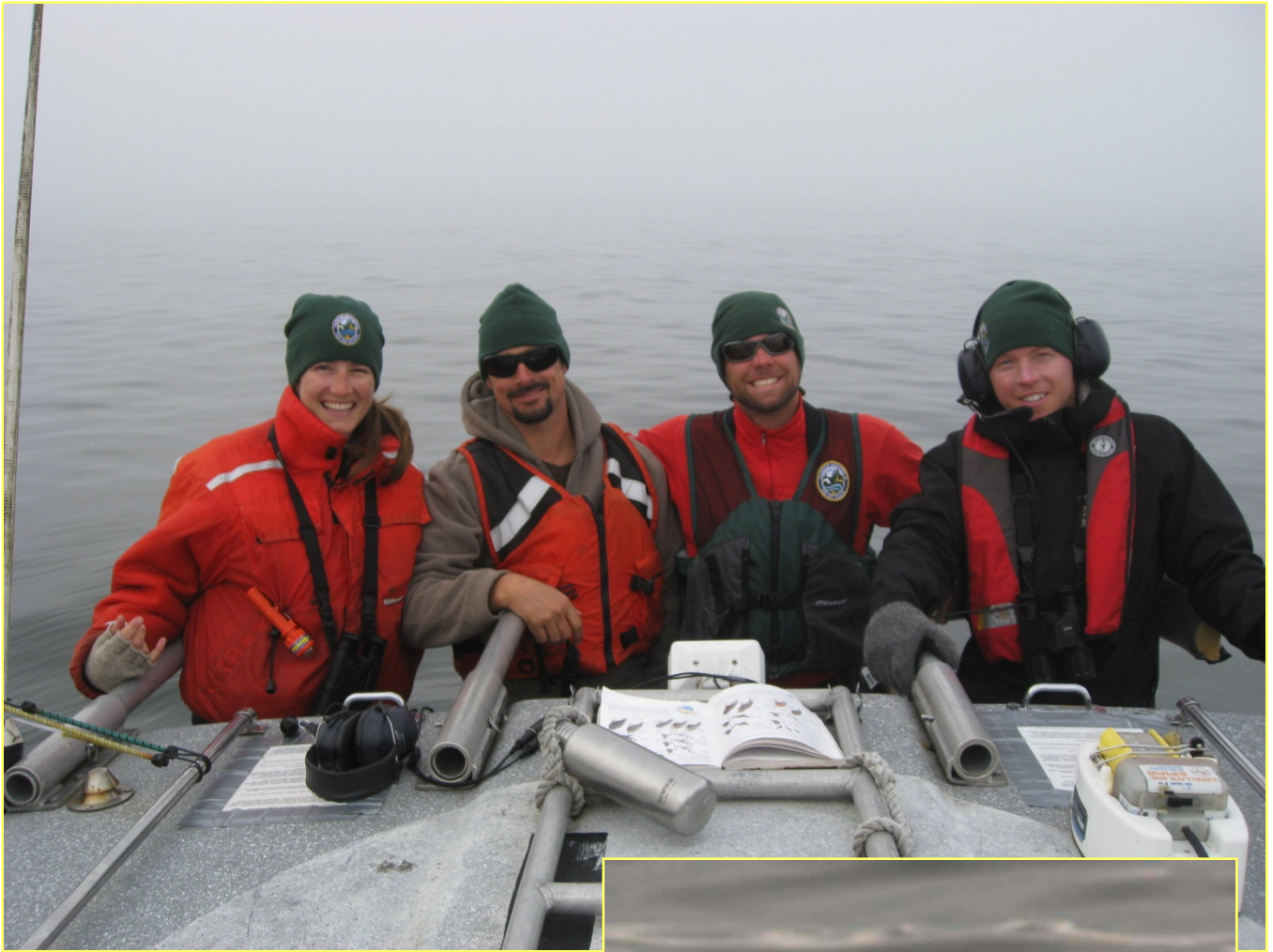


2009 Washington At-Sea Marbled Murrelet Population Monitoring: Research Progress Report

**Scott F. Pearson, Martin G. Raphael, Monique M. Lance
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**Washington Department of
Fish and Wildlife
Wildlife Program
Science Division**

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Cover photos: marbled murrelet (Josh London, NOAA) and Research 4 and survey crew (Monique Lance, WDFW)

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Research Progress Report**

Scott F. Pearson¹, Martin G. Raphael², Monique M. Lance¹, and Thomas D. Bloxton, Jr.²

¹Washington Department of Fish and Wildlife
Wildlife Program, Wildlife Science Division
600 Capitol Way North Olympia, WA 98501-1091

²USDA Forest Service
Pacific Northwest Research Station
3625 93rd Ave. SW, Olympia, WA 98512-9193

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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, 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. 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 U.S.D.A. Forest Service Pacific Northwest Research Station; Zone 2 includes the Washington outer coast and is monitored by Washington Department of Fish and Wildlife. Within Zone 1 there are three geographic strata defined by 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 most of Hood Canal; and Stratum 3: south Hood Canal and central/south Puget Sound. Within Zone 2 there are two geographic strata based on marbled murrelet density: Stratum 1 (north of Pt. Grenville – high density) and Stratum 2 (south of Pt. Grenville – low density). Each stratum is divided into primary sampling units (PSUs), which are roughly rectangular areas along approximately 20 km of coastline.

