

MARbled MURRELET *BRACHYRAMPHUS MARMORATUS* USE OF A FRESHWATER LAKE ON VANCOUVER ISLAND, BRITISH COLUMBIA, 2018–2023

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ABSTRACT

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Marbled Murrelets *Brachyramphus marmoratus* are small seabirds widely distributed in nearshore waters on the west coast of North America, from Alaska to central California. A 1986 review of anecdotal records revealed that Marbled Murrelets use coastal freshwater lakes during the breeding season, possibly to forage, and in winter, possibly while prospecting for nest sites in old-growth forest. Our weekly surveys and observations on Sproat Lake (central Vancouver Island, British Columbia, Canada) from November 2018 to March 2023, confirmed year-round use by murrelets, with absences during the prealternate molt (beginning mid-March) and the prebasic molt (August and September), when the birds were probably at sea. Putative pairs predominated in all months, which suggests mated adults; single murrelets were recorded infrequently when pairs would have been separated during incubation. Murrelets were not observed holding prey, and fledglings were not recorded on the lake. The emerging importance of freshwater lakes and their watersheds as an aspect of Marbled Murrelet life history requires further research, particularly in light of this species' possible sensitivity to human recreational and other disturbances when using lakes. Identification of recurring use of freshwater lakes, such as Sproat Lake, by Marbled Murrelets could inform conservation actions directed toward potential nesting habitat in nearby old-growth forests.

Key words: annual cycle, *Brachyramphus marmoratus*, breeding status, freshwater resources, group size, Marbled Murrelet, Sproat Lake

INTRODUCTION

In the decades following the discovery that the Marbled Murrelet *Brachyramphus marmoratus* (hereafter, murrelet) nests in old-growth trees—some located more than 75 km inland from the sea—researchers have focused mainly on the species' at-sea distribution, attributes of breeding biology and populations, terrestrial habitat associations, and timing and progression of molt. The non-breeding season has received less attention (but see Naslund 1993, O'Donnell *et al.* 1995, Parker *et al.* 2003, Pearson *et al.* 2022). Observations beginning in the early 1900s revealed that Marbled Murrelets use freshwater lakes during the breeding season, as well as during the non-breeding season (i.e., fall and winter) in regions where lakes do not freeze (Carter & Sealy 1986). Of the 67 records compiled by Carter & Sealy (1986) at 33 lakes from the US states of Alaska, Washington, and Oregon, and in the province of British Columbia (BC) in Canada, 57 originated from lakes in BC, mostly on Vancouver Island. Carter & Sealy (1986) hypothesized that Marbled Murrelets frequent lakes during the breeding season to forage and during the winter while prospecting for nest sites in nearby old-growth forest. This hypothesis is supported by stable-isotope analysis (Hobson 1990). We extended Carter & Sealy's (1986) study by recording the presence of Marbled Murrelets throughout the annual cycle at Sproat Lake, a large freshwater lake west of the city of Port Alberni on central Vancouver Island (Fig. 1).

Our study was stimulated by observations on 01 January 2018 of two widely separated pairs (hereafter, duos) of Marbled Murrelets

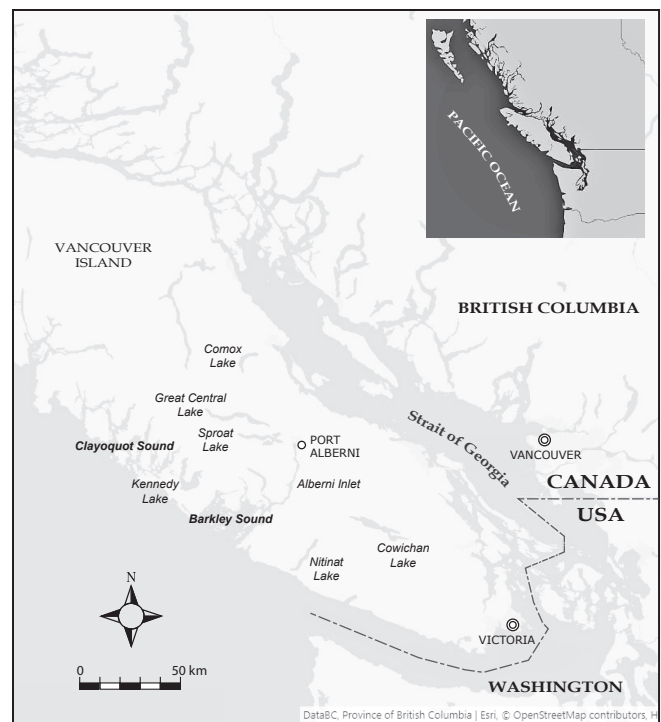


Fig. 1. Lakes on central and south Vancouver Island, Canada, where Marbled Murrelets *Brachyramphus marmoratus* have been reported (small lakes not shown). The inset shows coastal British Columbia, Canada; Washington, USA; and the northern part of Oregon, USA.

swimming and diving on Kleekoot Arm, the northeastern arm of Sproat Lake. The presence of Marbled Murrelets on the lake in January through February suggested to us that the birds were not vagrants. We conducted weekly surveys of Marbled Murrelets at Sproat Lake from November 2018 through March 2023 to document seasonal use and to determine whether attendance is related to demands of nesting and molt.

