2005 At-Sea Marbled Murrelet Population Monitoring

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INTRODUCTION

In 1992, the Marbled Murrelet was listed under the Federal Endangered Species Act of 1973 as a Threatened species in California, Oregon and Washington. A recovery plan was published in 1997 (U.S. Fish and Wildlife Service 1977) that outlined recovery strategies including developing and conducting standardized at-sea surveys. These surveys were viewed as critical to the recovery of the Marbled Murrelet because they allow researchers to model population trends and demographics and because detecting changes in populations is critical to the evaluation of recovery actions and ultimately to the determination of 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, Miller et al. 2005). The goal of this monitoring strategy is to estimate Murrelet population size and changes in population size for the area between the Washington – Canada border and San Francisco. Results will be used to evaluate any USFWS incidental take criteria and to facilitate the Recovery Plan development and evaluation. In addition to meeting the requirements of the Endangered Species Act, long-term Marbled Murrelet monitoring is required 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. The Murrelet was identified as a conservation and monitoring target for evaluating the effectiveness of this plan.

Since 2000, Washington Department of Fish and Wildlife along with researchers from the US Forest Service, US Fish and Wildlife Service, Crescent Coastal Research, and the University of California Berkeley have been estimating 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 km^2. This area of coastline has been subdivided into the five Marbled Murrelet Conservation Zones identified in the Marbled Murrelet Recovery Plan (Figure 1; US Fish and Wildlife Service 1997). Washington Department of Fish and Wildlife has been responsible for monitoring the outer Washington coast (Figure 2; Zone 2 - from the northwest tip of the state to the mouth of the Columbia River). The first four years of monitoring have been summarized for the entire Washington to California region in Miller et al. (2005). Preliminary results indicate that for all zones combined, we will be able to detect an annual population change of 2% in 15 years (with 95% power) or a 3% annual population change over 10 years (with 80% power). These results suggest that long-term monitoring is required to confidently detect changes in population size.

Here we summarize the methodology, sampling and results for the 2005 at-sea monitoring on Washington's outer coast (Cape Flattery to the south jetty of the Columbia River).

METHODS

Sampling Design

Marbled Murrelets were monitored from mid-May through the end of July when the Murrelets detected on the water are most likely local breeding birds. Conservation Zone 2 on the outer coast of Washington (Cape Flattery to the south jetty of the Columbia River) is divided into two geographic strata (Figure 2). 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. More sampling effort is devoted to stratum 1 because the density of Murrelets is higher than in Stratum 2 (Thompson 1999).

The following is a detailed summary of the methodology used in Conservation Zone 2 and is consistent with the population monitoring methods developed by the Marbled Murrelet Effectiveness Monitoring program used throughout the Northwest Forest Plan area since 2000 (Raphael et al. 1999, 2004, Miller et al. 2005). Each stratum is divided into primary sampling units (PSUs), which is a roughly rectangular area about 20 km of coastline in length. There are 8 PSUs in Stratum 1 and 6 PSUs in Stratum 2 (Figure 2). The width of the PSU (the distance

between the nearshore and offshore boundaries) varies by stratum. The PSUs meet end to end without any gaps along shore. Each PSU consists of two subunits, the nearshore and the offshore units (Figure 3). For Conservation Zone 2, the nearshore subunit starts at 350 m from shore and extends 1,500 m offshore to the "centerline". The offshore subunit extends 3,500 m offshore from the "centerline" in Stratum 1 and 6,500 m offshore from the "centerline" in Stratum 2 (Figure 3). These widths for the nearshore and offshore units were used because most Murrelets occur within 1500 meters from shore and at least 95% of Murrelets occur within 5,000 and 8,000 m from shore in Strata 1 and 2, respectively (Thompson 1997a, 1997b, 1999).

Parallel transects are used in the nearshore subunit and zigzag transects are used in the offshore subunit. Within the nearshore subunit, the entire length (approximately 20 km) of the PSU was divided into four 5 km transects and divided into four 'bins' parallel to shore (Figure 3). One transect was randomly placed in each of the four bins ensuring that transects were distributed spatially at different distances from shore. Within the offshore subunit, a zigzag transect traversed the entire width of the subunit and a portion of the length of the PSU; in some cases the entire length of the PSU. The zigzag configuration will sample across the density gradient associated with distance from shore while allowing less effort per area in this low density subunit. The transect trajectory was determined from a random starting point. The length of the zigzag transect in each area was roughly calculated from a formula based on strata area and Murrelet densities (from previous data). See Miller et al (2005) for further details.

