Fall-Winter 2012/2013 Marbled Murrelet At-Sea Densities For Four Strata Associated with U.S. Navy Facilities in Puget Sound:

Annual Research Progress Report

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INTRODUCTION

The overarching goal of this project is to estimate on-the-water marbled murrelet (*Brachyramphus marmoratus*) densities during the fall/winter (October-February) for four Navy facilities: (1) Crescent Harbor on Naval Air Station Whidbey Island; (2) Fleet Logistics Center Manchester Fuel Department; (3) Naval Base Kitsap Bangor and Dabob Bay Range; and (4) Naval Magazine Indian Island. However, because the nearshore marine environment and murrelet densities adjacent to any one of these facilities is too small to derive reliable site-specific at-sea murrelet densities, Washington Department of Fish and Wildlife (WDFW) use a stratified sampling approach outlined in Pearson and Lance (2012) to derive stratum specific density estimates. This approach uses line-transect or distance sampling methods (Buckland et al. 1993) to derive murrelet density estimates for four strata using nearshore and offshore transects placed in 32 primary sampling units (PSUs) (Figure 1).

METHODS

WDFW use the approach and methods from the survey effort described by Raphael et al (2007) and Miller et al. (2012) and modified by Pearson and Lance (2012). WDFW use this approach because: (1) it addresses issues of detectability, (2) it is customized to murrelet distributions and densities in this region, (3) it used pre-survey information to develop the sampling design, (4) their work was peer reviewed (Raphael et al. 2007, Miller et al. 2012), and because (5) our survey effort for this project and the spring/summer murrelet monitoring effort funded by USFWS are consistent which will allow us to compare estimates for the same sampling units between seasons.

Survey Effort

Thirty-two primary sampling units (PSUs) were split among 5 strata (see Fig. 1 and Table 1). However, because there is only one PSU in Stratum 1 and the area is too small to provide reasonably precise estimates of murrelet density, we combined Strata 1 and 2 for all analyses that follow. Combining these strata seems reasonable because they are adjacent and ecologically similar. Average PSU area was 24.9 km2 and covered about 20 km of shoreline (Figure 1). The average transect length per PSU was 34.45 km that was split between a nearshore segment (average length = 20.74 km) and offshore segment (average length = 14.18 km) with more effort (more transect traveled) in the nearshore where murrelet densities are higher (Miller et al. 2006, Raphael et al. 2007). Most core PSUs (adjacent to naval facilities) were surveyed monthly and their order was randomly selected. Non-core surveys were also randomly surveyed, but because the number of available survey days per month was limited, not all PSUs were visited each month. The actual survey schedule for each PSU is provided in Table 1. We (WDFW) used the PSU numbers from the Marbled Murrelet Effectiveness Monitoring Program (Raphael et al. 2007) so that we could make comparisons, if needed, to spring/summer derived encounter rates for these same PSUs. The Effectiveness Monitoring effort uses a similar survey design to this Navy effort but, because the area of interest is much larger in the Effectiveness Monitoring Program and the goals differ between these efforts, the geographic definitions of the strata are very different between programs but the geographic boundaries of the PSUs and their numbers are identical (but see Raphael et al. 2007). Although the Effectiveness Monitoring Program did not include a PSU in Dyes Inlet, the Navy requested this area be sampled. As a result, a new PSU was created and labeled "900" to avoid any confusion with those PSUs already established.

Observer Training

The crew 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 primary sampling unit (PSU) to avoid survey fatigue. All of the observers had previous experience monitoring seabirds at sea and or on colonies. Observers 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 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.

Field Methods and Equipment

Two observers (one on each side of the boat) scanned from 0^o off the bow to 90^o abeam of the vessel. More effort was spent watching for marbled 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. 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 traveling and foraging together and therefore not independent), plumage class (Strong 1998), and water depth (from boat depth finder).

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 (DLOG3 developed by R.G. Ford, Inc., Portland, OR.) that is interfaced with a GPS unit and collects real time location data. DLOG3 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 DLOG3. Additional data such as PSU identification, weather and sea conditions, on/off effort, and names of observers were recorded manually into the DLOG3 program.

The crew used a 26-foot Almar boat with twin-outboard engines. 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.

