Inland Flight Patterns of Marbled Murrelets, *Brachyramphus marmoratus*, on the Queen Charlotte Islands, British Columbia

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Numerous published field accounts indicate that Marbled Murrelets (*Brachyramphus marmoratus*) leave the ocean at dusk and fly to unknown destinations inland during the breeding season. We describe here characteristics of the frequent flight activity of murrelets observed at Coates Lake, 6 km from the west coast of the Queen Charlotte Islands, British Columbia. Most flights between the lake and the ocean occurred within 30 minutes of sunrise and sunset. Bidirectional flights occurred during both periods. Morning flights were often circular over the lake and included frequent vocalizations while evening flights trended to be unidirectional and silent. We observed repeated use of characteristic flight paths through the old growth forest around the lake during particular time periods (± 5 minutes) on successive nights. Some of these flight paths terminated at particular trees; we observed single birds or pairs of murrelets in trees on fifteen occasions. One of these is interpreted as a mating event while others appear to represent feeding flights from the ocean to presumed prefledglings in the trees. Since nesting sites of this species are largely unknown, our observations suggest that the high fidelity of flight paths can be exploited to locate potential nesting trees.

Key Words: Marbled Murrelet, *Brachyramphus marmoratus,* inland flight, nesting areas, Queen Charlotte Islands, old growth forest, reproductive behaviour.

Marbled Murrelets (*Brachyramphus marmoratus*), one of the common alcids in Pacific coastal waters, are exceptional among alcids in nesting solitarily, often at considerable distances from the ocean and in a diversity of habitats (Drent and Guiguet 1961; Day et al. 1983). Despite decades of field surveys, only 12 nests have been found (Sealy 1974a; Carter and Sealy 1986) and these are geographically distant. Adult birds are common in nearshore oceanic waters during summer and are regularly observed flying inland during the breeding season (Summers 1974; Sealy 1974b). However, since these flights occur at the onset of darkness, specific nesting areas or general destinations inland have not been determined.

During a five-year survey of aquatic birds at Drizzle Lake (Reimchen and Douglas 1984a), in the north-eastern Queen Charlotte Islands, several Marbled Murrelets were occasionally observed during summer and were suspected of nesting in adjacent forests. Unlike observations within the forests, lakes provided a large open area of high visibility where flight patterns could be observed and vocalizations heard. As such, during ichthyological surveys of lakes throughout the Queen Charlotte Islands (Reimchen, unpublished data), general observations of murrelet activity were made (Reimchen 1991). Three lakes with relatively high murrelet flight activity were discovered, of which one was chosen for systematic observation. We describe here the frequency, direction and daily pattern of flight activity. Our results suggest that nest sites can potentially be located with these methods.

Methods

Preliminary observations on flight activities of Marbled Murrelets at Coates Lake (53°40'N, 132°51'W), were made June 1982 (by TER) while extended observations were made daily from 1 June to 3 August, 1986 (by AEE). This lake (elevation 35 m) is 2.2 km long and lies approximately 6 km up a forested valley from the west coast of Graham Island, the largest island in the Queen Charlotte Group. The surrounding old-growth forest is a mixture of Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*), Western Red Cedar (*Thuja plicata*), and Yellow Cedar (*Chamaecyparis nootkatensis*). The canopy ranged from about 40 m to 70 m in height. Ground cover was predominantly moss (80-100%) over deadfall (10-30%). The valley was bordered to the north and south by ridges (to 700 m) with subalpine scrub forest of Lodgepole Pine (*Pinus contorta*) and cedars and some alpine vegetation.

