Chapter 11

Patterns of Seasonal Variation of Activity of Marbled Murrelets in Forested Stands

Brian P. O'Donnell[1] **Nancy L. Naslund[2]** **C. John Ralph[3]**

Abstract: Determining the annual cycles of Marbled Murrelet (*Brachyramphus marmoratus*) behavior is crucial both for understanding the life history and for management of this species. In this paper we review available information on the annual patterns of behavior in forests throughout its range, with special emphasis on California. Data were derived from standardized forest surveys. Murrelet activity peaks during the summer (breeding season), is lower during the winter (non-breeding season), and absent or very low during transition periods (pre-alternate and pre-basic molts). Murrelets are regularly detected at some breeding stands even in the non-breeding season, however, birds are rarely observed flying through or below the forest canopy during this period. Vocalizations and flock size exhibit seasonal variation as well. While certain aspects of seasonal activity and behavior patterns conform with our limited understanding of its life history, much of the species' behavior within the forest remains a mystery. Current guidelines for monitoring the Marbled Murrelet at inland sites restrict surveys for management purposes to the breeding season.

Determining the annual cycles of Marbled Murrelet (*Brachyramphus marmoratus*) activity and behavior at inland sites is important for an understanding of this species' life history and its management. In order to assess the probable presence of nesting murrelets in a forest stand, we must first know how their behavior in the forest changes through the year, and what these seasonal changes tell us about its biology. With this information in hand, we can then determine how best to develop a survey protocol. In this chapter we review available information on the annual cycles of activity and behavior in the forest. We draw heavily from the results of two studies in California (Naslund 1993,b; O'Donnell 1993). Data in these studies were collected using intensive survey techniques (Paton, this volume; Paton and others 1990; Ralph and others 1994). Additional information, derived from general and intensive survey techniques, are reported from studies throughout the range of the species. As the measure of activity we use the "detection": the observation of one or more birds acting in a similar manner.

[1] Wildlife Biologist, Pacific Southwest Research Station, Redwood Sciences Laboratory, USDA Forest Service,1700 Bayview Drive, Arcata, CA 95521

[2] Wildlife Biologist, U.S. Fish and Wildlife Service, U.S. Department of Interior, 1011 E. Tudor Road, Anchorage, AK 99503

[3] Research Biologist, Pacific Southwest Research Station, Redwood Sciences Laboratory, USDA Forest Service, 1700 Bayview Drive, Arcata, CA 95521

Variation in Detection Levels

Numbers of detections vary dramatically through the year, and in general, are greatest during the summer months. Detection levels were compared between months through the year in two studies in California. Naslund (1993a) compared detections at two sites in central California between three periods: (1) breeding season—April through July; (2) transition periods—March, and August through October; and (3) winter—November through February. She found detections were significantly greater during the summer period (*table 1*). O'Donnell (1993) also found significant differences between months at each of three sites in northwestern California. He found that mean numbers of detections per survey were greatest in July at all sites (*fig. 1*). Mean numbers of detections per survey in April through June ranged from 28 to 62 percent of those in July, and mean detections per survey in May and June were always intermediate between those in April and July.

Murrelet detection levels also tended to peak during July and early August in most locations to the north of California. In Oregon, Nelson (1989) found the greatest detection levels from 12 July to 9 August at sites (*fig. 2*). She also noted an early period of high activity in late May and early June. The two activity peaks were detected during both dawn and evening surveys. During the 1990 breeding season in northwestern Washington, Hamer and Cummins (1990) noted 60 percent of all detections occurred between 25 June and 27 July (*fig. 3*). Numbers of detections per survey were greatest from mid-July through the end of the month. In the following summer, 77 percent of all detections were recorded between 8 July and 11 August, with the greatest numbers of detections per survey occurring in the week of 22 July (Hamer and Cummins 1991) (*fig. 4*). During 1990, weekly mean numbers of detections of murrelets peaked in the last week of July at two sites in the Queen Charlotte Islands, British Columbia (Rodway and others 1993b) (*figs. 5, 6*). However, detection levels at sites on Vancouver Island, British Columbia, reached their greatest levels in late June (Manley and others 1992) (*fig.7*). At a site on Mitkof Island, in southeastern Alaska, where Doerr and Walsh have conducted one to three morning surveys each month since December 1992, the numbers of detections peaked in July (Doerr, pers. comm.; Walsh, pers. comm.). Kuletz and others (1994c) found that seasonal peaks of murrelet activity in Prince William Sound, Alaska, were similar to those reported for the more southerly areas of the species' distribution (*figs. 8, 9*). They also noted an early period of greater activity in

Table 1—Variations in Marbled Murrelet detections by season at the Waddell Creek and Opal Creek nest sites. Results are given for each ANOVA comparing total detections, occupied detections, and percent of occupied detections between seasons

Variable	*n*	Total detections $\bar{x}$	*s.d.*	(range)	Occupied Detections $\bar{x}$	*s.d.*	(range)	Percent Occupied[a] $\bar{x}$	*s.d.*	(range)
Waddell Creek										
Season										
Summer	32	50	32.8	(18-176)	5	8.6	(0-45)	18.6	17.1	(0-55.6)
Transition	16	12	17.1	(0-49)	0	0.6	(0-2)	8.7	25.5	(0-100.0)
Winter	2	17	2.8	(15-19)	1	0.7	(0-1)	16.7	23.6	(0-33.3)
ANOVA		*F* = 14.6,	df = 2,	*P* = 0.0001	*F* = 4.11,	df = 2,	*P* = 0.0230	*F* = 2.79,	df = 2,	*P* = 0.0723
Opal Creek										
Season										
Summer	18	100	28.5	(59-159)	2	2.1	(0-7)	6.3	6.1	(0-21.7)
Transition	11	25	41.5	(0-121)	0	0.3	(0-2)	0.2	0.7	(0-2.4)
Winter	2	80	22.6	(64-96)	0	0.0				
ANOVA		*F* = 16.51,	df = 2,	*P* = 0.0001	*F* = 2.51,	df = 2,	*P* = 0.1019	*F* = 7.92,	df=2,	*P* = 0.0022

