

STATUS AND CONSERVATION OF THE MARBLED MURRELET IN CALIFORNIA, 1892-1987

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Abstract. We collated published and unpublished information from 1892 to 1987 on the Marbled Murrelet (*Brachyramphus marmoratus*) in California to determine the past and present status of the breeding population and to document conservation problems. The state breeding population size was estimated to be about 1650-2000 birds for the years 1979-1980. One nest was found in an old-growth Douglas-fir and 17 downy young and fledglings were found in coastal old-growth forests. From 1904 to 1987, murrelets were found at 68 inland localities mainly in three nesting regions: 1) Del Norte and northern Humboldt counties ($n = 43$ localities up to 15 km inland); 2) Southcentral Humboldt County ($n = 4$ localities from 20 to 40 km inland); and 3) Southern San Mateo and northern Santa Cruz counties ($n = 18$ localities up to 20 km inland). Murrelets were recorded in old-growth forests during the breeding and non-breeding season on over 600 occasions in 17 years since 1946 at Prairie Creek Redwoods State Park and on over 36 occasions in nine years since 1959 at Big Basin Redwoods State Park. Two populations of murrelets at sea were identified: 1) the northern California population from the Oregon border to Eureka in Del Norte and northern Humboldt counties and 2) the central California population from Half Moon Bay to Santa Cruz in southern San Mateo and northwest Santa Cruz counties. These at-sea areas occurred adjacent to known nesting regions. In addition, small numbers of birds occurred at sea and may breed in southern Humboldt, Mendocino and Sonoma counties. Cases of suspected loss of nesting habitat in old-growth forests were recorded in northern and central California. Mortality from gill-net fishing was recorded in Monterey Bay from 1979 to 1987. Mortality from large oil spills and chronic oiling was recorded in central and southern California. The current small population size of Marbled Murrelets in California probably reflects a population decline due mainly to the extensive loss of old-growth forests by logging over the past century. With continued logging and eventual liquidation of old-growth forests outside of parks, we expect continued population decline and possible extinction unless extensive management action is taken in the near future.

Key words: *Brachyramphus marmoratus*; breeding distribution; California; conservation; Marbled Murrelet; populations.

INTRODUCTION

Concern exists about the continued existence of viable populations of the Marbled Murrelet (*Brachyramphus marmoratus*). This is especially true in southern parts of its North American range, where old-growth forests, which the species uses for nesting, are being removed rapidly by clear-cut logging (Sealy and Carter 1984, Carter and Sealy 1987, Marshall 1988). However, less than 20 definite nests of this species have

ever been found in the world (Ewins et al., in press), which makes it difficult to assess the magnitude and urgency of the threat of extinction. This situation is particularly perplexing in California, Oregon, and Washington where murrelets occur in smaller numbers and coastal old-growth forests are in shorter supply than in more northerly areas.

All existing information on Marbled Murrelets is needed to assess the threat posed by the removal of nesting habitat and other mortality factors in California. This will permit the justification of research and conservation actions that are required now and in the future. To serve this purpose, we have collated published and unpublished information from 1892 to 1987 on breed-

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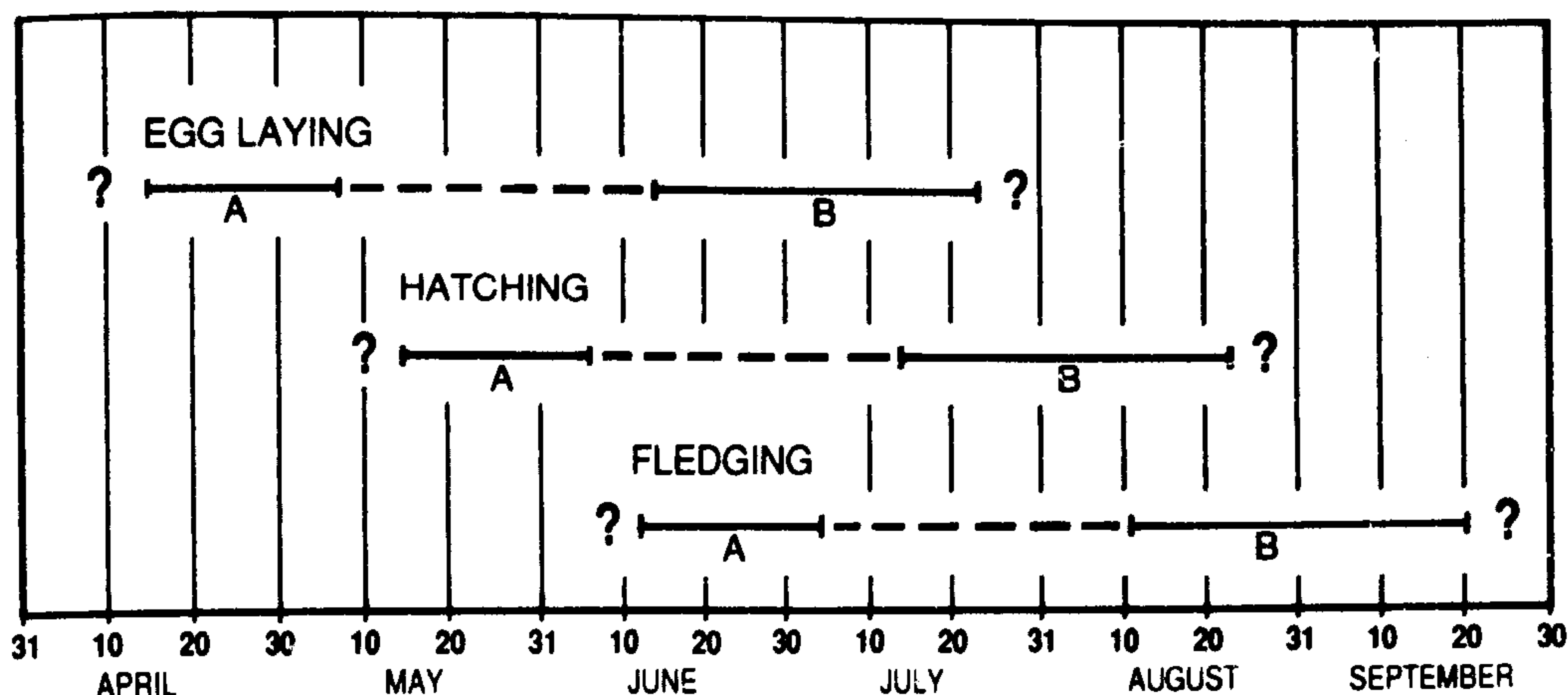


FIG. 1. Estimated timing of breeding of Marbled Murrelets in California based on inland records of fledglings (see Appendix 1). Dates of fledgling records fell into Group A ($n = 7$ records) or Group B ($n = 6$ records). Ranges of egg-laying and hatching dates were backdated from fledgling dates. Question marks indicate that ranges may be greater than indicated.

ing chronology, at-sea distribution, breeding population size, use of coastal forests and conservation problems of Marbled Murrelets in California.

