

# 2013 Washington At-Sea Marbled Murrelet Population Monitoring: Research Progress Report

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*Cover photos:* marbled murrelet picture by Ryan Merrill, and Washington Coast picture by Barry Troutman

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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, 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.

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 now monitored by the Washington Department of Fish and Wildlife, but 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 2013 monitoring season (15 May - 31 July).

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2013 (Zone 1) was 4,395 birds (95% confidence interval = 2,275 – 6,740 birds) with a -3.88% (standard error = 1.73%) average annual rate of decline for the 2001-2013 period ( $p = 0.0499$ ). The population estimate for the Washington coast for 2013 (Zone 2) was 1,257 birds (95% confidence interval = 920 – 1,846 birds) with a -7.37% (standard error = 1.70%) average annual rate of decline for the 2001-2013 period ( $p = 0.0016$ ). For Washington State (Zones 1 and 2 combined) the estimate of annual rate of change in murrelet density was -4.65% (standard error = 1.33%) for the 2001-2013 period ( $p = 0.0059$ ).

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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 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 designed to evaluate the effectiveness of the Northwest Forest Plan (Madsen et al. 1999), and are also used to evaluate the effects of incidental take under the Endangered Species Act, and marbled murrelet recovery.

Since 2000, Washington Department of Fish and Wildlife along with researchers from Pacific NW and Pacific SW 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<sup>2</sup>. 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 2013. This report focuses on the methods and results from the 2013 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 and southern Hood Canal. Conservation Zone 2 on the outer coast of Washington (Cape Flattery to the south jetty of the Columbia River) is monitored by WDFW and 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. In previous years, rather than using one boat/crew in Zone 1 as we did in 2013, the crew consisted of two teams (one based in Port Townsend and the other in Friday Harbor). Each team had a crew leader and 2 crew members and the three members rotated between boat operator and observer duties.

Both boat captains and all six observers had previous experience with this marbled murrelet at sea program. Observers in both crews had one week of training that consisted of office and on-water training. Office training included a presentation of background information, survey design and protocols, sampling methodology, 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), and practice transects, and distance estimation testing using laser rangefinders. Boat safety training included instructions and reminders for weather and sea condition assessment, use of the 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 (Raphael et al. 2007, Huff et al. 2003, Mack et al. 2003).

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 period. During these tests, each observer estimated five perpendicular distances to floating targets and the actual perpendicular distance was measured with a laser rangefinder. 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. 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. Beaufort 3 is described as a gentle breeze, 7-10 knot winds, creating large wavelets, crests beginning to break, and scattered whitecaps. Note: The Zone 1 crew surveyed in short stretches of Beaufort 3 associated with tidal rips or other bathymetric features common in Puget Sound.

### *Equipment.*

For Zone 1, the crew surveyed from a 24-foot Almar boat with twin-outboard engines. This was a change from previous years where 17 or 20 foot Boston Whaler boats were operated by two different crews. For Zone 2, the crew used a 26-foot Almar boat with twin-outboard engines. This is the same boat that has been used for all previous years.

In Zone 1 and 2, 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 Zone 1 and 2, for each marbled murrelet sighting 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).

This was the first year that the DLOG2 program was used in Zone 1. In previous years, observers in Zone 1 dictated all observations into hand-held voice-activated digital recorders and they transcribed this information onto datasheets and then entered it into the computer. In previous seasons, or Zone 1 transect survey length was calculated in ArcGIS prior to the season and is therefore a theoretical distance.

### *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. 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. Each PSU was sampled twice during the survey season with replicate one completed by 21 June. A random approach was used to spread the survey effort out both spatially and temporally by randomly selecting a Stratum 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 southern Hood Canal and Central/South Puget Sound and accessed from Olympia, Tacoma, Manchester, or Hood Canal. PSUs for Zone 1 in Stratum 2 and 3 were surveyed using the “Zone 1 crew”. The “Zone 2 crew” sampled those PSUs in Zone 1 Stratum 1 located along the Strait of Juan de Fuca because it made more sense geographically and logistically.

*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 were sampled three times. To sample Stratum 1 (PSUs 1-8), 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 were 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.

#### *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 and SAS 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. 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 2013, two replicates of all 30 PSUs in Conservation Zone 1 were sampled to protocol. Because of the sheltered nature of Conservation Zone 1, cancelled surveys are uncommon and the only deviations from the randomly chosen survey schedule occurred when surveys in a given area were switched due to wind

on a given day or between two consecutive days. Only one survey had to be repeated due to buoy maintenance and a hovering helicopter.

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2013 was 4,395 birds (95% confidence interval = 2,275 – 6,740 birds) with a -3.88% (standard error = 1.73%) average annual rate of decline for the 2001-2013 period (Table 1, Figure 7,  $p = 0.0499$ ). Two juvenile (hatch year) marbled murrelets were seen this season, one on July 1<sup>st</sup> in PSU 8 on the east side of Orcas Island and the second on July 18<sup>th</sup> in PSU 23 near Deception Pass Bridge. This monitoring strategy was not designed to track juvenile recruitment.

#### *Population Estimates and Trends – Washington Coast (Zone 2)*

In 2013, three replicates of all PSUs in Stratum 1 were sampled and all PSUs in Stratum 2 were sampled once. Throughout the 11-week season, poor weather and rough seas precluded surveying on 2 days in May, 5 days in June and 2 days in July.

