ARTICLES

A NEW METHOD FOR AGEING MARBLED MURRELETS AND THE EFFECT ON PRODUCTIVITY ESTIMATES

Linda L. Long, C. John Ralph, and Sherri L. Miller

***Abstract*:**: Accurate knowledge of the number of newly-fledged juveniles offshore is critical to estimates of productivity of the threatened Marbled Murrelet (*Brachyramphus marmoratus*). We describe a method for collecting productivity data which allows researchers to objectively evaluate age determinations and their effect on juvenile percentages. This has the potential to reduce the effect of observer variability and the number of misidentified birds, especially late in the breeding season when adults in late pre-basic molt are very similar to juveniles. We analyzed the timing of this molt in adults, and found some variation between regions and years. Therefore, critical dates for identification of adults in late molt versus juveniles may need to be reassessed annually. During our study, productivity estimates ranged from 1% to 7% juveniles. We used two methods for assessing the effect of missed juveniles. Even after adjusting for misclassified murrelets, the resulting juvenile percentages (1% to 17%) would suggest an unstable population in our study area.
***Key words*:** *Marbled Murrelet*, Brachyramphus marmoratus, *productivity, juvenile, molt, ageing*

INTRODUCTION

A measure of productivity is one of the vital components of a demographic model. Productivity of Marbled Murrelets (*Brachyramphus marmoratus*) has been estimated from the proportion of the newly-fledged young on the sea (Beissinger 1995, Ralph and Long 1995, Strong et al. 1995, Kuletz and Kendall 1998). It has been the only feasible way to estimate productivity, as nests are notoriously difficult to find and monitor. The newly-fledged young have a plumage that is dark above and light below, quite distinct from the mostly dark alternate plumage of the potentially breeding adult. We will address methods to improve the quality of age determinations and thus the estimates of productivity.

A few critical factors influence correct identification of juveniles at sea, including observer variability, the stage of progression of pre-basic molt in adults, and the timing of fledging of juveniles. Young fledge rather asynchronously for a seabird, over a 24-week period in some areas (Hamer and Nelson 1995), therefore dark-and-light (basic-plumaged) birds can include both newly-fledged juveniles and adults in late pre-basic molt. Also, a small percentage (about 2% in Prince William Sound, Alaska) of adults may not molt into alternate plumage in the spring, but remain in basic plumage all year (Kuletz and Kendall 1998). Despite these uncertainties, counts of juveniles at sea form an important part of the basis for listing of the species as "threatened" (USFWS 1992), as they document the species' apparent low reproductive rates (Beissinger 1995).

Since 1993, we have been using and testing methods to evaluate murrelet plumage data. In this study, we evaluated observations taken by our observers. We describe and evaluate several factors that may influence the timing of adult molt and discuss their effect on correct identification of young and resulting productivity estimates.

METHODS

We collected plumage data on Marbled Murrelets during offshore surveys in northern California, from the Oregon border south to False Cape Mendocino in Humboldt County starting in 1994. Each year, we began collection of plumage data when the first dark-and-light murrelet was seen on the water, usually in mid-July. For analyses, we divided the field season into 10-day periods.

Crews were trained in murrelet ageing criteria and adult molt patterns at the beginning of the survey season, using museum study skins and photographs of murrelet plumages. At sea, experienced observers trained the crews after the first juveniles and molting adults appeared on the water. Observers and drivers discussed the observations in order to increase consistency between observers.

Data collection and ageing criteria

We collected data on Marbled Murrelet plumages during line transect census surveys conducted at variable distances from shore. We collected data on the first 5-10 birds encountered on each 2-km sampling unit. One observer recorded all data. When the bird was sighted, observers used binoculars to obtain the best view of the bird. The driver maneuvered the boat toward the bird to the closest distance possible without flushing the bird. We observed birds from a mean distance of 28 m (from 1 to 80 m), and a mean time of 15 seconds (minimum 1 second [breeding birds], maximum 5 minutes [dark-and-light birds]). After sufficient data were collected, the census survey resumed.

For each bird, observers recorded data on four feather areas: the neck, sides, breast, and belly. Some areas were seen best during certain behaviors. The breast and belly were most visible when the birds flapped their wings, and the posterior portion of the belly was visible as birds dove. For each feather area, the observer recorded the percentage of the plumage that was dark, consisting of either blotches or fine markings. For example, a bird in full alternate (breeding) plumage with dark blotches covering most of the neck, would be scored 90% for that area. The observer estimated the percentage of dark by regarding the bird as if covered by a grid of 1-cm squares, each cell being approximately the size of one feather, and estimating the percentage of all the cells that were predominantly dark. The observer also recorded the presence or absence of fine markings on the feathers, described as "speckling" by Carter and Stein (1995).