An initial survey (2-5 June) of murrelet flight activity consisted of overnight surveillance from the lake shore and from three points along the north ridge. Subsequently, most observations were made from a gravel bar near the southeast corner of the lake and from an inflatable raft about 200 m

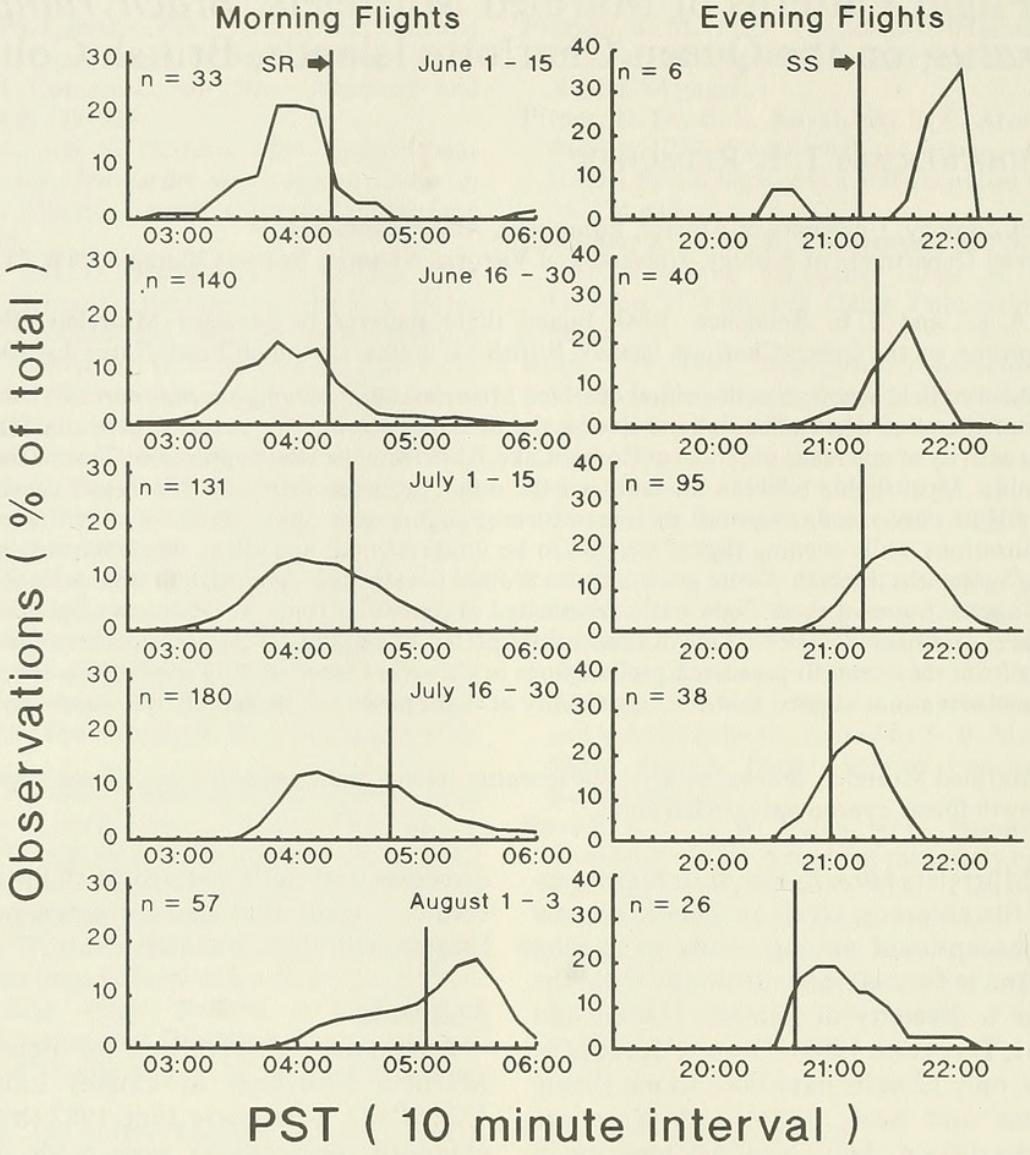

FIGURE 1. Dawn and dusk flight frequencies per ten minute period (PST), averaged over two week periods. Local astronomical sunrise (SR) and sunset (SS) are indicated. Numbers of observation days for biweekly time blocks are 7, 15, 6, 11 and 3 days respectively for dawn flights and 10, 15, 6, 12 and 3 days, respectively, for dusk flights.