METHODS

This paper is a condensed version of an unpublished report prepared for the California Department of Fish and Game (Carter and Erickson 1988). Published information and unpublished reports were obtained largely from an extensive search of the literature undertaken by Carter in the course of other range-wide summaries of information on murrelets (e.g., Carter and Sealy 1986, 1987) and other studies of seabird mortality from gill-net fishing and oil pollution in California (e.g., Takekawa et al. 1990, Page et al. 1990). This information was supplemented with local literature and unpublished data collected by Erickson during general studies of the distribution of birds in California plus recent unpublished reports provided by other murrelet researchers. We also examined all specimens of Marbled Murrelets in the California Academy of Sciences, the Humboldt State University Museum, and the Museum of Vertebrate Zoology at the University of California, Berkeley. Unpublished observations of murrelets were obtained from bird record files maintained by Erickson, S. W. Harris, Santa Cruz Bird Club, state parks, the northern California regional editors for *American Birds* (AB) and field notes housed at

the Museum of Vertebrate Zoology. Additional observations were obtained through solicitation of a wide range of bird watchers and seabird researchers in California and elsewhere as part of this and earlier studies. This was supplemented with further contacts for updating and correcting information obtained. In addition, we have included our own extensive sets of unpublished observations on murrelets in California; Erickson has kept records on murrelets in northern California since the mid 1970's and Carter and T. G. Sander (unpubl. data) conducted intensive observations of murrelets at Prairie Creek Redwoods State Park and at other sites in 1987. We feel that our compilation of published and unpublished information is as complete as possible. Only one additional inland record (at Henry Cowell Redwoods State Park) has been added to our earlier report.

POPULATION STATUS

Breeding chronology

Up to December 1987, only 11 definite and 14 probable Marbled Murrelet nests have been found throughout their range (Day et al. 1983; Carter and Sealy 1987; Ewins et al., in press). However, behavioral observations and information on breeding status obtained from birds collected at sea have been used to determine timing of breeding in certain areas of British Columbia (Sealy 1974, Carter 1984). In California, the

dates that fledglings have been found at inland localities permit murrelet breeding chronology to be approximated (Fig. 1). Fifteen fledglings have been discovered in California between 12 June and 9 September (Appendix 1). By subtracting 28 and/or 30 days for nestling and incubation periods, respectively (Sealy 1974, Simons 1980, Hirsch et al. 1981), egg laying ranged from 15 April to 12 July and hatching from 15 May to 10 August. Fledgling dates fell into two periods: (1) 12 June to 4 July ($n = 6$); and (2) 11 August to 9 September ($n = 7$). We extended the second period to about 20 September such that the breeding season would be long enough to also account for a downy chick (about 75% grown) found on 13 September (Appendix 1). We believe that nesting activity probably occurs between these two periods and that the depiction of two periods may reflect the low sample size, unknown factors affecting the groundings of fledglings, or variation in the timing of breeding between years. The overall breeding season from 15 April to 20 September in California was reconcilable with the range of dates of 36 after-hatching-year (AHY) specimens in alternate plumage and 21 juvenal-plumage hatching-year (HY) specimens found in the collections of the California Academy of Sciences (CAS), the Museum of Vertebrate Zoology (MVZ) (University of California, Berkeley), and the Humboldt State University Museum (HUSM) (Appendix 2).

Egg laying begins earlier in California than farther north. While egg laying occurs as early as late April in British Columbia and southeastern Alaska, most egg laying there occurs in late May and early June (Sealy 1974, Carter 1984, Carter and Sealy 1987). From California to southern British Columbia, many Marbled Murrelets apparently remain near nesting areas during the non-breeding season, based on inland records of birds at the same localities in the breeding and non-breeding season (see Carter and Sealy [1986, 1987]; Carter and Erickson [1988]). By visiting nesting areas throughout most of the year in California, murrelets may come into breeding condition earlier. Earlier breeding is further supported by an earlier timing of pre-alternate body molt in California. We also examined 45 specimens of AHY murrelets collected between 16 February and 4 April (1907–1941) in the Monterey Bay area that are now housed in the Museum of Vertebrate Zoology, and the California Academy of Sciences. Of 11 specimens collected between 16 February and 6 March, 63.6% were

in complete (or almost complete) basic plumage and 36.4% were undergoing pre-alternate body molt. The earliest date on which a bird was molting was 18 February (CAS 10163). Of 34 specimens collected between 16 March and 4 April, 23.5% were in basic plumage, 47.1% were molting, and 29.4% were in complete (or almost complete) alternate plumage. The earliest date for a bird in alternate plumage was 26 March, although several such specimens were collected on this date (Appendix 2). This timing of pre-alternate body molt is earlier than the April to May period reported for the U.S.S.R. by Koslova (1957). However, Sealy (1975) found that adults arrived in breeding areas in northern British Columbia in late April "essentially" in alternate plumage.

At-sea distribution and population size

Marbled Murrelets occur primarily in near-shore waters within 1–2 km from shore (Sealy and Carter 1984). Thus, although specific at-sea surveys have not been conducted in California (before December 1987), their at-sea distribution can be described roughly with anecdotal observations from boat and shore observations since most of the coast is relatively accessible. The best series of observations to date were obtained during the U.S. Fish and Wildlife Service (USFWS) survey of California seabird colonies in 1979 and 1980 (Sowls et al. 1980). Two populations were identified where relatively large numbers of murrelets were observed (see Fig. 2; Appendix 3): (1) the northern California population between the Oregon border and Eureka (76% of 1979 sightings); and (2) the central California population between Half Moon Bay and Santa Cruz (14% of 1979 sightings). All USFWS sightings in 1980 were from these areas only. Sowls et al. (1980) estimated that about 2000 Marbled Murrelets bred in California, based on their at-sea observations but they did not provide details of their data or estimation procedures. Carter and Erickson (1988) re-examined the raw data and derived a similar estimate of 1650 birds. Future studies must focus on deriving more defensible estimates by conducting more thorough surveys (e.g., Sealy and Carter 1984; Speich et al., this volume), but, for ballpark figures, the 1979–80 population size can be considered to be between 1650 and 2000 breeding birds. Our look at the raw data indicated that about 70.5% and 23.5% of 1979–80 USFWS sightings were in the northern and central California populations, respectively

(Appendix 3). However, when census dates were considered, it appeared that about 83.6% and 13.6% of breeding birds occurred in the northern and central California populations, respectively, with 2.7% in between. This corresponded to projected population sizes of 1380–1670, 225–275, and 45–55 breeding birds for the northern, central, and in-between populations, respectively.

Reports to *American Birds* and other observations from 1955 to 1987 (Appendix 4) confirmed this general distribution and indicated that murrelets were observed consistently from year to year at certain localities (e.g., Crescent City, Pigeon Point, Año Nuevo, Point Santa Cruz) throughout the breeding season. However, the coast between Eureka and southern Sonoma County has not been adequately surveyed by USFWS or others, although few birds probably occur in this area. Almost no breeding season records occurred from Sonoma County to Pillar Point, San Mateo County, or south of Santa Cruz. Murrelets were observed mainly in late August in the latter areas and some were undergoing pre-basic molt. Two areas that need to be examined in greater detail are the vicinity of the Gualala River mouth and the area from Eureka to Shelter Cove where small, isolated populations may occur (see Appendix 4; Carter and Erickson [1988]).

During offshore surveys of seabirds in central California during the breeding season (D. G. Ainley, unpubl. data), murrelets were observed from 2.7 to 7.3 km from shore off central California (see Carter and Erickson [1988]). Elsewhere, murrelets also have been observed on occasion farther than one to two km from shore (Sanger 1972; Carter 1984; Sealy and Carter 1984; Speich et al., this volume). However, extensive aerial surveys of seabirds in shelf and slope waters off central and northern California in 1980–1983 did not identify Marbled Murrelets anywhere other than close to shore during the breeding season (Appendix 4; Briggs et al. 1987; Carter and Erickson 1988). Marbled Murrelets have not been recorded 29 km offshore at Southeast Farallon Island, despite daily observations since 1968 (DeSante and Ainley 1980; Point Reyes Bird Observatory, unpubl. data).

