ABUNDANCE AND PRODUCTIVITY OF MARBLED MURRELETS OFF CENTRAL CALIFORNIA DURING THE 2008 BREEDING SEASON

Final Report Submitted to:

California State Parks
95 Kelly Avenue
Half Moon Bay, CA 94019

By:

M. Zachariah Peery, Laurie A. Hall, James T. Harvey
Moss Landing Marine Laboratories
8272 Moss Landing Marine Laboratories
Moss Landing, CA 95039

and

Laird A. Henkel
Office of Spill Prevention and Response
California Department of Fish and Game
20 Lower Ragsdale Drive, Suite 100
Monterey, CA 93940

September 2008

[1]Email: zpeery@nature.berkeley.edu

Summary

We conducted at-sea surveys for Marbled Murrelets (*Brachyramphus marmoratus*) in Conservation Zone 6 (central California) offshore of breeding habitat between Half Moon Bay and Santa Cruz in 2008. Using distance sampling estimation techniques, we estimated the central California population to be 122 (95% CL: 61-184) with surveys delineated from the north (n = 3), 225 (95% CL = 131-319) with surveys delineated from the south (n = 3), and 174 (95% CL: 91-256) with all surveys (n = 6). These estimates represent 54-55% declines since 2007 and 71-80% declines since 2003. No juveniles were detected and the date-corrected juvenile ratio, an estimate of productivity commonly used to index reproductive success in Marbled Murrelets, was therefore equal to zero for 2008. This was the first year since surveys for juvenile ratios started in 1996 that no juveniles were detected. Our results, in concert with previous and ongoing demographic and genetic work, indicate that Marbled Murrelets in central California will almost certainly become locally extirpated when the current cohort of adults dies.

Introduction

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that is federally-listed as Threatened and state-listed in California as Endangered. Potential threats to Marbled Murrelets in California include loss of old-growth forest nesting habitat, changes in prey (small fish) availability, increasing predator populations, gill-netting bycatch, and oil spills (Carter and Erickson 1988, Peery et al. 2004). To work towards recovery of the species, various oil spill trustee councils have provided funding for restoration, including protection of nesting habitat and management of predatory corvids. In the last several years, the Command Trustee Council (for the 1998 T/V Command oil spill) has initiated efforts to control food sources for corvids in the Santa Cruz Mountains, initiated lethal control of some corvids, and acquired 80 acres of potential nesting habitat in the Santa Cruz Mountains, to be incorporated into Butano State Park.

Population monitoring of Marbled Murrelets typically is conducted using at-sea surveys. Other monitoring methods are used to monitor inland activity, including radar surveys and audio-visual surveys, but these methods do not provide estimates of population size. Regular (e.g., annual) at-sea surveys are critical in determining the success of restoration efforts and the current status of the species range-wide. Under the Northwest Forest Plan, annual at-sea monitoring occurs in California within Conservation Zones 4 and 5, from the Oregon border south to San Francisco Bay. Conservation Zone 6, from San Francisco Bay south to Monterey Bay, is not included in the Northwest Forest Plan, but population monitoring within Zone 6 was conducted from 1999 through 2003 with a combination of state, federal, and private funding. No decline was detected during this period, despite the fact that reproductive success was too low to compensate for adult mortality (Peery et al. 2006a). To aid in determining the success of restoration efforts in the Santa Cruz Mountains, the Command Trustee Council funded at-sea surveys in Zone 6 during the 2007 breeding season (Henkel and Peery 2008). These surveys suggested that the population had declined to 378 individuals in 2007 from 661-699 in the initial survey period (1999-2003). Here we report on similar surveys conducted in Zone 6 in 2008.

Methods

We conducted six approximately 100 km long at-sea surveys between Half Moon Bay and Santa Cruz in 2008 from 16 June to 15 September (Table 1) that followed zig-zag transect routes consistent with surveys conducted from 1999 through 2003, and in 2007 (Peery et al. 2006a). Surveys were always initiated immediately outside of the Half Moon Bay Harbor a random distance (200-2500 m) from shore. Surveys included between 69.4 and 78.0 km of transect in a "nearshore" stratum (200-1350 m from shore) and between 15.1 and 26.6 km of transect in an "offshore" stratum (1350-2500 m from shore). In previous years an equal number of routes were drawn from starting points at the north and south ends of the survey area, and transects drawn from the south tend to yield a higher densities that transect delineated from the north. Therefore, three of the six 2008 transects were drawn from the south and three transects were drawn from the north.

