed from Anacortes, Coronet Bay, Oak Harbor, Everett, Port Townsend, or Quilcene. PSUs in Stratum 3 are located in Central/South Puget Sound and accessed from Everett, Manchester, Tacoma, or Olympia.

Zone 2.— 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 in Zones 1, 2 and 1 and 2 combined (Washington estimate). 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 –Puget Sound and Strait of Juan de Fuca (Zone 1)

In 2015, two replicates of all 30 PSUs in Conservation Zone 1 were sampled to protocol. Because of the relatively protected nature and typically favorable summer weather in Conservation Zone 1, cancelled surveys are uncommon and deviations from the randomly chosen survey schedule occurred only when surveys in a given area were switched due to wind or fog on a given day or between two consecutive days, or a Naval installation activity preventing access.

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2015 (Zone 1) was 4,290 birds (95% confidence interval = 2,783 – 6,492 birds) with a -5.3% (95% CI = -8.4 to -2.0%) average annual rate of decline for the 2001-2015 period (Table 1, Figure 7). No juvenile (hatch year) marbled murrelets were observed this season, but this monitoring strategy was not designed to track juvenile recruitment. Interestingly, the density of murrelets in Stratum 1 (Strait of Juan de Fuca) doubled the 2014 estimate and was similar to the 2013 estimate, but still lower than earlier years of monitoring. Murrelet density in stratum 3 (southern Puget Sound) was the lowest since the inception of the monitoring program with only a single murrelet observed.

Population Estimates and Trends – Washington Coast (Zone 2)

In 2015, all 30 PSUs in Conservation Zone 2 were sampled to protocol including three replicates of 8 PSUs in Stratum 1 and 6 PSUs in Stratum 2 were sampled once. Throughout the 11-week season, poor weather and rough seas precluded surveying on 1 day in May, 2 days in June, and 1 day in July, which is

fewer than previous years. This is in part because the Zone 2 crew had flexibility to move if the weather was poor on the outer coast to the more protected PSUs in Zone 1 Stratum 1 located in the Strait of Juan de Fuca.

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 2015, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed for 7 subunits in Stratum 1 and 7 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. The crew 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 2015 (Zone 2) was 3,204 birds (95% confidence interval = 1,883 – 5,609 birds). No trend was detected for Conservation Zone 2; while the trend was below zero (-2.8%), the evidence was not conclusive because the estimate’s 95% confidence interval overlapped zero (-7.6% to 2.3%) (Table 1, Figure 8). As in all previous years, higher densities of marbled murrelets were observed in Stratum 1 than Stratum 2. In 2014 and 2015, the highest densities of marbled murrelets were observed in more northerly PSUs 2 and 3 in mid to late June rather than in PSU 6 and 7 (located south of Destruction Island to Kalaloch and the Raft River) where densities were historically the highest. For example, 360 marbled murrelets were recorded in PSU 2 on 18 June. The density of murrelets in Stratum 2 is low. However the highest number of murrelets ever observed in Stratum 2 was recorded in PSU 10 in late May. This single survey consequently had a large influence on the Stratum’s overall density. There were no juvenile (hatch year) marbled murrelets observed during the season, but this monitoring scheme was not designed to track juvenile recruitment.

Washington Population trends – Zones 1 and 2 Combined

For Washington State (Zones 1 and 2 combined) the estimate of annual rate of change in murrelet density was -4.4% (95% CI = -6.8 to -1.9) for the 2001-2015 period (Table 1, Figure 9).

Table 1. Estimates of average annual rate of population change (linear) for zones 1 and 2 and both zones combined for 2001-2015.

Zone	Annual Rate (%)	95% Lower CL for Annual Rate	95% Upper CL for Annual Rate	Adjusted R²	P-value
1	-5.3	-8.4	-2.0	0.444	0.0040
2	-2.8	-7.6	2.3	0.029	0.2555
1 & 2	-4.4	-6.8	-1.9	0.493	0.0021