Along the outer coast of Washington, physical features of the shoreline influenced navigation. In some instances, these physical features were permanent obstructions such as submerged groups of rocks or larger rocky islands (e.g. Cape Alava, Tatoosh Island). In other cases, these features were less permanent such as kelp beds. Tidal fluctuations swell height, and breaking waves also affected navigation especially in the near-shore transects. For Conservation Zone 2, the nearshore boundary was 350 m. In 2013, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed for 8 subunits in Stratum 1 and 9 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 coast for 2013 (Zone 2) was 1,257 birds (95% confidence interval = 920 – 1,846 birds) with a -7.37% (standard error = 1.70%) average annual rate of decline for the 2001-2013 period (Table 1, Figure 8,  $p = 0.0016$ ). As in all previous years, higher densities of marbled murrelets were observed in Stratum 1 than Stratum 2 and the highest densities of marbled murrelets were observed in PSU 7, located south of Destruction Island to Kalaloch and the Raft River. We did observe record numbers of murrelets in PSUs 1 and 2 ( $n=29$  and  $27$ , respectively) early in the season. There were no juvenile (hatch year) marbled murrelet observed during the season, but this monitoring scheme was not designed to track juvenile recruitment. Interestingly, the numbers of birds in Zone 1, Stratum 1 (Strait of Juan de Fuca) are back down to earlier levels and the apparent temporary increase in birds in 2011 and 2012 may have been caused by a temporary influx of birds into this region, perhaps in response to favorable foraging conditions (see Falxa et al. 2013). Birds on the waters of this region nest on both the Olympic Peninsula and on Vancouver Island (Bloxtton and Raphael 2008) as a result, there may be some back and forth in the distribution of birds on the water depending on local foraging conditions.

*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 -4.65% (standard error = 1.33%) for the 2001-2013 period (Table 1, Figure 9,  $p = 0.0059$ ).

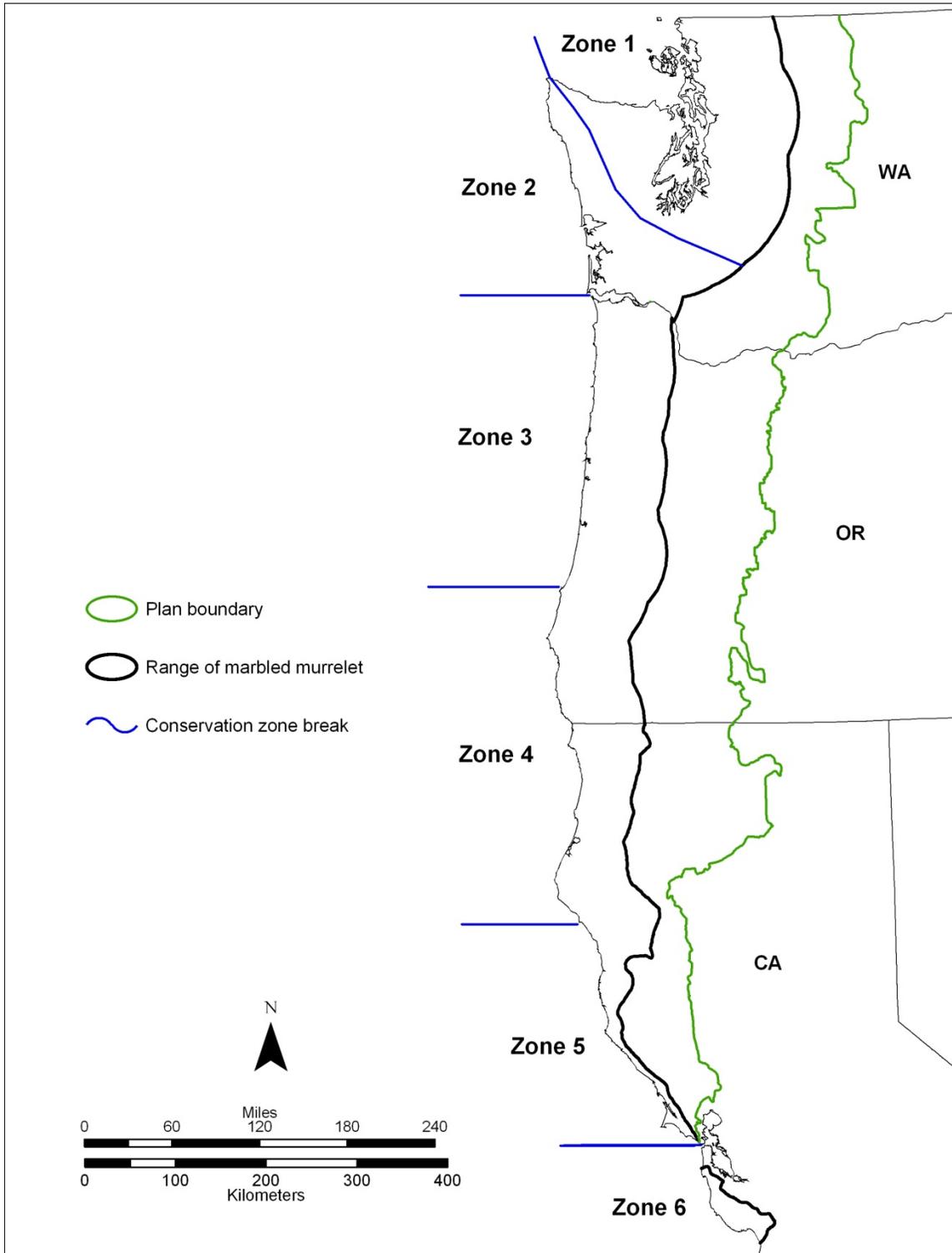
**Table 1.** Estimates of average annual rate of population change for zones 1 and 2 and both zones combined for 2001-2013.