This report focuses on monitoring results from Conservation Zones 1 and 2 during the 2009 monitoring season. At-sea survey effort began 15 May and ended 31 July. As designed, all PSUs in Zone 1 were visited 2 times. All PSUs in Stratum 1 of Zone 2 were sampled three times. All PSUs in Stratum 2 of Zone 2 were sampled once.

The marbled murrelet population estimate for all zones in the Northwest Forest Plan area in 2009 was 17,791 (95% confidence interval 14,631 – 20,952). The population estimate has ranged from 17,354 – 23,673 over the 9 years of monitoring. The population estimate for inland Washington waters for 2009 was 5,623 birds (95% confidence interval = 3,922 – 8,352 birds) with a 7.0% (standard error = 1.8%) annual rate of decline for the 2001-2009 period. The population estimate for the Washington coast for 2009 (Zone 2) was 1,266 birds (95% confidence interval = 751 – 1,881 birds) with no significant decline. For Washington State (Zones 1 and 2 combined), there was a significant decline in murrelet density for the 2001-2009 period (r^2 Linear = 0.65, $P = 0.009$).

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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). These surveys were viewed as important because they allow researchers to model population trends and because detecting changes in populations is critical to evaluating the outcome of recovery actions and ultimately for determining recovery success or failure. In response to this recovery goal, the U.S. Fish and Wildlife Service, U.S. Forest Service, and state wildlife agencies initiated a marbled murrelet monitoring strategy in 2000 (Raphael et al. 1999, 2004, 2007; Miller et al. 2006). The goal of this monitoring strategy is to estimate marbled murrelet population trends in each of 5 conservation zones between San Francisco and the Washington – Canada border. Results from this effort are used to evaluate incidental take under the Endangered Species Act and to facilitate Recovery Plan development and evaluation. In addition to meeting the requirements of the Endangered Species Act, long-term marbled murrelet monitoring is designed to evaluate the effectiveness of the Northwest Forest Plan (Madsen et al. 1999). This plan is a large-scale ecosystem management plan for federal lands in the Pacific Northwest. Marbled murrelet population trends were identified as conservation and monitoring targets for evaluating the effectiveness of this plan.

Since 2000, Washington Department of Fish and Wildlife along with researchers from the Pacific NW and Pacific SW Research Stations of the US Forest Service, US Fish and Wildlife Service, Crescent Coastal Research, and the University of California Berkeley 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. These transects cover ~8,800 km². This area of coastline has been subdivided into six marbled murrelet Conservation Zones identified in the marbled murrelet Recovery Plan (Figure 1; US Fish and Wildlife Service 1997). This report focuses on results from Conservation Zones 1 and 2 from the 2009 monitoring season.

We summarize the methodology, sampling, and results for the 2009 at-sea monitoring on Puget Sound, Strait of Juan de Fuca, and on Washington's outer coast (Cape Flattery to the south jetty of the Columbia River).

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. 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. Each team had a crew leader and 2 crew members. All three members of each crew took part in all aspects of boat operation and bird observation. The crew in Zone 2 consisted of one dedicated boat operator and three observers/data recorders. 2009 was the sixth season for the boat operator two of three observers had one year experience on the crew. The third observer had prior at-sea seabird identification experience in the Pacific Northwest. The data recorder and two observers (one responsible for each side of the boat) switched duties at the beginning of each PSU. 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, in particular 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 critical. 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 direct 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 three times 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 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. In Zone 1, observers reported directly into voice-activated recorders. Data were then transcribed onto field sheets at the end of each day. In Zone 2, observers relayed data via headsets to a person in the boat cabin who entered data directly onto a laptop computer with software that is interfaced with a GPS unit, which collects real time location data (detailed below).

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.

Equipment.

For Zone 1, both crews surveyed from 17-foot Boston Whaler boats. For Zone 2, the crew used a 26-foot Almar boat with twin-outboard engines. Observers in Zone 1 read all observations into hand-held voice-activated tape recorders and transcribed each evening into the computer. For Zone 1 transect survey length is calculated by a hand held GPS. In Zone 2, data were entered into a Windows based software program called DLOG2 as birds were encountered (developed by R.G. Ford, Inc., Portland, OR.) loaded onto a laptop computer. 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. During surveys, one of the survey crew manually entered bird observation data including: species, number of birds, estimated perpendicular distance of the bird(s) from the trackline of the boat at first detection regardless of distance from the line, and behavior (flying, on water, flushed, etc.) in real time into the laptop as relayed from both the port and starboard observers through audio-headphones. In addition to these data, 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).

