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Loon abundance and behaviour over four decades at a remote ecological reserve on Haida Gwaii, British Columbia, Canada

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Abstract

Early studies (1976–1982) of the Drizzle Lake Ecological Reserve on Haida Gwaii, British Columbia focussed on the endemic Giant Threespine Stickleback (*Gasterosteus aculeatus*) and their predators. These surveys showed daily visits to the small lake (110 ha) by up to 59 adult non-breeding Common Loon (*Gavia immer*), an important stickleback predator and up to 19 breeding and non-breeding adult Red-throated Loon (*Gavia stellata*), which leave daily to forage in nearby marine waters. We continued loon surveys for 17 additional years (1983–1989, 2011–2020) and found that aggregations of non-breeding Common Loons occurred annually on the lake during July with maximum daily numbers of 78–83 individuals in 1987, 2018, and 2020 and a large increase from 2011 to 2020. We did not detect any relationship of these differences with the Pacific Decadal Oscillation but a significant inverse correlation with average wind speed. Average yearly numbers of Red-throated Loons declined by 50% from 1976 to 1989 and have remained low, with lowest numbers (<2) occurring in 2017. Two Red-throated Loon nesting territories on the lake were occupied from 1976 to 1995, with chicks occurring in 24 of 36 nests, but no successful nesting was observed on the lake over the last decade. The relative decline of Red-throated Loon in this reserve is similar to that reported in Arctic and Subarctic surveys of the species in the north Pacific and northern Europe. We discuss the implications for the evolutionary ecology of the sticklebacks and the conservation of the ecological reserve.

Key words: Common Loon; *Gavia immer*; *Gasterosteus*; Drizzle Lake; dystrophic; ecological reserve; Haida Gwaii; predation; Red-throated Loon; *Gavia stellata*

Introduction

Ecological reserves are part of an international program of protected spaces that offer opportunities for studies of intact ecosystems (Krajina *et al.* 1978). Systematic baseline surveys on reserves become more valuable over time given the rapid anthropogenic changes in ecosystems (Arcese and Sinclair 1997). British Columbia, Canada, has 148 reserves that represent the major biogeographic regions in the province (http://bcparks.ca/eco_reserve/). Initial species inventories of many of these reserves provide a baseline assessment of the general occurrence and distribution of species within the reserve but replicated surveys over time are limited.

The Drizzle Lake Ecological Reserve on Haida Gwaii was established in 1973 as a representative bog lake ecosystem that included an endemic population of Giant Threespine Stickleback (*Gasterosteus aculeatus*), assessed and listed as Special Concern (COSEWIC 2013; SARA Registry 2020). The reserve is surrounded by Provincial Crown Land and has no road or boat access so remains relatively intact (Figure 1). Examination of aquatic birds on Drizzle Lake from 1976 to 1982 showed extensive use by Common Loon (*Gavia immer*) and Red-throated Loon (*Gavia stellata*; Reimchen and Douglas 1980, 1984a). These studies found that numbers of non-breeding adult Common Loons on the lake increased sharply in early July, reaching a peak (59 individuals) in the third week of July and thereafter gradually declining. These birds arrived on the lake singly or in small groups near dawn, with numbers increasing until mid-morning. Most individuals departed the lake in large groups by mid-day, moving to marine waters or adjacent lakes, with this daily pattern repeating itself for much of July. Common Loon are important predators on the endemic giant stickleback, with yearly fluctuations in Common Loon numbers producing a detectable evolutionary response on stickleback defense morphology (Reimchen 1994, 1995).