Inland distribution

Early observers such as Dawson (1923) and Grinnell (Grinnell and Miller 1944) were puzzled by murrelets flying and calling over inland localities in California (see excerpts in Carter and Erickson [1988]). Most appeared to assume that

murrelets were in transit between nesting areas farther inland and coastal feeding areas. In the 1970s, it became clear that murrelet activity at Big Basin Redwoods State Park, Santa Cruz County, was associated with an old-growth forest nesting area. On 7 August 1974, the only Marbled Murrelet nest to be found in California (before December 1987) was discovered in the park on a 45 m-high branch of a 61 m-high old-growth Douglas-fir (*Pseudotsuga menziesii*) located within an uncut stand dominated by Douglas-fir and coast redwood (*Sequoia sempervirens*) (Binford et al. 1975, Singer and Verardo 1975). The nest site was a depression in the bark surrounded by a rim of moss (*Isoetecium cristatum*) and droppings located 6.8 cm from the trunk on the flat base of the 41 cm diameter wide and 15 m long branch (see Binford et al. [1975] for details of the nest, eggshell fragments, and chick; specimens are in the California Academy of Sciences, nos. CAS 8717, 68895). This nest was one of only four definite tree nests (before December 1987) discovered throughout the breeding range (Ewins et al., in press). Further indications of nesting in old-growth forests in the park were 8 grounded fledglings found on the forest floor from 1960 to 1982 (Appendix 1). Murrelets were recorded calling and flying over the park on over 36 occasions in nine years from 1959 to 1987 (Appendix 5; see Carter and Erickson 1988). In 4 years, murrelets also were detected there during winter (January–March) when birds also probably visit nesting areas and/or nest sites as documented for other alcids in California and elsewhere (Carter and Sealy 1986, Greenwood 1987, Harris and Wanless 1989, Ainley and Boekelheide 1990).

Winter and summer activity by murrelets in old-growth forests also has been recorded in 4 years from 1956 to 1987 at nearby Portola State Park, San Mateo County, and on over 600 occasions in 17 years from 1946 to 1987 at Prairie Creek Redwoods State Park, Humboldt County (Appendix 5; see Carter and Erickson [1988]). At both of these localities, fledglings also have been discovered (Appendix 1), providing a further link between murrelet nesting areas and their activity in and over old-growth forests. Observations of murrelet activity over many years at several localities have indicated that old-growth forest nesting areas probably are well-established and used traditionally, as known for other well-studied alcids (Nettleship and Birkhead 1985). While it is not yet clear where murrelets detected

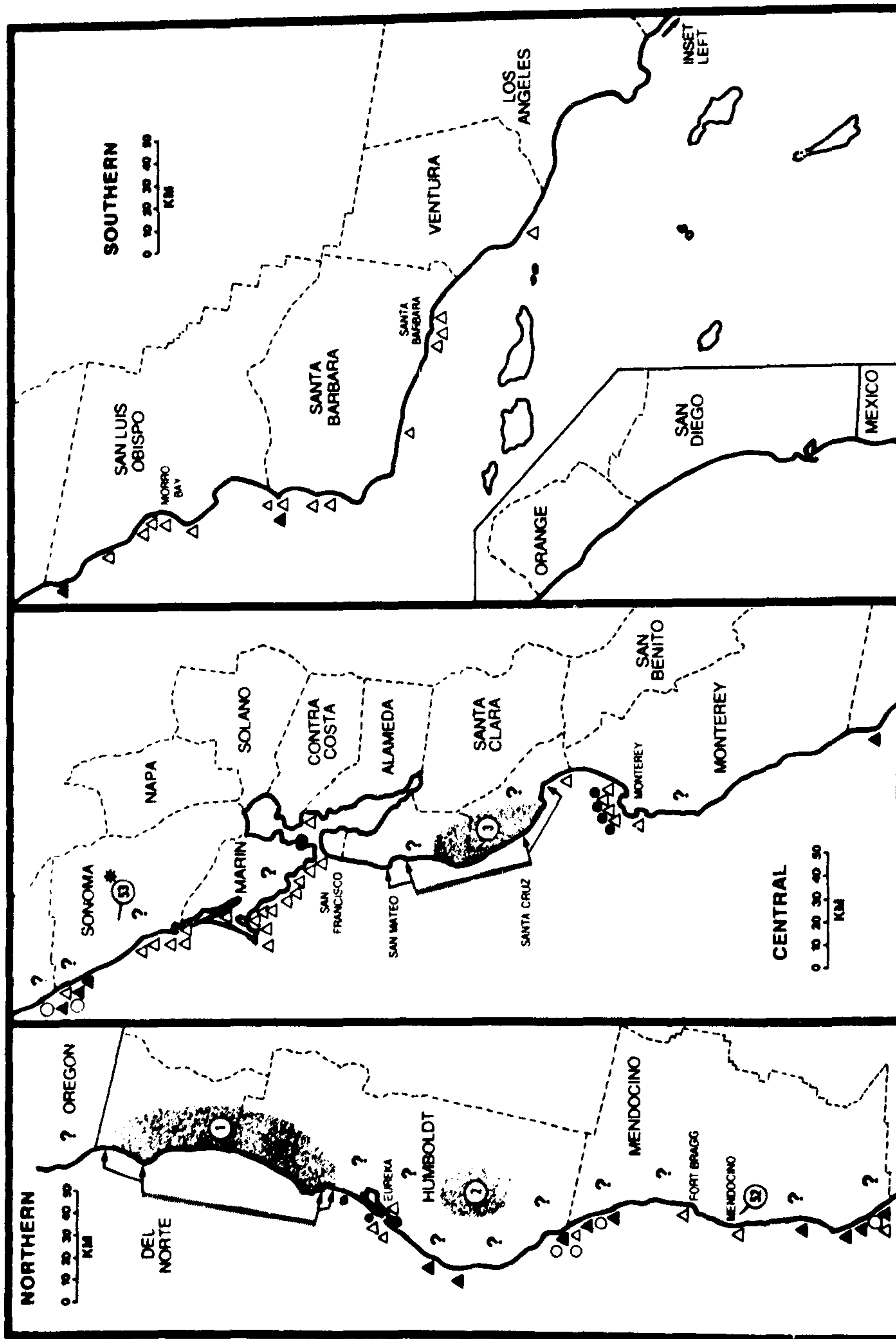


FIG. 2. At-sea distribution and general locations of the Marbled Murrelet in California. Bracketed coastlines indicate where relatively large (thick portion) and relatively small (thin portion) numbers of birds occur at sea during the breeding season (see Appendix 3, 4). For other coastal areas, various symbols refer to localities where birds have been recorded at sea during the breeding season (Appendix 2, 3, 4; see Carter and Erickson [1988]). Nesting regions are shaded and two inland localities in Mendocino (52) and Sonoma (53) counties listed in Table 5 are noted (see Fig. 3 for details). Possible nesting areas—where murrelets have not been detected but where potential old-growth forest nesting habitat exists—are indicated by question marks

at specific locations within an old-growth forest actually nest, it is reasonable to expect that, at least where high levels of murrelet activity occur, nesting occurs somewhere nearby.

Based on the multitude of inland records of murrelets available in California, we identified three nesting regions in the state (see Figs. 2, 3) and uncovered some general characteristics of murrelet nesting behavior in these regions. Over 925 records at 68 inland localities have been documented from 1904 to 1987 (Appendix 1, 2, 5; see Carter and Erickson [1988]) including one nest, 17 grounded young at 7 localities, and 66 localities where calling, flying, or grounded AHY birds have been found. Such an extensive data base has not been developed elsewhere in the species' range. Thus, we have had the opportunity, for the first time, to describe in a general fashion the inland distribution of the Marbled Murrelet for a particular section of its range. We divided inland records of murrelets in California into three geographically-distinct regions for further discussion below.

