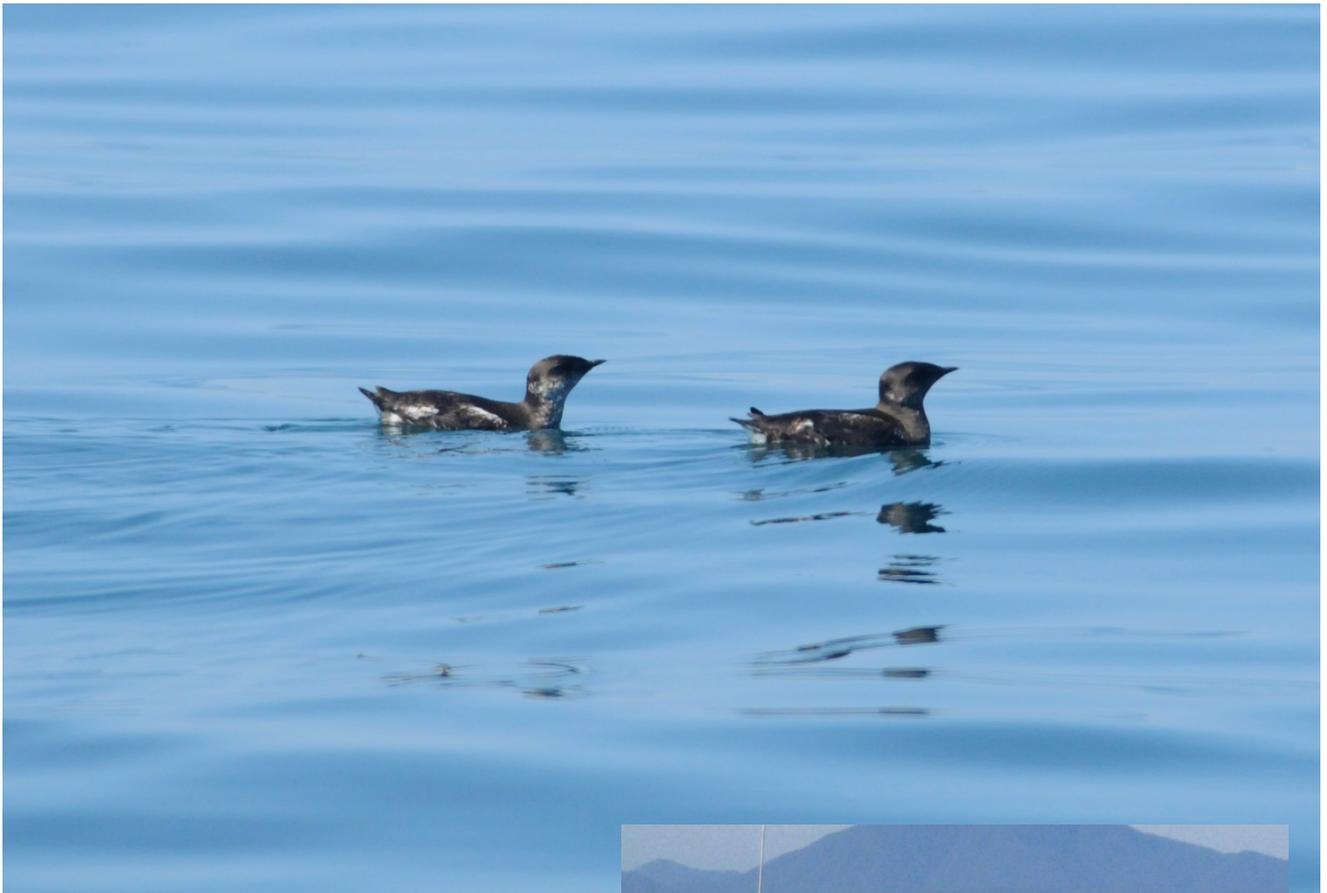


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**Monique M. Lance, Scott F. Pearson, Martin G. Raphael,
and Thomas D. Bloxton, Jr.**



**Washington Department of
Fish and Wildlife
Wildlife Program
Science Division**



**USDA Forest Service
Pacific Northwest
Research Station**



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Cover photos: marbled murrelet (Ryan Merrill, WDFW), Research 4 (Monique Lance)

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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, US Fish and Wildlife Service, and other state, federal and private researchers have participated in a program to estimate marbled murrelet population size and trends 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 (Conservation Zones) throughout this range, two of which are located in Washington; Zone 1 includes the Strait of Juan de Fuca, Puget Sound, Hood Canal and the San Juan Islands and is monitored by the USDA Forest Service Pacific Northwest Research Station; Zone 2 includes the Washington outer coast and is monitored by Washington Department of Fish and Wildlife. This report focuses on monitoring results from Conservation Zones 1 and 2 during the 2012 monitoring season (15 May - 31 July).

The marbled murrelet population estimate for all zones in the Northwest Forest Plan area (San Francisco Bay to the Canadian border) in 2012 was 21,284 (95% confidence interval 16,700 - 25,867). The population estimate has ranged from 16,798 – 23,673 over the 12 years of monitoring. The population estimate for Puget Sound and the Strait of Juan de Fuca in 2012 (Zone 1) was 8,442 birds (95% confidence interval = 5,276 – 12,030 birds) with a 3.17% (standard error = 2.00%) average annual rate of decline for the 2001-2012 period. The population estimate for the Washington coast for 2012 (Zone 2) was 1,240 birds (95% confidence interval = 833 - 1,504 birds) with a 7.59% (standard error = 2.01%) average annual rate of decline for the 2001-2012 period. For Washington State (Zones 1 and 2 combined) the estimate of annual rate of change in murrelet density was -4.07% (95% confidence interval -7.47%, -6.02%) for the 2001-2012 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 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 US Fish and Wildlife Service, US Forest Service, and state wildlife agencies initiated a marbled murrelet monitoring strategy in 2000 (Raphael et al. 1999, 2007; Miller et al. 2006). 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 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 US Forest Service, US 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; US 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 2012. This report focuses on the methods and results from Conservation Zones 1 and 2 from the 2012 monitoring season.