<b>Zone</b>	<b>Annual Rate (%)</b>	<b>SE (Annual rate)</b>	<b>95% Lower CL for Annual Rate</b>	<b>95% Upper CL for Annual Rate</b>	<b>Adjusted R<sup>2</sup></b>	<b>P-value</b>
1	-3.88	1.73	-7.60	0.00	0.242	0.0499
2	-7.37	1.70	-11.04	-3.55	0.577	0.0016
1 & 2	-4.65	1.33	-7.54	-1.67	0.469	0.0059

## **Acknowledgments**

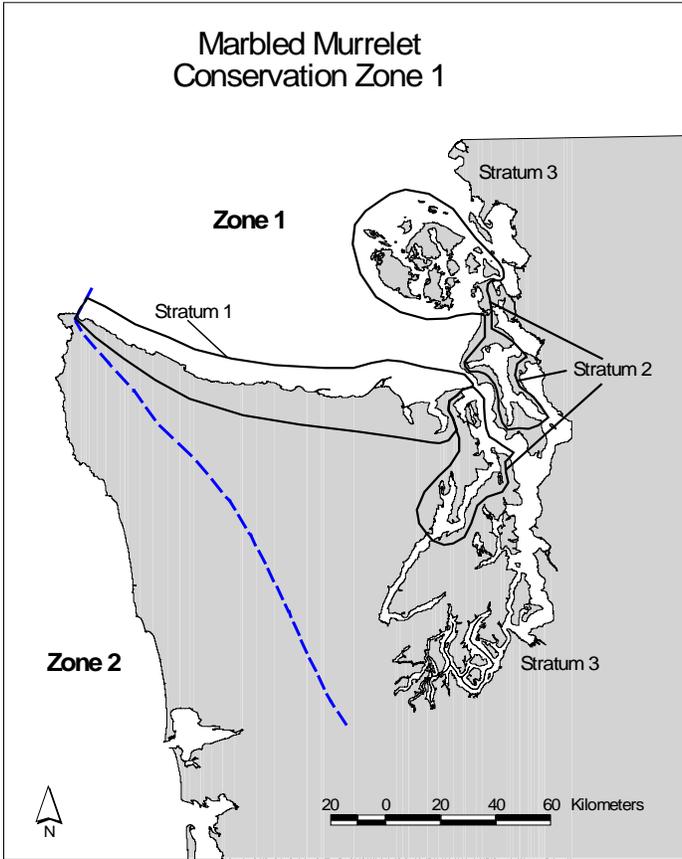
In 2013, funding was provided by U.S. Fish and Wildlife Service Contracts (contract # F12AP00744 & F12AP00845) and by the Washington Department of Fish and Wildlife. We thank Rus Geh who was the boat captain and Lindsay Hennes, Corey VanStratt, and Mallore Weinheimer who were observers in Zone 1. We thank Chad Norris who was the boat captain and Amy Baker, Ryan Merrill, and Amy Willoughby who were observers in Zone 2. We thank Jim Baldwin (USFS, PSW Research Station) who provided statistical analyses; Rich Young (USFWS) who provided survey coordinates and GIS support; Steve Jeffries (WDFW) who allowed us to borrow Research 4; the Lacey office of the USFWS (Deanna Lynch) who loaned us the USFWS Almar. Our thanks to NOAA who allowed us to use their research trailer at Neah Bay and to the U.S. Coast Guard for allowing us access to the Neah Bay base.

**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.

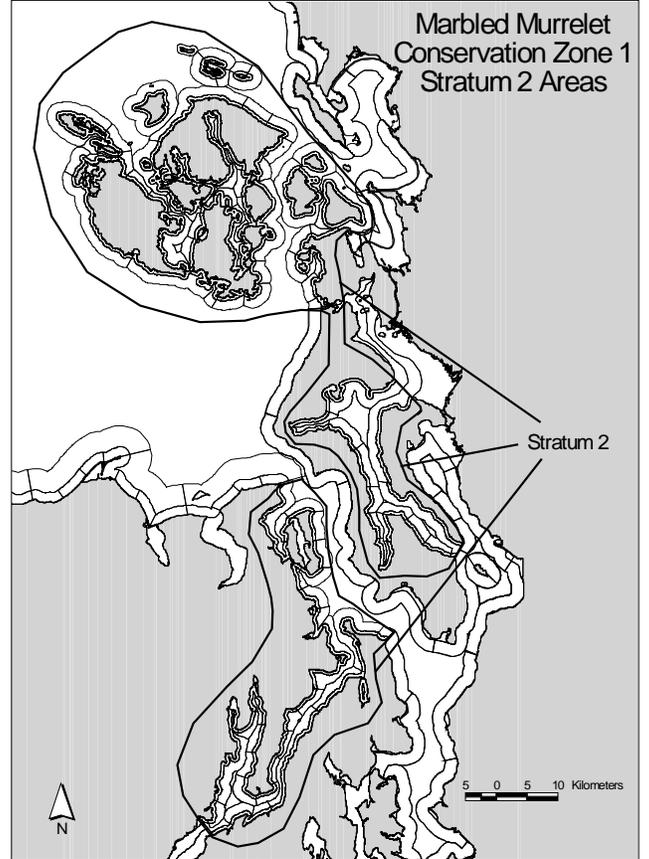


Figure 3. Strata 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2 (from Huff 2006).