Survey Effort

Zone 1.— PSUs around the San Juan Islands were accessed by one crew headquartered at Friday Harbor. 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 at Sequim. 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 varies.

Zone 2--. 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. From the selected port, the PSU to be completed each day was 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

Group size and perpendicular distance data were compiled for each marbled murrelet observation and 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.

Results

Population Estimates and Trends –Puget Sound and Strait of Juan de Fuca (Zone 1)

In 2009, two replicates of all 30 PSU's in Conservation Zone 1 were sampled to protocol. For the first time since monitoring began in 2000, both Zone 1 crews used GPS tracklines created within ArcGIS to follow survey paths. Previously, these crews used radar to estimate distance from shore which proved difficult to estimate in areas of gently-sloping coastline. Surveyors with multiple years experience commented that the new method of following GPS tracklines is preferable due to consistency issues and having less equipment to deal with. Comparisons were made between trackline position and radar position and differences were found to be negligible (i.e. tens of meters, not hundreds).

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 inland Washington waters for 2009 was 5,623 birds (95% confidence interval = 3,922 – 8,352 birds; Figure 6) with a 7.0% (standard error = 1.8%) annual rate of decline for the 2001-2009 period. Five juvenile (Hatch Year) marbled murrelets were observed in Zone 1 including one observed on 2 June in Admiralty Inlet near Marrowstone Island. The other four were observed in the Strait of Juan de Fuca.

Population Estimates and Trends – Washington Coast (Zone 2)

In 2009, three replicates of all PSUs in Stratum 1 were sampled, in addition to a fourth survey of PSU 7. All PSUs in Stratum 2 were sampled once. Throughout the 11-week season, poor weather and rough seas precluded surveying on three days, one day each in May, June and 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. For Conservation Zone 2, the nearshore boundary was 350 m. In 2009, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed for three subunits in Stratum 1 and eight 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 2009 population estimate for the Washington coast was 1,266 birds (95% confidence interval = 751 – 1,881 birds). Density and population size estimates for 2009 appeared to decline relative to the previous 7 years of monitoring with the most notable apparent declines occurring in Stratum 2 but this trend was not significant.

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 around Destruction Island south to Kalaloch and the Raft River. No murrelets were observed in four of six PSU surveys in Stratum 2. There were no juvenile (Hatch Year) marbled murrelets observed in any PSU during the season, but this monitoring scheme was not designed to track juvenile recruitment.

Washington Population trends

For the 2001-2009 survey period, there was a significant decline in murrelet population density (Zones 1 and 2 combined, r^2 Linear = 0.65, $P = 0.009$). We excluded 2000 from this analysis because distances to birds were not recorded and because fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.