For wing molt, we recorded: (1) the presence or absence of a gap in the flight feathers, which occurs early in the molt sequence when the inner primaries (and/ or secondaries) are molting; and (2) wing shape, as either pointed (a normal wing) or blunt (when all of the outer primaries have molted later in the sequence) (Carter and Stein 1985).

Other data were taken which might aid in identification of young birds. The observer recorded an individual's size as the percentage relative to others in the group, with the largest in the group being 100%. When young fledge, Carter and Stein (1995) thought them to be about 70% of the size of an adult, thus potentially separable when accompanied by an adult. Other potential juvenile characteristics, such as egg tooth, bill coloration, or unusual behaviors, were also noted.

Observers then recorded their appraisal of the type of plumage and stage of molt using the following *plumage categories*: B = breeding plumage, no molt; E = early molt, molt covers less than 50% of the body; M = mid-molt, molt covers more than 50%

TABLE 1. Criteria for determining age of birds and quality of observation. Ageing criteria are listed in order of importance for assigning certainty levels for an age classification. For instance, a dark-and-light bird with blunt wings might be a "certain late-molt adult," but one identified as a juvenile based mainly on its small size might be an "uncertain juvenile." Few criteria are absolute (these are marked *), but each contributes to the overall quality of the observation.

1A. Criteria for differentiating adults and juveniles

	Adult	Juvenile
Ageing criteria		
Wing:		
Gap in primaries or secondaries	present*	absent
Tip shape	blunt, paddle-shaped*	pointed
Breast, neck, side, or belly plumage:		
Characteristic of dark coloring	blotchy*	fine makings*
Percent dark	0-95%	0-15%*[1]
Size (compared to accompanying bird)	100%	<90%
Criteria, by date, required to age dark-and-light birds		
Before 15 August	plumage molt	none, but certainty = "probable" without other criteria
15 August-1 September	plumage molt	no wing molt, fine markings
After 1 September	plumage molt	fine markings

[1]Used as an absolute criterion for age if 0% dark and before 15 August, with full wings before 1 September, or if dark coloration is fine markings

1B. Criteria for quality of observation

	Good	Poor
Length of observation (secs)	≥ 15	< 15
Nearest distance to bird (m)	≤ 40	> 40
Backlighting	no	yes
View of bird	front, side	back

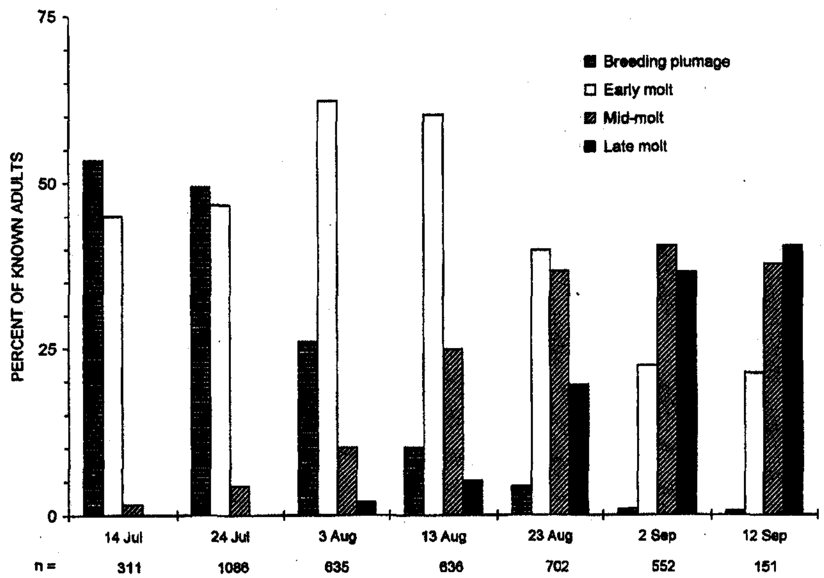

FIGURE 1. Percentage of known adults in four plumage categories by 10-day periods during 1995-1998. Date is the beginning of each 10-day period. n = sample size.

of the body, but easily distinguishable as a molting bird at a distance; L = late molt, bird appears as a bird in basic plumage at a distance, but still distinguishable as an adult by molt in the wings or belly; W = basic (winter) plumage, unidentifiable to age; or J = juvenile bird, in juvenal plumage (fine markings), or a basic-plumaged bird determined to be a juvenile because of an early observation date (before August 15). Since up to 2% of adults may not molt out of basic plumage in some areas (Kuletz and Kendall 1998), juveniles aged by date alone were usually given a probable certainty level (see below). We have used plumage categories to age murrelets since we started collecting this type of data in 1993, and continued to refine them over the next two years.