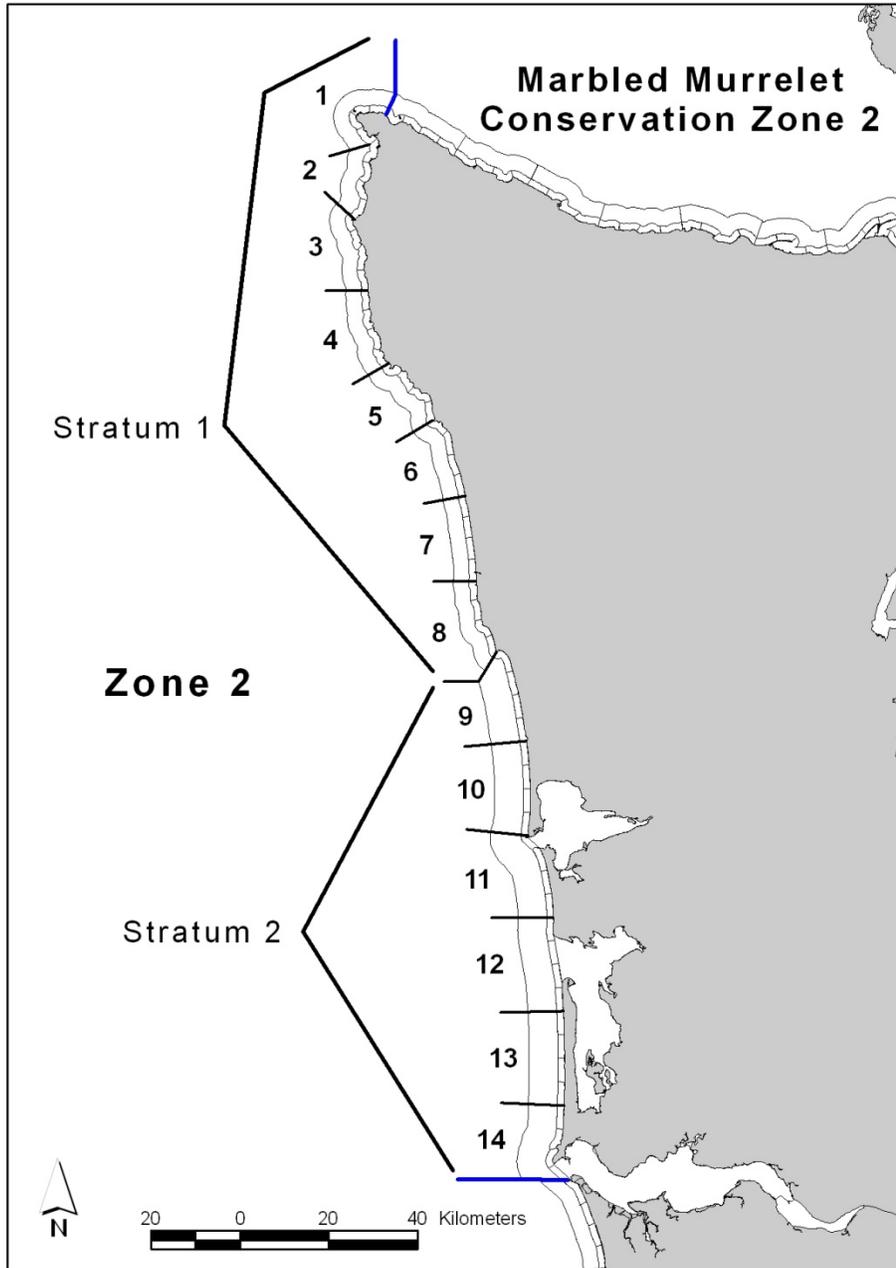


Figure 4. Marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore).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