Region 1: Del Norte and northern Humboldt counties.—In this region, murrelets have been recorded at a fairly continuous series of 43 inland localities (Fig. 3) that stretch along the coast from the Smith River (Hutsinpillar Creek, locality no. 9) in the north to just south of Trinidad at Little River (loc. no. 29) in the south. Only one grounded fledgling has been discovered at Prairie Creek Redwoods State Park (Appendix 1, Fig. 3) and no nests have been found in this region. Almost all localities are represented by calling and/or flying birds. Marbled Murrelets have been detected most frequently at Prairie Creek Redwoods State Park (loc. nos. 31–44), the Redwood Experimental Forest (loc. no. 19), and Jedediah Smith Redwoods State Park (loc. nos. 11–13) (Appendix 5). Murrelets have been detected as far as 15 km inland at Bridge Creek (loc. no. 45) in Redwood National Park. The only record of a Marbled Murrelet at a freshwater lake in California was one bird flying over Lake Talawa (loc. no. 17); this record was omitted by Carter and Sealy (1986).

Several inland localities were found along Prairie Creek, Redwood Creek, and the Klamath River. River courses appeared to be movement corridors to and from nesting areas and the ocean (see Fig. 3). However, murrelets also flew directly from the ocean into Prairie Creek Redwoods State Park passing over many points along Gold Bluffs Beach (loc. nos. 38–42) and into Jedediah Smith

Redwoods State Park from points at and south of Crescent City (loc. no. 1–3). Both Prairie Creek and the Smith River bend parallel to the coast such that some murrelets flew the shortest distance from the ocean to nesting areas rather than following these drainages.

The actual boundaries of this nesting region are not known. Nesting areas appeared to thin out north of the Smith River where the species composition of coastal forest shifts, and redwoods near the northern limit of their range (Griffin and Critchfield 1972). Suitable old-growth forest habitat is much reduced just north of the Smith River. South of Little River, Douglas-fir and redwood forests occur farther inland opposite Arcata and Humboldt bays. There are isolated records of a fledgling murrelet at Eureka in 1924 (Appendix 1, Fig. 3) and of grounded adults at Eureka in 1916 and at Freshwater in 1983 (Appendix 2, 5). Whether these records represent a southward extension of this region or a small isolated nesting area is not clear. The distribution of Marbled Murrelets at sea in the northern population corresponds closely with the distribution of inland localities (Fig. 2) such that nesting may not occur to any great degree north of the Smith River or south of Little River.

Region 2: Southcentral Humboldt County.—This region is comprised of an apparently isolated group of four inland localities on the Van Duzen and upper Eel rivers (Figs. 2, 3). Only one grounded fledgling has been discovered at Humboldt Redwoods State Park (Appendix 1, Fig. 3) and no nests have been found in this region. Only at two localities on the Van Duzen River (loc. nos. 22, 27) have murrelets been detected in the last 20 years. All four localities occur between 20 and 40 km inland, representing the farthest inland nesting area known in California. The farthest inland locality was Grizzly Creek Redwoods State Park. Redwood forests only occur far inland in this area (Griffin and Critchfield 1972) and the lack of inland records of murrelets closer to the coast may reflect less suitable nesting habitat, less available nesting habitat, loss of nesting habitat, or a lack of observer effort. It is not clear whether murrelets nesting in region 2 feed north of the mouth of Humboldt Bay (where larger numbers occur at sea) or anywhere southward to the Mendocino county border (where fewer birds occur at sea) (see Fig. 2). All of these at-sea areas are a similar distance from region 2.

Region 3: Southern San Mateo County—Northern Santa Cruz County.—This region is

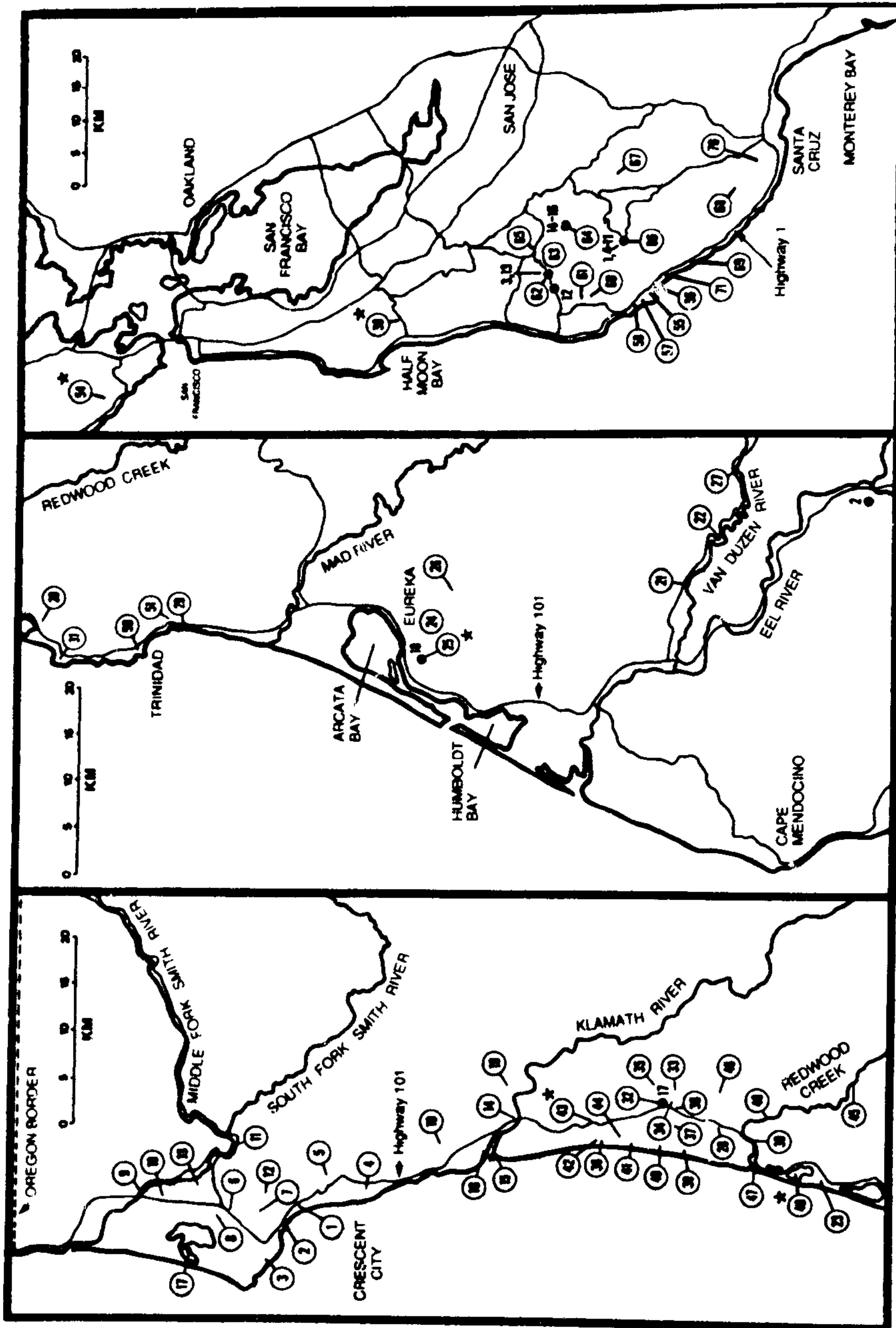


FIG. 3. Distribution of inland localities where Marbled Murrelets have been detected in three nesting regions in California (see Fig. 2). Numbered localities where after-hatching-year birds have been detected calling and/or flying overhead are indicated by open circles with a pointer; all records for these localities are summarized in Appendix 5. Localities with an asterisk indicate where censuses have been conducted but murrelets have not yet been detected. Localities 52 and 53 are indicated on Figure 2. Numbered localities where the nest with a downy young and/or fledglings have been found are indicated by solid circles (see Appendix 1).

comprised of a small but well-defined pocket of 18 inland localities where murrelets have been recorded between La Honda and Santa Cruz (Figs. 2, 3). Fourteen of 17 grounded young and the only nest found in California were discovered in region 3, at Big Basin Redwoods State Park, Portola State Park, Memorial County Park, and Loma Mar (Appendix 1, Fig. 3). At Big Basin Redwoods State Park (loc. no. 66), a long series of observations have been made (Appendix 5). Murrelets have been detected as far as 20 km inland at Kings Creek (loc. no. 67).