[a] Percent of detections ≤ 100 m from the observer

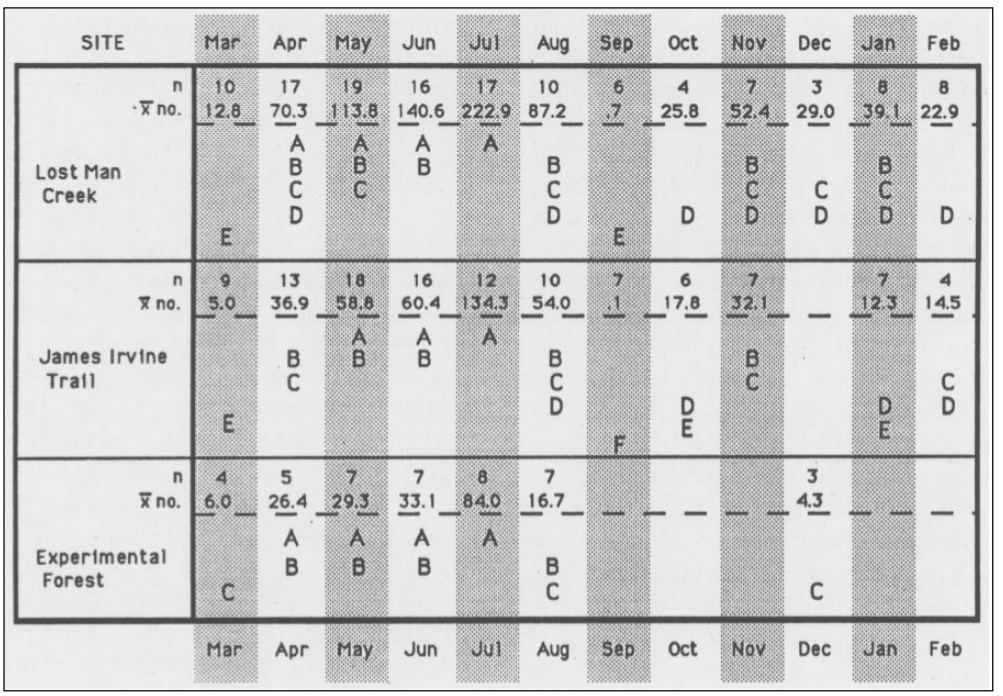

Figure 1—Results of Ryan-Einot-Gabriel-Welsh multiple range test comparing numbers of detections of Marbled Murrelets per survey between months at three sites in northwestern California, 1989–1991. Months with the same letter indicate that the mean numbers of detections were not significantly different from each other. "n" indicates the number of surveys in the respective month and " $\bar{x}$ no." is the mean number of detections per survey. Means presented are untransformed values. Surveys from all years were combined for the analysis, and months with less than three surveys were not included in the analysis. From O'Donnell 1993.

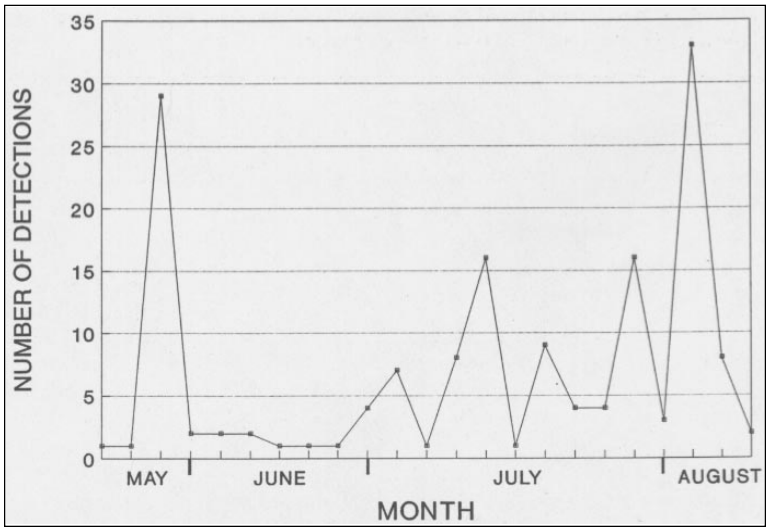

Figure 2—Number of detections of Marbled Murrelets by survey month on 20 general surveys (Paton, this volume) along roads, central Oregon Coast Range, 1988. From Nelson 1989.

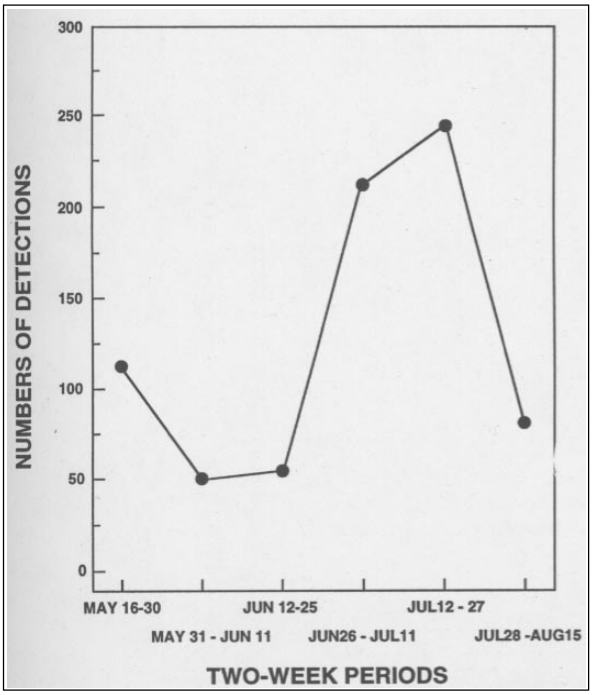

Figure 3—Total number of Marbled Murrelet detections for each two-week period from 16 May to 15 August, 1990, at 41 sites (245 survey mornings) in northwestern Washington. From Hamer and Cummins 1990.

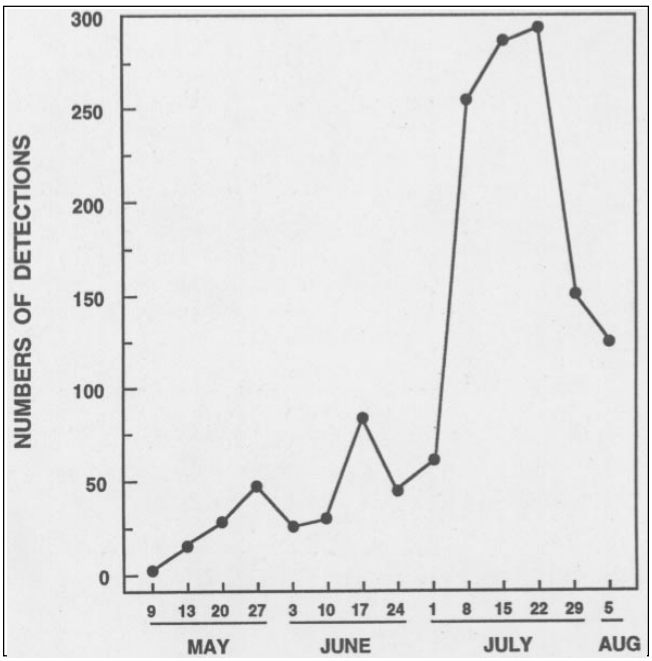

Figure 4—Total number of Marbled Murrelet detections for each one-week period from 9 May to 9 August, 1991, at 75 sites (287 survey mornings) in northwestern Washington. From Hamer and Cummins 1991.