Acknowledgments

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

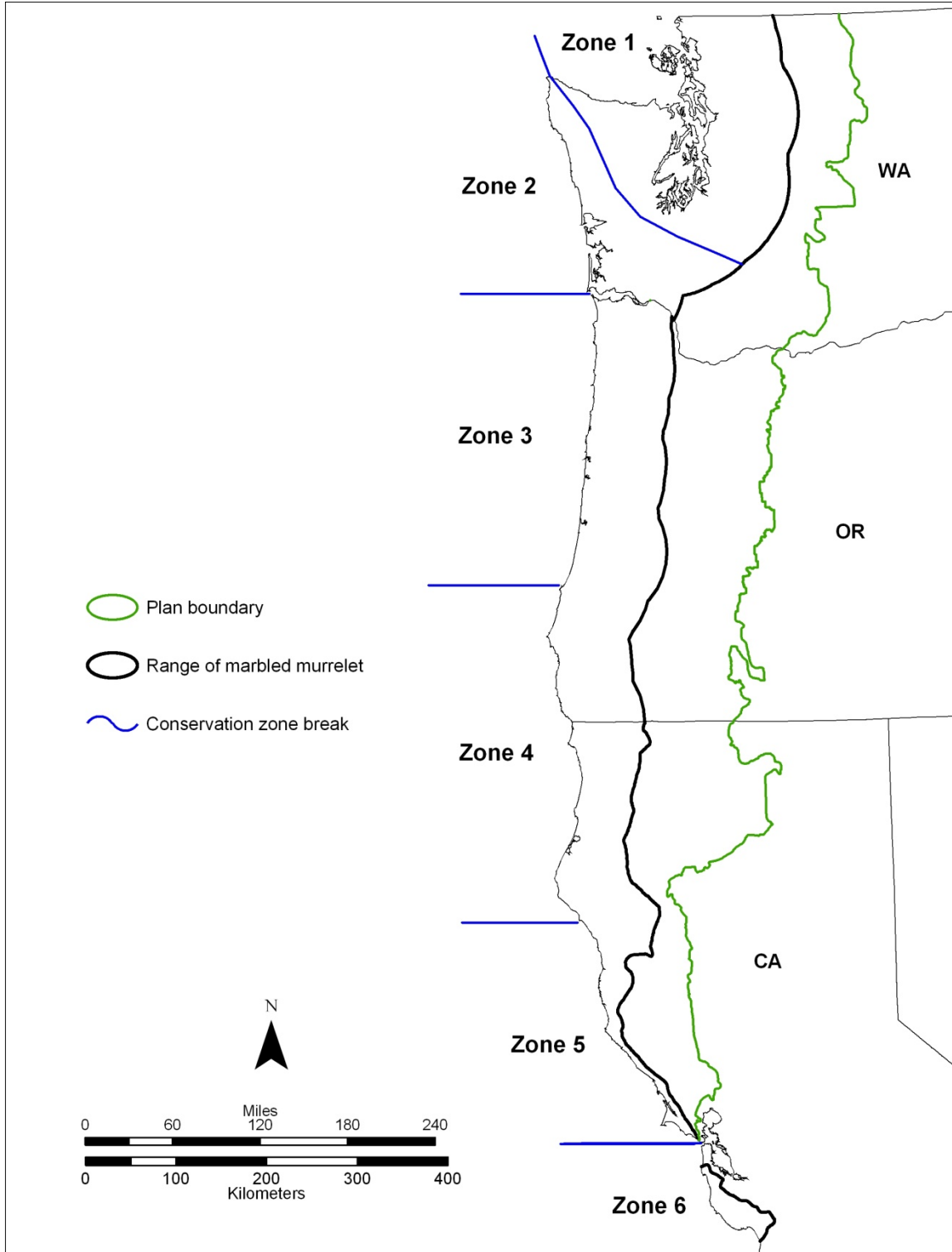


Figure 2. A) marbled murrelet Conservation Zone 1 with Strata 1 and 2 circled. Stratum 3 is the remaining area within Zone 1. B) marbled murrelet Conservation Zone 1 enlargement of Stratum 2.

A.

B.