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 and is monitored by the U.S.D.A. Forest Service Pacific Northwest Research Station (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 crew in Zone 1 consisted of two teams (Port Townsend and Friday Harbor). Each team had a crew leader and 2 crew members. All three members rotated between boat operator and observer duties to avoid survey fatigue.

The crew in Zone 2 consisted of one dedicated boat operator and three observers/data recorders. 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.

Most observers had previous experience monitoring seabirds at sea and or on colonies. Observers in all 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), 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 quality assurance tests. 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. 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, the observer’s results were assessed. 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 close to the transect line ahead of the boat (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 sighting 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: Zone 1 crews surveyed in short stretches of Beaufort 3 associated with tidal rips or other bathymetric features common in Puget Sound.

Equipment.

For Zone 1, crews surveyed from 17 or 20 foot Boston Whaler boats. 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. For Zone 1 transect survey length is calculated in ArcGIS prior to the season and is therefore a theoretical distance. Comparisons of this theoretical distance with actual distance as recorded by using onboard GPS systems have shown very close agreement (< 1% difference on average; Raphael, unpublished data).

For Zone 2, the crew used a 26-foot Almar boat with twin-outboard engines. In Zone 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 with software (DLOG2 developed by R.G. Ford, Inc., Portland, OR.) that is interfaced with a GPS unit and collects real time location data. DLOG2 interfaces with a handheld GPS and GIS overlays of the Washington shoreline and adjacent bathymetry, and uses these data to record GPS coordinates and perpendicular distance to shore at operator-defined time intervals (e.g. every 30 seconds). Transect survey length was calculated from the GPS trackline 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). Zone 1 surveyors also collected water temperature (SST) at each murrelet observation.

Survey Effort

Zone 1.— Primary Sampling Units (PSUs) around the San Juan Islands were accessed by one crew headquartered at Friday Harbor, San Juan Island. That crew launched the boat from the dock at the University of Washington's Friday Harbor Laboratory. All other PSUs were accessed by a separate crew headquartered in Port Townsend. That crew used boat launches that were closest to the desired PSU and that were accessible given expected tides that day. Each PSU was sampled twice during the survey season, and every effort was made to spread the survey effort out both spatially and temporally. As in previous years, we sampled 5 PSUs in Stratum 1, 20 in Stratum 2, and 5 in Stratum 3. The same PSUs are sampled each year, but the order of sampling varied.

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 LaPush) 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 US 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 2012, two replicates of all 30 PSU's in Conservation Zone 1 were sampled to protocol. Because of the sheltered nature of Conservation Zone 1 cancelled surveys are uncommon. Deviations from the randomly chosen survey schedule were made to ensure the crews could survey each day. For example, if the weather was too windy in Stratum 1 (Strait of Juan de Fuca) the crew would reschedule that survey for the next favorable weather window and instead survey in the more protected waters of Hood Canal or Puget Sound.

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2012 was 8,442 birds (95% confidence interval = 5,276 – 12,030 birds) with a 3.17% (standard error = 2.00%) annual rate of decline for the 2001-2012 period (Table 1, Figure 7). Twenty juvenile (Hatch Year) marbled murrelets were observed in Zone 1 including ten observed on 19 July on PSU 3 (Stratum 1) near Clallam Bay in the western Strait of Juan de Fuca.

Population Estimates and Trends – Washington Coast (Zone 2)

In 2012, three replicates of all PSUs in Stratum 1 were sampled and all PSUs in Stratum 2 were sampled once. A fourth replicate was made of PSUs 1 and 2 and a second replicate of PSUs 13 and 14 were conducted to increase spatial and temporal sampling. Throughout the 11-week season, poor weather and rough seas precluded surveying on 5 days in May, 4 days in June and 1 day 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 2012, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed for 13 subunits in Stratum 1 and 16 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 2012 (Zone 2) was 1,240 birds (95% confidence interval = 833 – 1,504 birds) with a 7.59% (standard error = 2.01%) annual rate of decline for the 2001-2012 period (Table 1, Figure 8). 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 PSUs 6 and 7, which are located in the area from Destruction Island south to Kalaloch and the Raft River. We did observe record numbers of murrelets in PSU 13 (n=20) late in the season. There was 1 juvenile (Hatch Year) marbled murrelet observed in PSU 13 on 12 July and 2 juvenile (Hatch Year) marbled murrelets observed in PSU 4 on 17 July during the season, but this monitoring scheme was not designed to track juvenile recruitment.

Washington Population trends

For Washington State (Zones 1 and 2 combined), there was a 4.07% (standard error = 0.1921) annual rate of decline in murrelet density for the 2001-2012 period (Table 1, Figure 9).