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

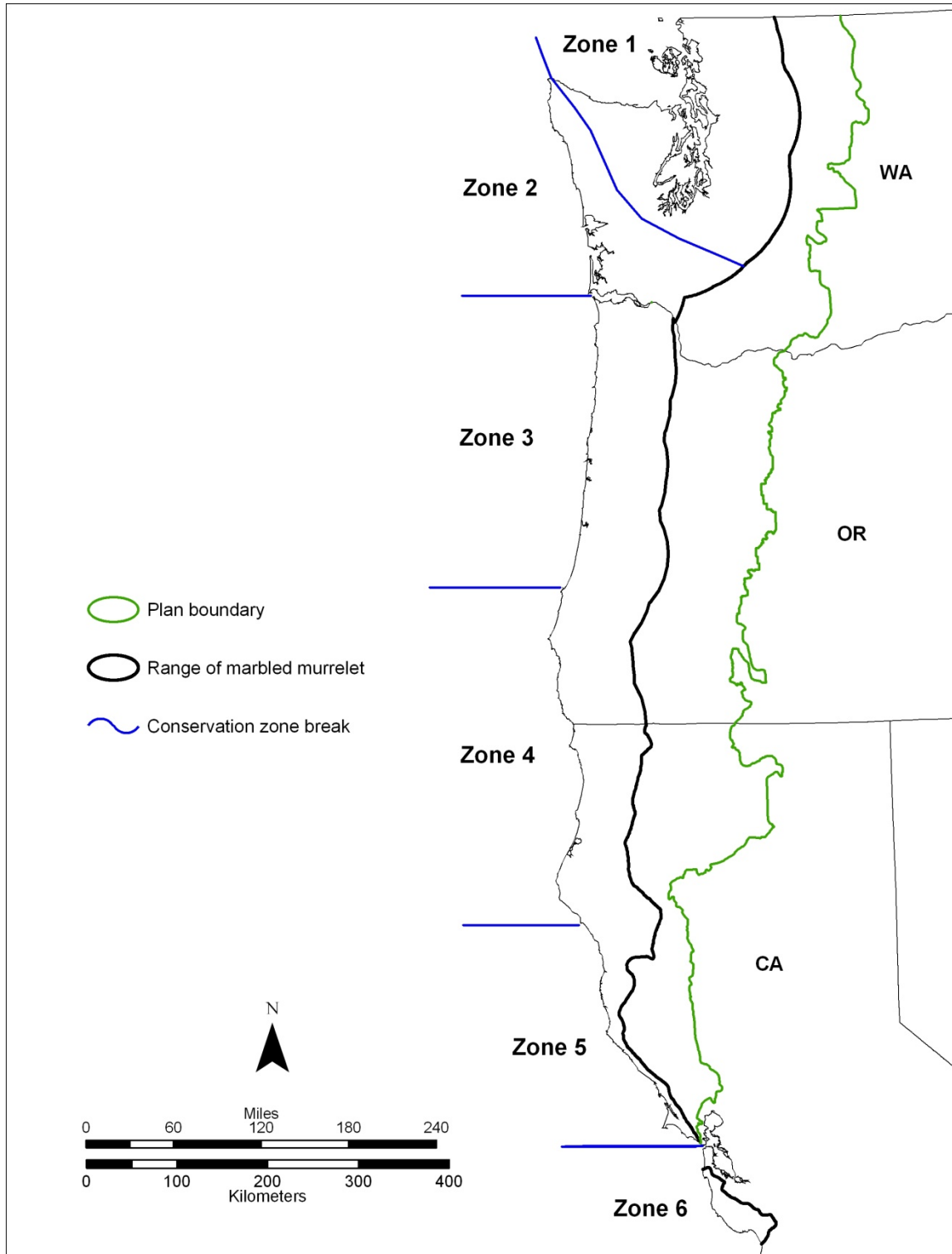
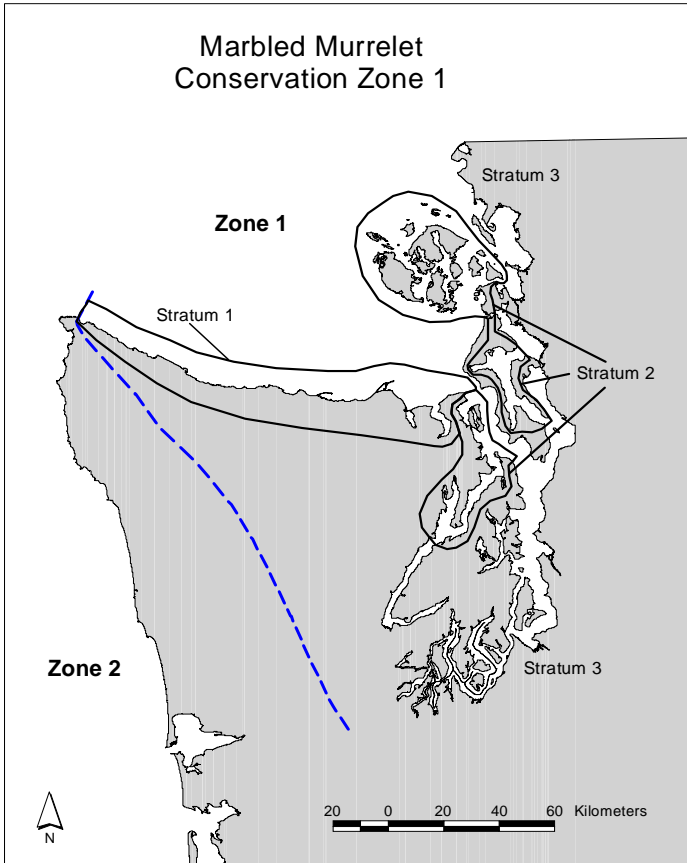


Figure 2. A) marbled murrelet Conservation Zone 1 with Strata 1 and 2 circled. Stratum 3 is the remaining area within Zone 1. B) marbled murrelet Conservation Zone 1 enlargement of Stratum 2.

A.



B.