Federally designated as Threatened in Canada (COSEWIC 2012) and Blue-listed in BC (i.e., of “special concern...particularly sensitive or vulnerable to human activities or natural events”; BCCDC 2023), there were an estimated 99 100 (range 72 600–125 500) Marbled Murrelets in BC in 2007. This amounted to about 28% of the world’s population, of which most were in Alaska (~67%, ECCC 2023). The estimated number for Vancouver Island in 2007 was 22 650 (19 700–25 600; ECCC 2023), nearly a quarter of the BC population. However, the overall population trend for BC is one of decline, calculated at –2.4% per year based on radar counts in breeding areas from 1996 to 2018 (Drever *et al.* 2021). The current size of BC’s Marbled Murrelet population is not accurately known, but using the annual growth rate of –2.4% and extrapolating the 2007 data to 2023 (+16 years), we arrive at a rough estimate of 67 200 (49 200–85 100) birds [from $N_t = N_0(1 + r/100)^t$, where N_0 = estimated population size in 2007, $r = -2.4$, and $t = 16$]. A similar calculation for Vancouver Island gives a current estimate of ~15 400 Marbled Murrelets.

The number of Marbled Murrelets using individual lakes is small relative to the total population, but collectively, Sproat Lake and other lakes provide habitat of underappreciated importance. As lake use by Marbled Murrelets may indicate the presence of nesting territories in nearby forested watersheds, it is a conservation imperative to identify the species’ year-round habitat on both Vancouver Island and the south coast of the province.

STUDY AREA AND METHODS

Sproat Lake is ~24 km long and is shaped into four arms (Kleekoot Arm, Taylor Arm, Two Rivers Arm, Stirling Arm) that converge at 49.261°N, 124.966°W (Fig. 2). At an elevation of approximately 32 m above sea level and with a surface area of ~37.8 km², Sproat Lake averages 66.5 m deep, with a maximum depth of 195 m (Michalski & Schlag 2014). The water level fluctuates seasonally but is highest in winter and lowest in summer. Of the lake’s freshwater inputs, Taylor River at the western end of Taylor Arm is the largest. Sproat Lake drains into the Sproat River at the eastern end of Kleekoot Arm. The nearest body of saltwater is Alberni Inlet, which is 5–6 km southeast. Like most large lakes on Vancouver Island, Sproat Lake is cold and oligotrophic (Michalski & Schlag 2014).

Kleekoot Arm (also known as Faber Arm) and Stirling Arm are surrounded by homes or recreational properties, whereas the shores and upland areas of Two Rivers Arm and Taylor Arm are sparsely developed. Taylor Arm is fjord-like, long and narrow with steep, forested sides along much of its length. Kleekoot Arm is the most accessible for year-round observations, via Sproat Lake Provincial Park (SLPP) on the arm’s eastern side. Potential Marbled Murrelet nesting habitat has been mapped in watersheds surrounding Sproat Lake through a combination of habitat modeling (Mather *et al.* 2010) and standardized low-level aerial surveys (J.L. Cragg, BC Ministry of Water, Land and Resource Stewardship, pers. comm.,

14 July 2023). Most of this potential nesting habitat is located to the south and west of Sproat Lake, nearest to Two Rivers Arm and Taylor Arm, in the adjacent Nahmint Lake and Kennedy River drainages (J.L. Cragg, pers. comm.).

Surveys

Following an observation of four murrelets on 01 January 2018, we recorded individuals through a spotting scope weekly (when possible) in January and February 2018, and again in November and December of that year. Throughout 2019–2022 and the first three months of 2023, we conducted all surveys at Kleekoot Arm from the shore of SLPP and, less often, from the privately owned Kleekoot Marina, which overlooks the bay on the western side of the arm (West Bay). In the spring of 2020, because SLPP was closed from 08 April to 14 May due to COVID-19 restrictions, we surveyed from Kleekoot Marina. The areas of Kleekoot Arm covered by our surveys are indicated in Fig. 2. Murrelets were found usually within 1 km of the survey stations, but sometimes they tracked up to ~1.5 km away; two anchored markers (each ~0.7 km from the main survey location at SLPP) aided in estimating distance. We