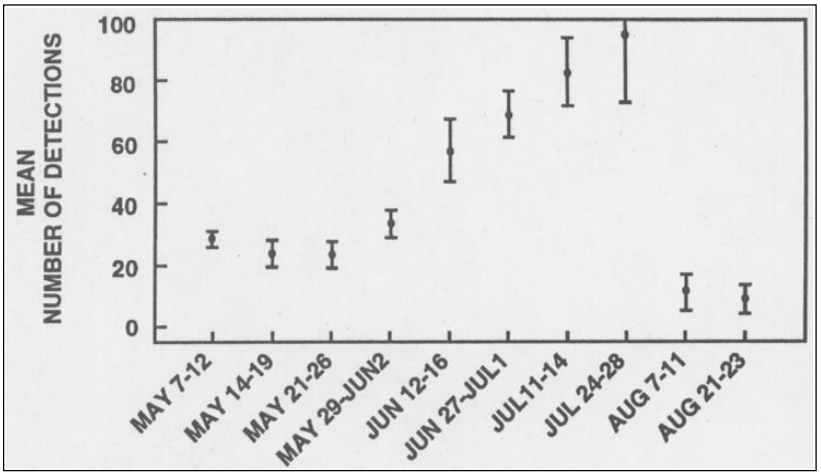

Figure 5—Weekly mean (± *s.e.*) numbers of Marbled Murrelet detections per survey at Phantom Creek, British Columbia, in 1990. A total of 49 morning surveys were conducted. From Rodway and others 1993b.

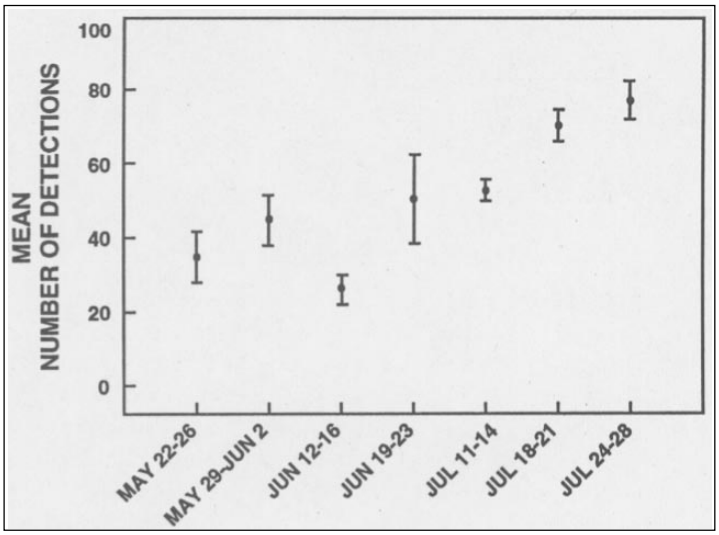

Figure 6—Weekly mean (± *s.e.*) numbers of Marbled Murrelet detections per survey at Lagins Creek, British Columbia, in 1990. A total of 33 morning survey were conducted. From Rodway and others 1993b.

late May, similar to that reported by Nelson (1989). At two sites, detection levels during this period were approximately equal to or even exceeded those during July.

Patterns of Detections in Winter

Winter attendance at breeding stands is well documented for California (*figs. 10, 11*). For example, Sander (1987) detected murrelets on 66 percent of 53 mornings surveyed between January and mid-March at a site in northwestern California. Carter and Erickson (1988) also report on the detection of murrelets from January through March at Big Basin State Park (central California) over several years. Murrelets have also been detected at forest stands during the winter in Oregon (Nelson, pers. comm.), Washington (Hamer, pers. comm.), and southeastern Alaska (Naslund, unpubl. data; Walsh, pers. comm.).

At the three sites in northwestern California, O'Donnell (1993) found that mean numbers of detections per survey during the winter months (November through February) ranged from nine to 24 percent of mean levels in July, with detection numbers in November consistently the greatest in this period. Naslund (1993b) found that mean numbers of detections for winter surveys ranged from 35 to 80 percent of mean summer detection levels for five sites in central California (*fig. 12*). Doerr and Walsh noted similar differences between winter

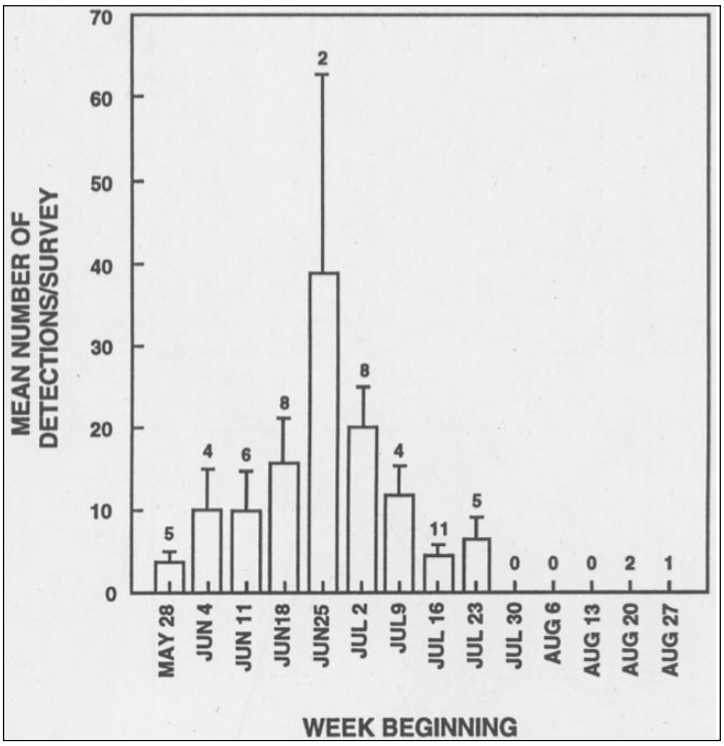

Figure 7—Weekly mean numbers (bar segment) of Marbled Murrelet detections per survey per week along upper Carmanah Creek, British Columbia, 28 May to 27 August 1990. The standard error (line segment) and number of surveys in each week are also given. From Manley and others 1992.

and summer detection levels on Mitkof Island, Alaska (Doerr, pers. comm.; Walsh, pers. comm.).

The remaining two months, March and September, had low to no activity (Naslund 1993b, O'Donnell 1993). In northwestern California, detections in March ranged from four to seven percent of those in July, and September levels were less than one percent of July levels. Detection levels in March and September were usually significantly lower than all other months (O'Donnell 1993).