Quality of observations

We recorded the viewing conditions to assess the quality of the observation (Table 1). The observer recorded the closest distance to the bird while obtaining the majority of the data and an estimate of the total time that the bird's plumage characteristics were visible. Observers also recorded if the bird was backlit during the entire observation. Based on the above data, as well as the overall amount and quality of information leading to the age determination, the observer recorded the certainty of the observation as definite, probable, or uncertain.

Evaluation of observations

Observations were later independently evaluated, using criteria similar to those used by the observers. The evaluator first considered ageing criteria, and then the quality of the observation (Table 1). We evaluated those birds that were most difficult to separate: juveniles, mid- and late-molt adults, and winter-plumaged, unknown birds.

We used two critical dates for ageing. Dark-and-light birds observed before 15 August, without other plumage information, such as blunt wings or dark blotches, were considered juveniles. This date was chosen because less than 3% of adults seen prior to 15 August were in late-molt plumage (Figure 1). After this date, we felt that juveniles needed at least one other plumage criterion to be aged, such as full wings (no gaps in primaries, pointed shape) or fine markings (Table 1). After 1 September, dark-and-light

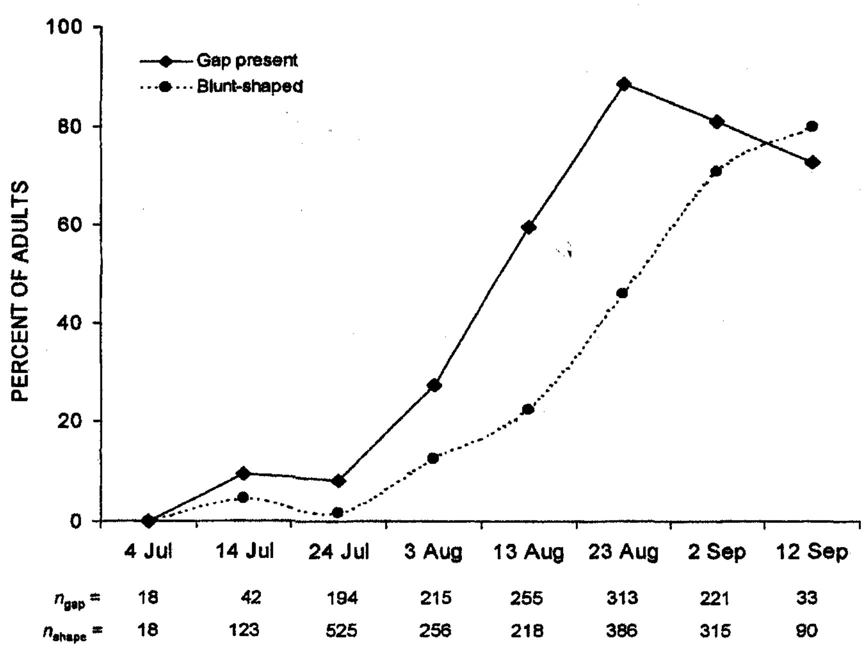

FIGURE 2. Percentage of adults examined at sea during 1994-1999 showing wing gaps (inner primaries or secondaries molting) or blunt-shaped wing tips (outer primaries molting). n_{gap} or n_{shape} = number of birds for which the presence or absence of gaps or the type of wing shape, respectively, were recorded. Date is the beginning of each 10-day period.

birds were considered unknown-aged and in basic (winter) plumage, unless the observer recorded fine markings (a definite juvenile) or the last stage of adult molt (usually on the belly or in the wings). After this date, full wings on a dark-and-light bird were not considered indicative of juveniles, because adults could have completed wing molt. Wing molt can last as little as 45 days (Carter and Stein 1995), so the most conservative estimate for completion of wing molt would be about 1 September, 45 days after 14 July when wing gaps were first observed (Figure 2).