Several localities (loc. nos. 60–66) were associated with Butano, Pescadero, and Waddell creeks, but widespread movement across the coast at or near Ano Nuevo State Reserve (loc. nos. 55–58, 69, 71) indicated that some murrelets flew more directly to and from nesting areas and ocean feeding areas. Most inland localities (except loc. nos. 59, 67, 68, 70, 72) occur between La Honda and Waddell Creek, matching the coastal area where murrelets occur in relatively large numbers at sea (Fig. 2) and where most of the remaining old-growth coast redwood and Douglas-fir forests occur in central California (Griffin and Critchfield 1972; S. Viers, pers. comm.). However, dawn movements at sea to the south indicated that some murrelets do not forage immediately adjacent to nesting areas (D. L. Suddjian, pers. comm.). Thus, at-sea distribution in this area may only approximately depict nesting in adjacent coastal forests (see Sealy and Carter 1984).

CONSERVATION PROBLEMS

Loss of old-growth forests

Loss of old-growth forest nesting habitat has been recognized for some time as the greatest conservation problem facing Marbled Murrelets throughout most of their range but especially in California (Remsen 1978, Harris et al. 1979, SOWLS et al. 1980, Sealy and Carter 1984, Carter and Sealy 1987, Marshall 1988). Extensive logging of coastal old-growth forests in California has occurred since the early 1800's (reviewed in Green 1985). For example, by 1978, less than 15% of the original 1.9 million acres of old-growth redwood remained and about 30% of remaining old-growth redwood acreage (or about 4% of its original acreage) was preserved in parks (Green [1985]). About 83% of 1978 old-growth redwood forests in California occurred in Mendocino, Humboldt, and Del Norte counties while about

88% of park acres of old-growth forest occurred in Humboldt and Del Norte counties. Parks contained between 1.1% and 15.4% of total 1978 old-growth acreage in each county.

Since Marbled Murrelets appear to nest only in coastal old-growth forests in California, this massive removal of potential nesting habitat must have resulted in a substantial removal of actual nesting habitat. Yet, most old-growth removal occurred prior to ornithologists' awareness that murrelets nested in this habitat. There is little direct evidence that murrelet nest trees have been removed in California except for a single record of an adult bird that fell out of a tree being felled by loggers near Freshwater in July 1983 (Appendix 2, 5). However, we have uncovered some indirect evidence that suggests this has occurred on a large scale as indicated in the following cases:

1. In July 1923, J. Grinnell (MVZ field notes) noted extensive murrelet activity at Carlotta, Humboldt County (Appendix 5, loc. no. 21; and see Carter and Erickson [1988]), when he reported murrelets flying low enough to be seen and heard very clearly several times as well as circling overhead, all activities strongly suggestive of a nesting area as Grinnell suspected. However, much reduced murrelet activity reported from 1929 to 1932 (i.e., distant brief calls) after the area was logged, closely depicted behavior of murrelets in transit between the ocean and nesting areas farther inland. This before-and-after-logging series of observations suggested that a nesting areas was eliminated or greatly reduced by logging of old-growth forest.

2. On 18 May 1914, W. L. Dawson (1923)—while camped on Majors Creek, Santa Cruz County (loc. no. 68)—aptly described murrelets in transit along what appeared to be a regularly-used route. On 25 July 1987, T. G. Sander conducted a dawn census at the junction of Majors Creek and Smith Grade Road (Carter and Sander, unpubl. data). No murrelets were detected, suggesting that either they no longer use this flight route and/or they no longer nest farther inland. This area of the Santa Cruz mountains has been extensively logged and little old-growth forest remains. Similarly, L. Hawkins (field notes provided by D. L. Suddjian) noted murrelets flying and calling over Henry Cowell Redwoods State Park (loc. no. 72), near Santa Cruz, on 3 May 1930 but they have not been observed there since although some old-growth forest still remains in this area.

3. From 16 to 24 July 1981, R. A. Erickson

(unpubl. data) noted high levels of murrelet activity at Terwer Valley, Del Norte County (loc. no. 18), including high and low flying, circling and seaward flight, and clear and faint calling. This behavior indicated both activity associated with a nesting area plus murrelets in transit from this and other nesting areas farther inland to the ocean. Even while making these observations, logging was occurring a short distance up the valley. On 10 July 1987, T. G. Sander found much lower activity at this location comprised only of high flying, faint calling, and seaward flight (Carter and Sander, unpubl. data). This suggested that murrelets no longer nested nearby but still used the valley as a flight route. Between 1981 and 1987, most old-growth forest visible from the end of the Terwer Valley Road had been logged. These observations suggested that a nesting area had been lost.

Gill-net fishing mortality

Although significant mortality of Marbled Murrelets in nearshore gill nets has been reported in British Columbia and Alaska (Carter and Sealy 1984, Sealy and Carter 1984), little attention has been paid to known mortality of murrelets in gill nets in California. Extensive nearshore gill-net fishing occurred between Monterey Bay and the Russian River (Sonoma County) in central California between 1979 and 1987, resulting in a heavy mortality of seabirds, especially Common Murres (*Uria aalge*) (Evens et al. 1982, Atkins and Heneman 1987, Takekawa et al. 1990). Three Marbled Murrelets were observed in nets during a shipboard bycatch monitoring program conducted by the California Department of Fish and Game (P. W. Wild and C. W. Haugen, unpubl. data). Two murrelets were caught in a net set for white croaker (*Genyonemus lineatus*) at a depth of 19 m off the mouth of the Pajaro River in Monterey Bay on 3 December 1981 (see Sealy and Carter [1984]) and one murrelet was caught in a croaker net set at a depth of 27 m about 3 km off San Gregorio Creek, San Mateo County, on 21 November 1986. Despite this low level of observed gill-net mortality, relatively large numbers of dead Marbled Murrelets were found on Monterey Bay beaches between October 1980 and January 1981 where large numbers of other species also killed in gill nets had beached; 24 dead murrelets were estimated to have washed ashore on Marina State Beach and at Seaside in October 1980 while 30 and 48 dead murrelets were estimated to have beached in December

1980 and January 1981, respectively, on Sunset and Zmudowski state beaches (CDFG 1981). In addition, Stenzel et al. (1988) reported two dead murrelets on Laguna Creek Beach and four dead murrelets on Sunset State Beach in November and December 1980. These latter six birds comprised about 26% of all Marbled Murrelets found during 14 years of beached bird surveys along the California coast from 1971 to 1985. This level of mortality was much higher than found in even the worst years of natural mortality for other seabird species, suggesting that non-natural sources of mortality, such as gillnetting, probably were responsible. We estimated that on the order of 150 to 300 murrelets were killed between 1979 and 1987. It is not known what proportion of birds killed were local breeders, since murrelets killed in Monterey Bay in the non-breeding season may belong to local and more distant breeding populations.