Observer Training

In 2005, two Murrelet observers returned from previous years and two were new to the program. For the returning members, this was the fifth season for one and the third season for the other (the boat operator). The crew consisted of one 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. Observers had one week of training that consisted of on water and office 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 safety orientation, seabird identification, practice transects, and distance estimation testing using laser rangefinders. Washington Department of Fish and Wildlife observer training was designed to be consistent with training conducted by USFWS and other groups within the Murrelet Effectiveness Monitoring program (Mack et al. 2003, Huff 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. The estimates of distance 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 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 Murrelets would be encountered on real surveys (see Huff et al. 2003 for details). Each Washington Department of Fish and Wildlife observer completed 80 distance estimates during pre-survey training.

Quality assurance tests were repeated weekly throughout the entire survey period where each observer was tested on their ability to accurately estimate distances. Observers made a set of five estimates of perpendicular distance to five 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 actual distance. In addition, one of the project leads accompanied the survey crew and observed their overall performance and ability to detect Murrelets three times during the survey season and completed an audit form created by the Murrelet Monitoring Program (Huff et al. 2003). The results of the

audit and were shared with the observers after the survey day was completed for feedback and discussion.

Observer Methods

Two observers scanned from 0^o off the bow to 90^o abeam of the vessel. More effort was expended watching for Murrelets close to the transect line ahead of the boat (within 45^o 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. 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

As in previous years, a twin-outboard 26' Washington Department of Fish and Wildlife vessel, *Research 4,* was the survey platform. Data was collected during at-sea surveys using a windows based software program called DLOG2 (for 'datalog', developed by R.G. Ford, Inc., Portland, OR.) loaded onto a laptop computer. DLOG2 interfaces with a 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 weather and sea conditions, on/off effort, and names of observers were recorded manually in DLOG2. One of the survey crew manually enters bird observation data including: species, number of birds, 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), estimated perpendicular distance of the bird(s) from the trackline of the boat at first detection regardless of distance from the line, plumage class (Strong 1998), and water depth (from boat depth finder). The DLOG2 program interfaces with a thermosalinograph, which was installed on *Research 4* to collect water parameter data (temperature and conductivity). These parameters were recorded automatically every 30 seconds as well as each time an entry was made.

2005 Data Analysis

Washington Department of Fish and Wildlife at-sea surveys began 16 May and ended 29 July. PSUs were accessed from four ports along the Washington coast: Neah Bay (PSUs 1-3), La Push (PSUs 4-8), Westport (PSUs 9-11), and Ilwaco (PSUs 12-14). The sampling period was divided into three 18-day periods (excluding weekends and 2 holidays) to avoid clustered sampling and ensure PSUs were selected randomly without replacement and distributed evenly over the field season.

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.

In 2005, A third replicate of PSUs 2, 3, and 7 was not completed due to time restrictions and poor weather (each PSU in Stratum 1 should have been sampled three times). Poor weather and rough seas precluded surveying on six days. More often this year than in previous years, weather (fog, wind and primarily swell) influenced completion of surveys after they had been >50% complete, requiring multiple attempts on successive days. Despite multiple attempts, we were unable to sample PSU 12 (which should have been sampled once) due to large swells and breakers across the Willapa Bar – which is an extremely difficult location to navigate. It was not possible to attempt these PSUs after 31 July because the survey protocol restricts the survey dates to 15 May - 31 July. All other PSUs were sampled.

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 and swell height also affected navigation. For Conservation Zone 2, the nearshore boundary was 350 m. In 2005, for some PSUs sampled in both Stratums 1 and 2, the innermost subunit (e.g. 350 or 450 m) had to be moved further from shore in order to be completed. 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 program DISTANCE was to calculate densities as described in Miller et al. (2005) and the 95% confidence intervals were also constructed as described in Miller et al. (2005).