In the evaluation of certainty levels, we considered approximately 15 seconds as an adequate time to age most birds (Table 1). Distances under 40 m gave the best viewing for plumage details. Backlighting was considered a negative factor since, with poor lighting, a late-molt adult could be mistaken for a breeding bird. Plumage details that were "absolute" (Table 1) increased the certainty level (such as fine markings for juveniles or wing molt for adults). Together, the quality of the observation and plumage category were used to assign a new certainty level. For instance, a 5-second observation, at >40 m from the observer, and backlit would be considered to have poor viewing conditions. However, if a gap in the wings was recorded, the evaluation would be a definite molting adult.

Statistical analyses

Timing of adult molt—The differences in timing of adult molt between years and regions might affect classification of juveniles and, therefore, our estimates of productivity. We compared the percentage of birds in late molt for all possible paired combinations of years (1995 vs. 1996, etc.) within 10-day periods, using the *z*-test for two independent percentages ($P < 0.05$, Hicks 1993:32) to test for differences between years. We also compared the percentage of birds in each stage of molt between north and south regions within 10-day periods.

.We understand the inherent problems with possible interactions between two variables (year or region with 10-day periods). However, percentage data have a binomial distribution and cannot be analyzed with regular ANOVA tests. After consultation, it was suggested we use this approach.

Calculated upper and lower percentage boundaries—To assess the possible impact of adding unknown birds to the productivity index, we estimated the potential upper and lower boundaries of the percentage of juveniles in the population (Table 2). We calculated the upper boundary by including all the unknown birds as juveniles. For the lower boundary, we included all the unknown birds as adults. We did this for 1994-1997, the years that we evaluated observations.

Adjusted percentages from regression model—Another method we used to assess the potential effect of misidentified juveniles was to base the percentage of juveniles on a period of the breeding season when few juveniles are misidentified. We used the 3-12 August period, the period just before the adult molt makes it difficult to age juveniles. From data on fledging dates (Nelson and Hamer 1995), Beissinger (1995) used linear regression ($y = 0.012x - 1.919$; y = proportion of nests fledged, x = Julian date) to estimate the cumulative proportion of nests fledged for each date of the season. We calculated 78% of young had fledged by the end of the selected period. We then adjusted the percentages for each year by dividing by 0.78.

TABLE 2. Comparison of two methods for estimating misidentified juveniles late in the season for four years. The first method calculates the percentage boundaries by including the unknown birds into either the total number of adults (lower limit) or juveniles (upper limit). The second method is based on Beissinger's (1995) linear regression model of the cumulative percentage of fledged birds. For this, we adjusted the percentage from the 3-12 August period: adjusted percent of juveniles = $\text{percentage}_{old} / 0.78$.

Year	Unadjusted percent juveniles	Calculated percentage boundaries	Linear regression
1994	6.8	6.4 – 13.1	10.1
1995	4.5	3..3 – 7.7	3.1[1]
1996	1.4	1.4 – 3 .6	1.9
1997	3.8	3.3 – 16.9	4.4

[1]13-22 August period used, due to small sample size in 3-12 August period (n = 16). Adjusted percent of juveniles = $\text{percentage}_{old} / 0.91$.

RESULTS

Progression of molt in adults

We began offshore censuses by June from 1995-1998. We saw one unknown dark-and-light bird during censuses in late June 1997. In the other years, the first dark-and-light birds were observed in mid-July (Table 3).

The timing of adult molt influences our ability to distinguish molting adults from juveniles, as the adults in late molt closely resemble juveniles. As expected, the proportion of molting adults in each successive molt stage generally formed a sequence through the season (Figure 1). The proportion of adults in breeding plumage declined rapidly after the end of July, and approached zero by late August. The proportion of birds in early molt were highest in August. In mid-July, some birds were already in mid-molt, the heaviest molt with most feather areas involved. This stage of molt peaked from the end of August into early September.

Table 3. Dates of first dark-and-light birds observed on offshore surveys in northern California, 1995-1998, and observers' classifications. All surveys began by 1 June for these years.

Year	Date	Observers' age classification
1995	22 July	juvenile (no plumage data)
1996	14 July	unknown (no plumage data)
1997	26 June	unknown (no plumage data)
1998	14 July	juvenile (fine markings)

Adults in the late stage of molt were first seen in early August. By mid-September, over 50% of the adults were in late molt.