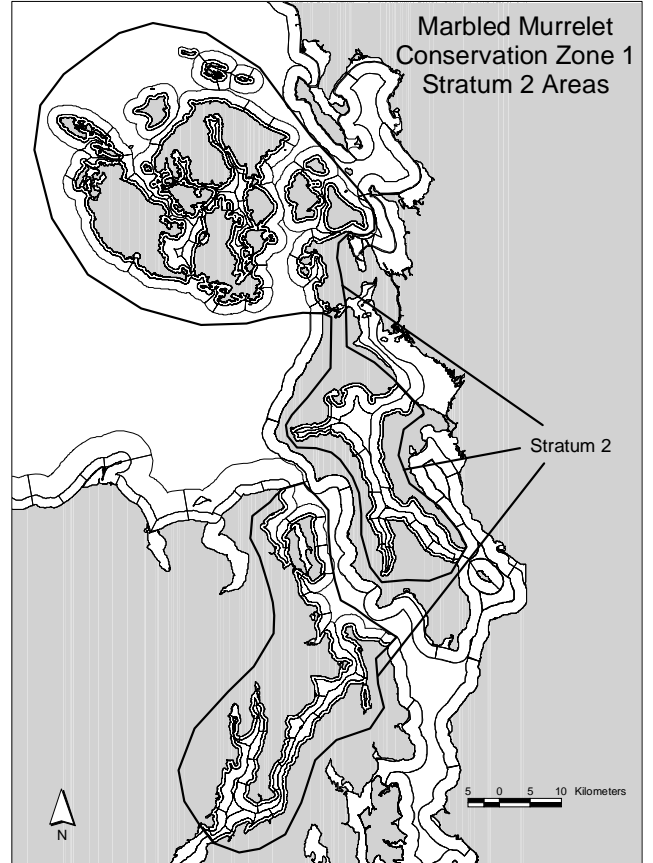


Figure 3. Stratums 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2 (from Huff 2006).

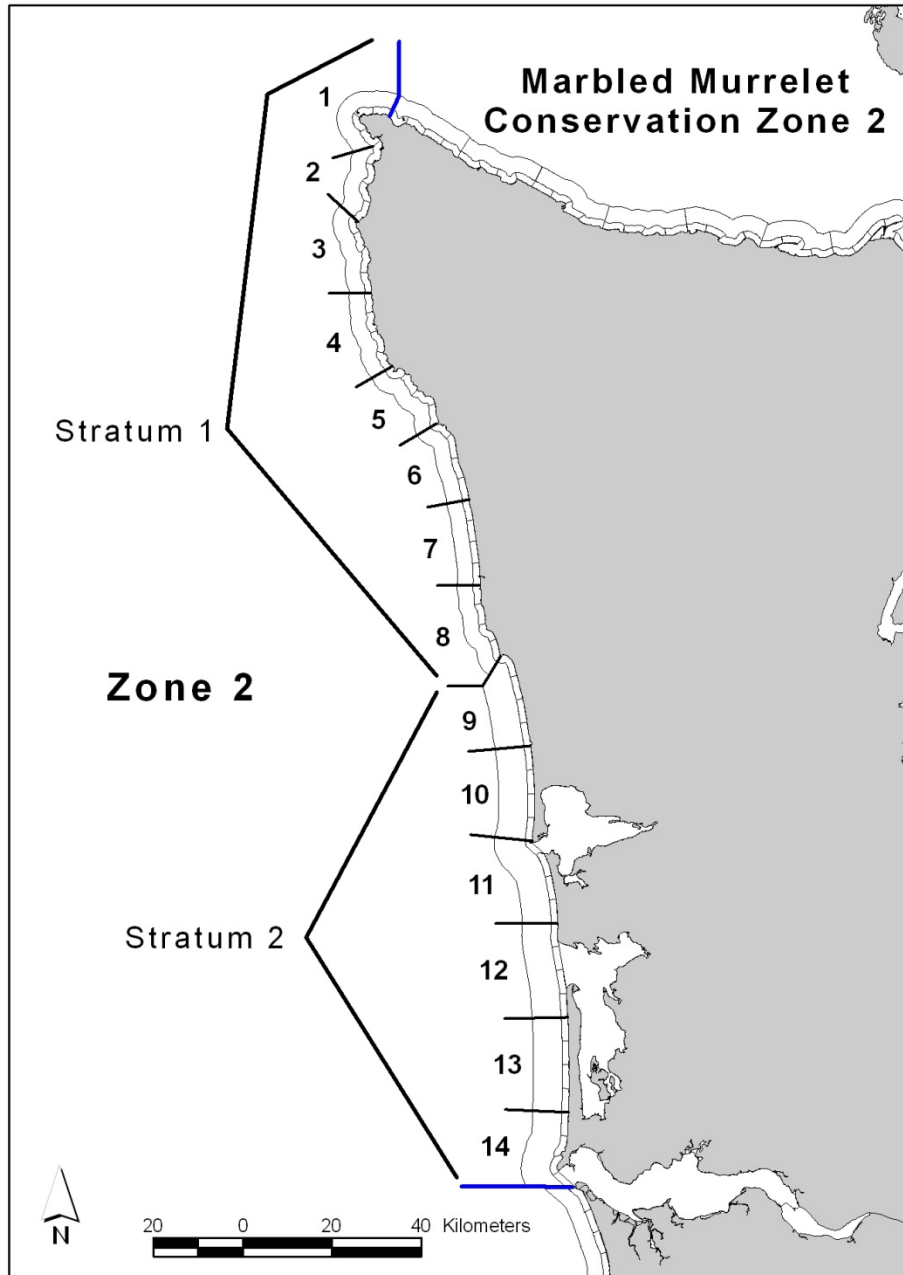


Figure 4. marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore).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

