

**2018 Washington At-Sea Marbled Murrelet Population Monitoring:
Research Progress Report**

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Abstract

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

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

Between 2000 and 2015 we conducted annual surveys of both of Washington's Conservation Zones. Starting in 2016 we implemented a reduced-sampling effort design, where Conservation Zone 1 is sampled in even years and Conservation Zone 2 is sampled in odd years. In Washington, this sampling design was implemented in 2016 with surveys conducted in Conservation1 but not in Zone 2 and we have alternated between Zones since. This report focuses on monitoring results from Conservation Zone 1 during the 2018 monitoring season (15 May - 31 July).

The population estimate for Puget Sound and the Strait of Juan de Fuca in 2018 (Zone 1) was 3,837 birds (95% confidence interval = 1,911 – 6,956 birds) with a -4.9% (95% CI = -7.3 to -2.4%) average annual rate of decline for the 2001-2018 period, assuming a constant rate of decline.

Table of Contents

List of Tables and Figures..... Error! Bookmark not defined.

Introduction..... **1**

Methods..... **1**

 Sampling Design..... 1

 Observer Training..... 1

 Observer Methods..... 2

 Equipment..... 2

 Survey Effort 3

 Data Analysis..... 3

Results **3**

Acknowledgments **4**

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 2018. This report focuses on the methods and results from Zone 1 during the 2018 monitoring season.

Methods

Sampling Design.

We monitored Zone 1 marbled murrelets from 15 May - 31 July, a time when the birds detected on the water are potentially nesting. 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. Each stratum is divided into primary sampling units (PSUs), each of which is a roughly rectangular area along approximately 20 km of coastline. At-sea sampling followed the methods described in Raphael et al. (2007).

Observer Training.

The survey crew consisted of one dedicated boat operator, two observers (one responsible for each side of the boat), and a data recorder. All crew members rotated amongst these duties at the beginning of each PSU (or as needed) to avoid survey fatigue.

The team of biologists had a minimum of 3 years and as many as 8 years of experience with this monitoring program and conduct year-round monitoring of murrelets. Because our crew moves directly

from winter to spring surveys using the same protocols and methodology, no training is needed. However, we repeat boat safety instructions prior to beginning the field season.

Distance estimates from the transect line are a critical part of the data collected and substantial time was spent practicing and visually ‘calibrating’ before surveys began, followed by weekly testing throughout the survey period. During distance trials, each individual’s estimate of perpendicular distance was compared to a perpendicular distance recorded with a laser rangefinder. These trials were conducted using stationary buoys and bird decoys as targets, which were selected at a range of distances from the transect line and in locations in front of as well as to the sides of the boat where marbled murrelets would be encountered on real surveys (see Raphael et al. 2007 for details). Each observer completed 100 distance estimates prior to starting our 2018 sampling season and were tested weekly throughout the survey season. During weekly tests, each observer estimated five perpendicular distances to floating targets. If all five estimates were within 15% of the actual distance, the trial was complete. If any of the five estimates were not within 15% of actual, the observer continued to conduct estimates in sets of five until all five distances were within 15% of the actual distance. In addition, the project leads conducted three audits of the survey crew to evaluate their overall performance and ability to detect marbled murrelets during the survey season (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 or double counting. Binoculars were used for species verification, but not for detecting birds.

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

Equipment.

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

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

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

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

Survey Effort

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 have been 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. Each PSU was sampled twice during the survey season with replicate one completed by 17 June. A random sampling unit selection approach was used to spread the survey effort in space and time. We accomplished this by selecting a Stratum randomly (1, 2, or 3) 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 1 are located along the Strait of Juan de Fuca and are accessed from Port Angeles and Sekiu. 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.

Data Analysis

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

Results

Population Estimates and Trends –Puget Sound and Strait of Juan de Fuca

In 2018, 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 2018 was 3,837 birds (95% confidence interval = 1,911 – 6,956 birds) with a -4.9% (95% CI = -7.3 to -2.4%) average annual rate of decline for the 2001-2018 period, assuming a constant rate of decline (Table 1, Figure 5). The results for this zone are that same in this report and in McIver et al. (2019). We observed 8 young of the year birds, one on 12 June, one on 3 July, and the remaining on 26 July. Seven of these young of the year birds were detected at the south end of Lopez Island and one was observed at the south end of Marrowstone Island.