from the shore. On about one-half of the nights, interspersed over the study period, flights were monitored at a number of locations in the surrounding forests. Activity was initially monitored continuously but observations periods were later reduced when it became apparent that most flight occurred near dawn and dusk. The characteristic whistling sound of murrelets' wingbeats and frequent vocalizations allowed detection of flight at darkness. For recording data, we considered a single "flight" as the full interval between when a murrelet was initially detected (visual or aural) until it could no longer be followed. During brighter periods before dusk and after dawn, we were able to note whether the flights were comprised of single birds or groups. Directional sources of weak vocalizations were determined with a parabolic microphone mounted on a rotating tripod. All times are given in Pacific Standard Time (PST).

Results

The survey of the ridge north of the lake yielded no evidence of murrelets in these high elevation habitats but calls were heard to come from the valley towards the lake. Observations on the lake shore immediately preceding and following the ridge survey showed extensive vocal and flight activity indicating that the lake and surrounding forests, rather than the ridges, were the active areas.

Flights occurred near dawn and dusk with no detectable activity during daylight (0700-2000 h) or "darkness" (2300-0230). Peak activity in the morning was about 30 minutes before sunrise throughout the observation period while most

evening flights occurred about 45 minutes after sunset in early June but thereafter occurred near sunset (Figure 1). Overall, dawn flights appeared to be more frequent than evening flights ($\bar{x}$ = 12.9/d, range 1-50 vs $\bar{x}$ = 4.5/d, range 0-22 respectively, $t = 3.57$, $P < 0.001$, $DF = 72$, unpaired t-test).

At dawn, the first flights (generally detected by vocalizations) originated from the forest adjacent to the lake. When visible, the birds flew in circular or other circuitous patterns over the lake and surrounding forest generally 100-200 m above the lake surface and treetops. These flights were comprised of single birds (N = 112), pairs (N = 26) and occasional small groups (3-5) (N = 4). Vocalizations were prevalent. Although flights were bidirectional, there appeared to be a net movement towards the ocean: the first flights detected were from the surrounding forests and the last flights from the direction of the sea.

In contrast, evening flights tended to to be unidirectional and silent. Inland (easterly) flights were more frequent than seaward (westerly) flights (68 versus 39 respectively) and generally occurred about 10 min earlier (Figure 2). Flights were predominantly singles (N = 85) and secondarily pairs (N = 6). Some flights followed consistent routes leading from the lake through particular gaps in shoreline trees to destinations in the forest. Some of these flight paths were "tracked" (by observations on successive nights) about 1 km up the south valley while two others were traced along a tributary creek to about 300 m up the valley. In one of these monitored from 19-30 July, not only was there fidelity of flight paths but these were consistent to within 2-5 minutes on successive evenings. Pairs of murrelets were occasionally seen flying into the forest on one of these routes yet occasionally, in 3-4 minutes, a single bird would return along the same flight path heading in the direction of the lake. That the second bird did not return, despite continuous observation for several hours, suggests that it remained in the forest during the night.

Marbled Murrelets were seen in large trees on fifteen distinct occasions and at seven localities. These were either trees on the lake shore or adjacent to openings in the forest canopy up to about 1 km from the lake. Most of these sightings involved brief visits in which the murrelets landed on higher branches, remained for up to five minutes and then departed. In one instance (13 June) during continuous observation at a tree, a single murrelet stayed overnight approximately two-thirds of the way up a Sitka Spruce on the lake shore and then departed at dawn. It was not seen on successive nights.