RESULTS

As in past years, higher densities of Murrelets were observed in Stratum 1 than Stratum 2 (Table 1). The highest concentrations of Murrelets were observed in PSUs 6 and 7 located near Destruction Island and to the south with Murrelets present in all three replicates and in both nearshore and offshore segments (Table 1). Higher numbers of Murrelets were typically, but not always recorded within nearshore subunits and varied among PSUs and replicates (Table 1). Murrelets were not observed in PSU 9 or 14 in Stratum 2. There were no juvenile (Hatch Year) Murrelets observed. Group size and perpendicular distance data were compiled for each Murrelet (or group of Murrelets) observation and were sent to USFWS statistician, Jim Baldwin, for analysis. Jim Baldwin provided preliminary estimates of density and population size for 2005 (Table 2, Figure 4). Preliminary results indicate no clear Murrelet population trend for the Washington coast (Zone 2; Figure 4). However, for all zones combined, we will need 15 years of data to detect an annual population change of 2% (with 95% power) or 10 years of data to detect a 3% change (with 80% power). These results suggest that long-term monitoring is required to confidently detect changes in population size.

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Figure1. Marbled Murrelet Recovery Plan Conservation Zones (from Miller et al. 2005).

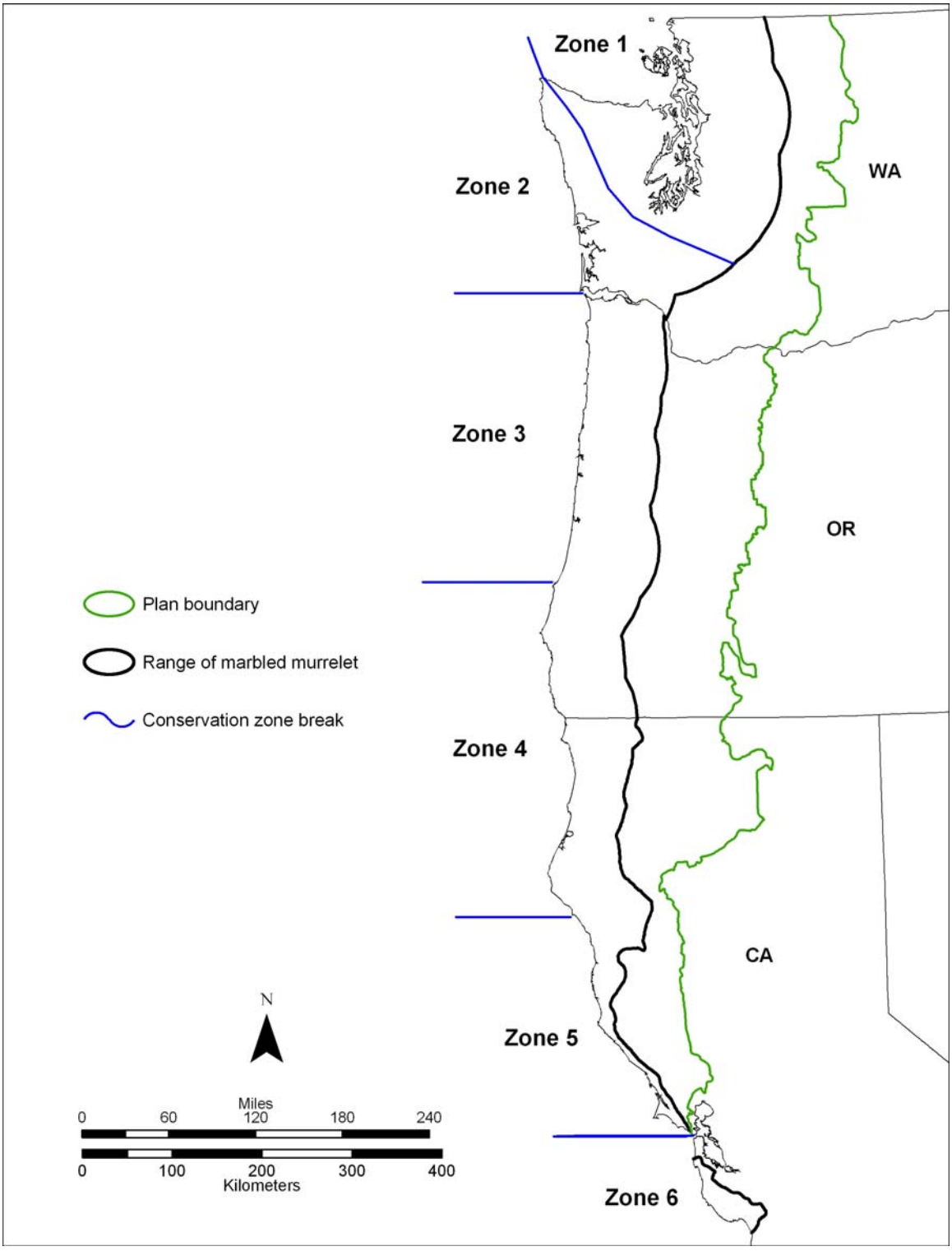

Figure 2. Stratums 1 and 2 along the outer coast of Washington and 14 PSUs in Conservation Zone 2 (from Raphael et al. 2004).