Murrelet densities were highest around Marrowstone Island south to Pt. Ludlow, southern end of Camano Island to Hat Island, and around the Elwah River.

Table 1. Estimate of average annual rate of population change (linear) for Zone 1, 2001-2018. This same information is reported in McIver et al. (2019).

Zone	Annual Rate (%)	95% Lower CL	95% Upper CL	Adjusted R²	P-value
1	-4.9	-7.3	-2.4	0.503	<0.001

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

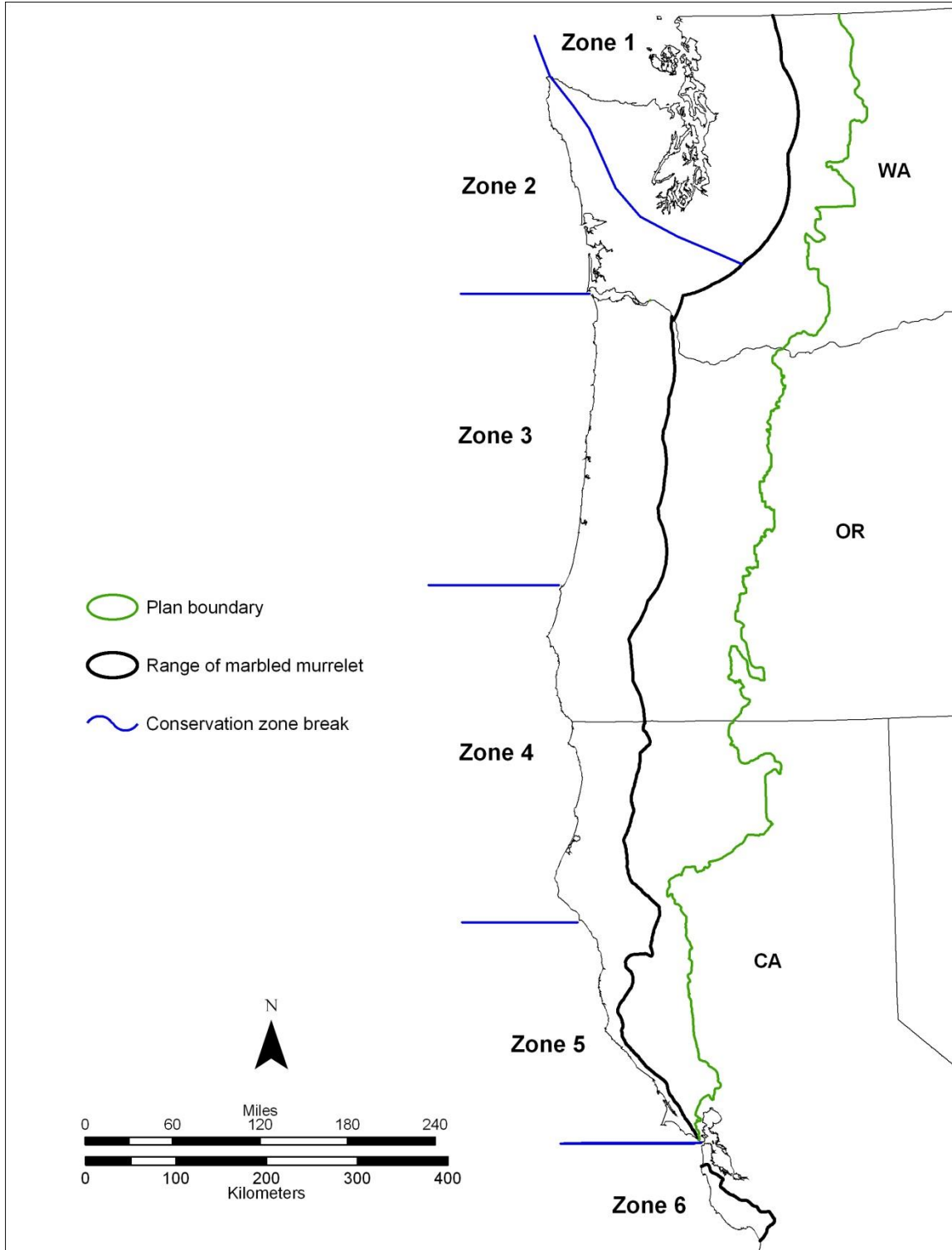