For all surveys, line transect methods were used (Becker et al. 1997, Peery et al. 2006a). Two observers, standing on either side of a 6-m open skiff, recorded angle off the transect line and distance to all groups of Marbled Murrelets seen (prior to each survey, observers calibrated distance estimation using a laser rangefinder on buoys in the harbor). Birds in flight were counted if they crossed a line perpendicular to the track line, even with the observers. Counting flying birds (2% of sightings were of flying birds) may result in overestimation of abundance (Spear et al. 1992, Piatt et al. 2007), but this method was used for previous surveys in central California, and was used in 2008 for consistency. Sightings data were analyzed using DISTANCE v.5.0 and density was estimated using

$$D = \frac{\hat{E}(n) \cdot \hat{E}(s)}{2L \cdot \widehat{ESW}}$$

where $E\hat{S}W$ was the estimated effective strip width, $\hat{E}(n)$ was the expected number of groups, $\hat{E}(s)$ was the expected number of birds per group, and L was the length of the line transect (km; Buckland et al. 2001).

Estimating *ESW* requires modeling the inevitable decline in detection probability as a function of distance from the sighting data. Due to the sharp decline in population size (see below), only 47 groups of Marbled Murrelets were detected during the six surveys conducted in 2008, a number that is insufficient to develop a robust detection function (Buckland et al. 2001). Therefore, we combined data from 2007 and 2008 (resulting in 131 detections) to estimate detection function parameters, but only estimated density and abundance for surveys conducted in 2008. All detections >120 m from the transect lines were discarded and the remaining detections were grouped into 7 20-m bins, similar to analyses conducted for previous years. A half-normal detection model with cosine adjustments (as used to model previous year's data) did not fit the pooled

2007-2008 data well, largely because of distance data collected during the 12 September 2008 survey. Eliminating this surveys resulted in reasonable model fit ($\chi 2 = 4.1$, df = 4, $P = 0.39$) and an ESW of 61.4 m. To estimate abundance from density estimates, we multiplied survey-specific density estimates for the nearshore stratum generated by DISTANCE by the total area of the nearshore stratum (104.65 km^2; no bird were detected in the offshore stratum in either 2007 or 2008). Confidence intervals for the mean 2008 abundance estimate were calculated based on the variance across surveys-specific abundance estimates.

Results

As was the case in previous years, surveys conducted in 2008 that followed transects delineated from the south yielded greater estimates of population size (mean = 225; 95% CL: 131-319, $n = 3$) than transects delineated from the north (mean = 122; 95% CL: 61-184, $n = 3$; Table 1, Figs 1 and 2). The mean estimate of abundance from all 6 surveys was 174 (95% CL: 91-256; range: 49-316; Tables 1 and 2). Using data from both directions, the estimated abundance in 2008 represents a 71% decline from 2008. Using data only from surveys drawn from the north, there was a 80% decline from 2003 to 2008; and from the south, there was a 75% decline. From 2007 to 2008, there was a 54%, 55%, and 54% decline in abundance in surveys conducted from both directions, from the north, and from the south, respectively.

No juveniles were detected during any of the four surveys conducted within the window used to estimate juvenile ratios (10 July to 23 Aug). Thus, estimates of both uncorrected and date-corrected juvenile ratios were equal to zero in 2008; 2008 being the only year since 1996 that no juveniles were detected (Table 3).

Discussion

Our results suggest that the Marbled Murrelet population in central California underwent a significant and rapid decline between 2003 and 2008, recognizing that population estimates were not available from 2004-2006. Peery et al. (2006a) determined that, based on low levels of reproductive success, the central California population should show a consistent annual decline in the absence of immigration. However, abundance estimates based on at-sea surveys conducted between 1999 and 2003 showed no such decline; thus, Peery et al. (2006) suggested that immigration from northern California was supporting the central California population. Recent genetic analyses support the hypothesis that immigration without recruitment into the breeding population may have masked underlying deterministic declines in the population (M. Z. Peery L. A. Hall unpub data). Whether immigration stopped or declined after 2003, making the local population decline evident in 2007 and 2008, or whether the remaining individuals in central California are largely immigrants from other populations is uncertain without more recent genetic, mark-recapture, and radio-telemetry work. The low abundance estimates in 2008, and to a lesser extent 2007, could also be due in part to increased dispersal out of the study area compared with previous years, as Marbled Murrelets sometimes disperse out of the central California study area during summer (Peery et al.