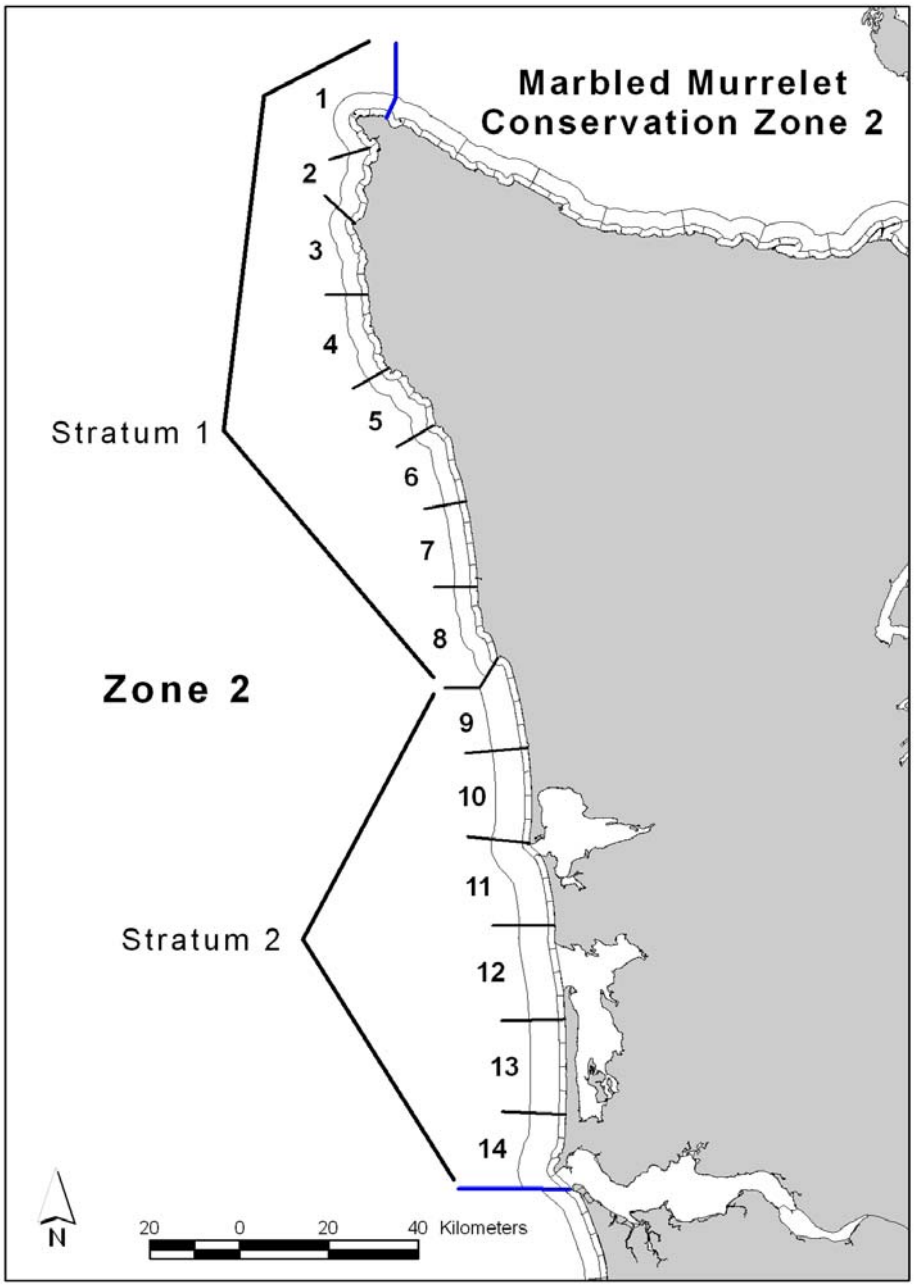

Figure 3. Marbled Murrelet primary sampling unit (PSU) with nearshore and offshore subunits. The nearshore unit is divided into four equal-length segments (about 5 km each) and four equal-width bins (bands parallel to and at increasing distances from the shore). One bin