Table 1. Estimates of average annual rate of population change for zones 1 and 2 and both zones combined for 2001-2012.

| Zone | Annual Rate (%) | SE (Annual rate) | 95% Lower CL for Annual Rate | 95% Upper CL for Annual Rate | Adjusted R² | P-value |
|-------------|------------------------|-------------------------|-------------------------------------|-------------------------------------|-------------------------------|----------------|
| 1 | -3.17 | 2.00 | -7.78 | 1.67 | 0.116 | 0.1495 |
| 2 | -7.59 | 2.01 | -12.21 | -2.72 | 0.526 | 0.0046 |
| 1 & 2 | -4.07 | 0.1921 | -7.47 | -0.602 | 0.3445 | 0.02632 |

Acknowledgments

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

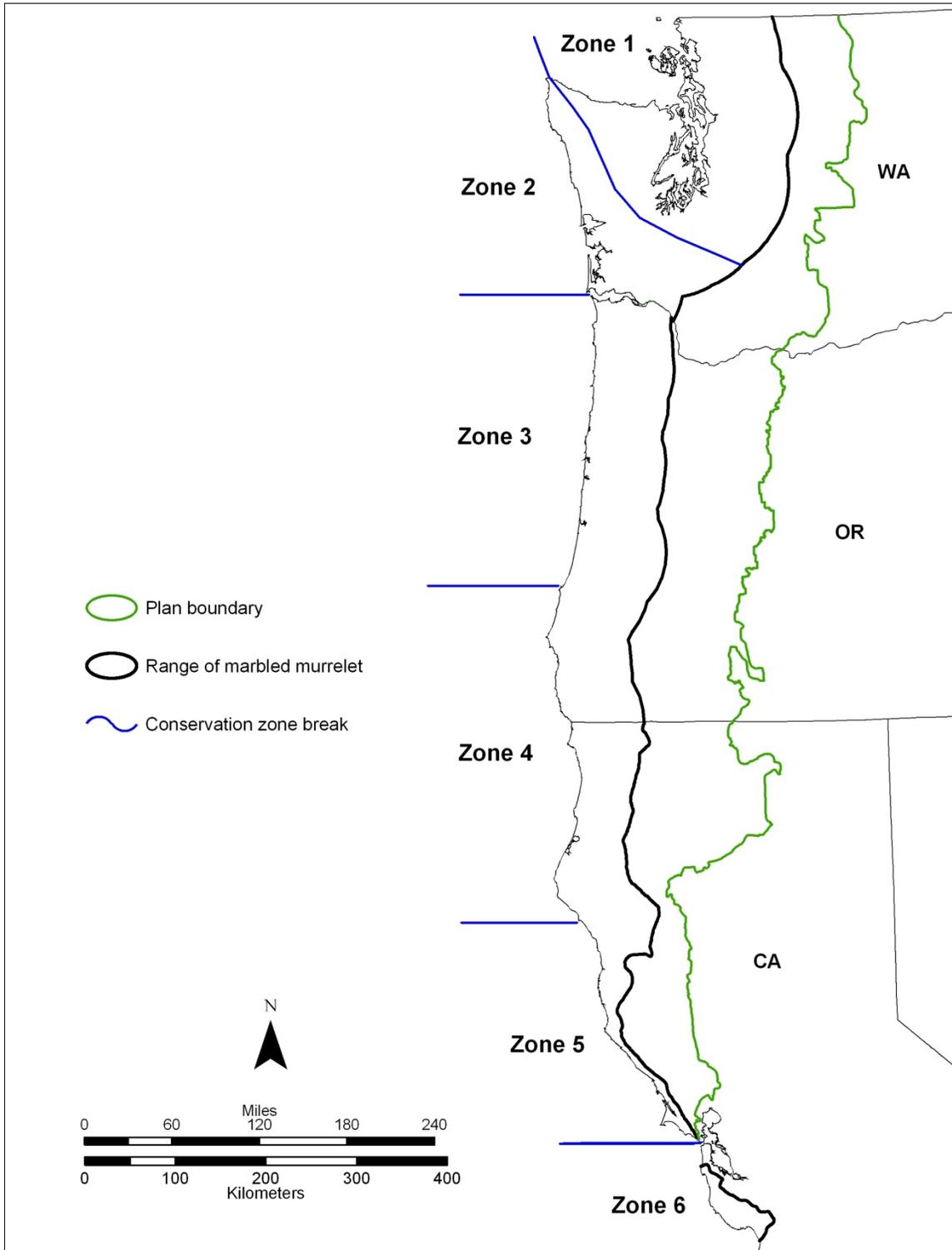
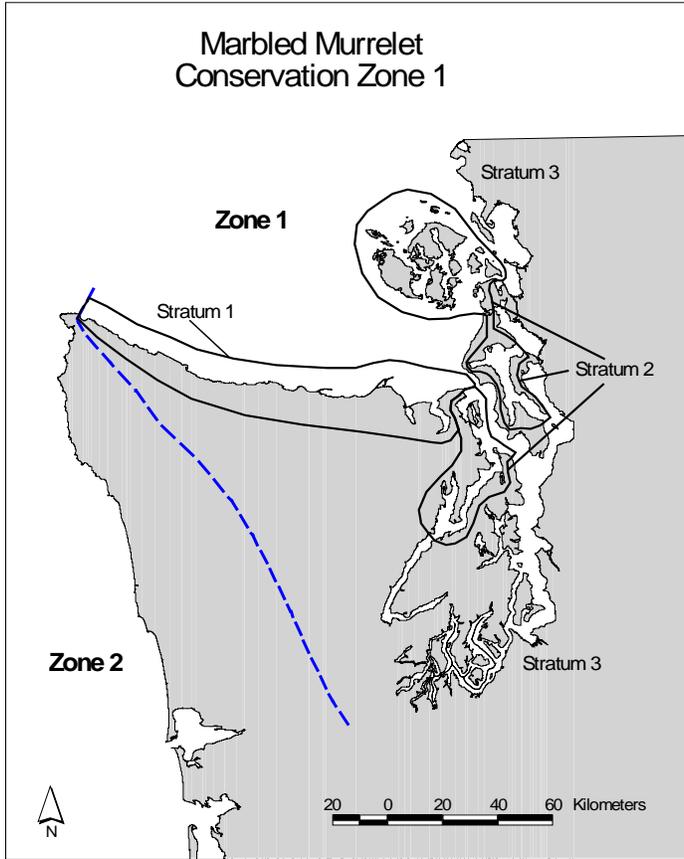


Figure 2. A) marbled murrelet Conservation Zone 1 with Strata 1 and 2 circled. Stratum 3 is the remaining area within Zone 1. B) marbled murrelet Conservation Zone 1 enlargement of Stratum 2.