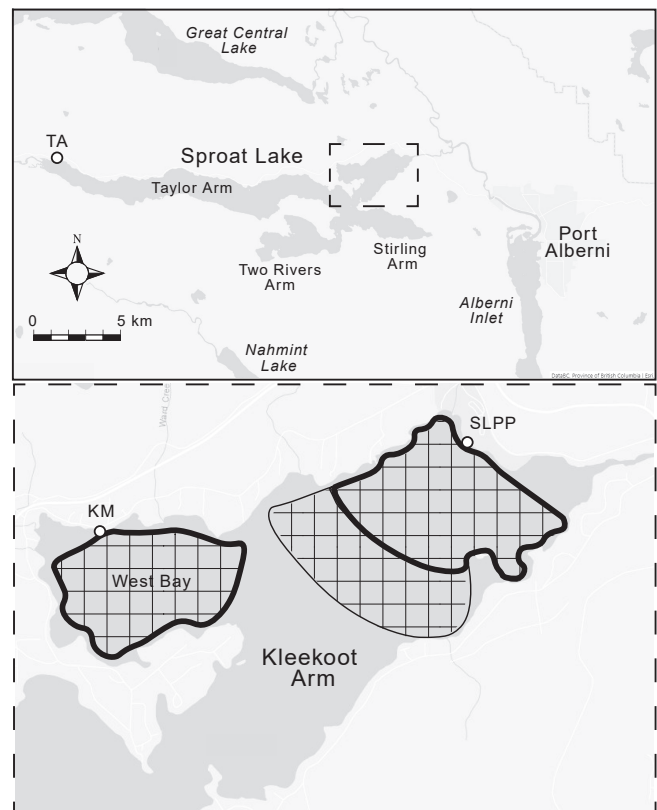


Fig. 2. Sproat Lake on Vancouver Island, British Columbia, Canada, with its four arms. Sproat Lake Provincial Park (SLPP) and locations from which observations of Marbled Murrelets *Brachyramphus marmoratus* were made are identified by white circles. KM = Kleekoot Marina, TA = Taylor Arm survey spot. Inset: Kleekoot Arm and areas covered by the survey locations at SLPP and KM. Thick outlines + hatching indicate areas out to ~1.5 km; the thin outline indicates the area out to ~1 km. Base maps were obtained from iMapBC (<https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc>) and modified using Adobe Illustrator.

conducted surveys during a range of weather conditions, but if mist, heavy rain, snow, or rough water prevailed, we attempted to return later that week. Morning fog over the lake from November through March necessitated surveys in early afternoon (~13h00–15h30), but when visibility improved, surveys were generally made in the morning (~08h30–11h00) when fewer recreational boats were active, especially in June through August. Limited surveys at the westernmost end of Taylor Arm were made from a point on the north shore, ~350 m east of an undeveloped campground near the Taylor River estuary.

For each encounter, we recorded group size and plumage as a proxy for timing of molt of the basic or alternate plumage, or plumages in transition. Plumage types are gross descriptions, as they were limited by viewing distance, prevailing light, and weather conditions. All observations were of murrelets swimming and diving. We interpreted diving, often repeatedly, as foraging (see Carter & Sealy 1990) and recorded whether each bird surfaced holding a fish in its bill.

For reporting survey counts, we divided each month into three 10-day periods (following Fig. 10 in O’Donnell *et al.* 1995). The survey effort at Kleekoot Arm averaged 2.26 h/period in 2019, 1.60 h/period in 2020, 3.17 h/period in 2021, 2.74 h/period in 2022, and 2.91 h/period in 2023. Details of the survey effort and the number of murrelets observed per hour in each period and year are given in Appendix 1 (available online).

Records of Marbled Murrelets at coastal lakes in North America

We updated Carter & Sealy’s (1986) list of coastal lakes used by Marbled Murrelets by extracting records of on-lake sightings in published accounts and from the eBird database (Sullivan *et al.* 2009). From eBird, we reviewed all records of Marbled Murrelets identified by markers on or near lakes from Alaska to Oregon; there were no records for California. We accepted eBird checklists backed by photographic or descriptive support, or ones submitted by field biologists. We contacted the originators of some of the checklists to obtain additional information. All records refer to birds observed on water. Our last eBird search was conducted on 24 October 2023.

RESULTS

Attendance on Sproat Lake

We detected murrelets in all months, but the numbers of individuals were spread unevenly among months and between some years (Fig. 3A). We recorded the highest single-day count (18 murrelets) on the afternoon of 04 February 2018: six birds on Kleekoot Arm and 12 on the west end of Taylor Arm (Appendix 2). In 2019–2022 at Kleekoot Arm, we recorded up to eight birds/survey from November to late February, up to three birds/survey in March through May, and up to six birds in June and/or July (except in 2020). Murrelets were scarce or absent in August and September: we detected only one murrelet in August (2021) in all years, two birds/survey twice in September 2019, and two birds in one survey in September 2022 (Fig. 3A).