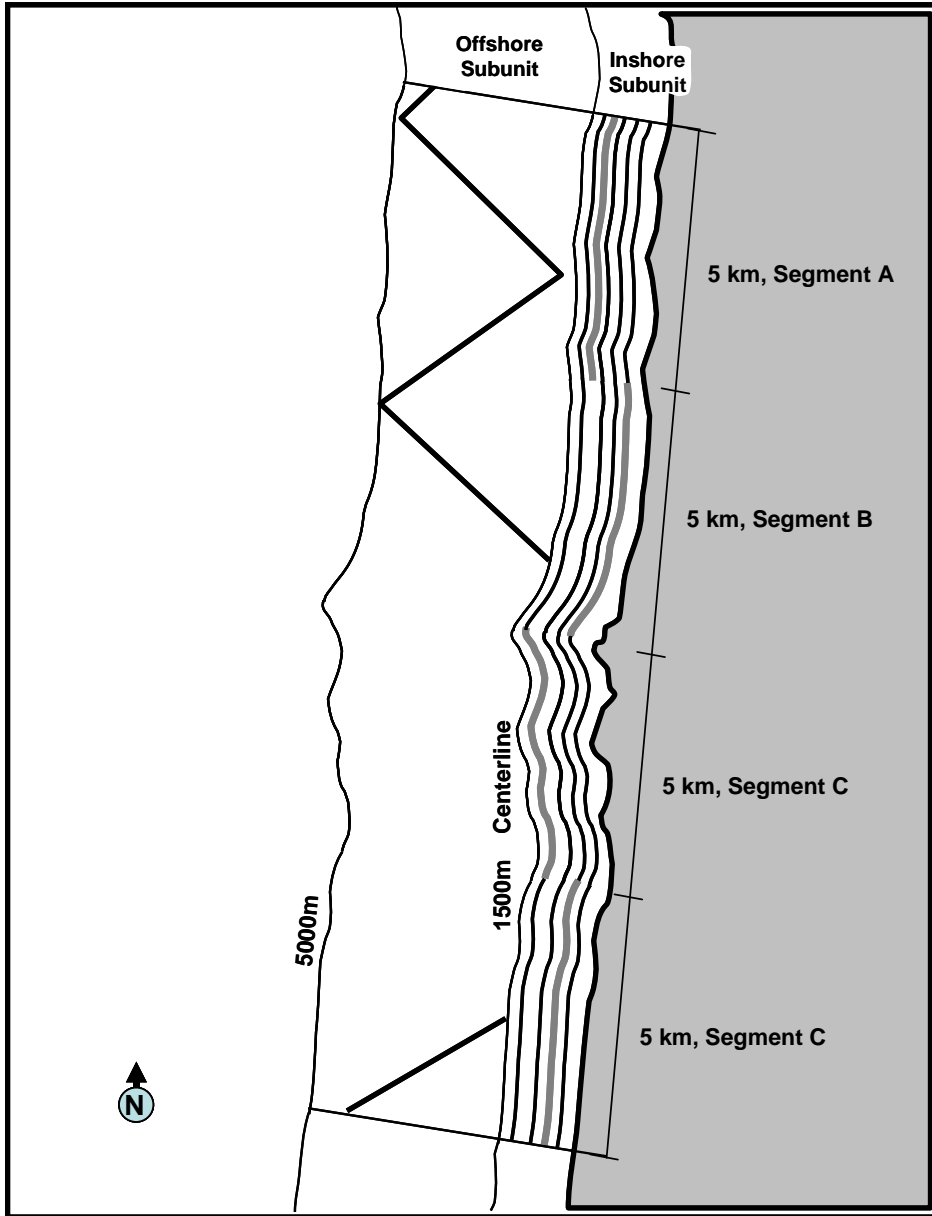


Figure 5. 2000-2009 marbled murrelet population densities (birds/km²) with 95% confidence intervals for Zone 1) and for the Strait of Juan de Fuca (Stratum 1) San Juan Islands and northern Hood Canal (Stratum 2) and southern Puget Sound (Stratum 3).