Wing molt of the adults began in the inner primaries and secondaries in mid-July, when 10% of the adults were recorded with wing gaps (Figure 2). This peaked in late August with almost 100% of adults with wing gaps. The outer primaries molted later, beginning around early August when about 10% of birds had blunt wings. The proportion of adults with molt in the outer primaries continued to increase through September.

As adults completed their molt, they became indistinguishable from many young. In this stage of plumage, both were classified as "unknown-aged." The proportion of unknown, basic-plumaged birds was low until mid-September, when they rapidly increased (Figure 3).

Annual differences in adult molt

Observations of adults in late molt (with mostly dark-and-light plumage) varied among years (Figure 4). In 1995, we observed a significantly ($P \leq 0.05$) higher percentage of adults in late molt earlier in the year than in 1996 and 1997, based on the 13-22 August sample. Adults molted later in 1996 compared to 1997, based on the lower percentage in early September.

Regional differences in molt

Adults appeared to molt earlier in the north (Crescent City to Klamath River) as compared to the south (Redwood Creek to False Cape Mendocino) (Figure 5). Specifically, in the north a significantly ($P \leq 0.05$) higher percentage of adults were in the final, late-molt stage, in three of the four time periods when late-molt adults were present. Conversely, the percentage of adults in early and mid-molt tended to be higher in the south over the five periods.

Evaluation of age classifications

Between 2 and 5% of the observations for all age classifications were reclassified by the evaluator; however, between 6 and 58% of the juveniles were reclassified (Table 4). Reclassification changed the estimated percentage of juveniles in the population by only 0.3% for any one year, except 1997 (which changed by 1.5%), primarily due to the very low numbers of young.

In some years, the number of birds misclassified by field observers could greatly change the estimate of percentage of juveniles (Table 4). In 1997, for example, we reclassified 34% of the juveniles (34 of 99). On the other hand, we did not reclassify similar numbers of adults and unknowns; only three adults and three unknown-aged birds were reclassified as juveniles. The overall result was a decrease of the original estimate, from 5.3% to 3.8%.

Timing of fledging and unknown-aged murrelets

As adults molt into basic plumage later in the year, juveniles can become indistinguishable from adults. If birds are still fledging as the adult molt is ending, we could be underestimating the productivity of the population. Juveniles

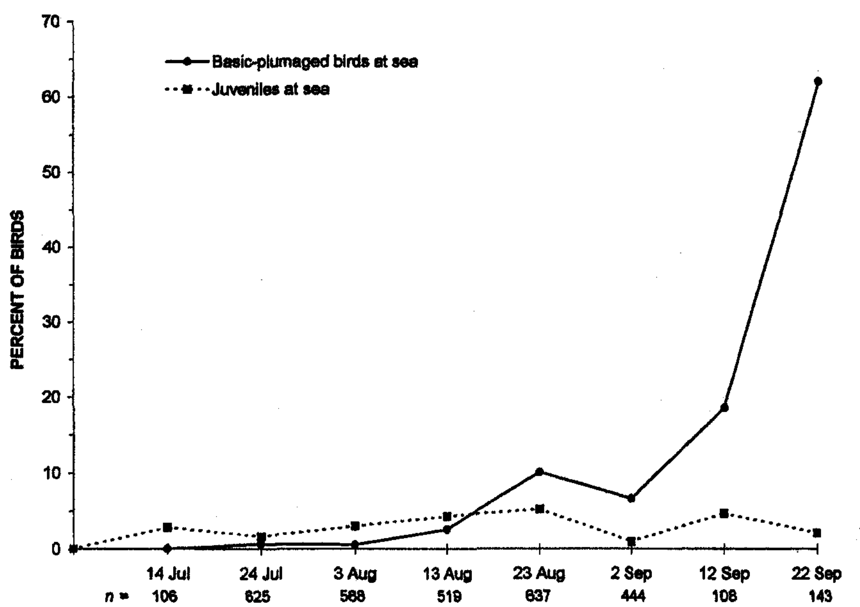

FIGURE 3. Cumulative percentage of basic-plumaged birds (1995-1997) and juveniles (1994-1997) of all murrelets observed at sea in northern California. Basic-plumaged birds consisted of unknown-aged and uncertain birds. Evaluated classifications were used for dark-and-light birds. Date is the beginning of each 10-day period. *n* = sample size of observations at sea 1995-1997.

were first seen in mid-July, and comprised ≤5% of the population (Figure 3). We were able to age young through late September.