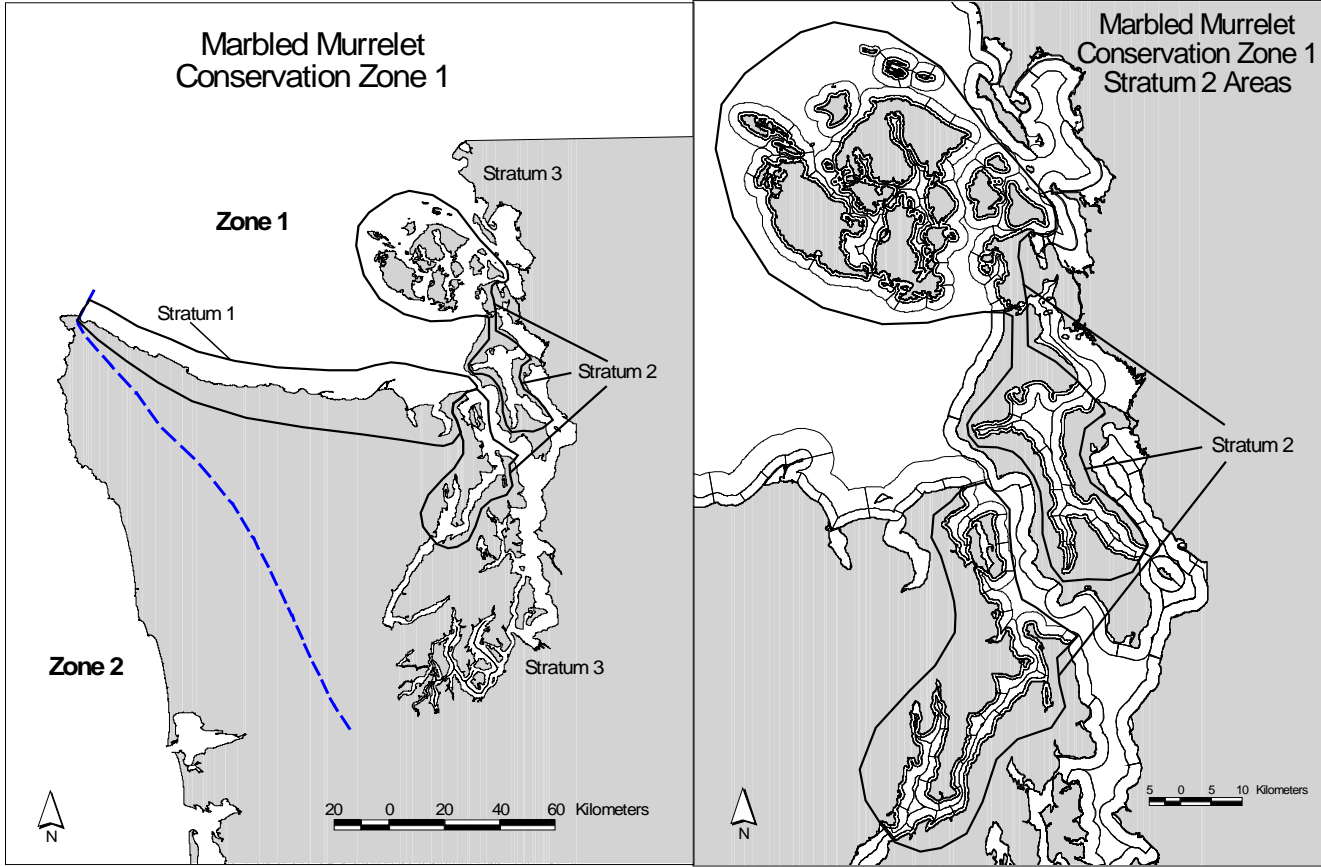


Figure 3. Strata 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2 (from Huff 2006).