Patterns of Absence from Stands

Marbled Murrelets are most often absent, or in much reduced numbers, from breeding stands during the two transition periods: (1) March, and (2) mid-August through October (Naslund 1993b, O'Donnell 1993) (*figs. 10, 11*). Doerr and Walsh failed to detect murrelets from 27 August to 2 October 1992, at their study site on Mitkof Island, Alaska (Doerr, pers. comm.; Walsh, pers. comm.). In central California, from 1989 through 1991, the proportion of surveys in August through October with murrelets present was significantly lower than for surveys in summer, in winter, or in March (Naslund 1993a). Similarly, murrelets were observed on a significantly smaller proportion of surveys in March than during summer or winter (Naslund 1993a) (*fig. 13*). At nine sites in northwestern California from 1989 through 1991, murrelets were not detected on 33 percent of 30 surveys conducted in March, nor on 31 percent of 80 surveys conducted in August through October (O'Donnell 1993). In addition, surveys with no detections occurred with significantly greater frequency from November through February than from April through July. Murrelets were not detected on 10 of 71 counts conducted from November through February, while birds were detected during all but one of 227 surveys from April through July (O'Donnell 1993).

Variation in Frequency of Behaviors and Flock Sizes

Flight Altitude

The behavior classes recorded during murrelet surveys differentiate between two classes of behaviors, those occurring above the forest canopy, and those at the top, below, and within the forest canopy. These latter behaviors occurring at or below the canopy we will refer to as "below canopy behaviors", and are considered most indicative of probable nesting (Ralph and others 1993). They have also been referred to as "occupied behaviors", that is, indicative of birds occupying a given stand for nesting. Studies in California (Naslund 1993b, O'Donnell 1993) found that the numbers of different behaviors, both above and below the canopy, differed significantly between months through the year (*table 1*). O'Donnell (1993) detected murrelets flying above the canopy throughout the year at three sites in northwestern California. The patterns of behaviors

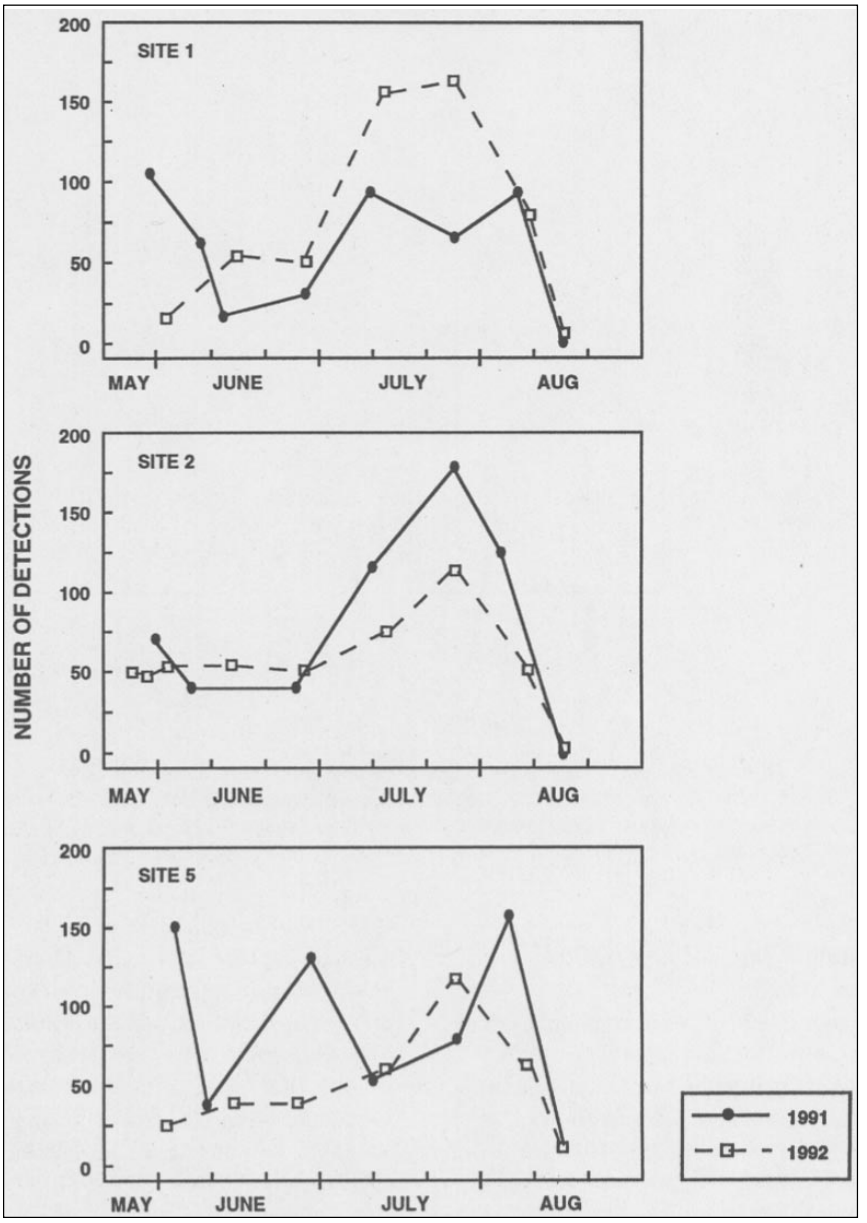

Figure 8—Numbers of detections of Marbled Murrelets per survey at three sites on Naked Island in Prince William Sound, Alaska, during the 1991 and 1992 breeding seasons. From Kuletz and others 1994c.

above the canopy at Lost Man Creek (*fig. 14a*) are representative of those at the two other sites. Numbers of these behaviors were greatest during the breeding season, reaching a peak in July, and lowest during the non-breeding season, with a small winter peak in November (*fig. 14b*).

Below canopy behaviors showed a more pronounced seasonality (*fig. 14a*) at Lost Man Creek and are representative of the two other sites. Naslund (1993a) found that only a small percentage of detections recorded near two nest trees during the winter, non-breeding season (October through March) consisted of below canopy behaviors (*table 1*). Similarly, at Lost Man Creek, below canopy behaviors made up 24.7 percent of detections from April through August, while from September through March, of 1,185 detections, only five were of murrelets flying below the canopy. Numbers of occupied behaviors were segregated by a multiple range test into three periods at Lost Man Creek (*fig. 14b*), reflecting peak levels in July, lower levels during the remainder of the breeding season, and their absence in the non-breeding season.