Two intervals of reduced numbers stand out across years, the first spanning the latter half of March and part of April, and the second spanning August and September (Fig. 3A). These

intervals coincide with the prealternate molt and the prebasic molt, respectively (Fig. 3B; Carter & Stein 1995). For example, on 08 March 2021 we observed two individuals, both in basic plumage. The next sightings on 15 April were of two individuals in alternate plumage, whereas a third bird still had white patches near the rump. Subsequent sightings, recorded on 25 April and in June/July, were of birds in alternate plumage. On 11 August, a lone murrelet initiating the prebasic molt showed a lighter coloration about the head and neck. We did not see this molting

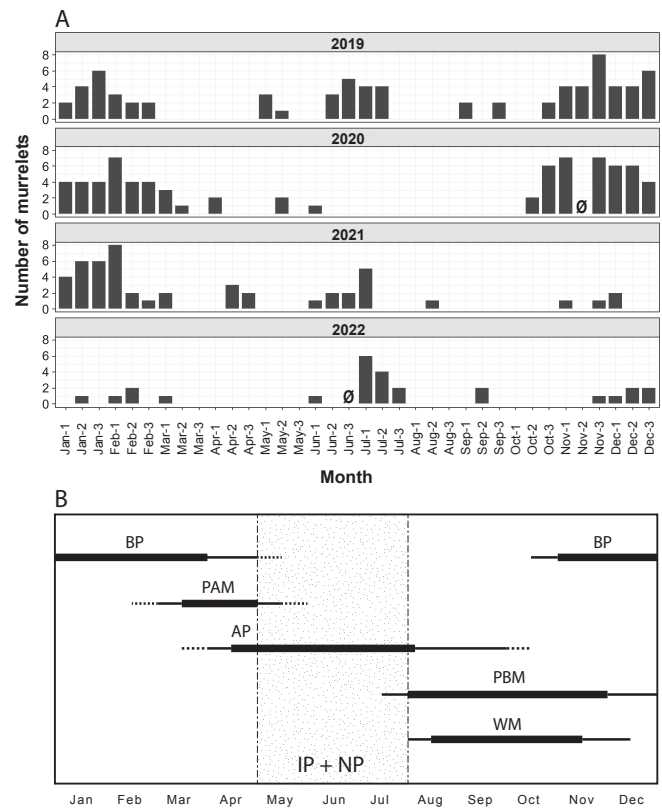


Fig. 3. A) Number of Marbled Murrelets *Brachyramphus marmoratus* present or absent on Kleekoot Arm of Sproat Lake, British Columbia, Canada, 2019–2022. Each month is divided into three periods: days 1–10, 11–20, and 21–last. Surveys were conducted in every period except two, which are indicated by Ø (period 2 in November 2020 and period 3 in June 2022); in all other periods, zero values indicate that no murrelets were observed. If more than one survey was conducted within a period that resulted in a different count, the higher number is shown. Serial observations, especially neighboring ones, in these time series may not be independent because they may include counts of some of the same individuals. B) Schematic representation of plumage, molt, and breeding phenology of the Marbled Murrelet in Barkley Sound, British Columbia, 1979–1980 (modified from Carter & Stein 1995). BP = basic plumage, PAM = prealternate molt, AP = alternate plumage, PBM = prebasic molt, WM = wing molt. The thick portions of the bars indicate timing for a “large portion of the population”, while the thin portions indicate the “usual range” (Carter & Stein 1995); dots at the ends of the bars indicate uncertainty as to when the phenomenon begins/ends. The stippled central area represents the breeding phase, which occurs mainly in May, June, and July, but may extend to mid-September for some pairs (Carter & Stein 1995). IP = incubation period, NP = nestling period.

bird again, and the next murrelet we observed, on 02 November, was a singleton in basic plumage. Three more birds, observed in late November and early December, were in basic plumage. Across all years, we did not detect any recently fledged young, which are distinguishable by plumage and size (Carter & Sealy 1987a, Carter & Stein 1995, Gutowsky *et al.* 2010).

Comparing across years, the numbers of murrelets recorded in November 2021 through February 2022 and during winter 2022/23 were lower compared to the same months in 2018–2020 (Fig. 3A, Appendix 2). This trend is also reflected in the declining number of murrelets observed per hour of survey effort from 2019 to 2023: mean 1.94 murrelets/h in 2019; 1.97 in 2020; 0.57 in 2021; 0.33 in 2022; 0.23 in 2023 (January through March) (Appendix 1). The decline across 2019–2022 (complete-survey years) is significant: $p < 0.05$; Kruskal–Wallis test: $\chi^2 = 10.44$, $df = 3$, $p = 0.015$. Statistical analysis was conducted in R, version 4.1.2.