A.



B.

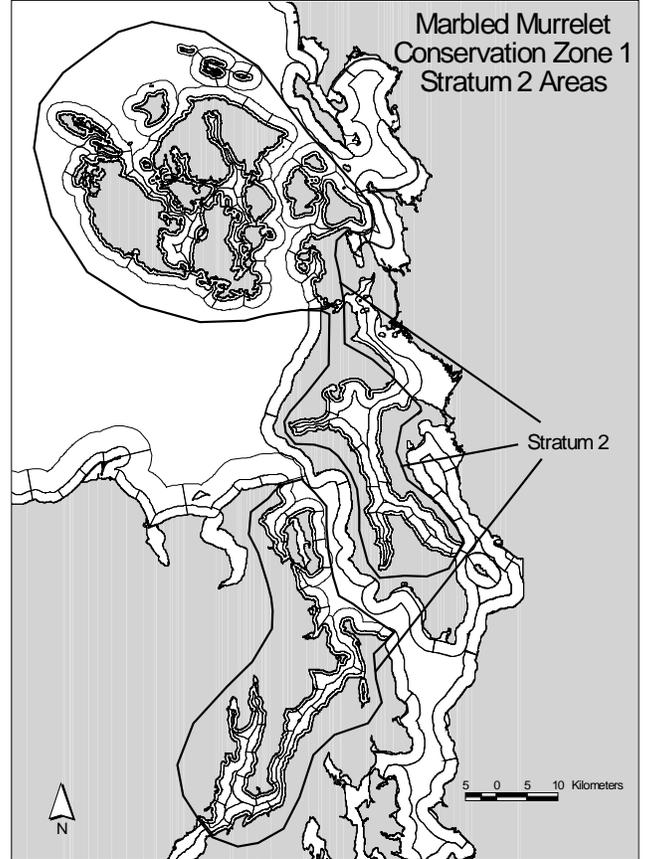


Figure 3. Stratum 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2 (from Huff 2006).

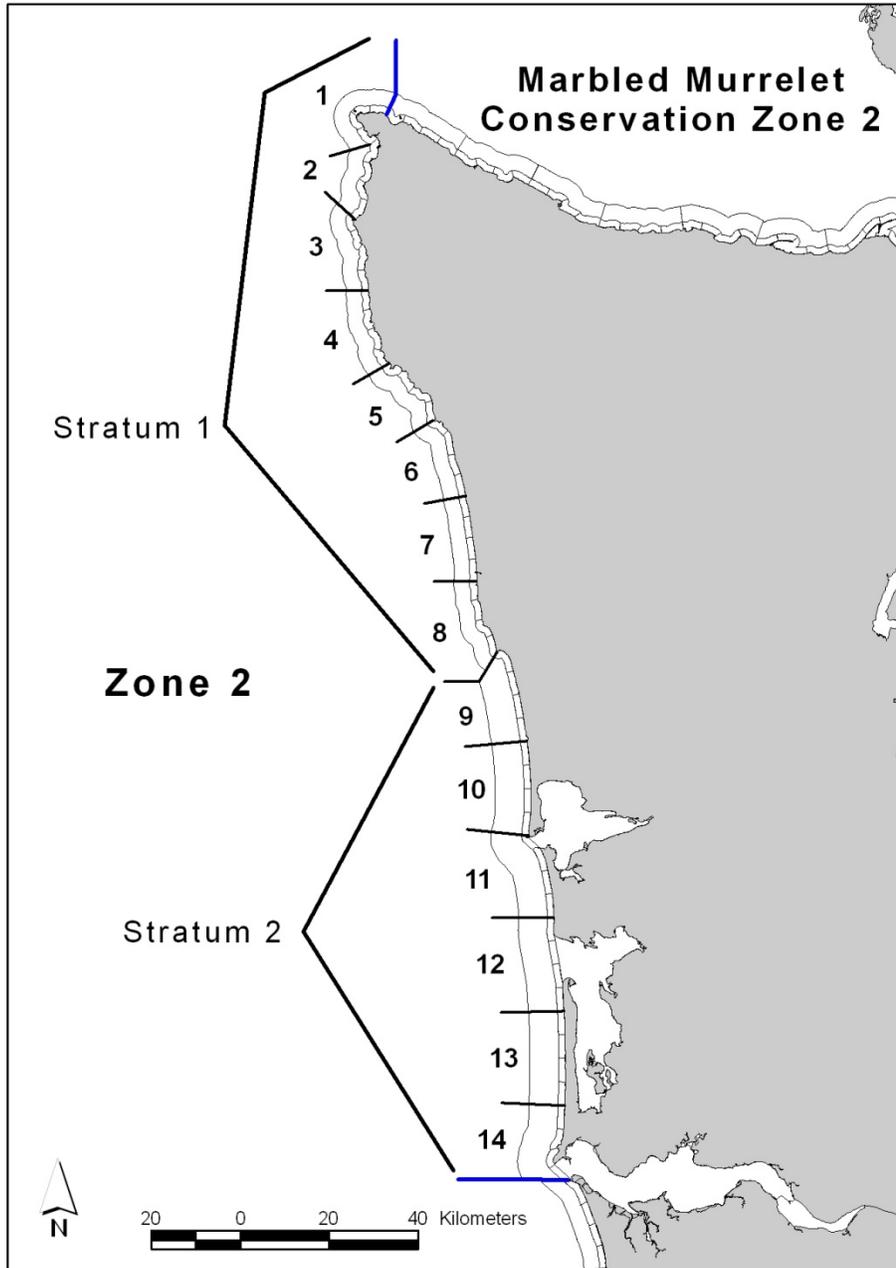


Figure 4. Marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore).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