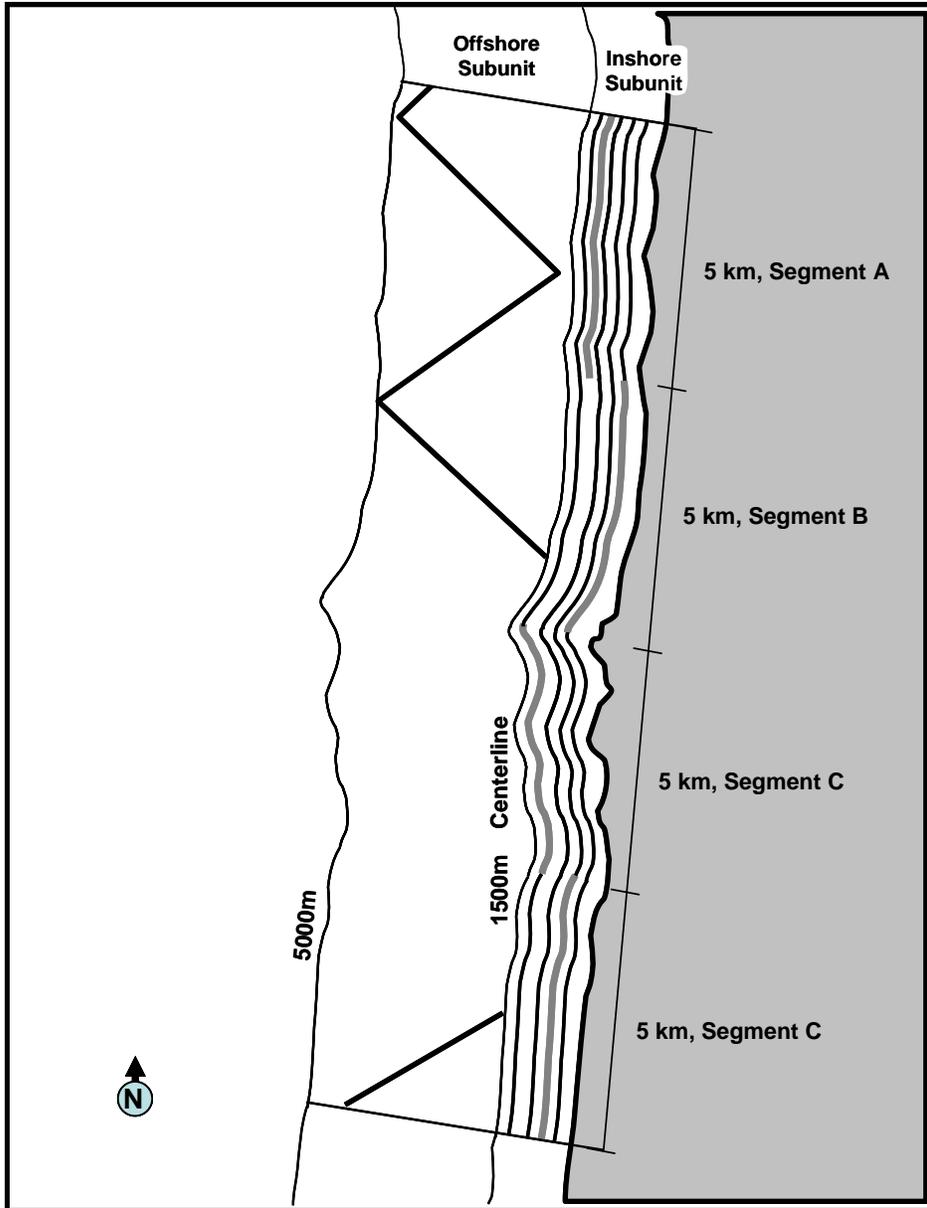


Figure 5. 2000-2013 marbled murrelet population densities (birds/km<sup>2</sup>) with 95% confidence intervals for Puget Sound and Strait of Juan de Fuca (Zone 1) and for the strata within this zone: 1) Strait of Juan de Fuca (Stratum 1), 2) San Juan Islands and northern Hood Canal (Stratum 2) and, 3) southern Puget Sound (Stratum 3).