Group size

We detected murrelets in groups of one, two, and three, but none greater than three (Table 1). Duos predominated, probably a male and a female (Evans Mack *et al.* 2004), but because individuals were not sexed, we refer to such pairs as duos (Appendix 3). Duos remained separate from one another during our observations (Appendix 3), which supports their classification as group size = 2. We observed just one trio, on 04 March 2020.

The percentage of duos for all four complete-survey years combined (79.5%) was heavily weighted to 2019 and 2020. This is because the proportion of duos was lower in 2021 and 2022, when we detected fewer murrelets overall (Table 1). For example, during the winter surveys in 2018, 30 of the 31 groups observed on Kleekoot Arm were duos (96.8%), whereas the last group was a singleton (Appendix 2). For 2019, we counted 35 duos (87.5%) and five singletons (12.5%); four of the latter were recorded in May and June (Fig. 3A). In 2022, however, 10 of 16 groups were duos (62.5%), whereas six were singletons (37.5%).

TABLE 1

Group sizes of Marbled Murrelets *Brachyramphus marmoratus* recorded on Kleekoot Arm of Sproat Lake, Vancouver Island, British Columbia, 2019–2022^a

| Year | No. of duos ^b (%) | No. of singletons ^b (%) | No. of trios (%) |
|-------------------------------|---------------------------------|---------------------------------------|---------------------|
| 2019 | 35 (87.5) | 5 (12.5) | 0 |
| 2020 | 36 (85.7) | 5 (11.9) | 1 (2.4) |
| 2021 | 20 (69.0) | 9 (31.0) | 0 |
| 2022 | 10 (62.5) | 6 (37.5) | 0 |
| Weighted average ^c | 79.5% | 19.7% | 0.8% |

^a From the count data in Fig. 3A.

^b Fisher's exact test of the number of duos and singletons recorded in 2019 or 2020 versus 2022 (the most divergent years) shows non-significant differences ($P > 0.05$): $P = 0.059$ and $P = 0.057$, respectively. Statistical analysis was conducted in R, version 4.1.2.

^c Sum of group percentages weighted by the following proportions: 0.315 for 2019, 0.331 for 2020, 0.228 for 2021, 0.126 for 2022.

Foraging

Duos tended to dive in unison. Despite observing numerous diving bouts, which we interpreted as foraging, we saw only one murrelet surface with a fish in its bill. On 17 February 2022, a duo was swimming and occasionally preening, when one bird dove and resurfaced 10–15 m away holding a small fish crosswise in its bill. Still holding the fish, it swam toward its putative mate but repositioned the fish lengthwise and swallowed it before reaching the other bird. Most murrelets must have consumed their prey underwater. We did not observe fish-holding Marbled Murrelets, albeit this behavior (described in Carter & Sealy 1987b) is known to be more frequent at dawn and dusk (Carter & Sealy 1990, Nelson 2020), i.e., outside our daytime survey window.

Flight

We observed murrelets in flight only twice at Kleekoot Arm. On 12 June 2021, a duo flew low above the water from the western side of the arm and landed close to SLPP. Another individual that was swimming and diving near SLPP on the morning of 07 June 2022 flushed and flew in a low zig-zag pattern over the lake toward West Bay. Otherwise, the birds remained on the lake during our surveys.

DISCUSSION

Attendance, molts, and breeding phenology

Our weekly surveys and observations of Marbled Murrelets on Sproat Lake from November 2018 to March 2023 confirmed year-round use, with absences during the prealternate molt (beginning in mid-March) and the prebasic molt (in August and September). To provide context for our observations, the annual cycle of molts, plumages, and breeding phenology of Marbled Murrelets in nearby Barkley Sound (~40 km south-southwest of Kleekoot Arm) is depicted in Fig. 3B, after Carter (1984) and Carter & Stein (1995). Carter (1984) noted that most Marbled Murrelets in Barkley Sound are in basic plumage in November through March and that the prealternate molt occurs relatively rapidly between mid-March and the end of April, which produces a cryptic alternate plumage prior to breeding. Breeding activity in Barkley Sound murrelets (represented by the combined incubation and nestling periods in Fig. 3B) occurs chiefly in May, June, and July, but this is asynchronous within the population and may extend into mid-September (Carter & Stein 1995). The prebasic molt, which involves both body and flight feathers, occurs in most Barkley Sound murrelets from early August to December and may last two to three months for each bird (Carter & Stein 1995). Our observations of the plumage and timing of molts of Sproat Lake murrelets (as described for 2021) are consistent with Carter's (1984) findings in Barkley Sound. We speculate that molting by the murrelets observed on Sproat Lake occurs at sea, possibly in Barkley Sound.