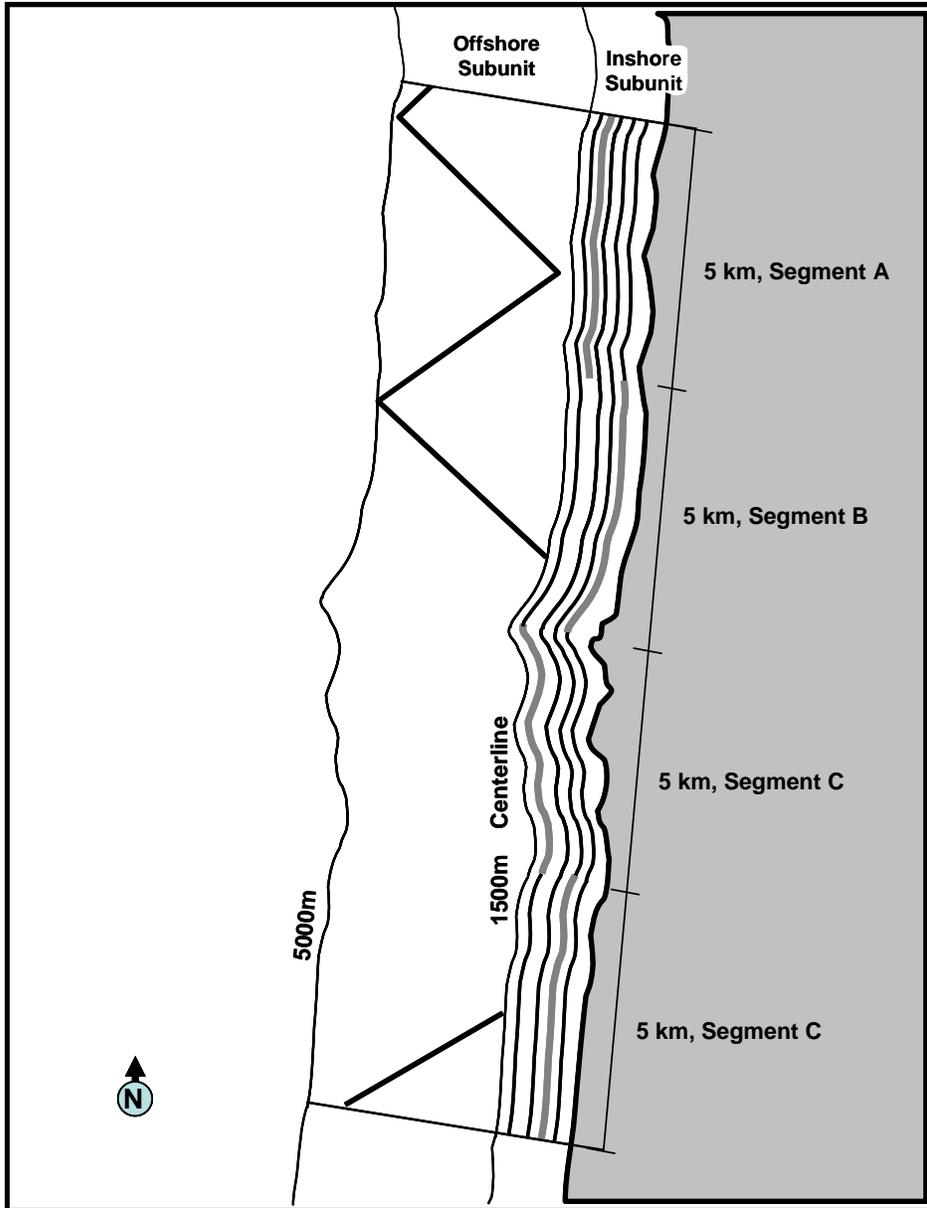


Figure 5. 2000-2012 marbled murrelet population densities (birds/km²) with 95% confidence intervals for Puget Sound and Strait of Juan de Fuca (Zone 1) and for the strata within this zone: 1) Strait of Juan de Fuca (Stratum 1), 2) San Juan Islands and northern Hood Canal (Stratum 2) and, 3) southern Puget Sound (Stratum 3).