is selected (without replacement) for each segment of transect (from Raphael et al. 2004).

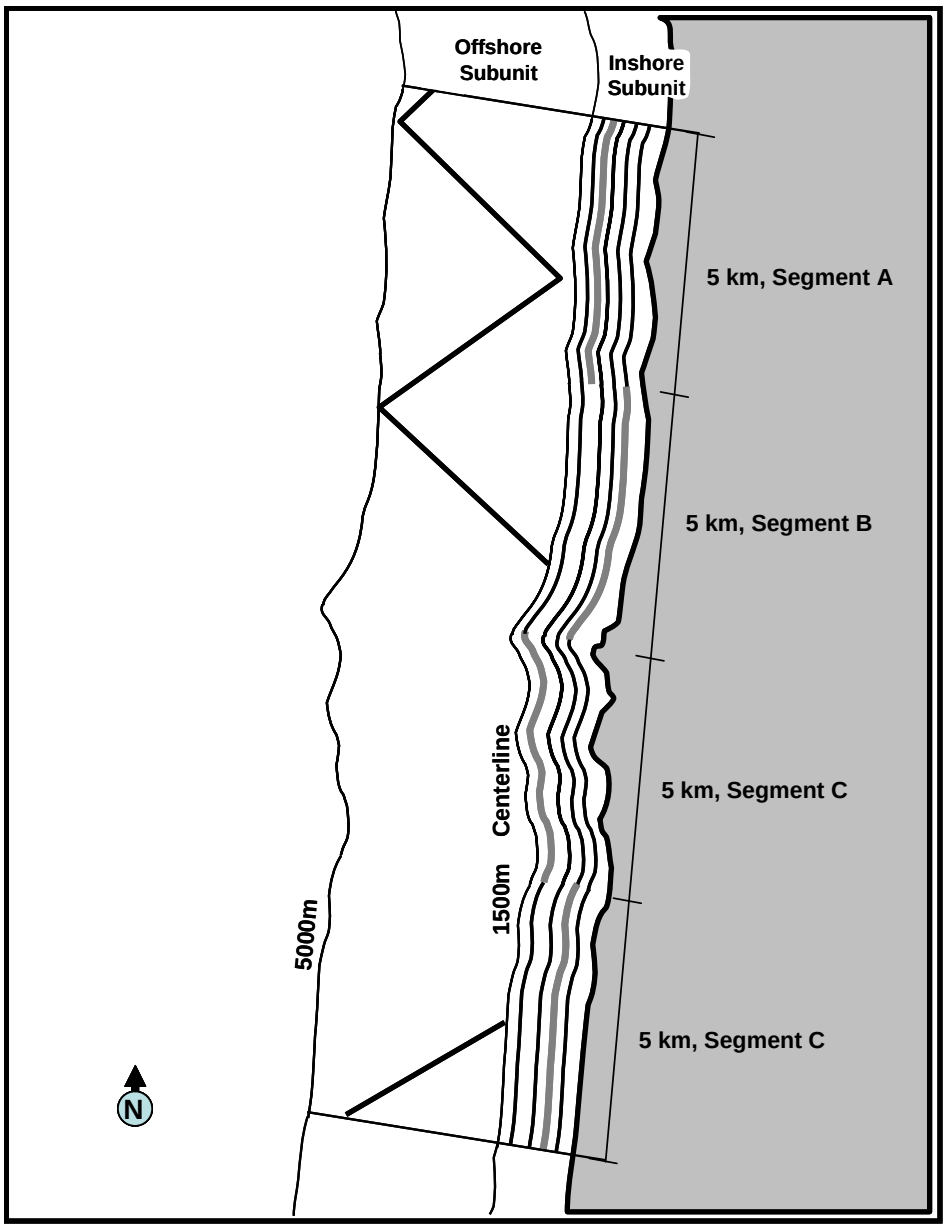

Figure 4. 2000-2005 Marbled Murrelet population densities (± 95% C.I.) for the Washington coast (Zone 2) and for northern (Stratum 1) and southern (Stratum 2) portions of Zone 2.