Data Analysis

Transect distances, murrelet group size, and perpendicular distances for each marbled murrelet observation were used in the program DISTANCE to derive density estimates by stratum. For details about our analysis approach, see Miller et al. (2006) and Raphael et al. (2007).

RESULTS

Surveys began in mid-October when the contract was finalized and nearly all core PSUs (associated with Naval facilities) were surveyed in all months except October. November weather was favorable and allowed us to complete almost all PSU surveys in all strata. In December, due to poor weather, core PSUs were surveyed first in all strata then in order of where weather would allow. Frequent Naval activity in Dabob Bay forced us to survey whenever we (WDFW) could, either weekends or one open day during the week. Relatively even coverage was possible in January and February, with some access limitations in Dabob Bay.

When examining density estimates by stratum (Table 2), higher densities were consistently found in Strata 1 and 2. Murrelet densities were considerably lower in Strata 3 and 4, but with more variable densities in Stratum 4. The overall density of murrelets in Stratum 5 was extremely low across all months. Using these overall densities, we estimated there were 2,081 (95% CI = 1,429-3,028) birds in all strata combined and 1,412 (839-2,377), 290 (137-611), 370 (262-523), and 8 (3-25) murrelets in Stratum 1 and 2 (combined), 3, 4, and 5 respectively.

Although we (WDFW) cannot derive PSU scale density estimates because of their small size and because relatively few birds are encountered within a PSU, we can qualitatively explore encounter rates (# murrelets encountered per kilometer of transect traveled; Table 3) by PSU. It appears that PSUs on the western side of Admiralty Inlet have the highest murrelet encounter rates (Table 3). Other PSUs with intermediate encounter rates include 35 (Stratum 3) at the tip of the Toandos Peninsula in Hood Canal and PSU 16 and 24 (Strata 4) off of Crescent Harbor and Mukilteo respectively. Some PSU/Stratum had consistently low encounter rates or no encounters including all of Stratum 5 (Table 3). Also, much of Stratum 4 has low encounter rates (Table 3). Because birds can move large distances during our sampling effort, there may be considerable variation in encounter rates among seasons and years at this spatial scale.

RECOMMENDATIONS FOR FUTURE SAMPLING

Additional years of sampling are recommended to help us understand monthly fall/winter and interannual variability in encounter rates and density estimates. Because our contract was not in place to begin monitoring until late October and we were only able to visit a few PSUs that month, we decided to increase our sampling effort in November. This resulted in our sampling nearly all PSUs in that month. This unusual monthly effort provides an opportunity to examine November stratum densities (Table 2) and to compare November with winter densities (January and February samples; Table 2). The results are fairly consistent among time periods with high densities in Strata 1and 2 and lower but variable densities in the other strata. The high coefficient of variation (CV) associated with these estimates suggests that for each month (or time period – see below), we should attempt to sample all PSUs in each stratum and not subsample (the CV decreases with total transect length– see figure 4 in Raphael et al. 2007). Because the budget for this effort is limited it is worth considering having 1, 2, or 3 months where all PSUs are surveyed and other months when no PSUs are surveyed (depending on what the budget allows). Using this approach, we could estimate densities at the stratum level for the months when all PSUs are sampled with much lower estimate associated CVs. Alternatively, we could split the fall/winter survey period (October – March) into three survey periods (1 = Oct/Nov, 2 = Dec/Jan, 3 = Feb/March) and during each period, we survey each PSU only once (including the cores). We recommend the later approach for logistical reasons.

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Figure 1. Stratum and primary sampling unit locations. Strata are defined in the figure Key and PSUs are labeled on the map.