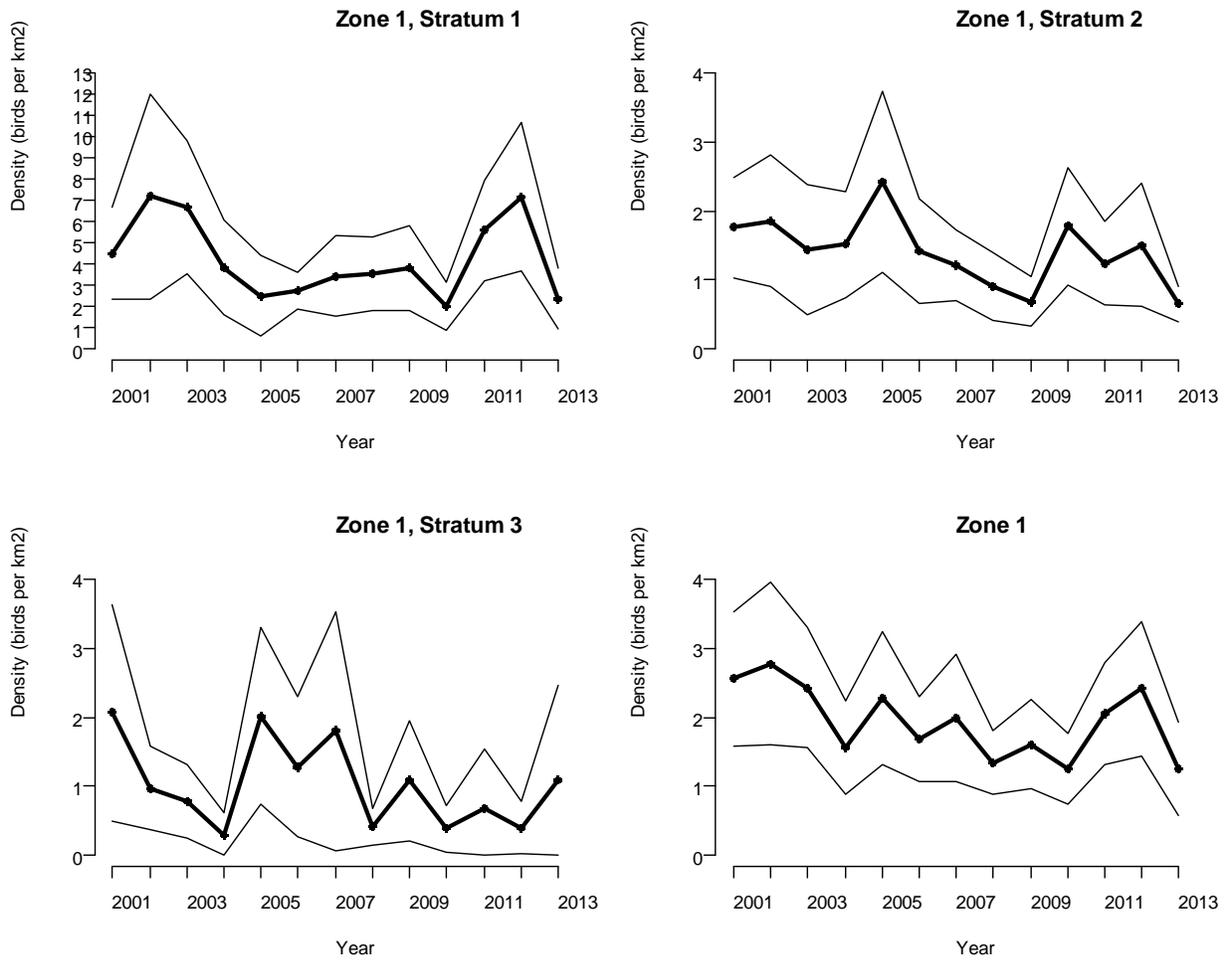


Figure 6. 2000-2013 marbled murrelet population densities (birds/km<sup>2</sup>) with 95% confidence intervals for the Washington coast (Zone 2) and for the northern (Stratum 1) and southern (Stratum 2) portions of this Zone.

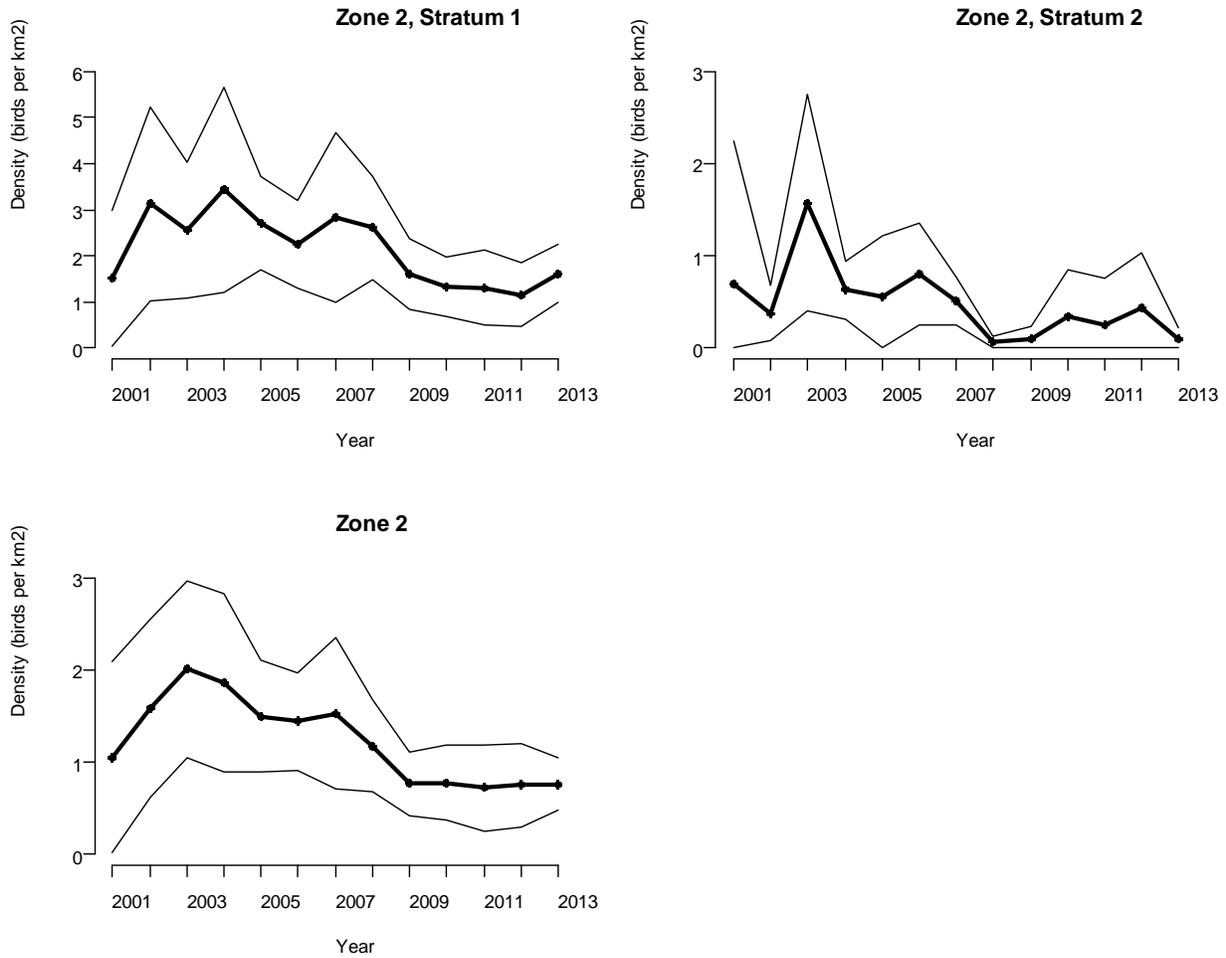


Figure 7. Washington marbled murrelet population density trend for 2001-2013 with 95% confidence intervals for Zone 1 (Puget Sound and Strait of Juan de Fuca). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