Oil pollution

The threat of oil pollution to Marbled Murrelet populations has been little addressed (but see Sealy and Carter [1984]) and few oiled murrelets have been reported in northern parts of the range prior to December 1987 (Racey 1930, Richardson 1956, Kazama 1971). In contrast, there are several instances of mortality from oil spills in California. After the March 1937 *Frank H. Buck* oil spill, 14 oiled Marbled Murrelets were found on San Francisco and Bolinas beaches; more were undoubtedly killed, since some unidentified murrelets and/or small alcids also were reported, and not all beaches were searched for dead birds (Aldrich 1938, Moffitt and Orr 1938). Marbled Murrelets were not recovered in the 1969 Santa Barbara or the 1971 San Francisco oil spills (Straughan 1971, Smail et al. 1972), although dead beached birds were not enumerated in the latter spill. Extensive documentation of live and dead beached birds occurred during the November 1984 *Puerto Rican* and February 1986 *Apex Houston* oil spills (PRBO 1985, Campbell et al. 1986, Page et al. 1990). Only one and three dead oiled Marbled Murrelets were found on beaches during these spills, respectively. However, G. J. Strachan (pers. comm.) independently recovered three other live oiled murrelets during the latter spill at the Ano Nuevo State Reserve, indicating that more were killed than reported.

Few other reports of oiled murrelets exist in California. Streater (1947) noted "many dead on the beach, oil soaked" in Santa Cruz County and

Munro (1957) provided evidence of chronic oiling of Marbled Murrelets from 1953 to 1957 at Morro Bay, San Luis Obispo County. One dead oiled murrelet found on Las Varas Ranch Beach, Santa Barbara County, on 21 September 1976 (Stenzel et al. 1988) and two dead oiled murrelets found on Hope Ranch Beach, Santa Barbara County, on 26 April 1986 (G. Johnson, pers. comm.) probably were victims of chronic oiling.

It is not known how oil-related mortality may have affected breeding Marbled Murrelets in California. All oiling records have been obtained during the non-breeding season or outside the breeding range in southern California and thus may have involved both local and more distant breeding birds. However, the *Apex Houston* spill probably directly affected birds in the central California population that were at sea adjacent to known nesting areas in region 3.

CONCLUDING REMARKS

Loss of old-growth forest nesting habitat and the small numbers of Marbled Murrelets in California have raised concern over whether these populations have been declining and are in danger of extinction. Little historical data exist on the numbers and distribution of murrelets at sea to compare with present data to determine specifically if a decline has occurred (see Sealy and Carter [1984]) and there is little convincing evidence that numbers of murrelets at sea opposite known present-day nesting areas have declined. However, the extensive removal of old-growth forest nesting habitat should have caused a large decline which would account for the current distribution and small numbers of murrelets in central and northern California.

Continued removal of nesting habitat probably will result in decline in population size because murrelets are distributed widely in remaining forests (see Fig. 3). Some nesting areas will be preserved in certain parks where murrelets nest but we doubt the continued existence of viable populations based solely in parks. The very small population sizes (hundreds of breeding birds) and fragmented and/or isolated nature of nesting regions 2 and 3 at the present time already places their populations in peril of extinction from natural catastrophes (e.g., fire, blowdown), human-induced mortality (e.g., oil pollution, gill-net fishing), and/or demographic and genetic problems. While the region 1 population is slightly larger (about 1000 breeding birds), it is also partly fragmented and, with fur-

ther decline, faces an eventual fate similar to that posed above for regions 2 and 3.

Intensive management and research efforts are required to prevent future decline. Since this paper was first presented in December 1987, a large research effort has developed to address the conservation of the Marbled Murrelet in California. In 1991, it was listed as a state endangered species.

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APPENDIX 1. Inland records of downy young and fledgling Marbled Murrelets in California (see Figure 3 for locations).

Rec. no.	Location	Date	Notes	Sources
Downy young				
1	Big Basin Redwoods State Park	7 Aug 1974	in nest	Binford et al. (1975); Singer and Verardo (1975) [CAS 68895]
2	Humboldt Redwoods State Park (Rockefeller Grove)	13 Sep 1979	on ground	S. W. Harris (<i>in litt.</i>) [HSUM 6752]
3	Memorial Park	11 Jul 1982	on ground	C. Kemnitz (pers. comm.)
Fledglings				
4	Big Basin Redwoods State Park	18 Aug 1960	on ground	Cutler and Pugh (1960); Anderson (1972); Singer and Verardo (1975)
5	Big Basin Redwoods State Park	17 Jun 1973	on creek	Park records
6	Big Basin Redwoods State Park	9 Sep 1974	on ground	Singer and Verardo (1975)
7	Big Basin Redwoods State Park	12 Jun 1976	on ground	Park records
8	Big Basin Redwoods State Park	4 Jul 1976	on ground	Park records
9	Big Basin Redwoods State Park	31 Aug 1977	on ground	Erickson and Morlan (1978) [CAS 69960]
10	Big Basin Redwoods State Park	14 Jun 1979	on ground	Park records [CAS 71228]
11	Big Basin Redwoods State Park	11 Aug 1982	on ground	Park records
12	Loma Mar	31 Aug 1985	on ground	C. Kemnitz (pers. comm.)
13	Memorial Park	Jul 1973	on ground	C. Kemnitz (pers. comm.)
14	Portola State Park	15 Jun 1957	on creek	Anderson (1972)
15	Portola State Park	27 Jun 1971	on ground	DeSante and LeValley (1971)
16	Portola State Park	summer 1972	on ground	B. G. Elliot (Amer. Birds files)
17	Prairie Creek Redwoods State Park	13 Aug 1984	on ground	Park records
18	Sequoia Park (Eureka)	4 Jul 1924	on ground	S. W. Harris (<i>in litt.</i>) [HSUM 2557]

APPENDIX 2. Specimens of Marbled Murrelets from California in complete (or almost complete) alternate or juvenal plumages housed in the Museum of Vertebrate Zoology, California Academy of Sciences, and Humboldt State University Museum.