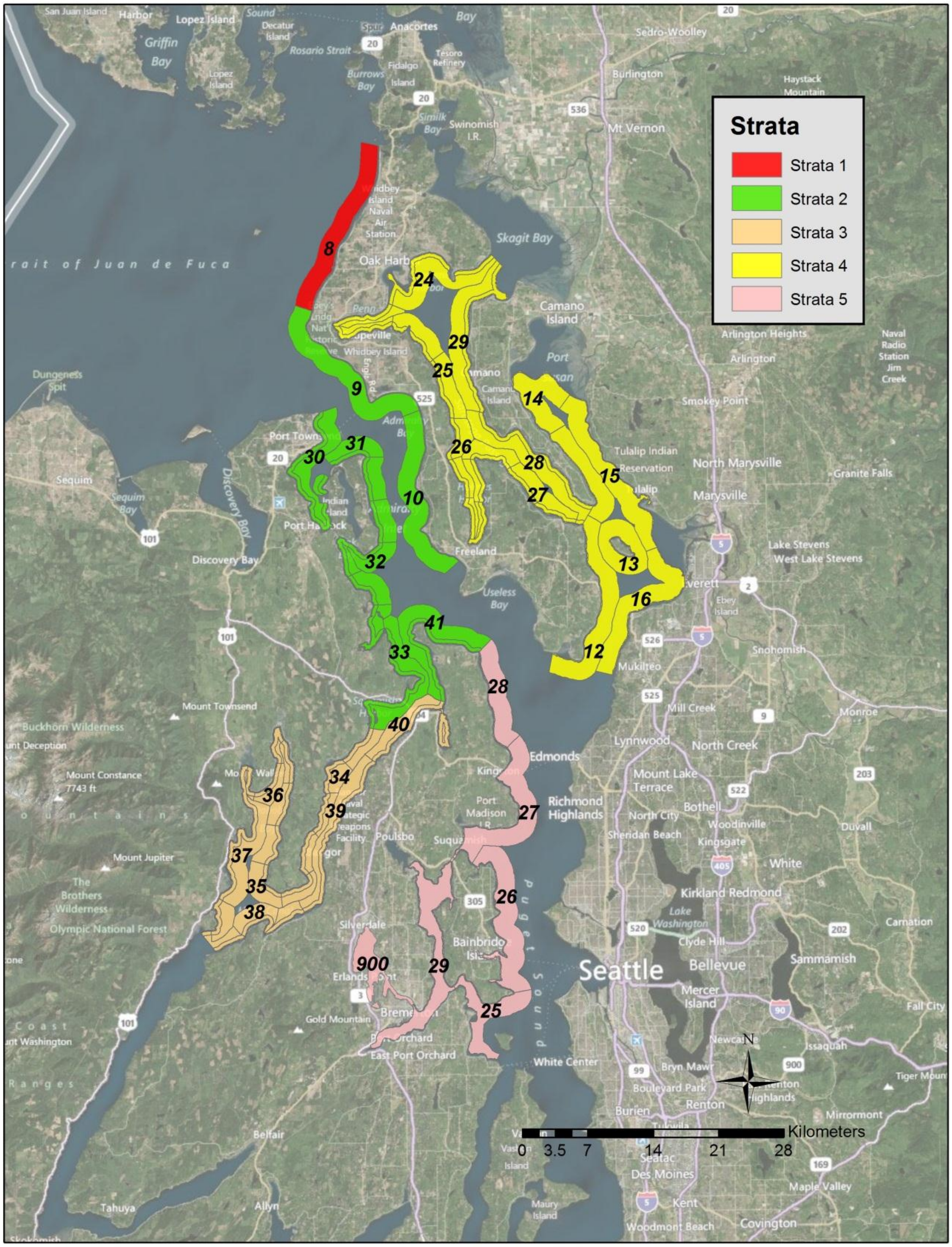

Table 1. Dates of Primary sampling unit (PSU) surveys by month during the fall and winter of 2012/2013. Primary sampling units adjacent to Naval facilities are in bold. Numbers in each month column represent the survey date. A "23" in the October column represents October 23rd 2012.

Stratum	PSU	October	November	December	January	February
1	**8**		14	10	4	11
2	9		14			11
	10		15			
	30		8	10	4	8
	31		14	10	4	8
	32		15			
	33		15			15
	41		27			15
3	34				14	
	35		2	12	15	19
	36		2	12	15	19
	37		1	12	15	19
	38		1	9	14	12
	39		1	9	14	12
	40		27			12
4	12		27			
	13		28		10	
	14	22	6			
	15	22	6	13	10	20
	16	19	6	13	10	20
	24	23	7	13	11	
	25		7			
	26		28		16	
	27		28		16	
	28	22				
	29				11	
5	**25**	24	16	18	2	4
	26		26	21	2	
	27		26	21	2	
	28		26			15
	29	24	16	5	3	4
	900			5	3	

Table 2. October – March, Fall (November), and winter (January/February) estimates of marbled murrelet density and population size for five Puget Sound Strata and all strata combined. Strata are defined in Figure 1. Note that no birds were detected in Stratum 5 during the January/February period and as a result, there is no estimate for the number of birds in this Stratum.

