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FORAGING DISTANCES OF RADIO-MARKED MARBLED MURRELETS FROM INLAND AREAS IN SOUTHEAST ALASKA[1]

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Abstract. We radiotagged seven female and two male Marbled Murrelets (*Brachyramphus marmoratus*) of undetermined breeding status and followed their movements through the inner passages of northern southeast Alaska during the breeding season (May–July) in 1998. Six of the nine murrelets were detected inland in the early morning hours from 24 June to 17 July. Inland visits for each individual were consistent to a particular location, but short in duration, which precluded locating nest sites. We recorded 46 locations at sea up to 124 km ($\bar{x}$ = 78 ± 27 km) from inland sites during the period 19 June to 16 July. We detected murrelets at inland sites and at sea on the same day on 20 occasions with a mean distance between these locations of 75 ± 42 km. The majority of murrelets were located at sea in western Icy Strait, a productive feeding area at the mouth of Glacier Bay, Alaska. This study provides the first direct evidence that Marbled Murrelets in southeast Alaska are consistently traveling considerable distances between potential nesting and foraging areas. These findings have important implications for murrelet conservation and management efforts in southeast Alaska.

Key words: Brachyramphus marmoratus, *foraging range, Glacier Bay, Marbled Murrelet, radio telemetry, southeast Alaska.*

The Marbled Murrelet (*Brachyramphus marmoratus*), and the closely related Asian species, the Long-billed Murrelet (*Brachyramphus perdix*), are unique among the Alcidae in their use of old-growth trees in coastal coniferous forests as nesting habitat (Konyukhov and Kitaysky 1995, Nelson 1997). Within their range in western North America, Marbled Murrelets are nearshore or coastal feeding seabirds, but are known to fly long distances inland to their solitary nests (generally within 40 km of the coast, although birds have been found up to 125 km inland; Hamer and Nelson 1995). Because murrelet nests are concealed within the forest canopy, and breeding birds are cryptic, secretive, and primarily crepuscular at nest sites, relatively few active nests have been found.

Southeast Alaska is generally considered the center of abundance for Marbled Murrelets in North America. Local murrelet numbers in southeast Alaska are known to fluctuate seasonally (Speckman 1996, Agler et al. 1998), and observations made during shipboard surveys have suggested murrelets may fly long distances between nesting and foraging areas during the breeding season (DeGange 1996; G. van Vliet, unpubl. data). However, studies of the detailed daily and seasonal movements of marked individuals have not been conducted in the region.

Stimulated by recent developments in capture and radio-marking techniques, several Marbled Murrelet radio-telemetry studies have been initiated and successfully tracked murrelets to inland nests in central California (E. Burkett, unpubl. data) and British Columbia (Lougheed 1999), and to potential nest sites in southcentral Alaska (Kuletz et al. 1995). These telemetry studies also have yielded valuable information concerning the at-sea movements and foraging ranges of individual murrelets. From May–July 1998, we conducted a study to determine the feasibility of using radio-telemetry to locate nests of Marbled Murrelets captured at Auke Bay, in northern southeast Alaska, during the breeding season. Concurrent with our efforts to locate nesting areas, we were interested in monitoring inland activity and determining the extent of foraging movements at sea. In this paper, we present the results of this pilot study, and discuss foraging ranges and the foraging areas used by radio-marked murrelets.

METHODS

STUDY AREA

We captured murrelets in Auke Bay (58°22′N, 134°40′W), a small embayment on the Alaska mainland located about 19 km northwest of Juneau (Fig. 1). Auke Bay is directly connected with the marine waters of the Gulf of Alaska via a series of interior

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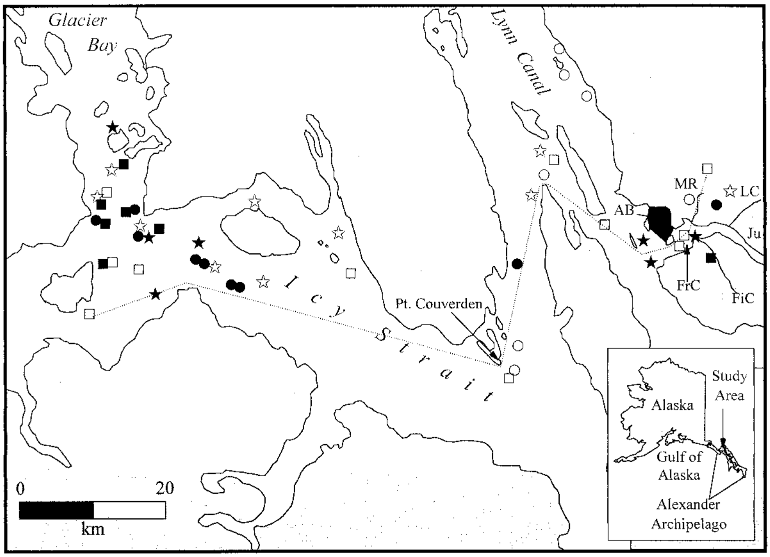