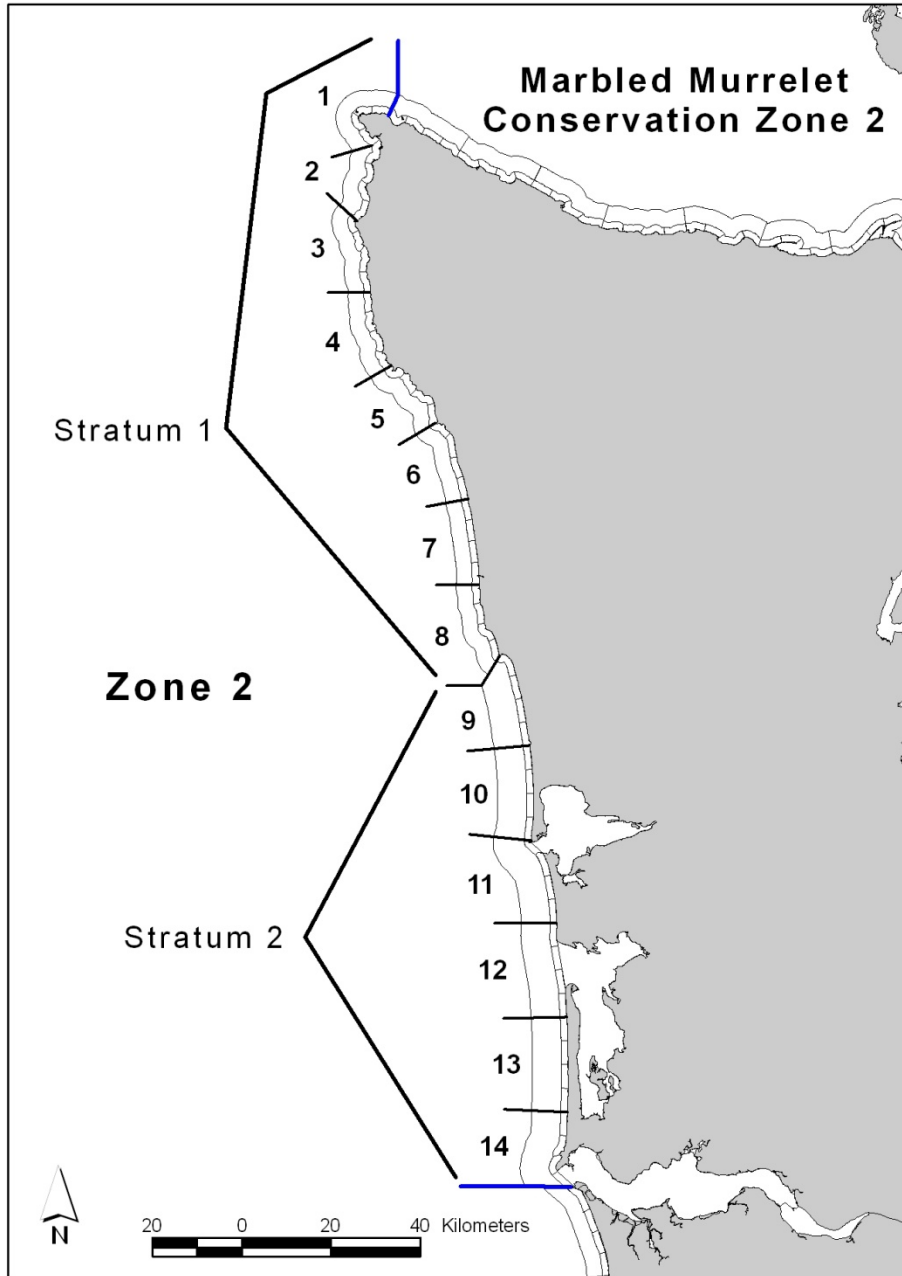


Figure 4. Marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore). One bin is selected (without replacement) for each segment of transect (from Raphael et al. 2007).

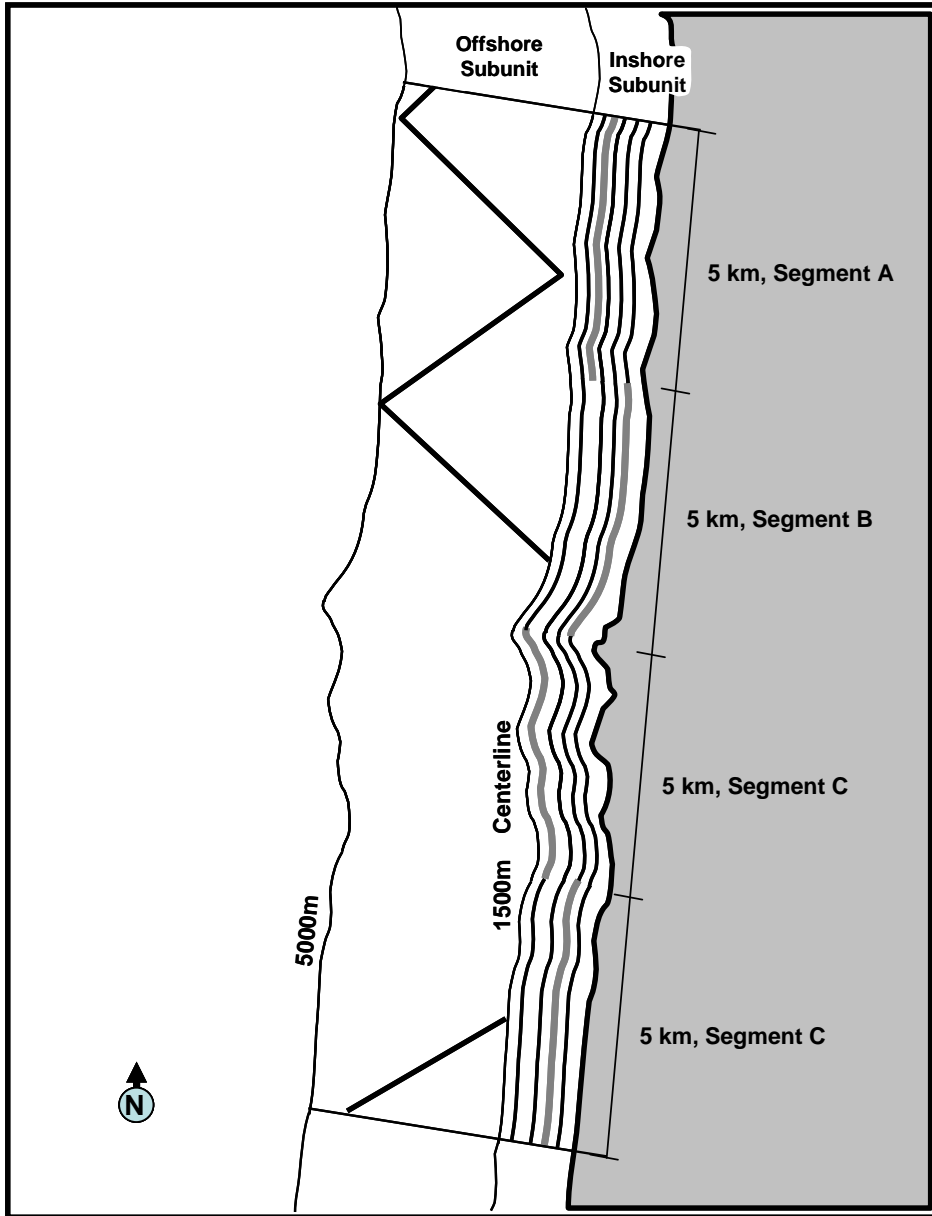


Figure 5. 2001-2015 marbled murrelet population densities (birds/km²) with 95% confidence intervals for Puget Sound and Strait of Juan de Fuca (Zone 1) and for the strata within this zone: 1) Strait of Juan de Fuca (Stratum 1), 2) San Juan Islands and northern Hood Canal (Stratum 2) and, 3) southern Puget Sound (Stratum 3). Note the Y axis scale differences among graphs.