2008). However, given the low productivity estimates in all 10 years that juvenile-ratio surveys were conducted from 1996 through 2008, the observed population decline, as well as future declines, is virtually inevitable. Indeed, our results indicate that current conservation projects in the Santa Cruz Mountains are insufficient to prevent the extirpation of Marbled Murrelets in central California when the current cohort of adults dies. Given the predicted and observed population decline, the genetic uniqueness of the population (Friesen et al. 2005, Piatt et al. 2007), and high probability of local extirpation, there is a clear need for immediate and stronger conservation actions in the region, and for annual monitoring of the success of these conservation efforts.

Acknowledgments

The survey boat and driver (Jack Ames) were provided by DFG-OSPR; we thank Jack Ames and other OSPR staff for their long hours of logistical support. This project was funded by the Command Trustee Council, via the California Department of Parks and Recreation, through a contract with the San Jose State University Foundation.

Literature Cited

Becker, B.H., and S.R. Beissinger. 1997. At-sea density monitoring of Marbled Murrelets in central California: methodological considerations. Condor 99: 743-755.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, UK.

Carter, H.R. and R.A. Anderson. 1988. Population status and conservation problems of the Marbled Murrelet in California, 1892-1987. Unpubl. Rept. for California Dept. of Fish and Game, Sacramento, CA.

Friesen, V.L., T.P. Birt, J.F. Piatt, R.T. Golightly, S.H. Newman, P.N. Hebert, B.C. Congdon, and G. Gissing. 2005. Population genetic structure and conservation of Marbled Murrelets (*Brachyramphus marmoratus*). Conservation Genetics 6(4): 607-614.

Henkel, L.A., and M.Z. Peery. 2008. Abundance and productivity of Marbled Murrelets off central California during the 2007 breeding season. Unpubl. Report, Moss Landing Marine Laboratories, Moss Landing, CA.

Peery, M.Z., S.R. Beissinger, S.H. Newman, E.B. Burkett, and T.D. Williams. 2004. Applying the declining population paradigm: diagnosing causes of poor reproduction in the Marbled Murrelet. Conservation Biology 18: 1088-1098.

Peery, M. Z., B. H. Becker, and S. R. Beissinger. 2007. Age ratios as estimators of productivity: testing assumptions on a threatened seabird, the Marbled Murrelet. Auk.124:224-240.

Peery, M.Z., B.H. Becker, and S.R. Beissinger. 2006a. Combining demographic and count-based approaches to identify source-sink dynamics of a threatened seabird. Ecological Applications 16: 1516-1528.

Peery, M.Z., S.R. Beissinger, E. Burkett, and S.H. Newman. 2006b. Local survival of Marbled Murrelets in central California: roles of oceanographic processes, sex, and radiotagging. Journal of Wildlife Management 70: 78-88.

Peery, M.Z., L.A. Henkel, B.H. Becker, S.H. Newman, J.T. Harvey, C. Thompson, and S.R. Beissinger. 2008. Effects of rapid flight-feather molt on post-breeding dispersal in a pursuit-diving seabird. Auk 125:113-123

Piatt, J.F., K.J. Kuletz, A.E. Burger, S.A. Hatch, V.L. Friesen, T.P. Brit, M.L. Arimitsu, G.S. Drew, A.M.A. Harding, and K.S. Bixler. 2007. Status review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia. USGS Open File Report 2006-1387, USGS, Reston, VA.

Spear, L.B., N. Nur, and D.G. Ainley. 1992. Estimating absolute densities of flying seabirds using analyses of relative movement. Auk 109(2): 385-389.

Strong, C.S. 1998. Techniques for Marbled Murrelet age determination in the field. Pacific Seabirds 25(1): 6-8.

Table 1. Results of six surveys for Marbled Murrelets between Half Moon Bay and Santa Cruz in 2008

Survey Date	Number of Groups	Mean Group Size	Number of Juveniles	Transect Length (km)[1]	Population Estimate[2]	Survey Direction[3]
16 July	13	1.4	0	78.0	207 (113-382)	South
22 July	11	2.2	0	68.2	316 (155-645)	South
6 Aug	3	1.3	0	74.0	49 (6-426)	North
12 Aug	7	1.7	0	70.8	152 (66-351)	South
12 Sep	9	2.1	NA	69.4	246[4]	North
15 Sep	3	2.0	NA	74.6	72 (25-211)	North

[1]Nearshore stratum only; no murrelets were seen in the offshore stratum.

[2]95% CL in parentheses.

[3]Direction transect drawn from.

[4]Estimated manually, not with DISTANCE; 95% CL not available.