Figure 2. A) marbled murrelet Conservation Zone 1 with Strata 1 and 2 circled. Stratum 3 is the remaining area within Zone 1. B) marbled murrelet Conservation Zone 1 enlargement of Stratum 2.

A.

B.

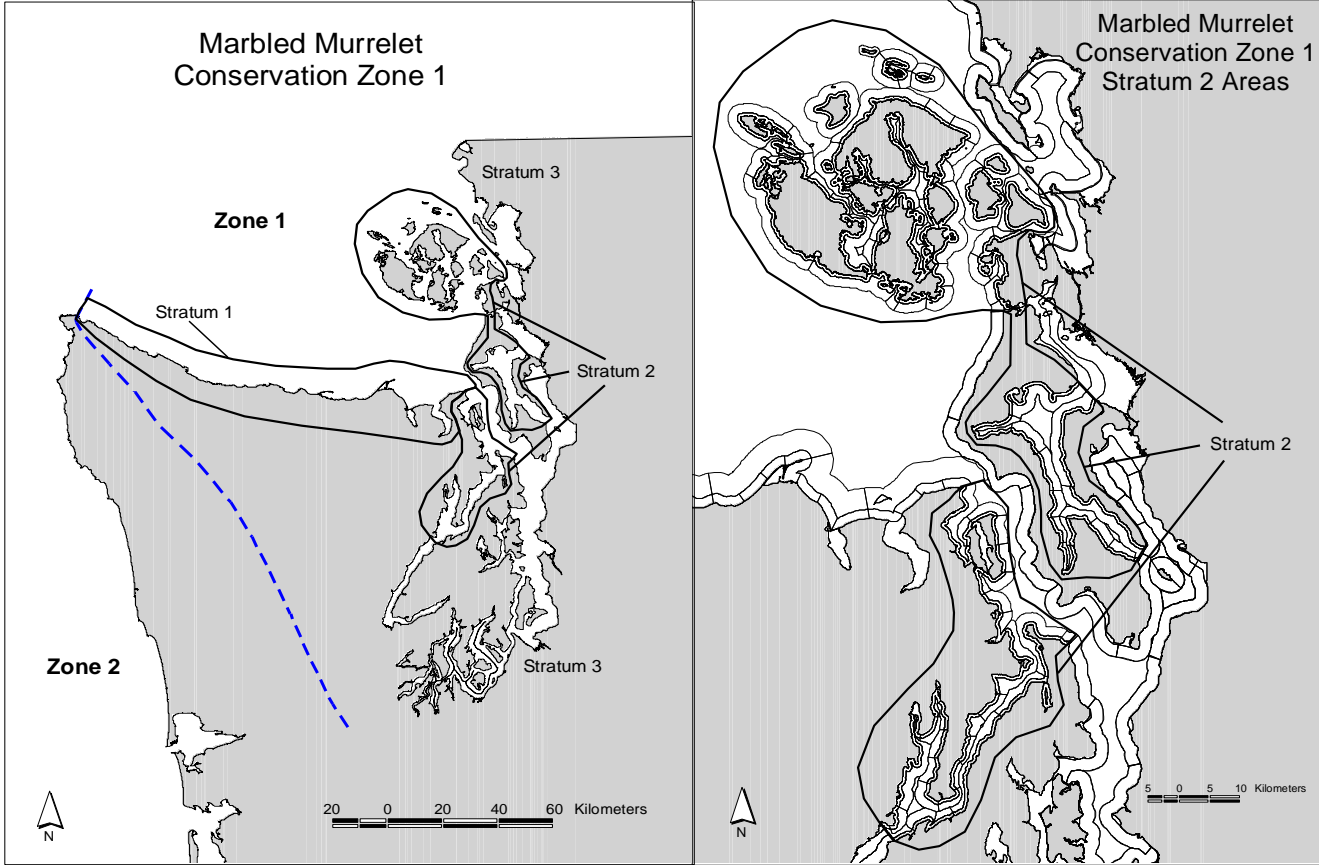


Figure 3. Marbled murrelet monitoring primary sampling unit (PSU) illustrating nearshore and offshore subunits and 1500 m centerline. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore).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