In late July, we found the first basic-plumaged murrelets we were unable to age (<1%). These birds were usually classified as unknown-aged because of inadequate information on the bird or poor viewing conditions. Throughout August, about 5% of the population was unknown-aged birds, until late August when the proportion increased to 10%. After mid-September, unknown-aged basic-plumaged birds made up 70% of the population.

Calculated upper and lower percentage boundaries—For 1994 and 1997, the upper boundaries were 13.1% and 16.9%, increases of 6.3% and 13.1%, respectively (Table 2). This was due to a high percentage of unknowns (6-13%) in September in these years. By contrast, the upper boundaries in 1995 and 1996 (7.7% and 3.6%) were much lower.

Adjusted percentages from regression model—The resulting adjusted percentages of juveniles for each year ranged from 2% to 10% (Table 2).

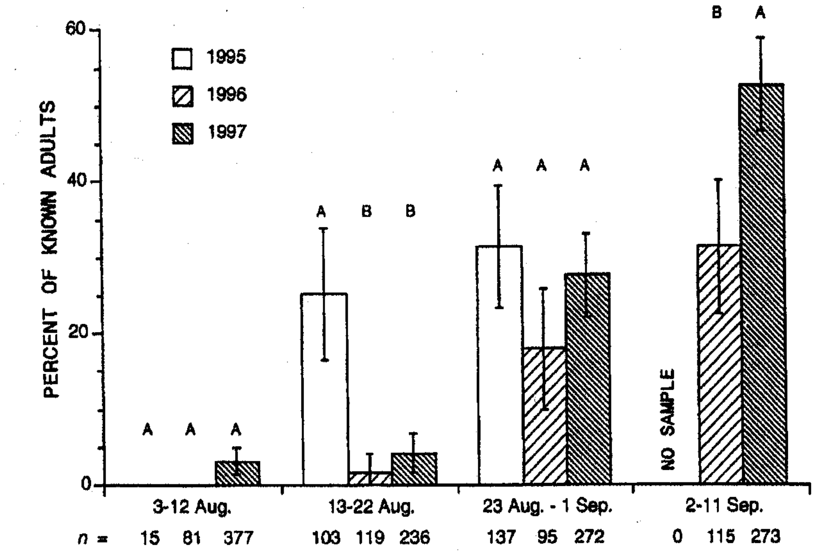

FIGURE 4. Percentage of late molt adults ± 5% C.I. by year and 10-day period for 1995-1997. Columns with different letters indicate a significant difference compared to other values in the same 10-day period ($P < 0.05$, z-test). n = number of adults of all molt stages observed.

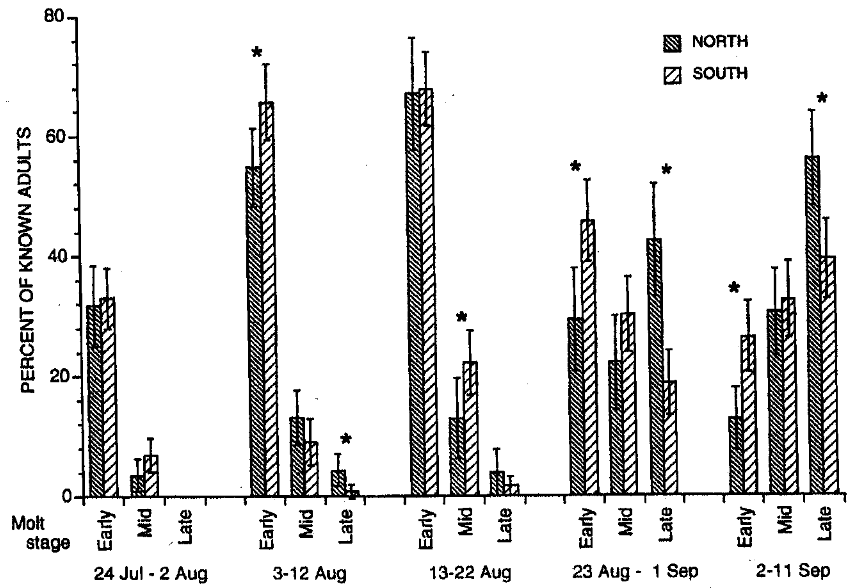

FIGURE 5. Percentage of known adults in three plumage categories by north and south regions (± 5% C.I.) and 10-day periods for 1996-1997 (no data were taken in the northern region for 1995). * $P < 0.05$, z-test.