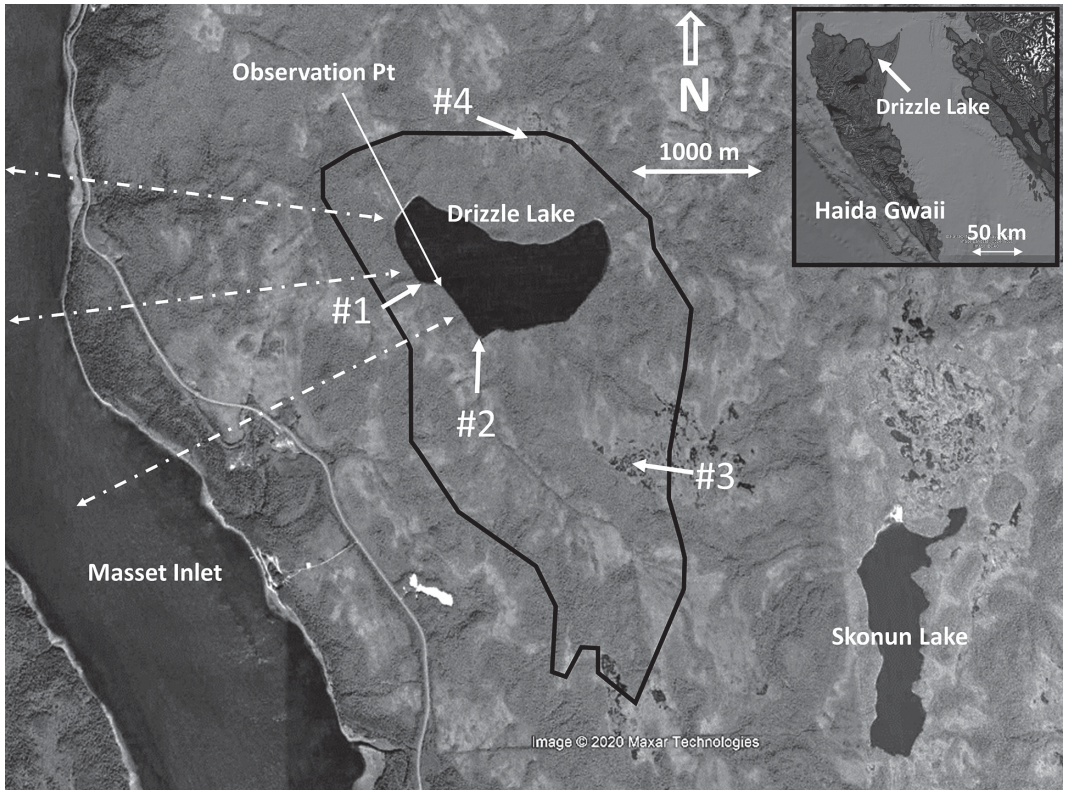

FIGURE 1. Drizzle Lake Ecological Reserve, Haida Gwaii, British Columbia. #1 to #4 show Red-throated Loon (*Gavia stellata*) nesting sites. Dashed lines indicate region of dominant flight paths of Common Loon (*Gavia immer*) and Red-throated Loon between the lake and marine waters of Masset Inlet. Ecological reserve boundary shown by dark solid line. Inset shows Haida Gwaii and location of Drizzle Lake. Imagery date: 13 December 2015. Accessed 18 March 2021.

Red-throated Loon, which on Haida Gwaii is at the southern reaches of their circumboreal breeding distribution (Rizzolo *et al*. 2020), increased over April to about 10–15 individuals. They usually arrived at the lake in pairs at dusk, stayed for the night and returned to adjacent marine waters at dawn. This diel pattern repeated itself from April to August. While most Red-throated Loons were non-breeding adults, up to four pairs occupied nesting territories on the lake and adjacent ponds. Adults foraged intermittently on the lake but young were not fed lake-resident fish. Rather, the attending adults made multiple daily flights from the lake and returned marine fish for the young throughout the 50 day pre-fledging period (Reimchen and Douglas 1984b, 1985).

Loons feature prominently in environmental assessment due to their sensitivity to anthropogenic impacts on nesting lakes and to adverse influences in overwintering marine habitats (Evers *et al*. 2019; Bianchini *et al.* 2020; Piper *et al.* 2020). Despite these effects, Common Loon appear to show relative stability in long-term continental population trends (Evers *et al.* 2020) even though productivity is declining in some regions (e.g., Tozer *et al.* 2013). However, Red-throated Loon in the north Pacific and northern Europe have suffered declines up to 85% over the last 40 years, largely due to low over-winter survival in marine habitats (Skov *et al*. 2011; Larned *et al*. 2012; Schmutz 2014).

For comparison with our initial loon studies, we extended observations on the Drizzle Lake Ecological Reserve (1983–1989, 2011–2020), with occasional summer visits in intervening years (1990–1996, 2003). In this paper, our objective is to: 1) report long-term trends in abundance of both loon species, 2) describe seasonal and daily patterns in abundance of Common Loon, 3) test whether abundance of Common Loon is influenced by wind, tides, or the Pacific Decadal Oscillation, 4) describe behaviour of both species including responses to disturbances, and 5) quantify long-term yearly patterns in reproductive success of Red-throated Loon. We also comment on several changes occurring on the reserve since its establishment that could influence variation in loon activity.