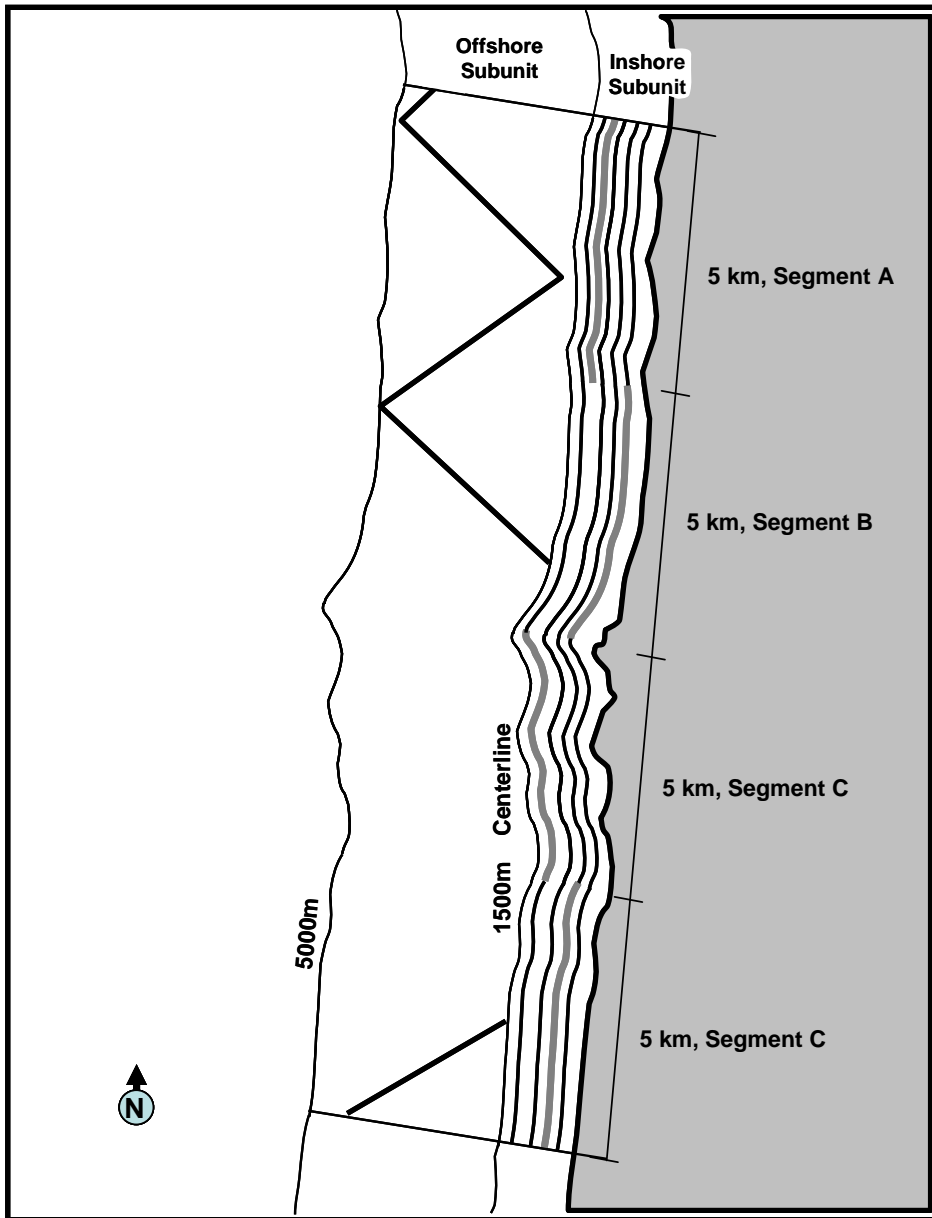


Figure 4. 2001-2018 marbled murrelet population densities (birds/km²) with 95% confidence intervals for Puget Sound and Strait of Juan de Fuca (Zone 1) and for the three strata within this zone: 1) Strait of Juan de Fuca (Stratum 1), 2) San Juan Islands and northern Hood Canal (Stratum 2) and, 3) southern Puget Sound (Stratum 3). Note the Y axis scale differs among graphs. The information here for this zone is identical to that reported in McIver et al. (2019; Table 3).