DISCUSSION

Estimates of Marbled Murrelet productivity rely on the ability of observers to age birds correctly at sea. Our method of collecting plumage data allows for independent evaluation of observations to reduce observer variability. We can also track the timing of adult pre-basic molt, which may change between regions or years, and can influence an observer's classification of murrelets. Studies that rely only on a determination of age made under field conditions, such as Strong's (1998) method, without gathering information on ageing criteria and observation conditions do not allow for this later evaluation and quality control.

Progression and timing of molt in adults

Understanding molt chronology is essential to ageing birds correctly and using time efficiently in the field. We found that dark-and-light birds in July can be aged as probable juveniles, because all adults in our area appear to molt into alternate plumage, unlike in some areas where a few adults remain in basic plumage all year (Kuletz and Kendall 1998).

As the molt progresses, a critical date based on the appearance of the earliest late-molt adults can be specified to begin collecting detailed plumage data on dark-and-light birds. This can make the time in the field more efficient early in the season as less time would need to be spent on each bird when juveniles are easily identified. However, because we found some differences in the timing of adult molt between years and regions, we feel that critical dates should not be considered fixed even within a study area. These dates may need to be reassessed yearly for variations in the first or cumulative appearances of adults in late molt. If the dates are to be applied over a large study area, then a more conservative date might be used to avoid misclassification. Most importantly, field crews should be aware of the potential for dark-and-light adults in the late stages of molt to appear early, as well as winter-plumaged adults that did not molt into breeding plumage. Observers should gather adequate data for juvenile identification prior to the earliest records for late-molt adults for the area, in case adults molt early in a particular year.

Reclassification of age categories

We found the potential for incorrectly classifying juvenile birds was high. Between 15% and 50% of juveniles were reclassified as adults or unknown-aged birds when data were reevaluated. The plumage information we collected allowed us to reevaluate the field observations and provided a method of quality control for our age determinations. Studies that rely only on determination of age made under field conditions and without further documentation of ageing criteria do not allow for this evaluation and quality control.

During often difficult field conditions, our method allows observers to concentrate on collecting accurate plumage information on uncertain birds, rather than assessing all potential ageing criteria. By recording the extent of molt in each feather area and the observation conditions, we can later evaluate age determination and potentially reduce the effect of observer variability and the number of misclassified birds. Also, if future analyses reveal new information on the timing of adult molt, we can reexamine the observations.

Timing of fledging and unknown-aged murrelets

Misidentified juveniles—If juveniles are not identified at the end of the season because they resemble adults in advanced molt, annual productivity will be underestimated. These juveniles may come from (1) juveniles that may be part of the 10% of the "unknown" population in late August (Figure 3) and about 15% of the nestlings remain to be fledged (Hamer and Nelson 1995), or (2) juveniles that fledge after 1 September when adults with completed molt are present. We used two different methods to attempt to adjust for possible missed juveniles: calculated upper and lower percentage boundaries, and adjusted percentage from Beissinger's (1995) linear regression model. Results from the two methods used to adjust for misidentified juveniles differed greatly. The upper estimate from the calculated confidence limits was always greater than percentages adjusted using the linear regression (Table 2).

Effect of misidentified juveniles—Even though we may be misidentifying up to 50% of the juvenile population, the adjusted percentages in the years of this study still would not result in an overall stable murrelet population according to Beissinger's (1995) model. He estimated that 15-22% juveniles would be needed to stabilize the population, a 400% increase above our unadjusted yearly average of about 4% (Table 4). The upper confidence limits of only two of four years (1994 and 1997) were near or above the 15% required for stability. This may indicate that, in at least some years, the population could be doing better than unadjusted juvenile percentages would indicate. However, this method assumes that all of the unknown-aged birds in September were juveniles, and that a larger than expected proportion of juveniles fledged late in the season. By contrast, percentages adjusted by linear regression approached the level needed for stability only in one year, with 10.0% for 1994. Although this is higher than the unadjusted percentages, it still indicates a potentially declining population.

ACKNOWLEDGEMENTS

We thank the U.S. Fish and Wildlife Service personnel, T. Shaw, D. Therry, and others, who participated in this cooperative project. We thank our field crews for their dedicated work, including B. Canon who helped with early evaluations of observations, J. Dahl, K. Hollinger, and B. O'Donnell. We thank D. Evans Mack, K. Kuletz, S. K. Nelson, and C. Strong for their reviews of the manuscript at various stages. We thank H. Stauffer and T. A. Matsumoto, who provided statistical counsel.