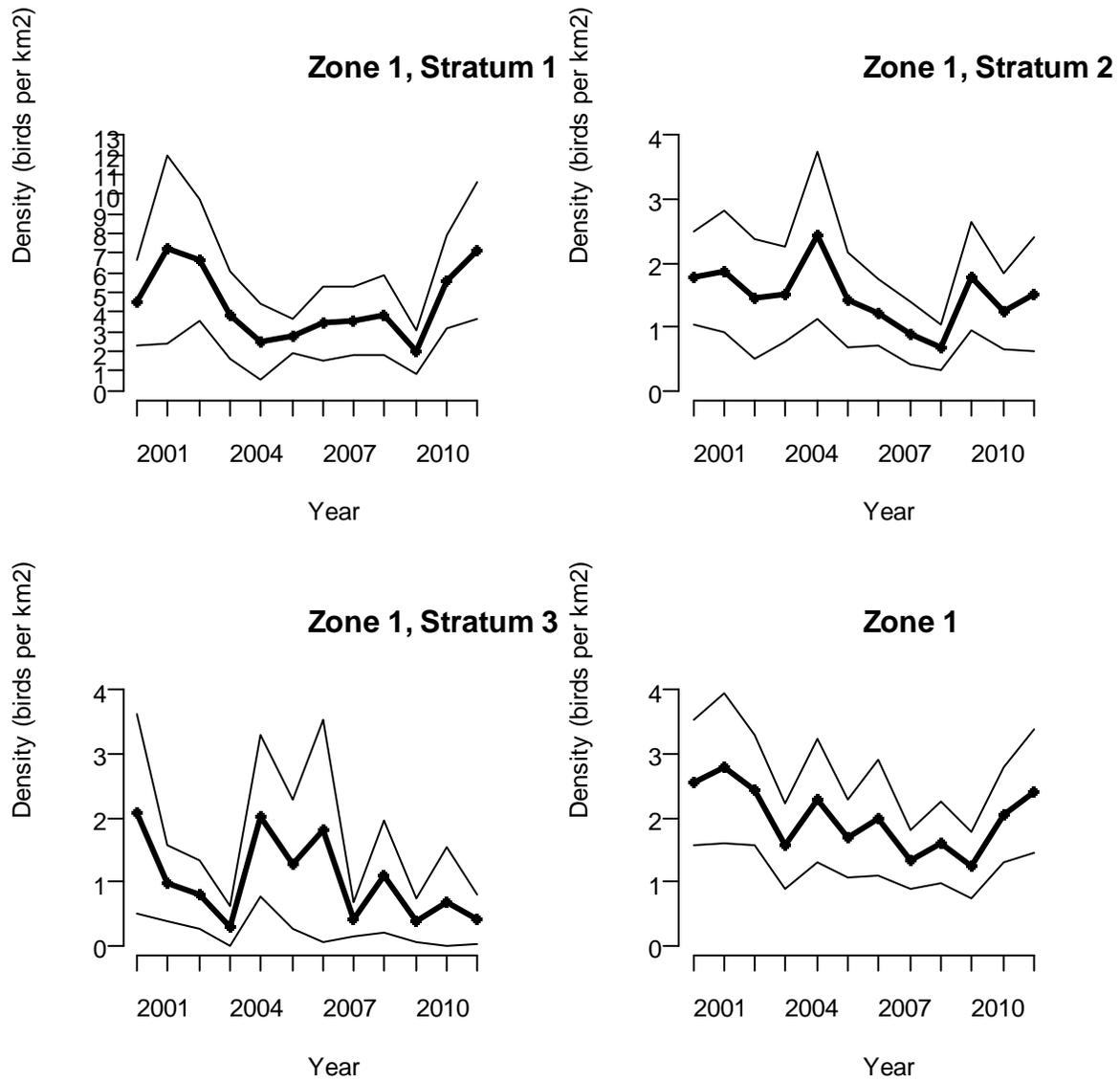


Figure 6. 2000-2012 marbled murrelet population densities (birds/km²) with 95% confidence intervals for the Washington coast (Zone 2) and for the northern (Stratum 1) and southern (Stratum 2) portions of this Zone. Note that the data from 2000 are not used in trend analyses because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