Methods

Drizzle Lake is one of several small lakes in an expanse of low-lying raised bog and coniferous forest in northeastern Haida Gwaii (Figure 1). The 837 ha Drizzle Lake Ecological Reserve encompasses the entire watershed of the lake (Krajina *et al*. 1978). Surveys of Common and Red-throated Loons were made on the lake during 1983–1989 and 2011–2020 for comparison with baseline data (1977–1982 for Common Loon; 1976–1982 for Red-throated Loon). We also made single visits to the reserve during the summers of 1990–1996 and in 2003 and recorded whether the major Red-throated Loon nesting territory was occupied. We did not obtain counts of Common Loons for 2013 or Red-throated Loons for 2020. Numbers of survey days varied among years and differed between species. For Common Loon, there was an average of 15 survey days (range 1–31) in July for each year. For Red-throated Loon, the average was 17 survey days (range 4–34), primarily in July but also including several surveys from May and June. To obtain daily loon counts on the lake, we used a protocol similar to that of the baseline data (Reimchen and Douglas 1980) and made multiple full-lake counts every 30 min from dawn until mid-morning (1000 h), intermittently near mid-day (1000–1400 h), and in the evening (1900–2200 h). These time blocks were chosen following baseline data that showed Common Loon numbers increased from dawn and reached a maximum near mid-morning, while Red-throated Loons, which were usually absent from the lake during the day, began to increase near 1800 h and reached a maximum just before dark.

All observations were made from the same position on the lakeshore that allowed observation of 97% of the lake surface (53.934177°N, 132.082024°W; Figure 1). Common Loons moved over the entire lake surface and regularly made foraging dives, but any single scan did not detect all birds. Consequently, we made multiple sequential scans until a maximum count was replicated on multiple further scans. Maximum numbers of Red-throated Loon may be slightly under-estimated due to the limited visibility near twilight, although we consider this to have a minimal effect on our counts. Even during the latest arrival to the lake near darkness, Red-throated Loon pairs vocalized, which helped us detect them. Individual pairs were recognizable as they tended to land in specific regions of the lake (Reimchen and Douglas 1980). There were four Red-throated Loon nesting territories within the reserve of which two (#1, #2; Figure 1) were monitored for occupancy and presence/absence of eggs or young over multiple years (1976–1996, 2003, 2011–2020). The remaining two (#3, #4) received nest surveys only several times, although their territory use was often identified through flight arrivals and departures. Pacific Loon (*Gavia pacifica*) was infrequent on the lake, occurring as solitary birds in two of 22 survey years (July 1979, July 2014), and each time, remained on the lake for several weeks. We saw no interactions between this species and Common and Red-throated Loons and do not consider it further in this study.

We plotted average daily counts and maximum July counts for each species for each year (1976–2020). "Average daily counts" comprised the maximum count per day averaged over all of the observation days during July, while "maximum July counts" comprised the daily maximum counts for all observation days. We grouped data into three time blocks: 1976–1982 (baseline surveys), 1983–1989, and 2011–2020, which provided an equal partition for the first survey period (1976–1989) that was separated from the third block by two decades. We used analysis of variance (ANOVA) to compare counts among years and among time blocks, and regression to evaluate the linear trends in abundance in the third time block.

To evaluate potential environmental predictors for yearly variability in Common Loon abundance, we used data on the Pacific Decadal Oscillation (PDO), a continuous monthly index of oceanic temperature that is associated with primary productivity including fish abundance (Mantua *et al.* 1997). PDO data were extracted from the National Oceanic and Atmospheric Administration (NOAA 2020), from which we computed a yearly average (all months), spring–summer average (April–July), and July only. To examine daily variability in Common Loon abundance on the lake each July, we extracted historical records of daily tidal conditions for adjacent marine waters (maximum daily tidal height, Masset tidal station, British Columbia) and maximum daily and monthly wind speeds (Sandspit Airport, British Columbia; Environment and Climate Change Canada 2020), and calculated correlations with daily numbers of Common Loon. We examined tidal cycles because during the baseline surveys, July daily loon counts appeared to show the same seven day cyclicity as the interval between spring and neap tidal heights. Wind speeds were also examined, as loons were rarely observed in flight during strong winds, which were prevalent in this geographical region. We used Spearman's rank correlation coefficients for correlating average monthly wind speed with average Common Loon numbers for each month (extracted from Reimchen and Douglas 1984a) and maximum daily wind speed with maximum daily Common Loon numbers for July. We also performed a combined analysis using a 2-way ANCOVA with Common Loon numbers as the dependent (response) variable and wind speed

and tidal cycle as independent (explanatory) covariates. All statistics were done with SPSS Version 25 (IBM 2020).