We found year-to-year variability in attendance on Kleekoot Arm. Specifically, we recorded fewer murrelets in November 2021 through February 2022 and during winter 2022/23, compared to the same months in 2018–2020 (Fig. 3A, Appendix 2). This difference may not be real because the presence/absence data for Kleekoot Arm may not be representative of Sproat Lake as a whole. Our sample size was small and murrelets may have occurred elsewhere on the lake; we did not survey Stirling Arm or Two Rivers Arm, and we rarely monitored the westernmost end of Taylor Arm. As

indicated above, our highest single-day count ($n = 12$) occurred on Taylor Arm in February 2018. Alternatively, the birds may have remained at sea.

Group size and reproductive behavior

Duos predominated our weekly observations, a trio was observed just once, and we did not observe group sizes greater than three, in contrast to larger aggregations recorded at sea by others (e.g., Hatler *et al.* 1978, Evans Mack *et al.* 2004). Group size is partly a function of local population size, so it is not surprising that groups on lakes are smaller than groups at sea, where hundreds of murrelets may congregate in one area (e.g., Burger 1995, Burger *et al.* 2008, Ronconi & Burger 2011). The difference could also be related to our daytime survey window; at sea, larger aggregations tend to form at dawn (Carter & Sealy 1990). Alternatively, it may be a peculiarity of murrelets attending certain lakes. For example, R.M. Stewart noted “seven or eight pairs of murrelets” in late April at Harrison Lake, BC (Brooks 1928), a large freshwater lake ~90 km east of the city of Vancouver, BC. Nonetheless, the preponderance of duos on Sproat Lake suggests the birds were mated pairs, reaffirmed occasionally by individuals engaged in the ‘bill-up display’ (Byrd *et al.* 1974; Appendix 3). Evidence from radio-tagged Marbled Murrelets revealed that successful breeders may maintain pair bonds for at least two years (McFarlane Tranquilla *et al.* 2003).

Do Marbled Murrelets that use Sproat Lake nest in nearby watersheds, as their presence and behavior during the breeding season suggest? Evidence for this is circumstantial. Our observations suggest that the birds were adults, as most were encountered in groups of two, probably a male and a female (Evans Mack *et al.* 2004). Specimens in breeding condition have been taken on two freshwater lakes elsewhere in BC: a Marbled Murrelet collected on Harrison Lake in late April 1928 was producing an egg (Brooks 1928, Sealy 2023), and the reproductive tracts of three males and one female taken on Johnston Lake (~75 km southeast of the city of Prince Rupert, BC) in June 1985 were in reproductive condition (see Sealy 1972, 1974; record #5 in Table 2; Appendix 4). Perhaps relevant to Sproat Lake, a recently fledged Marbled Murrelet (Beaty Biodiversity Museum #B019083; I. Szabo pers. comm., 25 March 2022) was found dead on 15 July 2021 in a watershed that drains into Taylor Arm (Henderson *et al.* unpubl. data).

Foraging

We did not observe fish-holding behavior. If murrelets were nesting near Sproat Lake, fish fed to their young may have been captured on the lake early in the morning or later in the day (Nelson 2020). Alternatively, they may have been captured elsewhere (perhaps in Barkley Sound, see Carter & Sealy 1990) and carried directly to nests, as possibly observed at Comox Lake (a freshwater lake 7 km southwest of the city of Courtenay, BC; record #11 in Table 2). The distance flown to Barkley Sound from Sproat Lake is plausible, considering those flown between the sea and inland sites in southern BC (Manley & Cullen 2003). Such distances have been confirmed by radio-tracking of Marbled Murrelets that foraged more than 100 km from their nest sites (Whitworth *et al.* 2000, Bradley *et al.* 2004, Lorenz *et al.* 2017). If suitable murrelet specimens become available, stable-isotope analysis may be used to distinguish between marine and lake origins of prey. Hobson (1990) applied this technique to tissues of Marbled Murrelets collected in Barkley Sound in July/August (10 male adults, eight female adults, one

hatch-year male) and at Johnston Lake in June (two males and one female, all adults). He found that $\delta^{15}\text{N}$ values did not differentiate between individuals that fed on freshwater or marine prey but $\delta^{13}\text{C}$ did; the Johnston Lake adults showed a lake signature. The hatch-year bird’s $\delta^{13}\text{C}$ value did not differ significantly from those of the Barkley Sound adults, which indicated it had been fed marine prey.