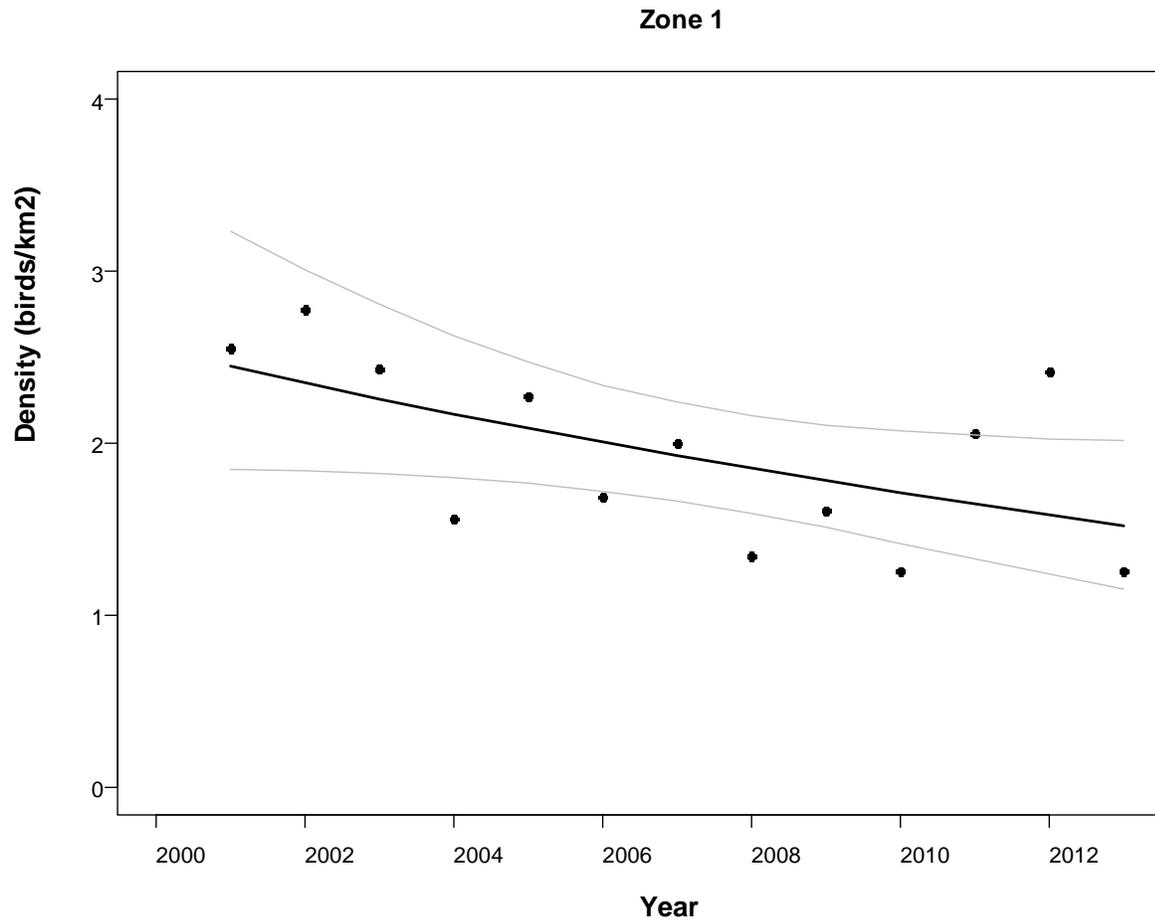


Figure 8. Washington marbled murrelet population density trend for 2001-2013 with 95% confidence intervals for Zone 2 (outer coast of Washington). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