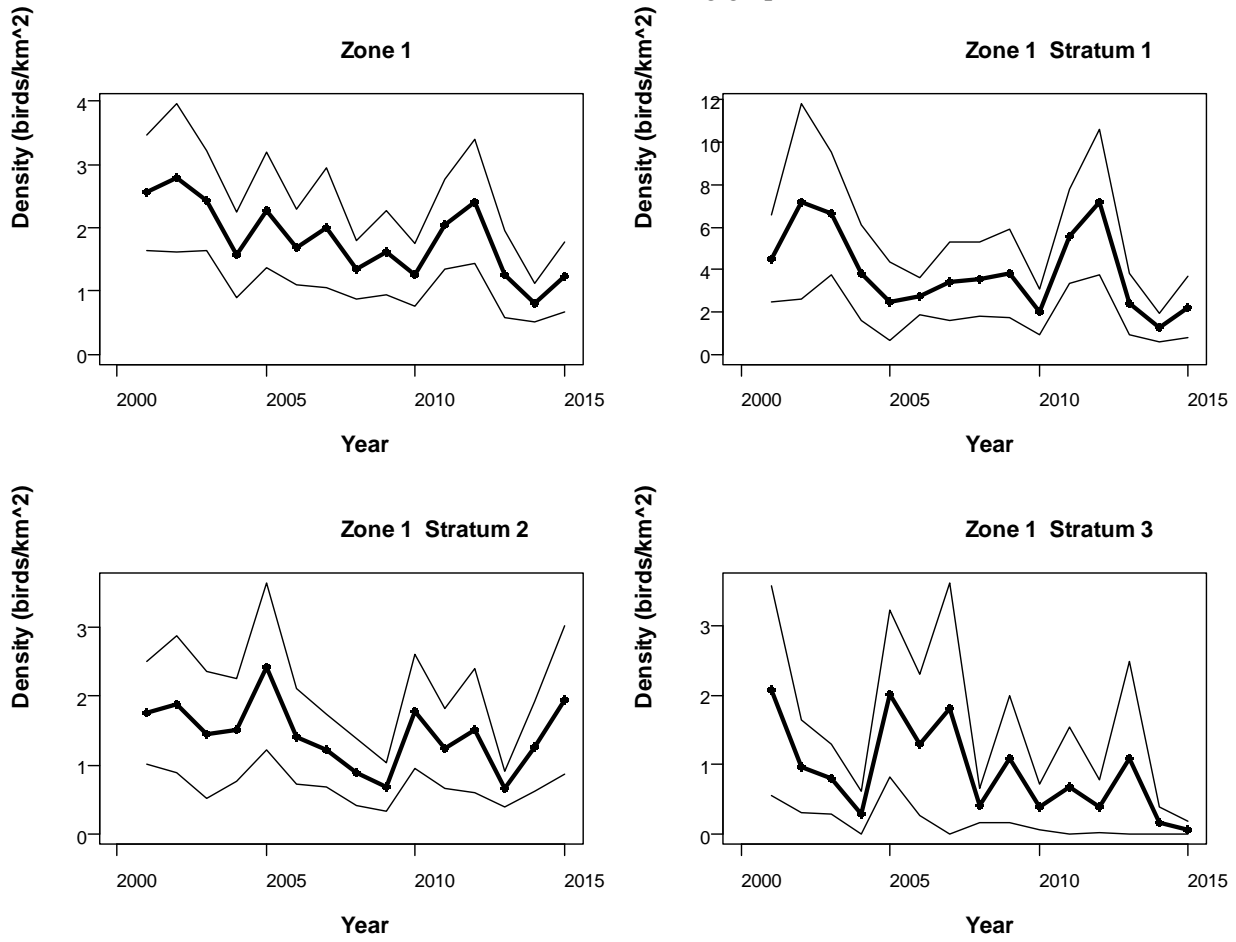


Figure 6. 2001-2015 marbled murrelet population densities (birds/km²) with 95% confidence intervals for the Washington coast (Zone 2) and for the northern (Stratum 1) and southern (Stratum 2) portions of this Zone. Note the Y axis scale differences among graphs.