Our observation of a fish captured in winter (February 2022) augments those of fish captured by Marbled Murrelets at other freshwater lakes in BC during the breeding season (Carter & Sealy 1986). Sockeye Salmon *Oncorhynchus nerka* were apparently taken by murrelets at Great Central Lake (5 km directly north of Sproat Lake) and at Cultus Lake (~80 km southeast of Vancouver, Carter & Sealy 1986), and “small fish which looked like salmon fry” were dissected from the female Marbled Murrelet taken on Harrison Lake in 1928 (Brooks 1928). Potential prey at Sproat Lake consists of Three-spined Stickleback *Gasterosteus aculeatus* and several species of *Oncorhynchus* salmonids [Sockeye Salmon, Coho Salmon *O. kisutch*, Cutthroat Trout *O. clarkia*, Rainbow Trout *O. mykiss*]. Taylor River is an important spawning area (Michalski & Schlag 2014).

Records of Marbled Murrelets at coastal lakes, Alaska to Oregon

When we updated Carter & Sealy’s (1986) list of coastal lakes used by Marbled Murrelets (Table 2), the earliest record for Sproat Lake was a sighting in 1984, followed by an observation in 2016 (records #14 and #15 in Table 2). Records of murrelets on the water at other freshwater lakes on Vancouver Island and elsewhere, from Alaska to Oregon, continue to emerge (Table 2), especially during spring and summer, when lakes are most likely to be visited by birders. The number of murrelets recorded on individual lakes is generally small, but when considered together, the importance of lakes to subpopulations of murrelets becomes apparent. As a rough measure of lake use by Marbled Murrelets on Vancouver Island, we calculated an index number by summing the highest counts of murrelets recorded in all seasons on 13 freshwater lakes listed in Carter & Sealy (1986) and/or Table 2, which gave a value of 96 Marbled Murrelets. This is a conservative estimate because some records involve counts of “many” Marbled Murrelets. Some lakes have only a single record reporting one or two birds, whereas lakes with multiple observations (e.g., Cowichan, Sproat, Vernon) tend to have higher counts. We excluded records of murrelets flying near lakes (e.g., A. Burger’s eBird record S82824391: Nahmint Lake, $n = 36$ birds “detected and counted with radar” on 09 July 2003).

Noteworthy among the records were 152 murrelets counted by A. Burger during a boat survey at Nitinat Lake on the southwestern coast of Vancouver Island (Fig. 1) on 26 June 2004, which far exceeded tallies of murrelets on any of the other lakes (record #19 in Table 2). We omitted this number from our calculation of the lake index, however, because it inflated the total for freshwater lakes. Nitinat Lake is a salt-stratified fjord lake, a tidal basin with a narrow and shallow connection to the Pacific Ocean located southeast of Barkley Sound (Nordin 2013, Michalski & Schlag 2014). Unlike freshwater lakes, Marbled Murrelets apparently use Nitinat Lake as a “staging area between the sea and inland nesting habitat” (A. Burger pers. comm., 26 June 2023).

Use of freshwater habitats by Marbled Murrelets was not immediately apparent to early ornithologists. Guignet (1956) concluded that breeding Marbled Murrelets probably do not use

TABLE 2
Selected observations of Marbled Murrelets *Brachyramphus marmoratus* on lakes in Alaska, Yukon, British Columbia, Washington, and Oregon recorded subsequently to those compiled by Carter & Sealy (1986)