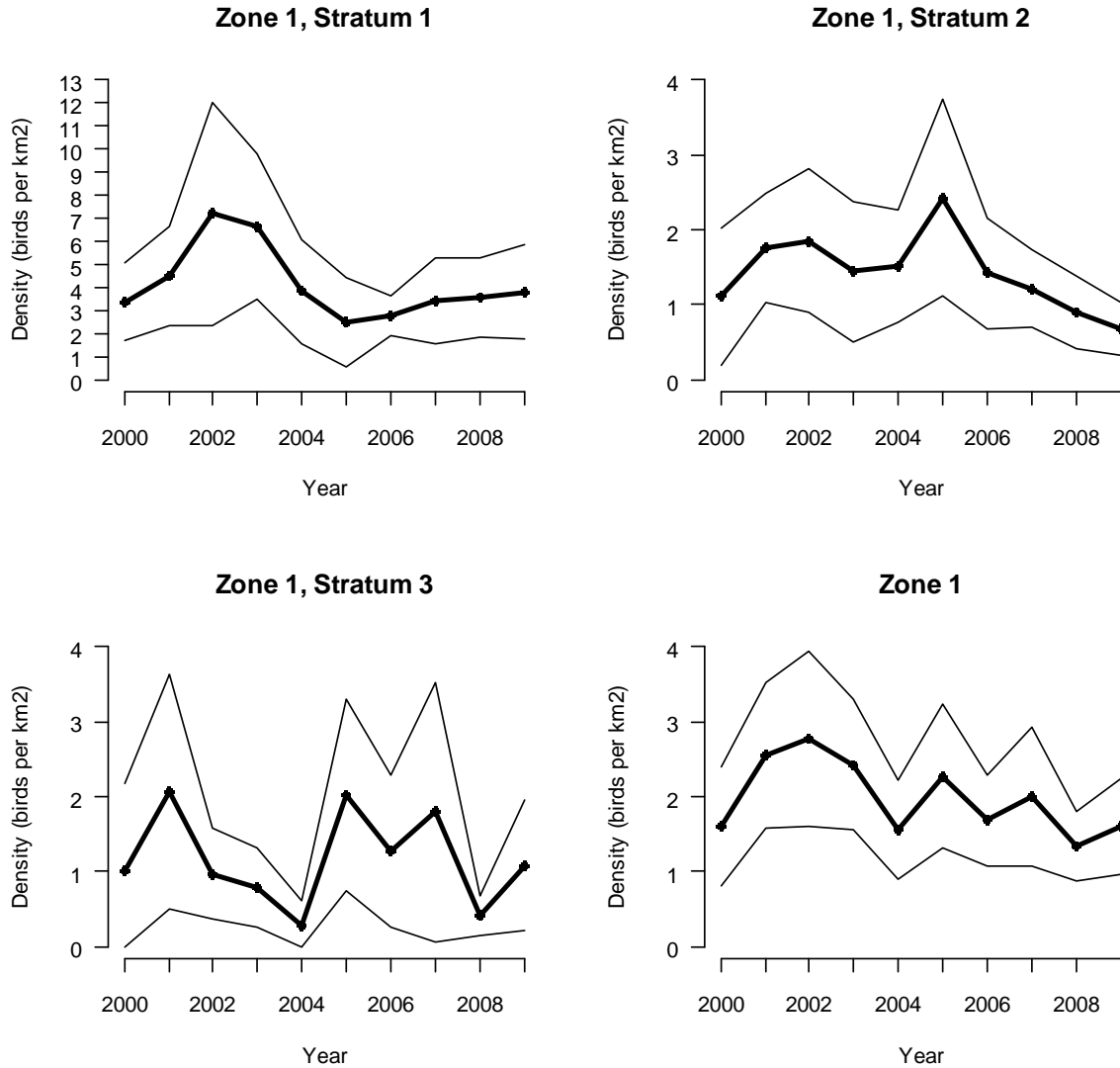


Figure 6. 2000-2009 marbled murrelet population densities (birds/km²) with 95% confidence intervals for the Washington coast (Zone 2) and for the northern (Stratum 1) and southern (Stratum 2) portions of Zone 2.