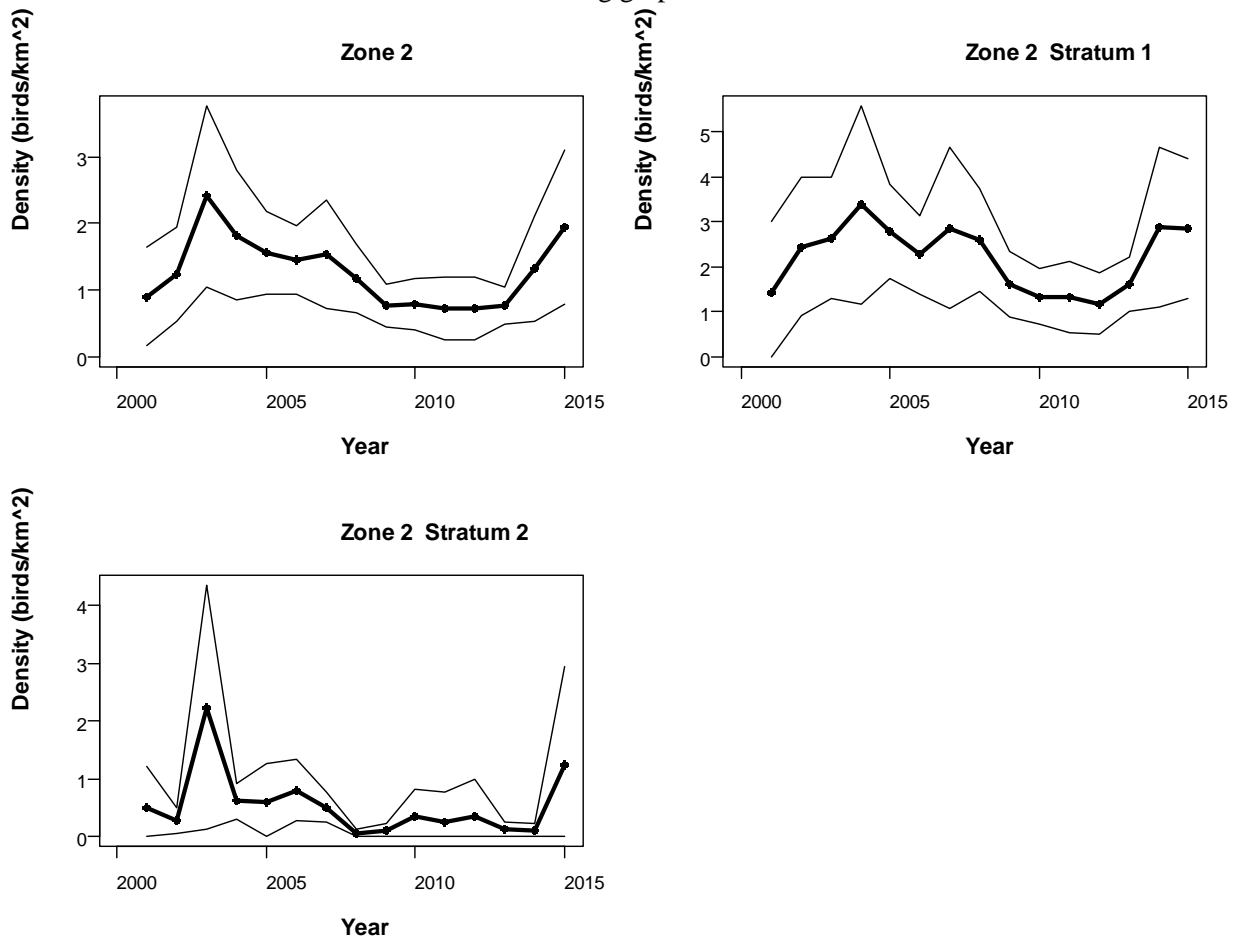


Figure 7. Washington marbled murrelet population density trend for 2001-2015 with 95% confidence intervals for Zone 1 (Puget Sound and Strait of Juan de Fuca). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