The most extensive observations of tree-associated activity were made at a large hemlock (est. 50 m tall, 1.2 m dbh) about 20 m from lake shore. On 8 June, beginning at 03:48, two murrelets repeatedly circled the tree in broad arcs and landed (14 times) on a branch about 35 m above the base of the tree and remained for 1 to 20 seconds. They were not visible when sitting on the branch. Seven of these landings were short duration (less than 5 seconds) and occurred when one of the murrelets appeared to fly onto the back of the leading bird as it landed. Although the birds were lost from sight during this brief interval, wing-flapping was heard on each occasion. Following these events, the birds flew over the lake

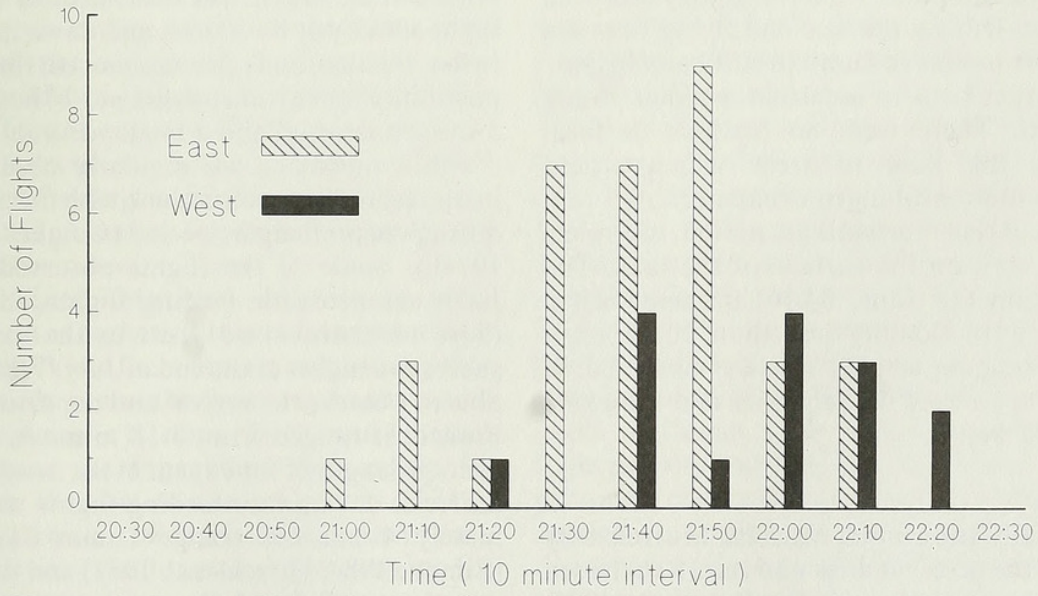

FIGURE 2. Evening flight directions per ten minute period (July only). Only visual sightings included.

and were lost from sight. On the following morning, at 03:50, two murrelets again flew to the tree, remaining on the branch for 16 minutes (no wing-flapping heard). This behaviour was repeated on the subsequent morning (10 July) during the same time period (03:52-04:07). No murrelets were observed in the vicinity of the tree on the next three nights and continuous observations at this tree were abandoned. Over the next week, the tree was monitored on five nights (7, 8, 9, 13, 14 July) but no activity was observed.

Observations of this tree were resumed on the evening of 31 July. At 21:11, a single murrelet landed on the tree, remained for three minutes, after which it departed and flew north across the lake and was lost from sight. On 1 August, at 20:56, a single murrelet attempted to land on the tree, but failed and flew over the lake. At 20:57, a murrelet, probably the same individual, approached from the lake and landed on the tree. In three minutes (21:00), a single call was heard from the tree and at 21:02, a second bird approached from the lake and landed on the tree. At 21:03, a single bird departed the tree and flew low over the lake. Over the next 17 minutes, a single call was heard from the lake. At 21:20, a second call was heard from the lake and within 2 seconds, the second murrelet departed from the tree. No more activity was observed at or near the tree that evening. On the following evening, at 21:06, a single bird, which appeared to be carrying a fish, flew to the same tree but failed to land and circled over the lake. Thirty seconds later, a murrelet (probably the same individual) landed on the branch. This branch was about 5 m higher than that used in early June. At 21:08, a second murrelet approached from the lake and landed on the branch. In three minutes, a single bird left the branch and flew over the lake. At 21:21, a single call was heard from the tree, immediately followed by a murrelet leaving the tree and flying over the lake. We were unable to climb to sufficient heights on this or other trees to ascertain whether young were present. There were no feathers or fecal material at the base of trees which would substantiate more prolonged occupancy.