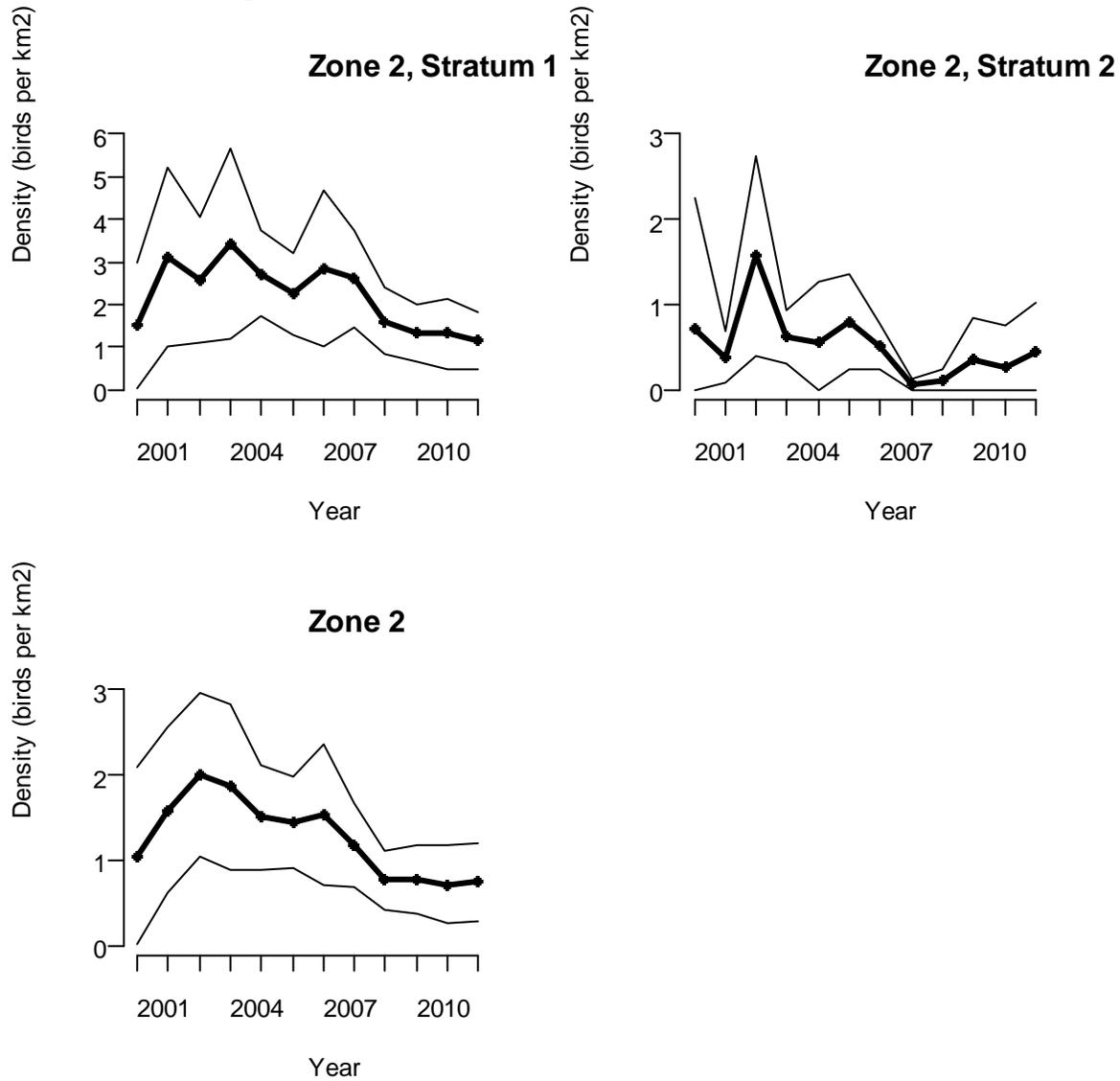


Figure 7. Washington marbled murrelet population density trend for 2001-2012 with 95% confidence intervals for Zone 1 (Puget Sound and Strait of Juan de Fuca). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

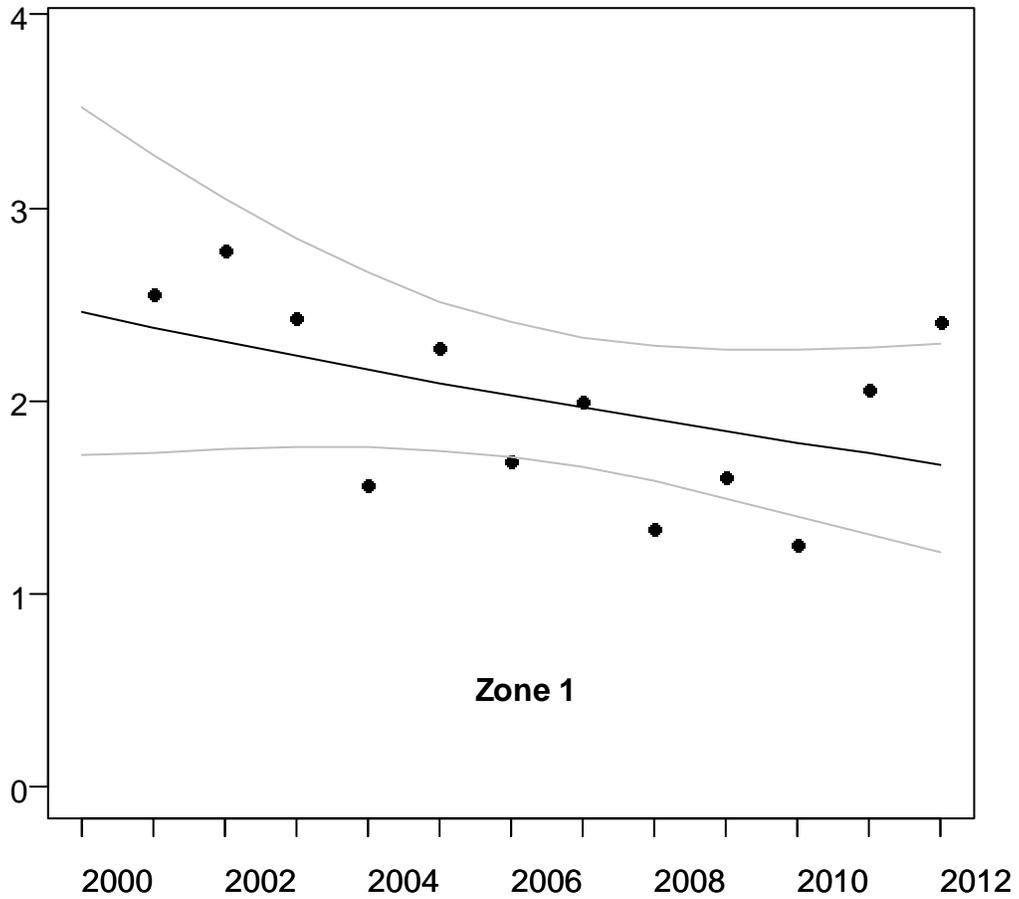


Figure 8. Washington marbled murrelet population density trend for 2001-2012 with 95% confidence intervals for Zone 2 (outer coast of Washington). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