Date	Locality	Collector	Source
After-hatching-year specimens			
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10140
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10141
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10143
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10144
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10145
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10146
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10147
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10148
26 Mar 1907	Monterey Bay	R. H. Beck	CAS 10149
27 Mar 1911	Monterey Bay	R. H. Beck	MVZ 17679
2 May 1915	Pescadero	C. Littlejohn	CAS 75190
8 May 1976	Humboldt Bay ^a (end of N. spit)	T. Harris	HSUM 3672
18 May 1929	Crescent City	F. J. Smith	HSUM 2558
24 May 1970	Trinidad	T. O. Osborne	HSUM 6747
24 May 1970	Trinidad	T. O. Osborne	HSUM 6748
27 May 1976	Mad River Beach ^a	T. G. Evans	HSUM 3746
30 May 1896	Santa Cruz	E. B. Towne, Jr.	CAS 75188
22 Jun 1907	Monterey Bay	R. H. Beck	CAS 10142
27 Jun 1899	Santa Cruz	J. Mailliard	CAS 43117
16 Jul 1916	Eureka ^b	F. J. Smith	MVZ 27096
Jul 1983	Freshwater ^c	Unknown	HSUM 5484
1 Aug 1892	Monterey	L. M. Loomis	CAS 75165
1 Aug 1892	Monterey	L. M. Loomis	CAS 75166
8 Aug 1896	Santa Cruz	E. B. Towne, Jr.	CAS 75184
15 Aug 1895	Monterey Bay	E. B. Towne, Jr.	CAS 75176
17 Aug 1895	Pacific Grove	J. Mailliard	CAS 43111
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43097
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43106
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43107
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43109
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43116
21 Aug 1896	Monterey Bay	J. Mailliard	CAS 43119
1 Sep 1970	Trinidad	T. O. Osborne	HSUM 2106
15 Sep 1940	Trinidad	C. I. Clay	HSUM 2562
16 Sep 1896	Monterey Bay	E. B. Towne, Jr.	CAS 75182
20 Sep 1909	Monterey Bay	R. H. Beck	CAS 15814
Hatching-year specimens			
1 Jun 1896	Monterey Bay	E. B. Towne, Jr.	CAS 75183
29 Jun 1907	Monterey Bay	R. H. Beck	CAS 10174
8 Jul 1892	Monterey	L. M. Loomis	CAS 75168
8 Jul 1892	Monterey	L. M. Loomis	CAS 75170
8 Jul 1892	Monterey	L. M. Loomis	CAS 75171
12 Jul 1907	Monterey Bay	R. H. Beck	CAS 10172
12 Jul 1907	Monterey Bay	R. H. Beck	CAS 10173
17 Jul 1983	Half Moon Bay	W. Lieber	CAS 75100
27 Jul 1897	Pacific Grove	J. Mailliard	CAS 43104
28 Jul 1892	Monterey	L. M. Loomis	CAS 75167
1 Aug 1892	Monterey	L. M. Loomis	CAS 75169
28 Aug 1938	Trinidad	C. I. Clay	HSUM 2560
30 Aug 1909	Monterey Bay	R. H. Beck	CAS 15544
13 Sep 1909	Monterey Bay	R. H. Beck	CAS 15599
22 Sep 1909	Monterey Bay	R. H. Beck	CAS 15815
22 Sep 1909	Monterey Bay	R. H. Beck	CAS 15816
22 Sep 1909	Monterey Bay	R. H. Beck	CAS 15817
25 Sep 1938	Trinidad	C. I. Clay	HSUM 2559
5 Oct 1909	Monterey Bay	R. H. Beck	CAS 10165
15 Oct 1922	Monterey Bay	R. Ellis	MVZ 145347
25 Oct 1909	Monterey Bay	R. H. Beck	CAS 15818

^a Found dead on beach.

^b Bird was caught alive inland from Eureka.

^c Bird fell out of tree being felled by loggers.

APPENDIX 3. Summary of at-sea records of Marbled Murrelets from northern and central California during the 1979-1980 USFWS seabird colony survey (Sowls et al. 1980).

	USFWS (unpubl. data ^a)		This study ^b		
	1979	1980	1979	1980	Combined ^c
Oregon border to					
Humboldt Bay mouth	145	358	130	235	270
Humboldt Bay mouth to					
Pillar Point	20	3	20	3	20
Pillar Point to Santa Cruz	25	90	25	90	90
Santa Cruz to Point					
Conception	0	5	0	3	3
Total	190	451	175	331	383

^a Total numbers of birds sighted were determined from direct tabulation of all records derived from archived materials (see Carter and Erickson 1988).

^b Totals included only highest counts for specific sections of coast at one point in the breeding season.

^c Totals included highest counts for specific sections of coast from 1979 or 1980.

APPENDIX 4. At-sea records of Marbled Murrelets in California during the breeding season from 1 April to 1 September. Data were summarized from more detailed records presented in Tables 6, 7, 8, and 9 in Carter and Erickson (1988).

Location	Range of record dates (month/year)	Number of records ^a	Range of numbers reported ^b
Del Norte County			
Castle Rock	07/76	1	1
Crescent City	07/76 to 07/87	8	1 to 150
Point Saint George	04/81 to 08/83	3+	5 to 10
White Rock (offshore)	05/81	1	4
Humboldt County			
Elk Head	05/79	1	6
Gold Bluffs Beach	04/83	1	25
Humboldt Bay (offshore)	04/70 to 05/73	3	10 to 30+
Humboldt Bay (King Salmon)	05/74 to 05/79	6	2 to 30
Humboldt Bay (North Jetty)	04/79	1	15
Patrick's Point State Park	07/62	1	2
Samoa	07/62	1	2
Trinidad	05/69 to 04/79	4	1 to 6
Trinidad (offshore)	06/81 to 07/81	1	5
Mendocino County			
Bear Harbor	04/82	1	24
Gualala River	06/80	1+	6 to 12
Gualala River (offshore)	06/85	2	1 to 2
McKerricker Beach State Park	04/77	1	2
Mendocino	07/76	1+	1
Sonoma County			
Bodega Bay	08/67 to 04/78	3	1 to 3
Bodega Harbor	04/84	1	2
Bodega Head	07/63 to 08/81	3	1 to 6
Doran Beach	04/80	1	1
Goat Rock	07/66 to 08/75	4	2 to 7
Jenner	07/70 to 08/79	3	2 to 10
Russian River mouth	07/87	1	2
Sonoma coast	07/62	1	6
Marin County			
Bolinas	08/87	1	2
Chimney Rock	07/77	1	1
Coast Camp	08/85	1	2
Drake's Beach	07/81	1	1

Location	Range of record dates (month/year)	Number of records ^a	Range of numbers reported ^b
Duxbury Point	07/73	1	2
Inverness	07/64	1	3
Limantour	09/78 to 07/87	6	1 to 8
Palomarin	08/66 to 08/87	4+	2 to 8
Point Bonita	07/75	1	2
Point Reyes	09/68 to 08/76	3	1 to 2
Point Reyes (offshore)	05/82	1	1
San Francisco County			
Baker's Beach	08/80	1	—
Farallon Islands (south of)	06/86	1	1
Land's End	08/65	1	1
Alameda County			
Berkeley dump	07/76	1	1
San Mateo County			
Ano Nuevo State Reserve	06/69 to 05/87	30	1 to 70+
Ano Nuevo Point (offshore)	05/81 to 04/87	4	2 to 3
Franklin Point (offshore)	04/87	3	2
Gazos Creek	07/77	1	8
Half Moon Bay	08/63 to 07/83	7	1 to 20+
Highway 1 (mile post 0.30)	04/86	2	2
Pescadero Creek/Point	07/62 to 07/87	6+	3 to 10
Pescadero Point (offshore)	04/87	2	1 to 3
Pigeon Point	07/63 to 07/87	49	2 to 83
Pigeon Point (offshore)	04/87 to 06/87	4	2 to 4
Pillar Point	07/65 to 07/79	3	1 to 6
Santa Cruz County			
Capitola	08/74	1	3
Davenport	06/86	1	7
El Jarro Point	04/87 to 05/87	3+	0 to 45
Monterey Bay	05/74 to 08/83	3	1 to 35
Natural Bridges State Beach	05/86 to 07/86	5	3 to 33
New Brighton State Beach	08/86	1	1
Santa Cruz	07/55 to 08/86	22	1 to 30
Scott Creek	07/86	1	13
Waddell Creek	07/67	1	2
Waddell Creek (offshore)	04/87	5	2 to 3
Monterey County			
Asilomar	05/84 to 06/83	1+	2
Carmel	07/62	1	1
Monterey	05/63 to 08/85	4	1 to 3
Pacific Grove	07/69	1	1
Pajaro River Mouth	08/74 to 08/76	3	1
Point Pinos	07/72 to 08/83	2	2
San Luis Obispo County			
Atascadero Beach	08/81	1	(1)
Cambria	08/66	1	1
Cayucos Pier	07/81 to 08/81	1+	6+
Montano de Oro	08/85	1	1
Morro Bay	04/59	1	(1)
Santa Barbara County			
Hollister Ranch Beach	04/77	1	(1)
Hope Ranch Beach	04/86	1	(2)
Point Sal	07/80 to 07/84	5+	2 to 9
Purisima Point	05/82	1	(1)
Santa Barbara	07/10 to 07/85	4+	1
Santa Maria River	08/83	1	1
Ventura County			
Point Mugu	05/82	1	1

^a Where a plus sign is indicated, individual records included more than one date.