LITERATURE CITED

Beissinger, S.B. 1995. Population trends of the Marbled Murrelet projected from demographic analyses. P. 385-394 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, technical editors. Ecology and conservation of the Marbled Murrelet. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. PSW-152. Albany, CA.

Carter, H.R. and J.L. Stein. 1995. Molts and plumages in the annual cycle of the Marbled Murrelet. P. 99-112 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, technical editors. Ecology and conservation of the Marbled Murrelet. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. PSW-152. Albany, CA.

Hamer, T.E. and S.K. Nelson. 1995. Nesting chronology of the Marbled Murrelet. P. 49-56 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, technical. editors Ecology and conservation of the Marbled Murrelet. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. PSW-152. Albany, CA.

Hicks, C. R. 1993. Fundamental concepts in the design of experiments. 4th edition. Oxford University Press, New York, NY. 509 p.

Kuletz, K.J. and S.J. Kendall. 1998. A productivity index for Marbled Murrelets in Alaska based on surveys at sea. J Wildl Manage 62:446-460.

Ralph, C.J. and L.L. Long. 1995. Productivity of Marbled Murrelets in California from observations of young at sea. P 371-377 *in* C.J. Ralph, G.L. Hunt, Jr., M.G. Raphael, and J.F. Piatt, technical editors. Ecology and conservation of the Marbled Murrelet. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. PSW-152. Albany, CA.

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

Strong, C.S., J. Jacobsen, D. Fix, and R. LeValley. 1995. Distribution, population, and productivity of the Marbled Murrelet from vessel surveys of the northern California Coast in 1994. Final report to the Marbled Murrelet Study Trust, March 1995. Report supplied by the author. 27 p.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; determination of threatened status for the Washington, Oregon, and California population of the marbled murrelet. Federal Register 57:45328-45337.

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Table 4. Comparison of observer's evaluation and classification of age by plumage to a later, independent evaluation based on plumage information gathered by observers, 1994-1997. All certainty levels are combined.

4A. Evaluator's changes in age classification, by observer's classification and year

Age of bird, as determined by		1994		1995		1996		1997	
Observer	Evaluator	Number	Percent of total[1]	Number	Percent of total	Number	Percent of total	Number	Percent of total
Adult	Adult	753	88.9	359	91.8	672	92.7	1746	81.8
	Juvenile	3	0.4	2	0.5	0	0.0	3	0.1
	Unknown	2	0.2	1	0.3	3	0.4	13	0.6
Juvenile	Adult	1	0.1	1	0.3	6	0.8	1	0.1
	Juvenile	50	5.9	14	3.5	5	0.7	65	3.0
	Unknown	2	0.2	1	0.3	1	0.1	33	1.5
Unknown	Adult	8	0.9	1	0.3	22	3.0	29	1.4
	Juvenile	3	0.4	1	0.3	5	0.7	3	0.1
	Unknown	25	3.0	11	2.8	11	1.5	243	11.4

4B. Effect of change in classification on estimate of percentage of juveniles observed

	1994		1995		1996		1997	
	Number	Percent of total[1]	Number	Percent of total	Number	Percent of total	Number	Percent of total
Changes in numbers of all age classifications								
Age changed by evaluator	19	2.2	7	1.8	37	5.1	82	3.8
Age remained unchanged	828	97.7	384	98.2	688	94.9	2054	96.2
Changes in numbers of juveniles								
Observer	53	6.3	16	4.1	12	1.7	99	4.6
Evaluator	56	6.6	17	4.4	10	1.4	71	3.8
Change	+3	+0.3	+1	+0.3	–2	–0.3	–30	–0.8
Age changed by evaluator[2]	3	5.6	2	12.5	7	58.3	34	34.3
Percent of juveniles[3]								
Observer	53/811	6.5	16/378	4.2	12/687	1.7	99/1861	5.3
Evaluator	56/818	6.8	17/378	4.5	10/710	1.4	71/1847	3.8
Change		+0.3		+0.3		–0.3		–1.5

[1]Total = total number of observations for that year

[2]Number of juveniles changed to adult or unknown-aged birds. Percentage = (number of juveniles changed by evaluator)/number of juveniles as aged by observer) X 100.

[3]Percentage based on known-aged birds only