FIGURE 1. Marbled Murrelet telemetry study area in southeast Alaska. Murrelet locations at sea and inland activity areas recorded from 19 June–16 July 1998: murrelet 152.051 = ●, 152.068 = ○, 152.151 = ■, 152.189 = □, 152.202 = ★ 152.241 = ☆. Black area indicates Auke Bay capture site. AB = Auke Bay, MR = Mendenhall River, LC = Lemon Creek, Ju = Juneau, FiC = Fish Creek, FrC = Fritz Cove. Dashed line demonstrates an example of the shortest possible over-water flight path used to calculate foraging distances.

waterways, but lies more than 130 km from the open Pacific Ocean. Large numbers (typically 100s but occasionally low 1,000s) of murrelets congregate in Auke Bay, and nearby Fritz Cove, particularly from late spring through mid-summer (Speckman 1996; G. van Vliet, unpubl. data). Observations of fledged chicks, adults carrying fish, and inland detections have indicated that significant numbers of Marbled Murrelets nest in the coniferous forests near Auke Bay and Fritz Cove (Speckman 1996). Murrelet breeding habitat is limited to relatively narrow coastal strips and river valleys along the inner passages as the surrounding mountains rise steeply to above treeline, although murrelets could potentially nest on the ground above treeline in some areas (DeGange 1996). We tracked murrelets inland in the Mendenhall, Lemon Creek, and Fish Creek watersheds (Fig. 1) during aerial and early morning ground-based surveys. The at-sea survey area covered the inner waterways and passages illustrated in Figure 1, but survey coverage was concentrated in the immediate Auke Bay-Fritz Cove area, Lynn Canal, Icy Strait, and lower Glacier Bay.

CAPTURE AND MARKING

We captured murrelets over five nights between 26 May and 1 June 1998. We used a night-lighting technique (Whitworth et al. 1997) for capture efforts between 22:00–03:30 Alaska Standard Time (AST) on dark, cloudy nights. All murrelets were radio-marked, photographed, fitted with U.S. Fish and Wildlife Service bands, and visually inspected for presence of a single medial brood patch. For each bird captured, we took morphometric measurements and collected a blood sample to determine sex (Griffiths et al. 1996).

Transmitter attachment techniques followed the subcutaneous anchor method (Newman et al. 1999). An inhalation anesthetic, Isoflurane, was used to sedate murrelets prior to attachment procedures. Transmitters (Model BD-2G, Holohil Systems Ltd., Woodlawn, Ontario, Canada) weighed approximately 2.0 g (< 1.0% of murrelet body weight) and were equipped with a 15-cm external whip antenna, a subcutaneous anchor, and front and rear suture channels. Transmitters had an expected lifespan of 6 weeks. Tests with stationary transmitters indicated the distance at which transmitters were detected depended on ambient conditions but ranged up to 10 km from the air and 4 km on the water.

TELEMETRY SURVEYS

We employed three different tracking methods: boat-based surveys, surveys from prominent mainland or island stations, and aerial surveys. Survey tracking methods were not consistent over the course of the study, because survey methods were modified as more was learned about the daily activity patterns of the radio-marked individuals. Boat or ground-based telemetry surveys of Auke Bay and Fritz Cove were performed almost daily throughout the study (27 May–17 July). Nocturnal ground-based surveys of potential nesting areas were initiated on 24 June. These surveys were performed with TR-2 receivers and TS-1 scanner/programmers (Telonics Telemetry, Mesa, Arizona), and "H" or four-element Yagi antennae. We conducted 10 aerial telemetry surveys between 19 June and 16 July using an aircraft equipped with paired four-element Yagi antennae mounted on wing struts.

We limited analyses of murrelet foraging ranges to 19 June–17 July when surveys were more extensive and frequent. All at-sea locations of radio-marked murrelets were plotted on nautical charts to determine foraging distances. Because murrelets fly relatively low over the water and rarely fly over large peninsulas or islands except while traveling to and from nesting areas (Carter and Sealy 1990), we used the shortest possible over-water flight paths to determine distances between at-sea foraging areas and inland sites (Fig. 1). For bird 152.202, an inland activity area was never pinpointed, so we calculated distances from an at-sea staging area in nearby Fritz Cove which the bird used before flying inland. We determined signal location at-sea to within approximately 1 km using a left-right switchbox. Potential inland nesting sites were defined as forest locations visited repeatedly by individual murrelets and were determined to within approximately 2 km from the direction and distance of signals received during inland surveys. All means are reported ± SD.