| Record no. | Location ^a | Date | No. of birds | Notes | Source ^b |
|--------------------------|-------------------------|-------------|--------------|---|---|
| Alaska, USA | | | | | |
| 1 | Skilak Lake | 18 Jun 2021 | 2 | “pair...foraging” | L. Langell, eBird S90402179 |
| 2 | Lake Aleknagik | 21 Aug 2013 | 1 | Dead hatch-year bird | Ruden 2016 |
| 3 | Naknek Lake | 25 Jul 2023 | 1 | Juvenile; “near the shore on Naknek Lake” | A. McGeoch/ J. Hume, eBird S145872609 |
| Yukon, Canada | | | | | |
| 4 | Teslin Lake | 22 Aug 2023 | 1 | Juvenile; first Yukon record; ~160 km from nearest marine water (Skagway, Alaska) | J. Jantunen, eBird S147897232; C. Eckert, eBird S147928222 |
| British Columbia, Canada | | | | | |
| 5 | Johnston Lake | 19 Jun 1985 | 4 | 3 adult males (RBCM 19400, 19402–03), 1 adult female (RBCM 19401) ^c | Hobson 1990; RBCM ^c |
| 6 | Anutz Lake, VI | 14 Jul 2017 | 1 | Juvenile | S. Green, eBird S38431247 |
| 7 | Woss Lake, VI | 22 May 2008 | 2 | “adults...on lake” | D. Tyson, eBird S24718281 |
| 8 | Vernon Lake, VI | 18 Jul 2002 | 4 | Group of 4; alternate plumage | M. Shepard, eBird S123527962 |
| 9 | Vernon Lake, VI | 02 Jun 2005 | 10 | Serial observations: 7 checklists by P.L. from 28 May to 12 July 2005, recording 1–10 murrelets; also single July records from 2003 (1 bird) and 2004 (5 birds) | P. Levesque, eBird S65251345 |
| 10 | Muchalat Lake, VI | 27 Jun 2020 | 1 | “breeding plumage” | S. Milligan, eBird S70930139 |
| 11 | Comox Lake, VI | 26 Jun 2020 | “a few” | “Several hundred overfly this site every morning to nesting areas above the lake. A few land on the lake.” | G. Monty, eBird S70837502 |
| 12 | Great Central Lake, VI | 05 Jun 2014 | 2 | “pair closely associating” | M. Shepard, eBird S18699750 |
| 13 | Great Central Lake, VI | 12 Jul 2014 | 1 | “adult” | M. Shepard, eBird S19081346 |
| 14 | Sproat Lake, VI | 24 Aug 1984 | 1 | “alternate plumaged adult on lake; able to dive; not seen to fly” | B. Whittington, eBird S32761726 |
| 15 | Sproat Lake, VI | 11 Nov 2016 | 2 | “On a lake! In late fall!” | S. McRuer, eBird S32491272 |
| 16 | Wahleach Lake | 25 Jun 1955 | 2 | “adult with a young murrelet at its side; resting” | Ryder <i>et al.</i> 2012 |
| 17 | Lower Kennedy River, VI | 09 Jul 2019 | 1 | Alternate plumage; video | I. Cruickshank, eBird S58067696 |
| 18 | Chilliwack Lake | 28 May 1955 | 1 | “on water surface resting; then dove under the water” | Ryder <i>et al.</i> 2012 |
| 19 | Nitinat Lake, VI | 26 Jun 2004 | 152 | “accurate count with slow boat speed”; all but 3 on water | A. Burger, eBird S80848840 |
| Washington, USA | | | | | |
| 20 | Lake Crescent | 01 Aug 2018 | 1 | “juvenile, swimming near shore” | C. Lambert, eBird S47626344 |
| 21 | Lake Washington | 23 Oct 2011 | 1 | Basic plumage | R. Merrill, eBird S9000713 |
| 22 | Lake Sammamish | 29 Sep 2020 | 1 | Basic plumage | H. Hauser, eBird S74220904 |
| Oregon, USA | | | | | |
| 23 | Henry Hagg Lake | 14 May 2020 | 1 | “breeding plumage”; multiple same-day reports | S. Schlick, eBird S69051107 |

^a VI = Vancouver Island

^b Published account or eBird checklist of Marbled Murrelets identified on lakes from Alaska to Oregon, arranged by latitude, north to south. All records refer to birds observed on water. Criteria for inclusion are noted in the Study Area and Methods section.

^c RBCM = Royal British Columbia Museum

freshwater lakes. He stated that “Fresh-water lakes are numerous in the coastal area, and they abound with trout. Consequently, fishermen prowl many of these lakes, yet have never reported seeing marbled murrelets there.” However, Guiguet (1971) changed course following observations of “concentrations” of Marbled Murrelet adults and juveniles in Barkley Sound:

A possible tie-in with these concentrations of breeding marbled murrelets are nearby bodies of fresh water such as Sproat and Great Central Lakes.

In the course of nocturnal studies on young sockeye, W.E. Barraclough... has recorded the presence of marbled murrelet on Great Central Lake at night. None is seen there during daylight hours, which may, or may not, indicate that this nocturnal occurrence is associated with breeding. Young sockeye are close to the surface at night, deep in the daytime, indicating perhaps, that food, not nesting, may be the factor.

Guiguet’s observations were prophetic, as both Sproat Lake and Great Central Lake are now known to be used by Marbled Murrelets.

Although the number of murrelets recorded at individual lakes is apparently small, collectively, lakes may provide important year-round habitat for the species, where murrelets may enjoy abundant and reliable food resources, as well as less competition from other seabirds. Identification of recurring use of freshwater lakes may help to confirm the inland presence of Marbled Murrelets and their use of inventoried nesting stands in the vicinity. Recognizable individuals are required to verify the integrity of pairs, whether the murrelets use lakes for extended periods of the year (and possibly over several years), and whether chicks are fed prey captured on lakes or exclusively at sea. Radar and/or audio-visual monitoring (Cragg *et al.* 2016) may confirm whether murrelets reach Sproat Lake from Barkley Sound via Alberni Inlet, or if they route via one of the watersheds of Clayoquot Sound (northwest of Barkley Sound). The use of coastal freshwater resources by Marbled Murrelets warrants further investigation, which should include identifying prey species and quantifying responses to disturbances such as human recreational activities that occur primarily during the murrelet breeding season.

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