Year	**Stratum**	**Density**	**StdErr**	**%CV**	**Birds**	**Birds 95% CL Lower**	**Birds 95% CL Upper**	**Area (km^2)**	**f(0)**	**Std. Err. Of f(0)**	**E(s)**	**Std. Err. Of E(s)**	**Truncation Distance (m)**
Global model (Oct - Mar)													
2013	**All**	**2.21**		**18.4%**	**2,081**	**1,429**	**3,028**	**942.0**	**0.011**	**0.000**	**1.998**	**0.034**	**211**
2013	1 & 2	5.50	1.57	25.3%	**1,412**	839	2,377	256.7					
2013	3	1.78	0.66	37.2%	**290**	137	611	162.5					
2013	4	1.07	0.18	17.0%	**370**	262	523	345.1					
2013	5	0.05	0.36	56.7%	**8**	3	25	177.6					
Fall model (Nov)													
2013	**All**	**2.42**		**22.2%**	**2,281**	**1,433**	**3,628**	**942.0**	**0.014**	**0.001**	**1.814**	**0.047**	**211**
2013	1 & 2	5.61	1.48	26.4%	**1,441**	795	2,615	256.7					
2013	3	1.31	0.56	42.5%	**213**	76	595	162.5					
2013	4	1.63	0.42	26.0%	**562**	319	989	345.1					
2013	5	0.20	0.11	54.6%	**35**	9	142	177.6					
Winter model (Jan/Feb)													
2013	**All**	**2.14**		**19.0%**	**2,014**	**1,366**	**2,969**	**942.0**	**0.010**	**0.001**	**2.190**	**0.092**	**211**
2013	1 & 2	6.17	2.91	47.1%	**1,583**	569	4,408	256.7					
2013	3	1.41	0.67	47.1%	**230**	86	612	162.5					
2013	4	0.83	0.25	29.5%	**288**	150	552	345.1					
2013	5	0.00			-								

Table 3. October – February marbled murrelet encounter rate (# birds detected/km transect length sampled) by primary sampling unit.

Stratum	PSU	October	November	December	January	February	Average
1&2	**8**		**0.29**	**0.06**	**0.10**	**0.09**	**0.13**
	9		0.54			0.05	0.30
	10		0.58				0.58
	30		**2.04**	**2.18**	**5.77**	**1.70**	**2.92**
	31		1.44	0.64	0.24	3.27	1.40
	32		1.40				1.40
	33		0.15			0.15	0.15
	41		0.91			0.84	0.88
3	**34**				**0.68**		**0.68**
	35		**0.21**	**2.42**	**1.25**	**0.06**	**0.99**
	36		**0.08**	**0.00**	**0.06**	**0.00**	**0.04**
	37		**0.03**	**0.36**	**0.41**	**0.06**	**0.22**
	38		**0.26**	**0.24**	**0.07**	**0.00**	**0.14**
	39		**0.00**	**0.06**	**0.22**	**0.00**	**0.07**
	40		0.61			0.00	0.31
4	12		0.34				0.34
	13		0.20		0.00		0.10
	14	0.00	0.00				0.00
	15	0.34	0.28	0.08	0.05	0.06	0.16
	16	**0.06**	**0.27**	**0.21**	**0.27**	**0.21**	**0.20**
	24	**0.14**	**0.63**	**0.10**	**0.28**		**0.29**
	25		0.30				0.30
	26		0.06		0.06		0.06
	27		0.20		0.06		0.13
	28	0.00					0.00
	29				0.14		0.14
5	**25**	**0.00**	**0.06**	**0.00**	**0.00**	**0.00**	**0.01**
	26		0.03	0.00	0.00		0.01
	27		0.00	0.00	0.00		0.00
	28		0.08			0.00	0.04
	29	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	900			0.00	0.00		0.00