^b Parentheses indicate dead beached birds.

TABLE 1. Summary of published records of first-hatching-year Marbled Murrelets in California, 1904-1987. Data were summarized from more detailed records presented in Appendix 1 in Carter and Erickson (1988). Records are generally unpublished except where indicated by footnote. An inland record was defined as the observation or collection of one or more birds at an inland locality (i.e., on or flying over land or fresh water) on one or more dates.

Local- ity num- ber	Location ^a	Range of record dates (month/year)	Mini- mum number of rec- ords ^b
Del Norte County			
1, 2 ^c	Crescent City (1 mile south)	-/78 to 06/84	3
3	Crescent City (Pebble Beach Drive at Pacific Avenue)	06/81	1
4	Del Norte Coast Redwoods State Park (Damnation Creek)	11/85 to 07/87	3
5	Del Norte Coast Redwoods State Park (Mill Creek Campground)	-/78 or -/79	1
6	Elk Valley Road (at Parkway Drive)	12/79 to 12/84	4
7	Elk Valley Road (at quarry on Jordan Creek drainage)	12/83 to 12/87	4
8	Elk Valley Cross Road (at Wonder Stump Road)	12/87	1
9	Hutsinpillar Creek	05/85 to 08/86	5
10	Hytrees Road	04/86 to -/87	2
11	Jedediah Smith Redwoods State Park (Hiouchi Stout Grove)	07/77 to 07/87	12+
12	Jedediah Smith Redwoods State Park (Howland Summit)	03/82 to 06/86	4
13	Jedediah Smith Redwoods State Park (end of Walker Road)	-/78 or -/79	2+
14	Klamath Post Office	08/81	1
15	Klamath River mouth (Fortain Ranch on south side)	-/80 to 10/82	10+
16	Klamath River mouth (Requa Hill on north side)	01/83	1
17	Lake Talawa	07/86	1
18	Terwer Valley	07/81 to 07/87	16
19	Yurok Redwood Experimental Forest ^d	04/85 to 05/86	22
Humboldt County			
20	Big Lagoon (Maple Creek)	08/49	9
21	Carlotta ^{e,f}	07/16 to 07/32	15+
22	Cheatham Grove	06/87	1
23	Dry Lagoon State Park	06/54	1
24	Eureka ^f	07/16	1
25	Eureka (Sequoia Park)	07/87	(1)
26	Freshwater	07/83	1
27	Grizzly Creek Redwoods State Park	04/73 to 08/87	5
28	Highway 101 (at Davison Road)	-/30 to -/84	20+
29	Highway 101 (north of Little River)	04/87	1
30	Orick	07/81 to 12/81	2
31	Patrick's Point State Park	-/75 to -/84	2
32	Prairie Creek Redwoods State Park (Big Tree)	02/87 to 07/87	35
33	Prairie Creek Redwoods State Park (Boyes Creek, 2 miles east of Elk Prairie)	06/87	2
34	Prairie Creek Redwoods State Park (Cal Barrel Road)	-/75 to -/84	2
35	Prairie Creek Redwoods State Park (East Ridge)	07/72	1
36	Prairie Creek Redwoods State Park (Elk Prairie)	10/65 to 09/87	601+
37	Prairie Creek Redwoods State Park (2 miles west of Elk Prairie)	06/46	8
38	Prairie Creek Redwoods State Park (Gold Bluffs Beach at Butler Creek)	-/30 to -/72	2
39	Prairie Creek Redwoods State Park (Gold Bluffs Beach at Espia Lagoon)	-/75 to -/84	5+
40	Prairie Creek Redwoods State Park (Gold Bluffs Beach from Espia Lagoon to Fern Canyon)	-/75 to -/84	5+
41	Prairie Creek Redwoods State Park (Gold Bluffs Beach at Fern Canyon)	05/87	1
42	Prairie Creek Redwoods State Park (Gold Bluffs Beach at Ossagon Creek)	05/82	1
43	Prairie Creek Redwoods State Park (Highway 101 at Ah Pah Road)	12/81	(1)
44	Prairie Creek Redwoods State Park (Lincoln Prairie)	06/75 to 06/87	2
45	Redwood National Park (Bridge Creek mouth)	-/76	1
46	Redwood National Park (Lost Man Creek)	-/75 to 07/87	11+
47	Redwood National Park (Redwood Creek mouth)	06/87	1
48A ^g	Redwood National Park (Tall Trees Grove)	08/75	1
48B ^g	Redwood National Park (Redwood Creek Trail Head)	-/75 to -/84	2+
49	Stone Lagoon	12/86	(1)
50	Trinidad (half mile inland) ^h	07/16	2+
51	Westhaven (Sixth Avenue)	05/86	1

APPENDIX 5. Continued.

Local- ity num- ber	Location ^a	Range of record dates (month/year)	Mini- mum number of rec- ords ^b
Mendocino County			
52	Russian Gulch State Park	05/76	1
Sonoma County			
53	Armstrong Redwoods State Park	07/87	(1)
Marin County			
54	Muir Woods National Monument	12/81-07/87	(2)
San Mateo County			
55	Ano Nuevo State Reserve	-/86 to-/87	4+
56	Ano Nuevo State Reserve (Ano Nuevo Creek)	03/84 to 03/86	2+
57	Ano Nuevo State Reserve (Cascade Creek)	03/84 to 03/86	2+
58	Ano Nuevo State Reserve (Whitehouse Creek)	03/84 to 03/86	2+
59	Apanolio Canyon	07/87	(1)
60	Butano State Park	10/75 to 07/87	3
61	Canyon Road (at Butano Creek)	07/77 to 07/87	4+
62	Memorial Park	07/87	1
63	Pescadero Creek ^c	08/04	1
64	Portola State Park	07/56 to 07/87	4
65	Sam MacDonald Park	07/87	2
Santa Cruz County			
66	Big Basin Redwoods State Park	04/59 to 09/87	37+
67	Kings Creek (Redwood Camp)	07/57	1
68	Majors Creek ^c	05/14	2
69	Pelican Rock	07/87	1+
70	University of California, Santa Cruz campus	06/76 to 06/77	3+
71	Waddell Creek	04/72 to 07/87	5+
72	Henry Cowell Redwoods State Park ^h	05/30	1

^a See Figs. 2 and 3 for locations of inland localities by locality number.

^b Where a plus sign is indicated, individual records included more than one date. Numbers in parentheses refer to the number of censuses conducted but with no murrelets detected.

^c These localities were found to be the same as indicated for locality number 2 on Fig. 3.

^d See Paton et al., this volume.

^e See Dawson (1923).

^f See Grinnell and Miller (1944).

^g These localities were found to be different than indicated on Figure 3; 48A is located slightly north of locality 45 and 48B is located slightly north of locality 48.

^h This record was obtained after completion of Carter and Erickson (1988). This location is not marked on Figure 3 but is just east of record 70.