Vocalizations

O'Donnell (1993) examined seasonal differences in the number of calls per detection at two sites in northwestern California, Lost Man Creek and James Irvine Trail. Detections with greater then 9 calls were assigned a value of ten for the analysis. The number of calls per detection

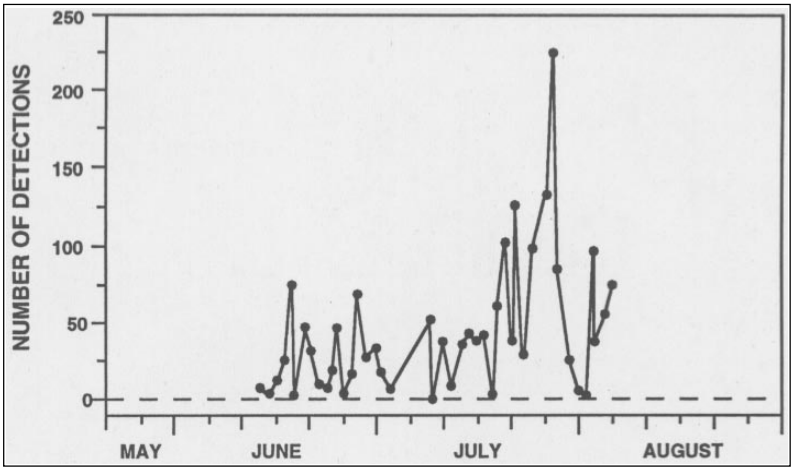

Figure 9—Numbers of detections of Marbled Murrelets throughout western Prince William Sound, Alaska, during the 1992 breeding season. Data was collected at 67 randomly selected (boat-based) sites. From Kuletz and others 1994c.

was greater during the winter, from October through February, than from March through August at both sites. For instance, at Lost Man Creek the mean numbers of calls per detection ranged from 7.4 to 9.3 from October through February. From March through August mean calls per detection ranged from 3.7 to 6.1 at this site. Numbers of calls were significantly different between months only at Lost Man Creek.

Rodway and others (1993b) compared levels of vocalizations between months at two sites in the Queen Charlotte Islands, British Columbia. Months compared were May through July at the Lagins Creek site, and May through August at the Phantom Creek site. They examined changes in both the number of calls per detection (all calls counted), as well as number of calls per survey (detections with "multiple" calls assigned a value of 25). Number of calls per detection were similar in May, June, and July at both sites. At Phantom Creek, vocalization levels dropped significantly after July 24. Number of calls per survey increased through July, reaching peaks in the last week of July at both sites, and falling rapidly in the second week of August at Phantom Creek.

O'Donnell (1993) also looked at the occurrence of grunt or groan calls (previously referred to as alternate calls) for evidence of seasonal patterns (Paton, this colume; Nelson and Hamer, this volume a). He compared between months, for above and below canopy detections, the proportion of detections which included these calls, and found seasonality was not marked. Only at Lost Man Creek, where the sample was greatest, was there significant differences between months in the proportions of detections above the canopy with alternate calls. These calls occurred in lower proportions in December through February than in the remainder of the year. However, a subsequent multiple range test did not distinguish any significantly different months. The percentage of detections of murrelets giving grunt calls below the canopy also showed seasonality only at Lost Man Creek, where they occurred in significantly greater proportions during July.

Flock Size

Changes in flock size through the breeding season have been noted in two studies (O'Donnell 1993, Rodway and others 1993b). O'Donnell (1993) found that both flocks observed above and below the canopy were smallest during May and June at each of three sites in California. Above canopy flocks at the Experimental Forest site had significantly fewer birds in June, and were also smaller in June at James Irvine Trail, though not significantly so (*fig. 15*). At Lost Man Creek, flocks above the canopy had significantly fewer murrelets in May, and significantly more birds in July. Reduction in the size of flocks below the canopy was especially marked at James Irvine Trail, where flock size was significantly less in May and June than during the remaining summer months (*fig. 15*). Below canopy flocks with the fewest numbers occurred in June at all three sites.

Rodway and others (1993b) similarly detected smaller flocks during May and June at their two sites in British Columbia. Single birds were observed most frequently in these two months, and flocks of two were most common in July at both sites.

Discussion

Seasonal Patterns of Behavior and Activity

Marbled Murrelets show consistent, seasonal patterns of activity and behavior. Throughout their range they exhibit the greatest levels of inland activity from April through August, with peak levels usually occurring from about the second week of July through early August. Hamer and Cummins (1990) suggested greater detection rates in late July may reflect increased food needs of nestling murrelets and the consequent increase in foraging trips by parent birds. Paton and Ralph

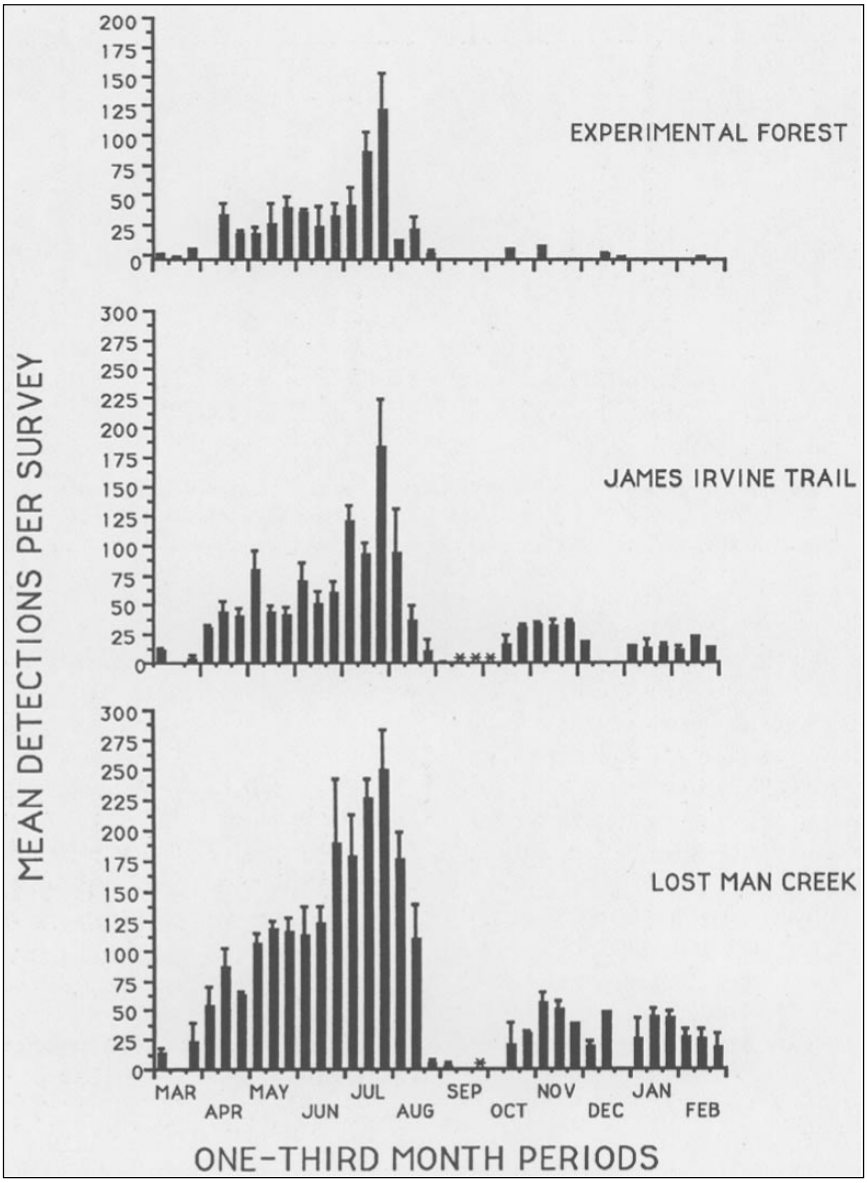

Figure 10—Mean numbers of detections of Marbled Murrelets per survey (± *s.e.*) for one-third-month periods at three sites in northwestern California, 1989-1991. Data from all years was combined for calculations. Asterisks (*) denotes periods in which no birds were detected during surveys; bars without standard error (vertical line segments) indicates only one survey was conducted during the period; all other blank columns represent weeks in which no data was collected. From O'Donnell 1993.