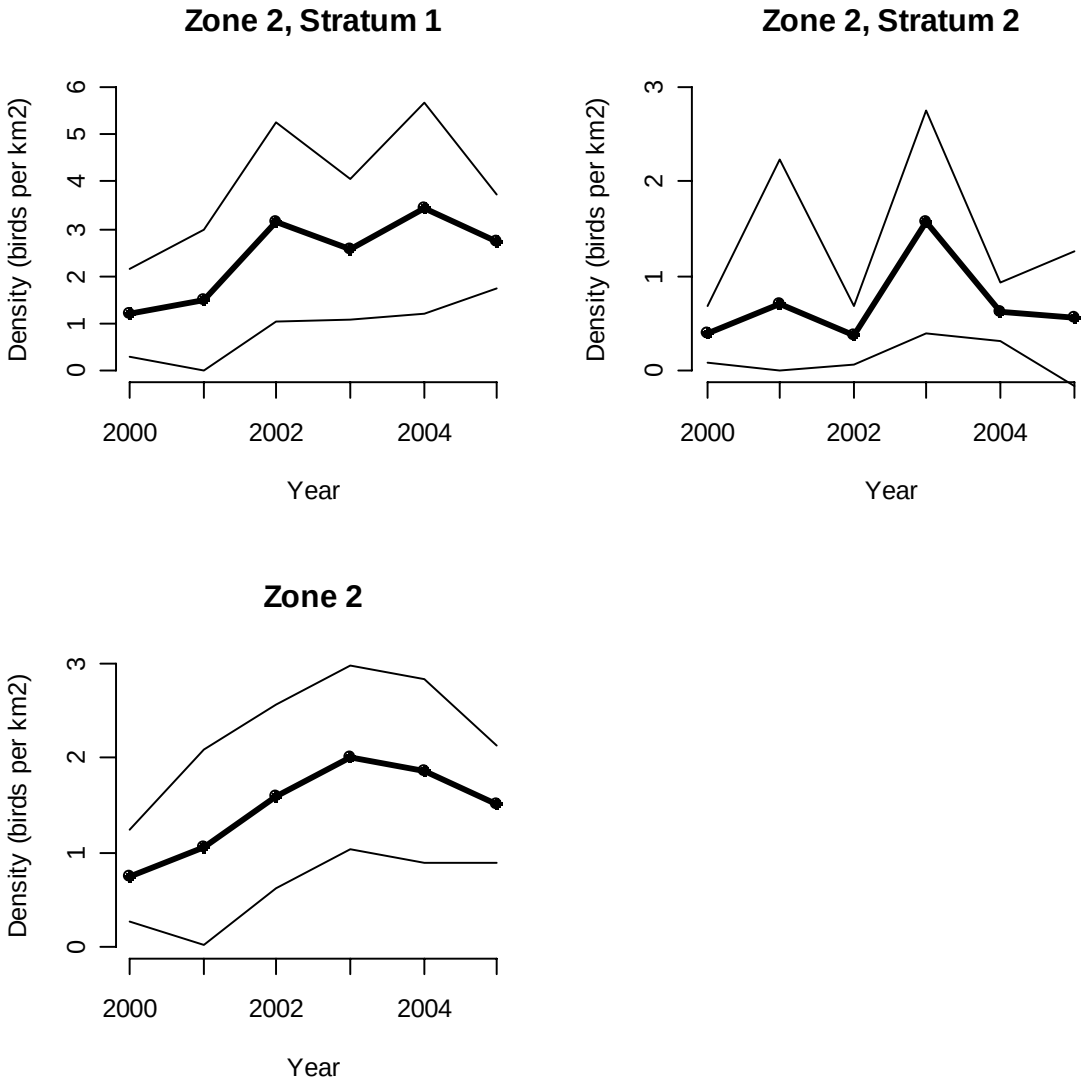

Table 1. Number of Marbled Murrelets (MaMu) in the nearshore (N) and offshore (O) subunits and distance surveyed (km) in each PSU during the 2005 survey season