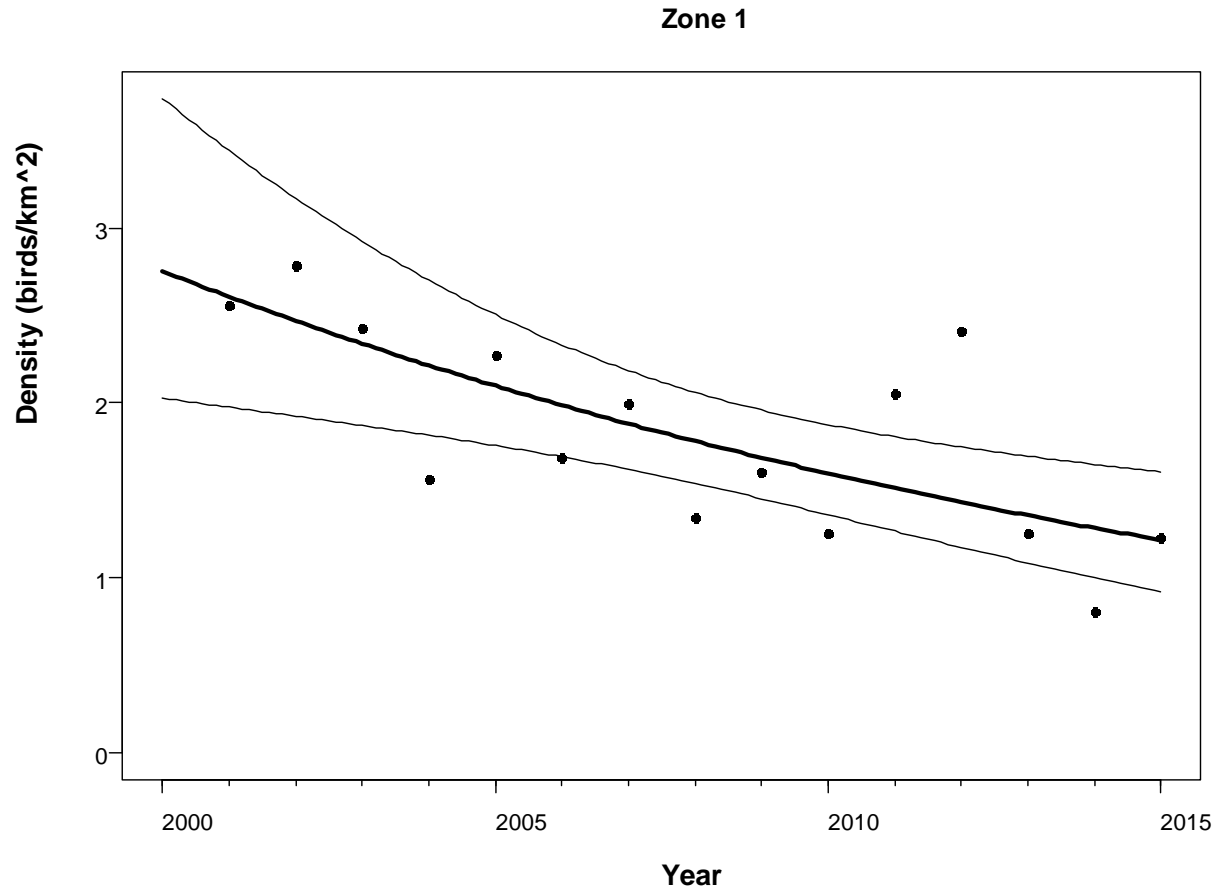


Figure 8. Washington marbled murrelet population density trend for 2001-2015 with 95% confidence intervals for Zone 2 (outer coast of Washington). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