(1988, 1990) felt the summer peak was likely the result of increased activity by breeding birds in the stand, perhaps in association with the fledging period, as opposed to an influx of non-breeding birds. However, many investigators have found that it is common among long-lived seabirds that defer sexual maturity for immatures to visit breeding sites later in the season in years prior to their first breeding attempt (Lack 1968, Sealy 1976, Gaston 1990). Sealy (1976) found increasing numbers of subadult Ancient Murrelets (*Synthliboramphus antiquus*) visiting nesting colonies later in the breeding season. He found that attendance by subadults peaked by about one month after 90 percent of adults and newly-hatched young had departed to sea. Increased activity at breeding stands in July by Marbled Murrelets may indeed involve non-breeders investigating potential breeding sites. An increased presence by non-breeding birds later in the breeding season might also contribute to the increase in flock size noted by both O'Donnell (1993) and Rodway and others (1993b).

In California, regular visitation at forest stands outside of the breeding season has been established. Fall and winter attendance has also been documented at several alcid colonies (e.g., Common Murre, *Uria aalge*, Razorbill, *Alca torda*, Black Guillemot, *Cepphus grylle*, Atlantic Puffin, *Fratercula arctica*, and Cassin's Auklet, *Ptychoramphus aleuticus*),

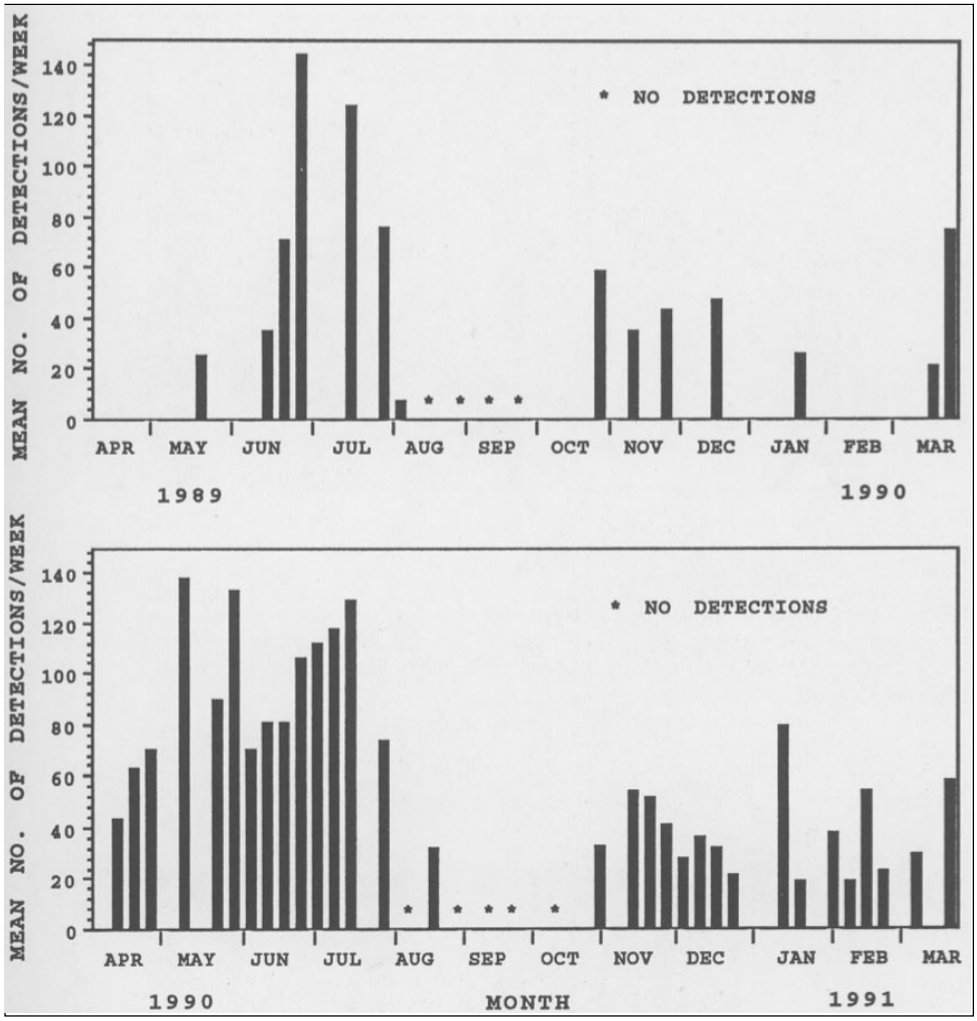

Figure 11—Mean number of Marbled Murrelet detections per week at Bloom's Creek Campground, California, in 1989-1990 (upper) and 1990-1991 (lower). Each weekly mean was calculated from 1–3 intensive dawn inventories. Asterisks (*) indicate that a survey was conducted but no murrelets were detected; all other blank columns represent weeks in which no data was collected. From Naslund 1993b.

generally at the southern end of each species' range (Ainley and Boekelheide 1990, Greenwood 1987, Harris 1985, Harris and Wanless 1989, Taylor and Reid 1981, Sydeman 1993, Thoreson 1964). Harris and Wanless (1989) found a positive correlation between winter visitation and breeding success in the previous and following breeding season for a population of marked Common Murres. Winter attendance at breeding stands by murrelets may similarly relate to prior reproductive success, and might also enhance pair bond maintenance, facilitate earlier breeding (Carter and Erickson 1988), and reinforce familiarity with flight paths to the breeding stands.

Two periods of very low (or no) activity occurred during March and from mid-August through early October. The pre-alternate molt period in California may begin as early as mid-February and extend through March (Carter and Stein, this volume). The relatively low level of March detections levels probably reflects this molt. Although murrelets do not molt flight feathers at this time (Carter and Stein, this volume), the increased energetic demands of molting body feathers could limit inland visits. The second period, from mid-August through early October coincides with the cessation of nesting and the molt into basic plumage. The more extensive nature of this prebasic molt (full body and simultaneous wing molt of the adults) is reflected in the longer period of time murrelets are absent from the forest.