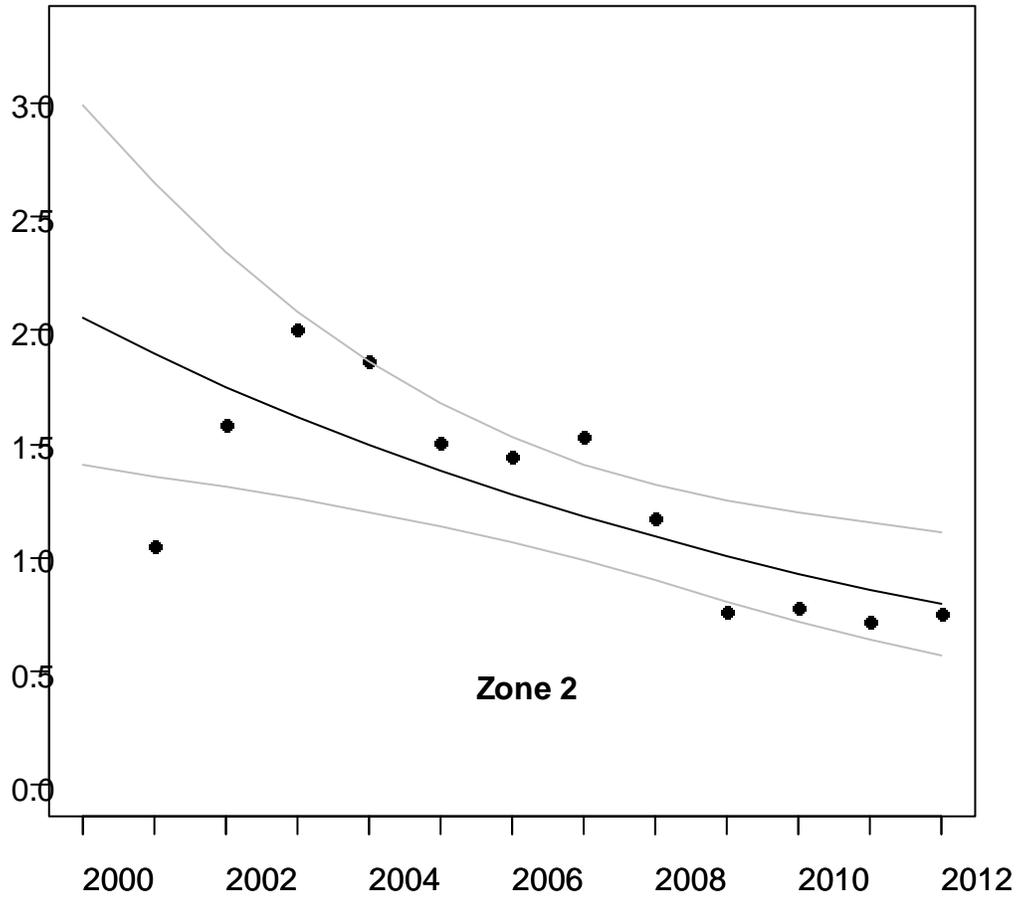
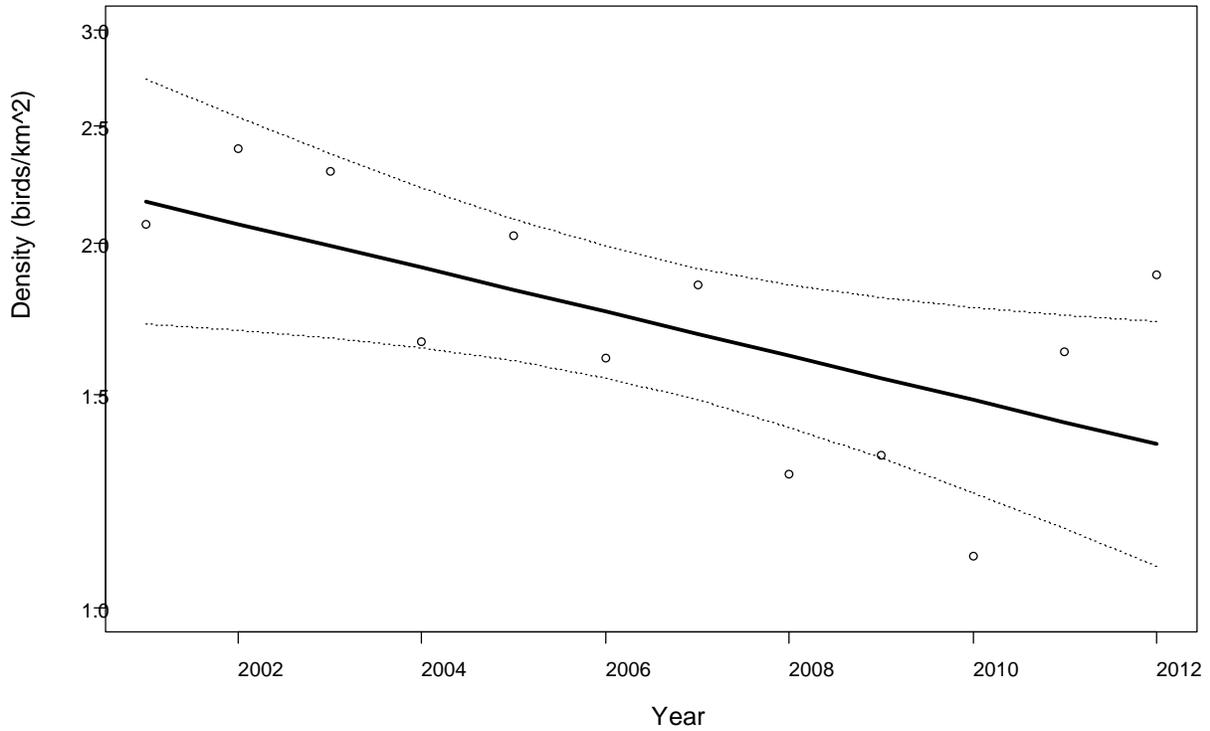


Figure 9. Washington marbled murrelet population density trend for 2001-2012 with 95% confidence intervals for Zones 1 and 2 combined (all marine waters of Washington State). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

Zones 1 & 2 Combined



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