Throughout the observational period, murrelets were rarely seen on the surface of the lake. The single occasion (18 June, 04:50) occurred when three birds were floating less than 10 m from shoreline. Foraging activity was not observed. It appeared that all were the same size and were able to fly equally well.

Discussion

It is generally known that Marbled Murrelets fly inland from the ocean at dusk and return to the sea by dawn (Sealy 1974a, 1975b; Summers 1975; Simons 1980; Carter and Sealy 1986). Our data indicate a relatively consistent pattern throughout summer with most flight activity occurring just before sunrise and just after sunset, roughly coinciding with the duration of civil twilight. At this latitude, there is no true darkness during June and July since astronomical twilight extends the entire period between sunset and sunrise (Anonymous 1946). However, we observed no substantive evidence for flight during the exceptionally low light levels beyond civil twilight. While visual detection of this flight would be difficult, the cessation of wing-beat sounds as evening darkness arrived and the onset of wing-beat sounds and vocalizations at dawn twilight strongly suggest an absence of "nocturnal" flight.

Copulation has not yet been observed in Marbled Murrelets and it is assumed that it occurs during darkness either on the ocean or near the nest site (Sealy 1975). The behaviour we observed of the two murrelets on branches is very suggestive of a mating sequence. The repeated short duration landings, associated wing-flapping and the equivalent behaviour on the following night, although not on successive nights, are all consistent with a ritualized behaviour which is very seasonally restricted. Egg-laying period in the Marbled Murrelet extends from 15 May to early July (Sealy 1974a) and thus the behaviour is also within the appropriate time period. That individuals were observed again on the tree at the end of July, in what may have been a feeding sequence, is further support. Each of these events in themselves could have numerous interpretations yet in concert, they support the initial impression of a mating event.

Marbled Murrelets exchange incubation duties during darkness and indirect evidence suggests this occurs every 24 hours (Sealy 1975, Simons 1980, Hirsch et al. 1981). Our observations which show flight activity at both dusk and dawn in early June (when incubation is probably occurring) raise the possibility for two exchanges per 24 hour period — a short nocturnal and a longer diurnal shift.

Adult murrelets are regularly observed flying inland from the ocean at dusk with fish in their bills during the prefledging period (Guiguet 1956; Sealy 1974b). Some of the flights observed at Coates Lake are probable feeding flights, in particular those which involved visits to the same tree on successive nights at the end of July. Where we were able to observe the arrival and departure from the branch, it ranged from 3-18 minutes. In Alaska, average length of time spent at the nest by the adult murrelet during four feeding flights was approximately 4 minutes (range 1 min 34 s - 8 min) (Simons 1984; Hirsch et al. 1985) and therefore the durations at Coates Lake were within the expected range for a feeding sequence. It is interesting that in

these presumed feeding flights, adults arrived at the lake at dusk in pairs. Sealy (1974a) also observed that during the prefledging period, pairs of adults occurred on the ocean during the day and flew inland at dusk, both with fish in the bills. This indicates that the prefledged young is left unattended during the day. There is indirect evidence that during darkness, the young is attended on some occasions but not on others. We observed pairs at dusk flying into the forest but within several minutes a single adult returned along the same flight path. As well, in July, evening seaward flights were observed about half as frequently as (and slightly later than) westward flights (Figure 2) further suggesting that some birds are overnighting in these forests. Yet, the observations at the end of July showed both adults arriving and leaving the tree at dusk. In both these instances, an additional feeding could occur at dawn if one or both of the adults returned. Although we have assumed that these flights represent breeding adults, we cannot exclude the possibility that individuals are non-breeders. However, if these were non-breeding adults, it seems likely that individuals would remain on the trees overnight rather than for several minutes.