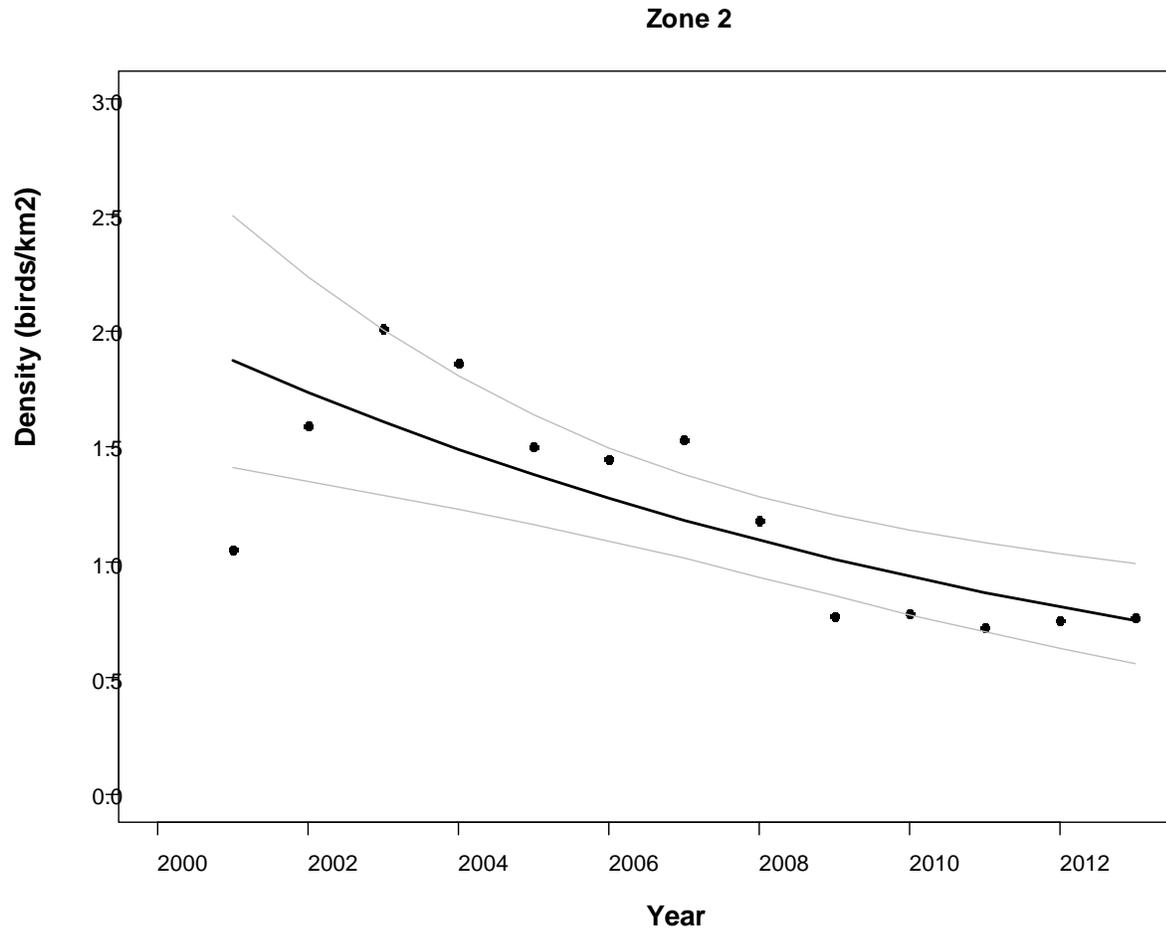
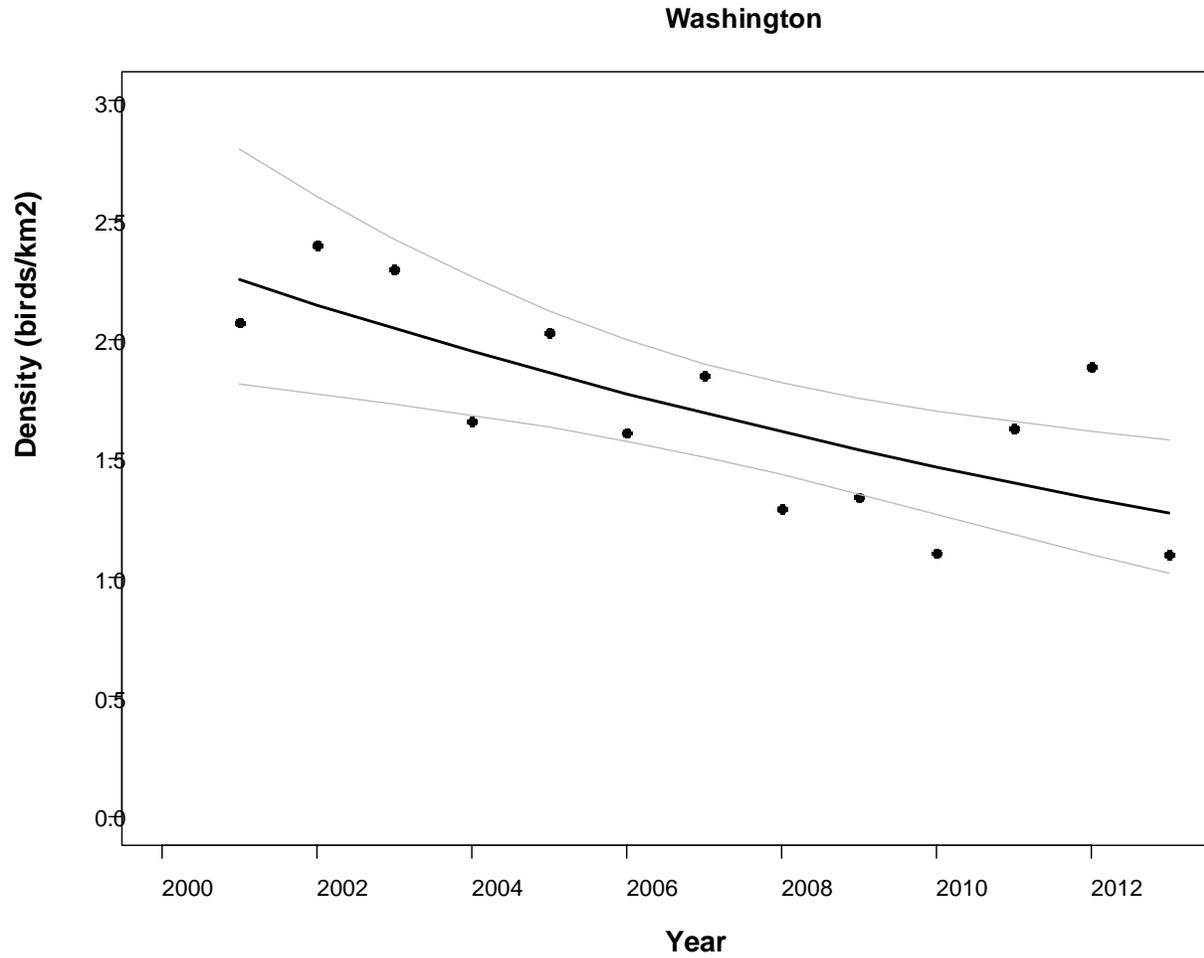


Figure 9. Washington marbled murrelet population density trend for 2001-2013 with 95% confidence intervals for Zones 1 and 2 combined (all marine waters of Washington State). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.



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