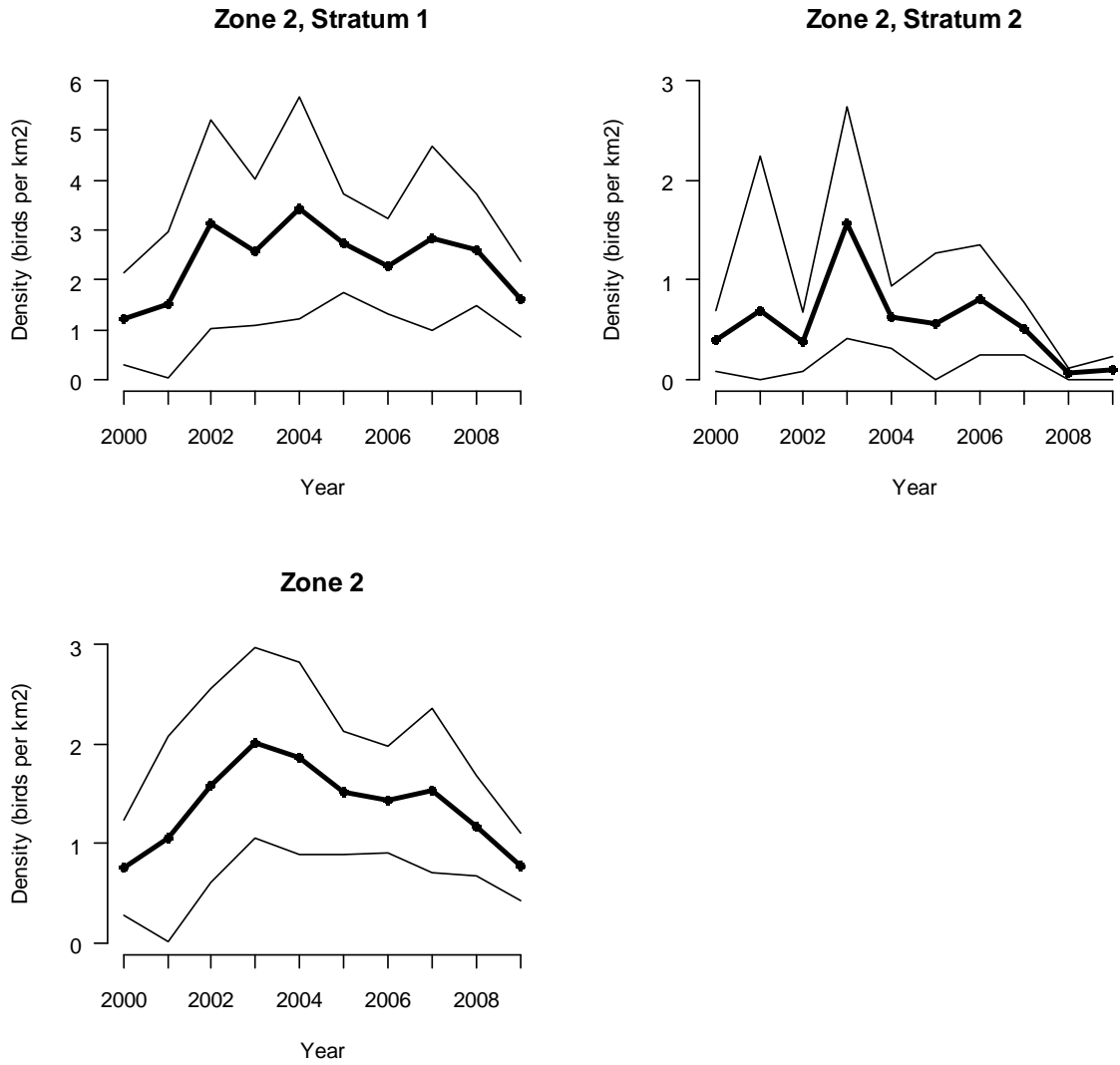
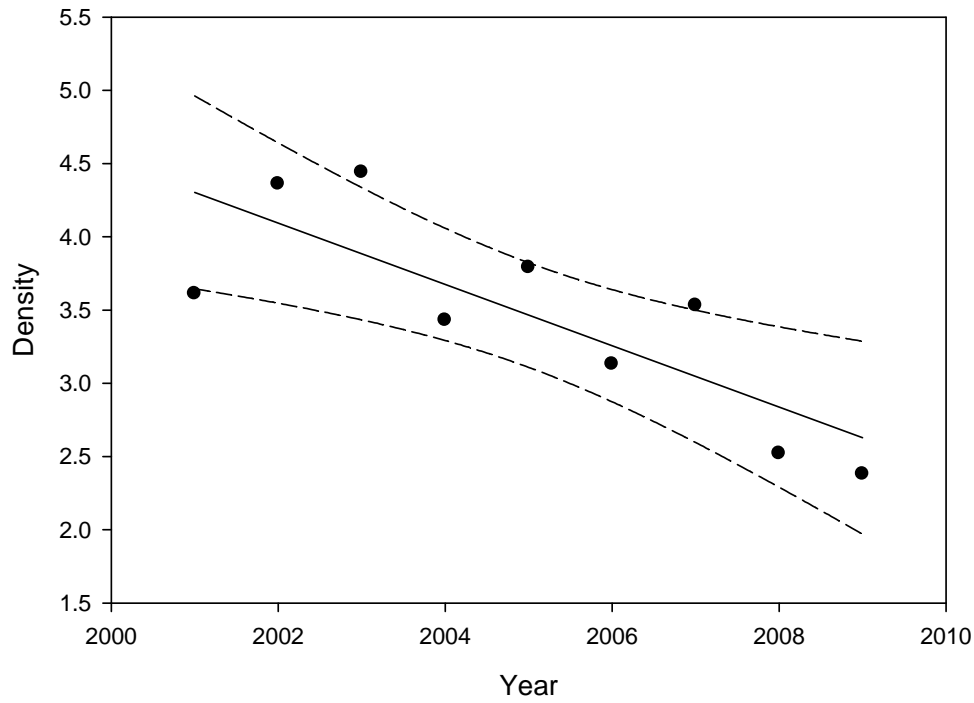


Figure 7. Washington marbled murrelet population density trend for 2001-2010 with 95% confidence intervals (Zones 1 and 2 combined, r^2 Linear = 0.65, $P = 0.009$). We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.



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