The extensive circular and highly vocal flight activity over the lake surface, and extending well beyond sunrise, has not been previously described in Marbled Murrelets. Similar behaviour, in which up to 11 individuals were involved, has also been noted at a lake on the north-eastern corner of Graham Island (Reimchen, 1991). Previous studies on Marbled Murrelets indicate unidirectional flights at least near the ocean (Summers 1974; Simons 1980). The significance of this circular flight activity is unknown. Since the accompanying vocalizations came from birds in flight, possibly it represents a vocal stimulus or invitation to the prefledglings or attending adults in the nests. The departure of the single adult from the tree following a call from the lake is consistent with this suggesiton. That the circular flights and vocalizations were observed only in the morning and were absent in the evening is further suggestive of a "holding pattern" and vocal stimuli prior to the departure to the ocean.

Newly fledged Marbled Murrelets were observed at sea as early as 6 July at Langara Island (Sealy 1974b). While there remain suggestions that prefledged birds can make their way to the ocean on the ground or via streams (Drent and Guiguet 1961), it seems more probable that young fly directly from the nest to the sea (Sealy 1974a). Coates Lake, which is connected to the ocean via a wide stream offers substantive opportunity for stream migration. Yet, our observations, made throughout the pre-fledging period, indicated no evidence of young birds on the lake surface and we strongly suspect (in agreement with Sealy 1974a) that young murrelets fly directly from the nest to the ocean.

Occasional site records of Marbled Murrelets on freshwater lakes led Carter and Sealy (1986) to suspect that inland lakes near breeding areas may be regularly used as foraging or staging areas. Data on Coates Lake and those from Drizzle Lake (Reimchen and Douglas 1984a), demonstrate exceptionally infrequent use of the lake surface. Perhaps, as suggested for the marine foraging of the Red-throated Loons on these lakes (Reimchen and Douglas 1984b), the proximity of the nesting habitat to the ocean where prey of appropriate sizes are abundant, limits utilization of freshwater habitat.

Nesting areas of Marbled Murrelets, which include a diversity of habitats, are suspected of being most prevalent in old-growth forests (Savile 1972; H. Carter, personal communication). This is certainly supported from our observations at Coates Lake in which flight activity was common in the forested regions but rare in the sub-alpine. Direct access to large trees along the shore or adjacent to open areas in the canopy may make these areas favourable nesting sites. At Drizzle Lake, on the eastern regions of Graham Island, in a broad expanse of *Sphagnum* bog and scrub coniferous forests, Marbled Murrelet flight activity was exceptionally uncommon throughout the year including the periods when activity should have been greatest (Reimchen and Douglas 1984a). Yet an additional lake in the lowland region, which differs in being surrounded by several ridges with old-growth forest, murrelet flight activity (July 1986; Reimchen, 1991) was as extensive as that observed at Coates Lake.

Numbers of Marbled Murrelets occupying the area around Coates Lake cannot be reliably determined at present although estimates are possible. The east end of the lake, where most observations were made has at least seven birds as this is the number observed in flight at a single time. Since the observational area represents about 10% of the valley, and assuming similar densities around the lake, up to 70 birds are present. This could be a highly conservative estimate since only a fraction of the birds would be active at any single time. Comparable numbers may occur at a lake surrounded by moss-laden forests five km to the north of Coates Lake where extensive low level flight activity was also observed (June 1982, TER, personal observation). Nesting habitat of this species is subject to widespread geographical disturbance (Carter and Sealy 1984), and therefore the impending logging of these old growth forests is a major threat to the murrelet populations.

Of the twelve known nest sites of Marbled Murrelet discovered within the last century, all have been found largely by accident rather than as the result of a systematic search (Carter and Sealy 1986). Our observations on flight paths of Marbled Murrelets at Coates Lake have identified, over a relatively short period, seven trees where potential nests may be located. The fidelity of flight paths on successive nights provides a valuable technique of following and identifying destinations of individual birds. It was evident to us that with additional field observers at this locality, each concentrating on a different flight path, many more potential nesting trees would have been identified.

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