Numbers of above canopy behaviors closely mirror the patterns of total detection levels through the year, with the greatest levels occurring in the summer months and lower levels during the remainder of the year. Detections of birds below the canopy, however, coincide with the breeding season (April through September), and are largely absent outside of this period. Investigations of murrelet behavior around nest sites have consistently reported on observations of single birds and pairs flying below the canopy in the vicinity of nest trees (Nelson and Hamer, this

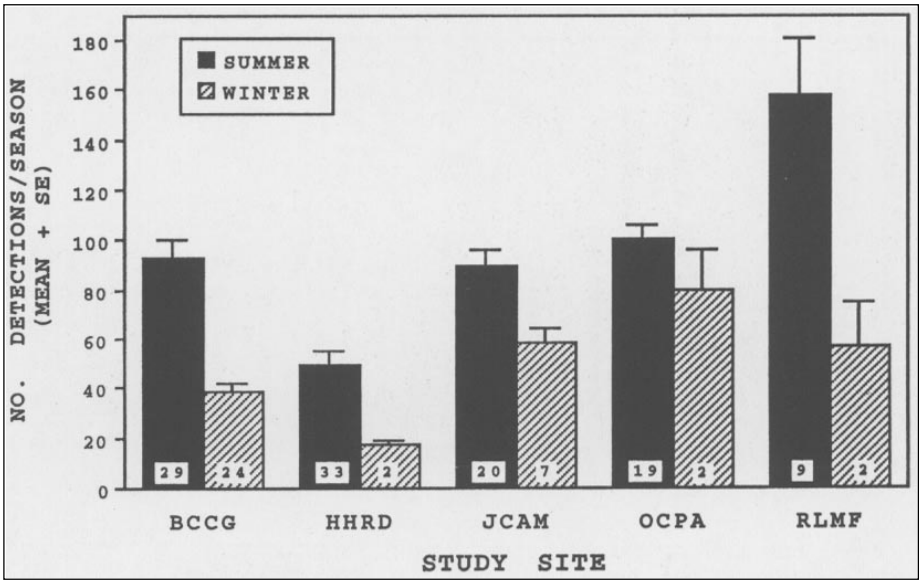

Figure 12—Mean number (histogram bar) and standard error (line segment) of Marbled Murrelet detections by season at five study sites in central California. "Summer" includes April–July and "winter" includes November–February. Sample sizes (number of surveys) are indicated in histogram bars. From Naslund 1993b.

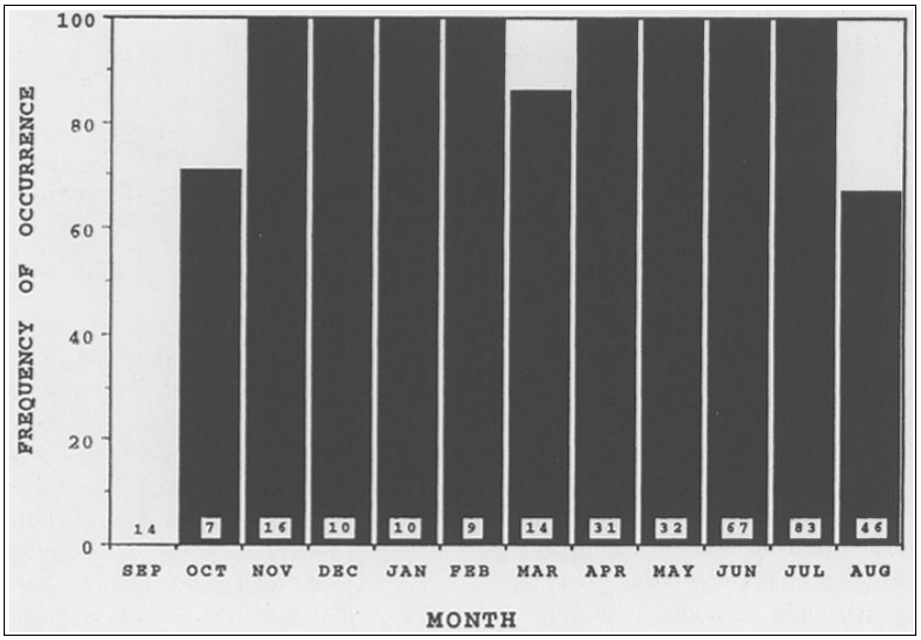

Figure 13—Percent of surveys with detections of Marbled Murrelets by month for five study sites in central California, 1989-1991. Surveys from all sites were pooled. Sample sizes (number of surveys) are indicated in the histogram bars. Missing histogram bar in September denotes that no murrelets were detected during 14 surveys. From Naslund 1993b.