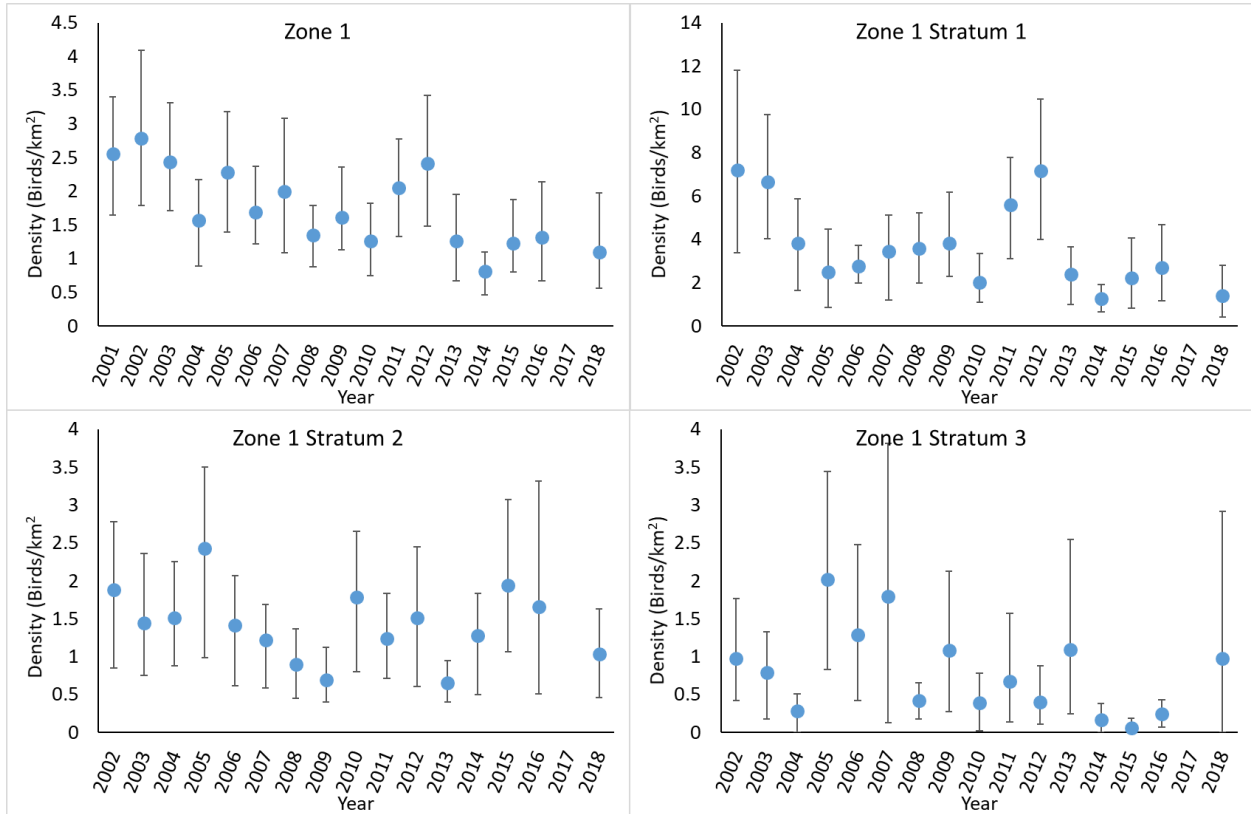
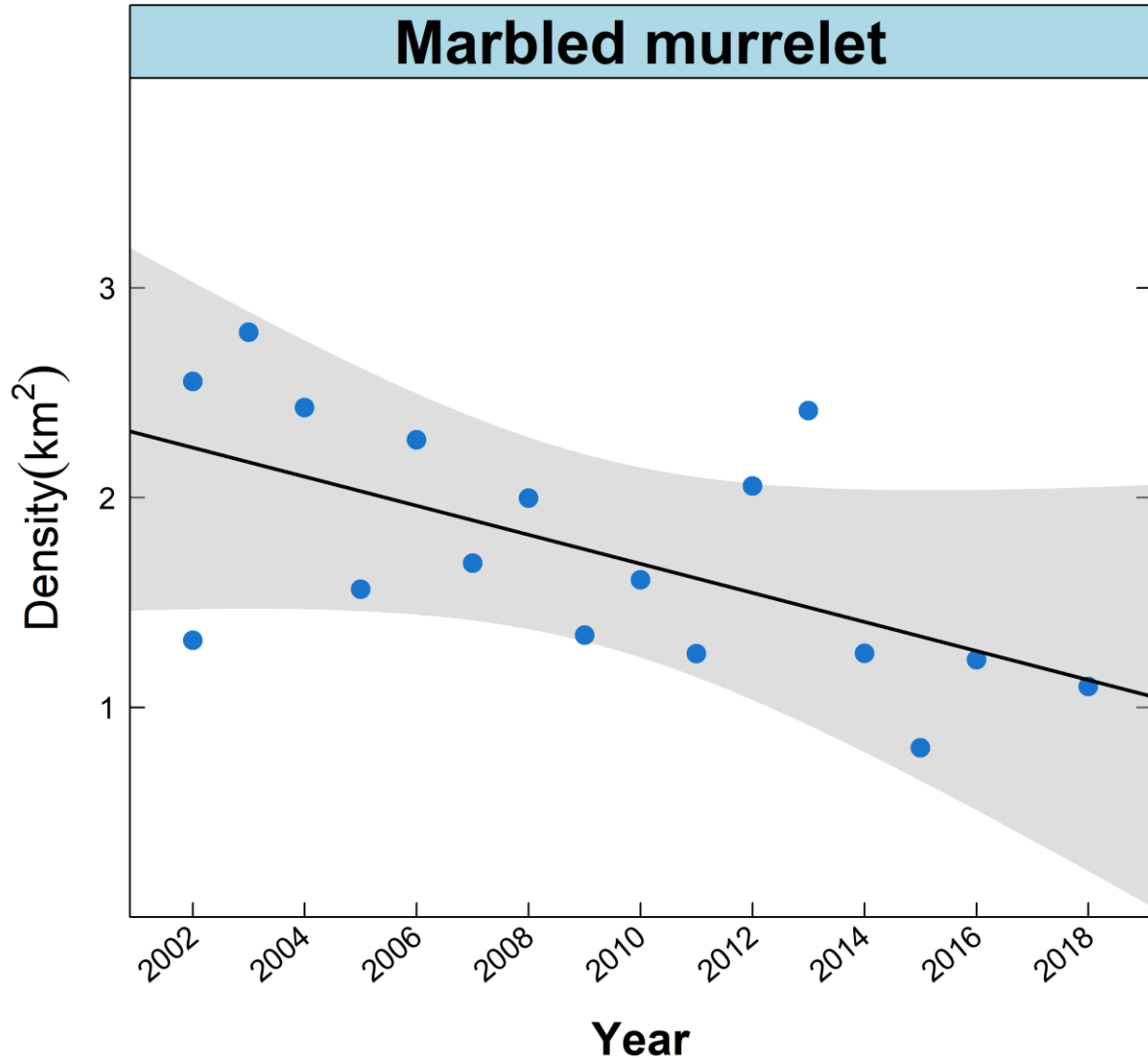


Figure 5. Washington marbled murrelet population density trend for 2001-2018 with 95% confidence band for Zone 1 (Puget Sound and Strait of Juan de Fuca). The trend is for a linear trend in the log of density. We excluded 2000 from this analysis because distances to birds were not recorded and fewer replicates were conducted in that year for Zone 2 and for Zone 1 Stratum 1.



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