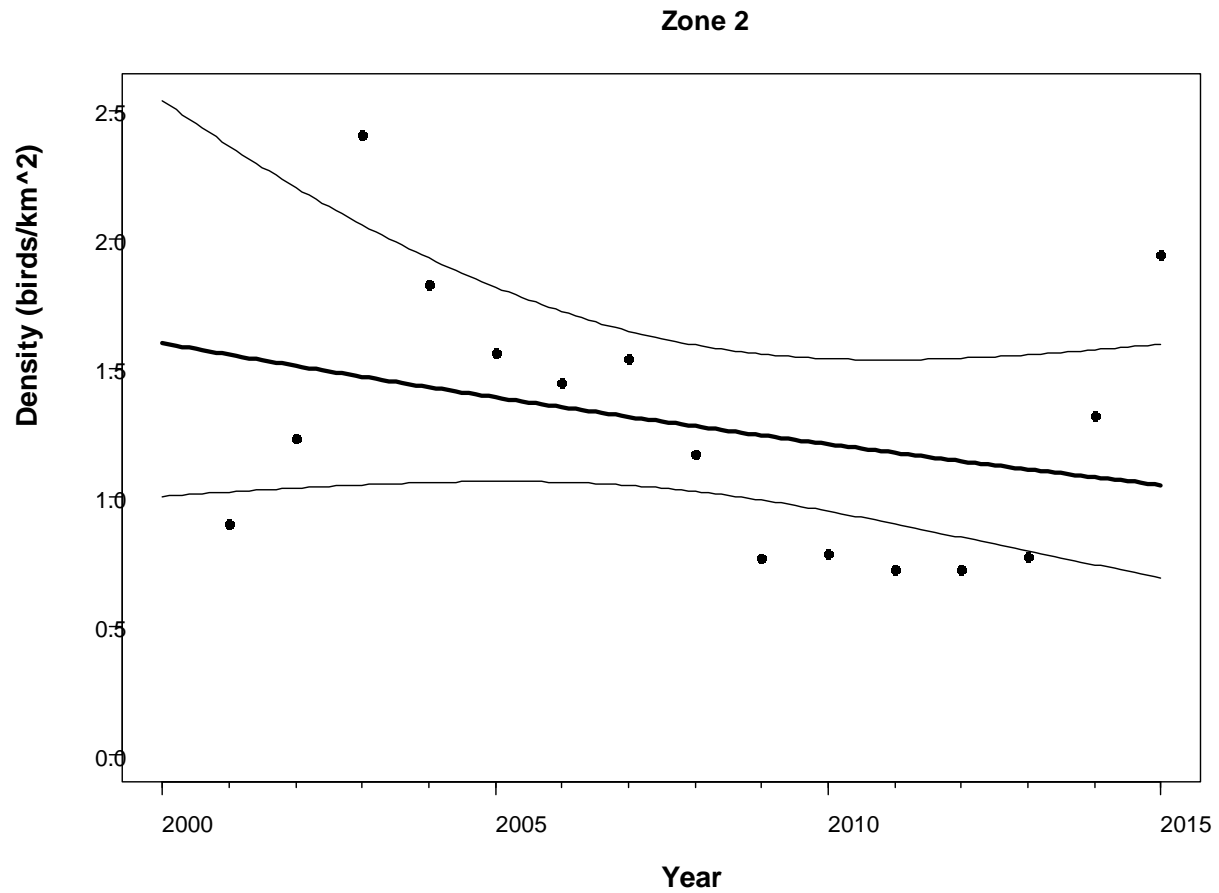
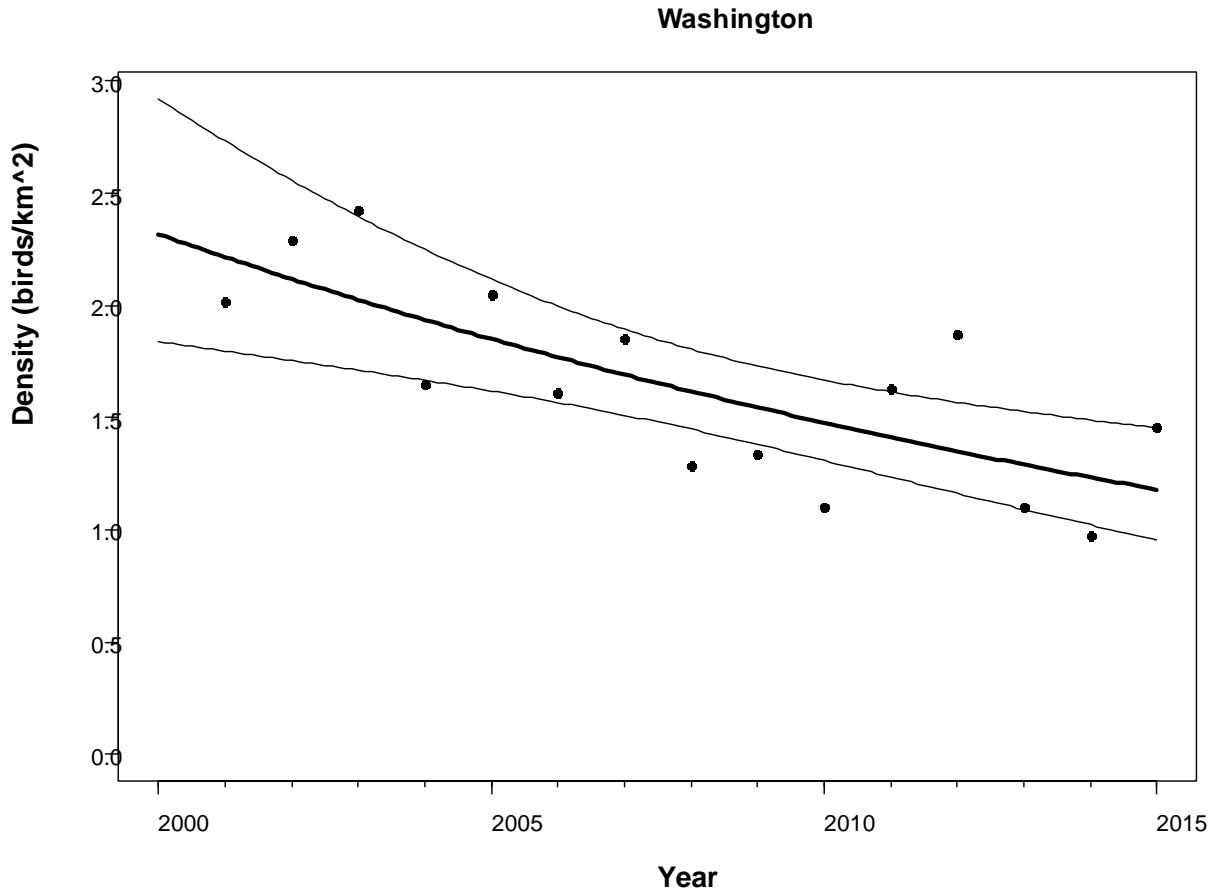


Figure 9. Washington marbled murrelet population density trend for 2001-2015 with 95% confidence intervals for Zones 1 and 2 combined (all marine waters of Washington State). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.



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