Date	PSU	Replicate	N (km)	MaMu N	O (km)	MaMu O	Total (km)	MaMu Total
05/25/05	5	1	19.33	13	22.80	5	42.13	18
05/25/05	4	1	18.64	3	23.99	0	42.63	3
05/26/05	7	1	20.06	31	23.53	34	43.59	65
05/26/05	6	1	19.67	30	23.42	10	43.09	40
05/31/05	3	1	18.13	14	22.60	4	40.74	18
06/01/05	1	1	17.42	13	20.04	5	37.46	18
06/07/05	8	1	19.00	5	23.42	6	42.42	11
06/08/05	9	1	22.09	5	37.94	4	60.03	9
06/08/05	11	1	19.74	0	36.26	0	56.00	0
06/09/05	2	1	19.29	27	21.08	1	40.36	28
06/14/05	3	2	16.57	16	22.54	1	39.11	17
06/15/05	1	2	17.31	14	23.33	0	40.65	14
06/21/05	10	1	21.35	18	38.10	5	59.45	23
06/24/05	4	2	17.18	13	23.19	2	40.36	15
06/27/05	5	2	20.02	3	23.35	15	43.37	18
06/29/05	8	2	18.92	16	23.50	8	42.43	24
07/06/05	6	2	19.86	44	23.57	4	43.43	48
07/07/05	7	2	19.52	28	23.64	2	43.16	30
07/13/05	2	2	19.42	5	23.53	0	42.95	5
07/14/05	1	3	18.79	8	23.58	0	42.37	8
07/19/05	13	1	21.49	2	38.08	3	59.57	5
07/20/05	14	1	19.59	0	29.10	0	48.68	0
07/22/05	8	3	18.89	17	23.52	9	42.41	26
07/26/05	5	3	19.13	2	24.43	10	43.56	12
07/28/05	4	3	17.73	1	19.79	0	37.52	1
07/29/05	6	3	19.35	45	23.28	45	42.64	90

Table 2. Marbled Murrelet population size and density estimates for Zone 2 during the 2000-2005 breeding seasons.

Year	Zone	Stratum	Density (birds/km^2)	Std. Err. (birds/km^2)	Birds	Birds 95% Lower Confidence Limit	Birds 95% Upper Confidence Limit	Area (km^2)
2000	2	1	1.2287	0.4592	890	422	1,712	724.470
2000	2	2	0.3903	0.1525	361	190	713	925.934
2000	**2**	**All**	**0.7583**	**0.2394**	**1,252**	**727**	**2,228**	**1,650.404**
2001	2	1	1.5059	0.7368	1,091	186	2,254	724.470
2001	2	2	0.6987	0.7697	647	104	2,449	925.934
2001	**2**	**All**	**1.0531**	**0.5164**	**1,738**	**575**	**3,888**	**1,650.404**
2002	2	1	3.1313	1.0485	2,269	397	3,471	724.470
2002	2	2	0.3790	0.1511	351	-	542	925.934
2002	**2**	**All**	**1.5871**	**0.4850**	**2,619**	**565**	**3,784**	**1,650.404**
2003	2	1	2.5615	0.7374	1,856	1,073	3,168	724.470
2003	2	2	1.5744	0.5839	1,458	521	2,355	925.934
2003	**2**	**All**	**2.0077**	**0.4800**	**3,314**	**1,959**	**5,039**	**1,650.404**
2004	2	1	3.4367	1.1146	2,490	1,236	4,000	724.470
2004	2	2	0.6281	0.1570	582	330	864	925.934
2004	**2**	**All**	**1.8610**	**0.4822**	**3,071**	**1,742**	**4,596**	**1,650.404**
2005	2	1	2.7283	0.4965	1,977	1,212	2,641	724.470
2005	2	2	0.5568	0.3579	516	146	1,552	925.934
2005	**2**	**All**	**1.5100**	**0.3069**	**2,492**	**1,629**	**3,642**	**1,650.404**

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