RESULTS

We captured and radio-marked nine Marbled Murrelets over 21 hr of capture effort. All murrelets had defeathered brood patches and were associated with at least one other bird on the water when captured. Mean murrelet weight was 230 ± 28 g (range = 207–280 g). Analysis of chromosomal DNA from blood samples indicated two male and seven female murrelets in the captured sample. Murrelets were tracked for an average of 67 ± 30 days, but seven of the nine transmitters were still active at the end of the study. The remains of one murrelet (including the functional transmitter) were found in a Bald Eagle (*Haliaeetus leucocephalus*) pellet after we received repeated signals near Pt. Couverden, Alaska. The status of the another murrelet was uncertain as it was located for only five days following release.

We documented six murrelets flying to and from inland sites in the early morning hours between 24 June and 17 July and obtained 58 inland locations (n = 1–18 inland locations murrelet^{-1}). Inland sites were less than 10 km from shore (range = 3.5–9.3 km; Fig. 1). We did not detect murrelets at inland sites after 05:48 during land-based or aerial surveys.

We obtained 46 locations at sea (n = 6–10 locations at sea murrelet^{-1}) for six murrelets during the period 19 June to 17 July (Fig. 1). Murrelets were found up to 124 km from the staging area in Fritz Cove or inland sites in the Mendenhall and Fish Creek watersheds. The most distant locations were from Icy Strait at the mouth of Glacier Bay. Overall mean distance of murrelets at sea from Fritz Cove or inland sites was 78 ± 27 km. On 20 occasions we detected murrelets inland on the same day that they were later located 75 ± 42 km away at sea.

DISCUSSION

FORAGING DISTANCES

This study provides the first direct evidence that Marbled Murrelets in southeast Alaska are traveling considerable distances (up to 250 km daily round trip) over water from inland sites (presumably nesting areas) to at-sea foraging areas in Glacier Bay and adjacent Icy Strait. Marbled Murrelets are still considered nearshore feeders, but telemetry studies have indicated that the extent to which they travel over water to foraging areas appears to depend on local geography. In other studies, radio-marked murrelets traveled relatively short distances over water, averaging 18 km and 21 km from nest sites in central California (E. Burkett, unpubl. data) and Prince William Sound, Alaska (Kuletz et al. 1995), respectively. However, in some fiord regions, murrelets apparently travel much farther over water to reach foraging areas. Extensive over-water foraging flights were speculated for murrelets in the fiords of Barkley Sound, British Columbia (Carter and Sealy 1990). Lindell, McAllister and van Vliet (in DeGange 1996) suggested, based on shipboard observations of murrelets using well-defined morning and evening ‘‘flyways’’ in Icy Strait, that the daily over-water foraging flights of murrelets likely exceeded 100 km in the inner passages and fiords of southeast Alaska, but this had never been confirmed by direct observation.

Indirect evidence collected during aerial and shipboard surveys of alcids at sea have long suggested that many species may forage far from breeding colonies when conditions warrant, but only recently has direct evidence concerning long-range foraging by alcids become available. Radio-marked Xantus' Murrelets (*Synthliboramphus hypoleucus*), presumed to be breeding, were located up to 170 km ($\bar{x}$ = 73 ± 34 km) away while they attended their colony at Santa Barbara Island, California (Whitworth et al., in press). Thick-billed Murres (*Uria lomvia*) fitted with distance-direction recorders traveled to foraging areas as far as 168 km ($\bar{x}$ = 83 ± 61 km, n = 9 flights) from their colony at Latrabjarg in northwest Iceland (Benvenuti et al. 1998).

Although high alcid wing-loading results in considerable energy expenditure to maintain the vigorous and rapid wingbeats necessary to sustain flight, long distance flights to dependable and predictable prey resources can be achieved rapidly. In such cases, foraging efficiency may be increased. During three studies in which marked alcids made long distance foraging flights, prey resources in the foraging areas could be considered predictable and dependable. Marbled Murrelets in Alaska traveled to a glacial sill (this study), Xantus' Murrelets in the southern California Bight flew to an upwelling zone (Whitworth et al., in press), and Thick-billed Murres in Iceland foraged at the edge of pack ice (Benvenuti et al. 1998).

Prey resources at our capture site in Auke Bay are patchily distributed, both spatially and temporally, as evidenced by variation in murrelet numbers there (Speckman 1996, G. van Vliet, unpubl. data). We observed large numbers of murrelets, including several radio-marked murrelets, in Fritz Cove and Auke Bay from late May through early June. By mid-June, most murrelets had departed the area. Shortly thereafter, we documented the long distance flights to and from Icy Strait by most radio-marked birds.