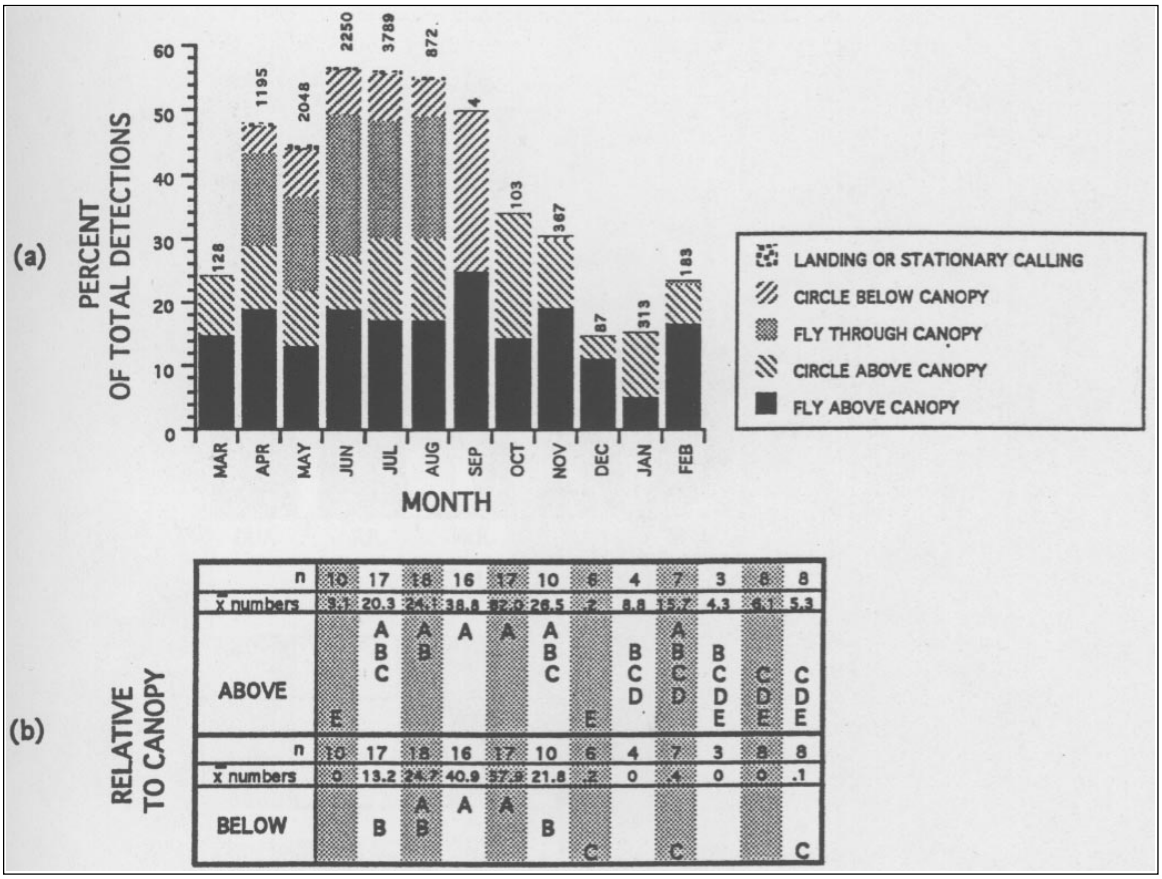

Figure 14—(a) Percent of detections of Marbled Murrelets in each month for five behaviors at Lost Man Creek, California, 1989-1991. The number of total detections in each month is shown above the bars, and the percent of "unknown" behaviors is not shown; (b) Results of Ryan-Einot-Gabriel-Welsh multiple range tests comparing numbers of above and below canopy behaviors by marbled murrelets between months. Months with the same letter indicate that the mean number of detections were not significantly different from each other. The term "n" indicates the number of surveys in the respective month and "$\bar{x}$ numbers" is the mean number of detections per survey. Means presented are untransformed values. Surveys from all years were combined for the analysis, and months with less than three surveys were not included in the analysis. From O'Donnell 1993.

volume a). Several studies (Naslund 1993a, Nelson and Hamer, this volume a; Nelson and Peck, in press; O'Donnell 1993, Rodway and others 1993b, Singer and others 1991) have also noted the tendency of birds below the canopy to fly silently without vocalizing. The sharp seasonality of below canopy behaviors, in conjunction with these behavioral observations gathered at nest sites, strongly reinforces the relationship between below canopy behaviors and breeding activity. It should be noted, however, that murrelets have on rare occasions been observed flying below the canopy in habitat not considered suitable for nesting (e.g., Habitat Restoration Group 1992; Keitt 1991; Singer and others 1991, 1992). These were usually in areas adjacent to suitable habitat.

Monitoring

Current guidelines, as recommended in Ralph and others (1993), restrict surveys for management purposes to the breeding season. The survey season in California begins on 15 April, in Oregon, Washington, and British Columbia on 1 May, and in Alaska on 15 May. The survey season ends on 5 August in all regions. The later start of the season at more northerly latitudes reflects a later breeding season in these areas (Kuletz and others 1994c; Hamer and Nelson, this volume a; Sealy 1974, 1975a). The timing of the survey season should of course maximize survey goals. Based on data collected in northwestern California (O'Donnell 1993), the recommended survey season for this state is a reasonable, if not slightly conservative, window for monitoring murrelets. Murrelets were detected during all surveys conducted at 9 sites in April (16 of which were conducted before 15 April) throughout the study. Mean detection levels were slightly higher, however, during the last two-thirds of the month. It has been clearly established that numbers of detections, as well as above and below canopy behaviors, usually reach peak levels during July throughout the range of the species. To minimize the likelihood of failing to detect murrelets when they are actually present, Ralph and others (1993)

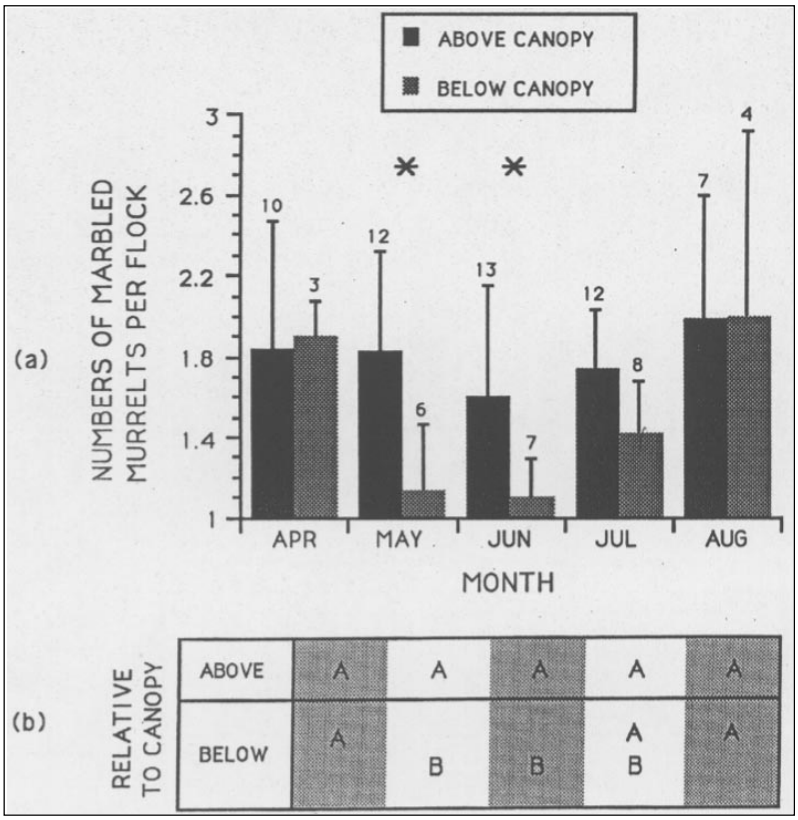

Figure 15—(a) Mean size of Marbled Murrelet flocks observed above and below the canopy during the breeding season at James Irvine Trail, California, 1989–1991. Surveys from all years were combined. The numbers of surveys in each month are shown above the bars. An asterisk (*) denotes a significant difference (P = 0.05) between above and below canopy flock sizes in the respective month; (b) Results of Ryan-Einot-Gabriel-Welsh multiple range tests comparing above and below canopy flock sizes between months. Months with the same letter indicate that the mean flock sizes were not significantly different from each other.

recommend that of four surveys conducted within a summer, two be conducted after 20 June, and at least one be conducted during the last three weeks of July. The earliest that birds were no longer detected at a stand in northwestern California was on 17 August (O'Donnell 1993). Detections of murrelets below the canopy, however, are absent earlier than this, and therefore 5 August is a reasonable termination date for the murrelet survey season in California.

Naslund (1993b) speculates that the population of birds visiting breeding stands during the winter may consist of a higher proportion of resident breeders than during the summer. Therefore, she suggests that surveys conducted during the winter may actually monitor, for management purposes, the most important segment of the population (i.e., breeding birds). Until the relevance of winter numbers is established, however, surveys should continue in the breeding season.

Acknowledgments

We thank Jim Baldwin, Ann Buell, Alan E. Burger, Peter Connors, George Hunt, Debbie Kristan, S. Kim Nelson, Lynn Roberts, Michael Rodway, Jean-Pierre Savard, Fred Sharpe, and Sherri Miller for helpful comments on this manuscript.