Table 2. Population estimates (95% CI in parentheses) of Marbled Murrelet in central California between 1999 and 2008. Historic data from Peery et al. (2006a); *n* = number of surveys. No surveys were conducted from 2004 to 2006.

Year	From North Pop. Estimate	*n*	From South Pop. Estimate	*n*	Both Directions Pop. Estimate	*n*
1999	487 (333-713)	5		0		0
2000	496 (338-728)	8		0		0
2001	637 (441-920)	8	733 (583-922)	7	661 (556-786)	15
2002	628 (487-809)	9	729 (494-1075)	6	683 (561-832)	15
2003	615 (463-815)	6	782 (570-1074)	6	699 (567-860)	12
2007	264 (142-489)	2	488 (408-585)	2	367 (240-562)	4
2008	122 (61-184)	3	225 (131-319)	3	174 (91-256)	6

Table 3. Annual estimates of hatch-year to after-hatch-year ratios (*R*) and standard errors (SE) for Marbled Murrelets from at-sea surveys conducted in the breeding season in central California, 1996-2003 and 2007-2008. Surveys used to estimate ratios were limited to 10 July to 23 August, 1996-2003, 2007. Corrected estimates were corrected for the proportion of hatch-year murrelets that had not fledged and the proportion of after-hatch-year murrelets still incubating at the time the survey was conducted (see Peery et al. 2007). n_{inds} = the number of individuals observed and $n_{surveys}$ = the number of surveys conducted.

	Uncorrected		Corrected			
Year	*R*	(SE)	*R*	(SE)	n_{inds}	$n_{surveys}$
1996	0.004	(0.003)	0.006	(0.004)	517	3
1997	0.010	(0.003)	0.022	(0.007)	701	5
1998	0.002	(0.003)	0.004	(0.004)	437	6
1999	0.015	(0.005)	0.030	(0.010)	693	10
2000	0.021	(0.010)	0.034	(0.016)	495	8
2001	0.031	(0.006)	0.063	(0.016)	400	8
2002	0.022	(0.005)	0.045	(0.011)	601	11
2003	0.024	(0.005)	0.049	(0.011)	424	8
2007	0.017	(0.017)	0.049	(0.051)	130	3
2008	0	(0)	0	(0)	47	4

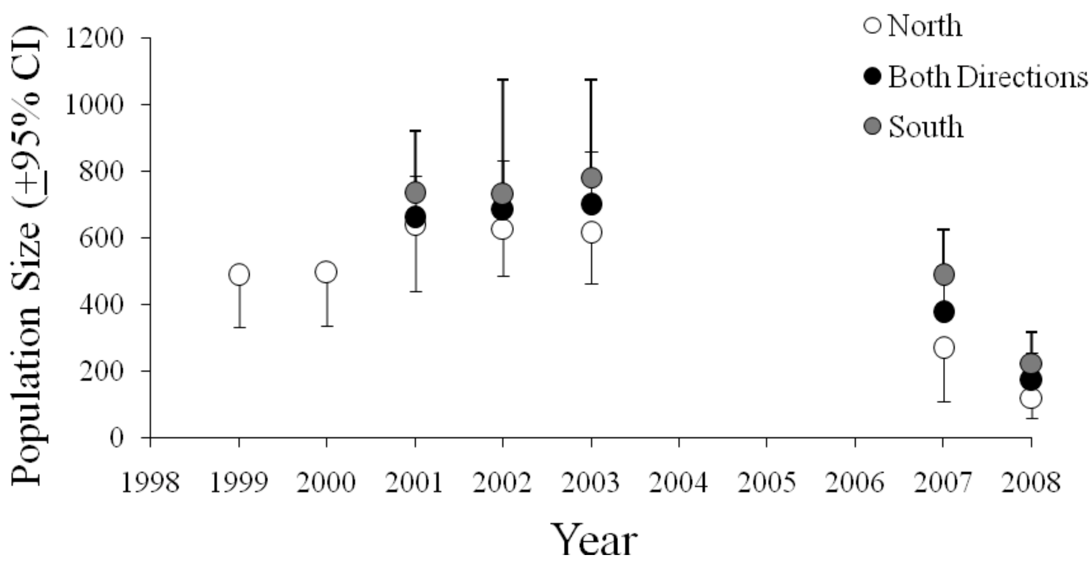

Figure 1. Abundance estimates for the central California population of Marbled Murrelets based on at-sea surveys, 1999-2008. Error bars are 95% confidence intervals. Because surveys before 2001 were conducted only on transects drawn from the north, these survey data are presented separately.