The mouth of Glacier Bay at Icy Strait is an oceanographically complex area which serves as an important feeding ground for a variety of marine animals, including several seabird and mammal species (Hale and Wright 1979, Krieger and Wing 1986). Tidal movement of fresh glacier water from Glacier Bay, upwelling over a large, shallow glacial sill at the mouth of the bay, and tidal forcing of marine waters through narrow inlets, results in turbulence, eddies, and convergent fronts which concentrate prey, including euphausiids (*Thysanoessa* spp., *Euphausia* spp.), sand lance (*Ammodytes* spp.), capelin (*Mallotus villosus*), and walleye pollock (*Theragra chalcogramma*; Krieger and Wing 1986; J. Piatt, unpubl. data). The rich feeding areas at the mouth of Glacier Bay appear to attract large numbers of Marbled Murrelets during the breeding season and support one of the largest foraging aggregations (> 10,000) in the species' range (Agler et al. 1998, DeGange 1996).

BREEDING STATUS AND INLAND ATTENDANCE

Frequent early morning visits by individual murrelets to specific inland sites indicated strong behavioral ties to those areas. We often observed numerous murrelets flying and calling overhead during early morning surveys in inland areas visited by radio-marked birds, areas which appeared to be good murrelet nesting habitat. However, murrelets were tracked to inland sites only for short periods (usually < 1.5 hr), which precluded following birds to nests. The activity patterns at inland sites and on the water by some of our radio-marked murrelets were not consistent with the 24-hr shifts expected of incubating birds (Nelson and Hamer 1995, Nelson and Peck 1995). It is possible that some murrelets had begun chick rearing by the time inland surveys were initiated, as murrelets were observed carrying fish during shipboard surveys in Icy Strait between 24–26 June. It also is possible that radio-marking resulted in nest abandonment by breeding murrelets, although studies using similar capture and marking techniques on Marbled Murrelets in British Columbia indicated few effects on actively-breeding birds (Lougheed 1999).

Marked birds observed on the water immediately after capture and on subsequent days exhibited normal foraging and flight behavior. Although one marked murrelet was preyed upon by a Bald Eagle, it is uncertain whether radio-marking was a contributing factor, as the remains of several unmarked murrelets also were found in the area. Another murrelet disappeared soon after marking, but studies using similar transmitters and radio-marking methods on murrelets and auklets have indicated that transmitter failures, and to a lesser extent attachment failures, accounted for a significant proportion of the birds not located (Newman et al. 1999).

Although some or all of the radio-marked murrelets may not have been actively breeding when tracked to inland sites, inland attendance by birds not actively breeding has been previously documented for radio-marked murrelets during the breeding season (E. Burkett, unpubl. data). Inland activity by murrelets has been observed throughout most of the year in central California and it has been speculated that this behavior is important for the maintenance of nest sites, territories, or pair bonds (Naslund 1993).

Long-distance movements of murrelets from Auke Bay to Glacier Bay during the breeding season has significant implications in terms of determining murrelet abundance and distribution in the region. Murrelet nesting biology precludes using censuses at breeding areas to obtain population estimates. Surveys of "flyways" (Strachan et al. 1995, DeGange 1996) or at-sea surveys (Agler et al. 1998) during the breeding season could yield valuable information on murrelet populations in the region, as well as document trends in murrelet populations over time. However, the extensive seasonal and daily variability in murrelet distribution at sea, demonstrated during this study and a recent banding program in British Columbia (Beauchamp et al. 1999), complicates efforts to census murrelets over large geographic ranges and long time periods (Agler et al. 1998). Large scale surveys should be performed over the shortest feasible time periods, and areas of known high murrelet densities should be surveyed concurrently to avoid missing or double counting birds. The tendency for murrelets from throughout southeast Alaska to aggregate over a relatively small area in Glacier Bay and Icy Strait may leave them vulnerable to local at-sea threats such as oil spills and gill-net mortality. Further studies with larger sample sizes and more extensive survey efforts are desirable to better understand the behavior and movement patterns of murrelets in southeast Alaska.

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PLUMAGE BRIGHTNESS AND BREEDING-SEASON DOMINANCE IN THE HOUSE FINCH: A NEGATIVELY CORRELATED HANDICAP?[1]

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Abstract. A variety of observations indicate that the carotenoid-based coloration of male House Finches (*Carpodacus mexicanus*) is an honest signal of quality. Plumage redness in this species positively reveals male nutritional condition, over-winter survival, and nest attentiveness. As a result, in the breeding season, male House Finches with brighter ornamental plumage are preferred by females as social mates over males with drabber plumage. In the nonbreeding season, however, bright red plumage does not seem to confer an advantage in aggressive interactions, as males with drabber plumage tend to dominate males with brighter plumage. We investigated this apparent paradox by conducting a breeding-season dominance experiment us-

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