Results

Common Loon

Throughout the observation period, Common Loon showed similar daily movement patterns, with singles or small groups arriving near dawn on the lake from adjacent marine waters and numbers increasing to a maximum by mid-morning. All loons were in adult summer plumage. There were minimal agonistic interactions, and birds commonly foraged while on the lake. Most loons departed the lake by mid-day and moved to the adjacent marine waters of Masset Inlet or to other lakes (Figure 1). This daily regime occurred throughout much of July and probably represents repeated visits by many of the same individuals. Baseline surveys (1977–1982) yielded average daily July counts of 15.6 birds with a maximum of 59 in 1978 (Figure 2). Subsequent counts (1983–1989) averaged 17.3 birds with maximum counts of 61 and 78 in 1983 and 1987, respectively. Resumption of counts during 2011–2020 showed an average of 19.0 with maximum values of 79 and 83 birds in 2018 and 2020, respectively. Although there were significant differences in average counts among individual years ($F_{22,373} = 7.4$, $P < 0.001$), there was no significant difference among the three time blocks ($F_{2,393} = 2.2$, $P = 0.12$). There was, however, evidence for a substantial increase in numbers over the most recent decade with the lowest average counts of 6.6 occurring in 2011 followed by an increase to an average of 48.1 in 2020 (regression slope $b = 3.0$, t = 9.2, $P < 0.001$).

We examined whether climatic conditions influenced the yearly variability in Common Loon numbers visiting the lake. Overall, the lowest monthly average wind speed of the year occurs during July, the month with the highest Common Loon numbers on the lake ($r_{22} = -0.62$, $P < 0.03$). However, July wind speeds for each year were not correlated with average Common Loon counts ($r_{22} = 0.17$, $P = 0.46$) or with maximum counts ($r_{22} = 0.07$, $P = 0.76$). Average PDO from April to July was not associated with mean Common Loon counts ($r_{22} = -0.02$, $P = 0.91$) or with maximum counts ($r_{22} = 0.04$, $P = 0.85$). As well, July PDO was not associated with mean counts ($r_{22} = 0.07$, $P = 0.75$) or with maximum counts ($r_{22} = 0.13$, $P = 0.58$).

Number of Common Loon arriving at the lake each day oscillated during the month (Figure 3). In several years (1988, 1989, 2015, 2017), the highest peaks were separated by six or seven days, yet in other years the interval between peaks ranged from three to 11 days. We tested whether tidal cycle or wind speed could contribute to these oscillations. Among the eight years for which we had continuous

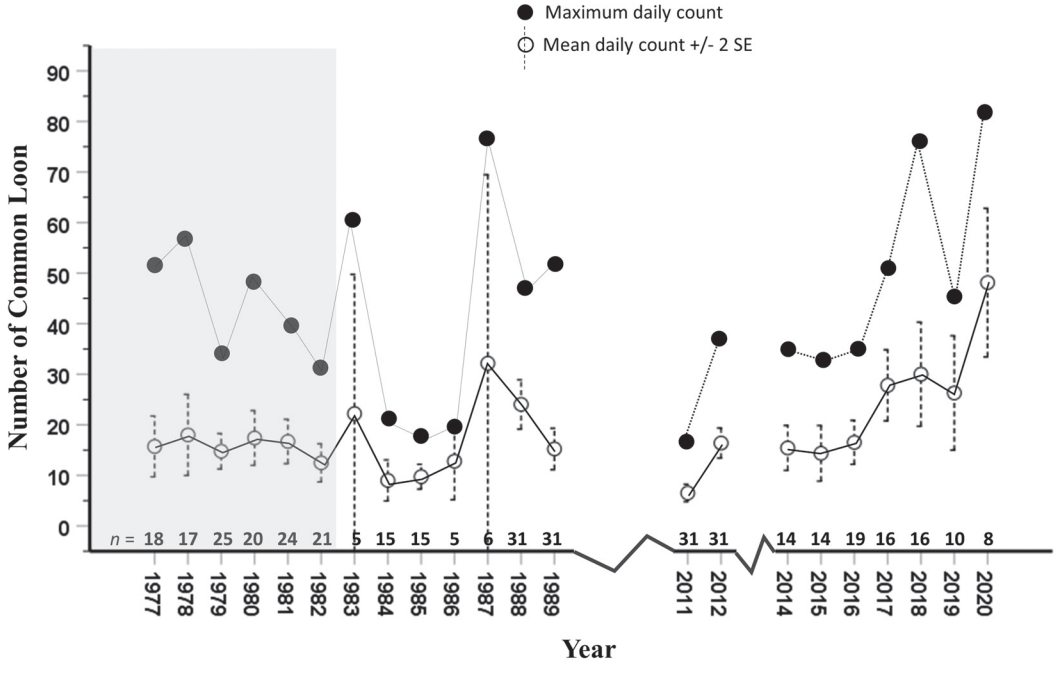

FIGURE 2. July average and maximum numbers of adult Common Loons (*Gavia immer*) at Drizzle Lake, Haida Gwaii, British Columbia. 1977–2020. *n* = number of census days. Shaded area shows baseline surveys (1977–1982).

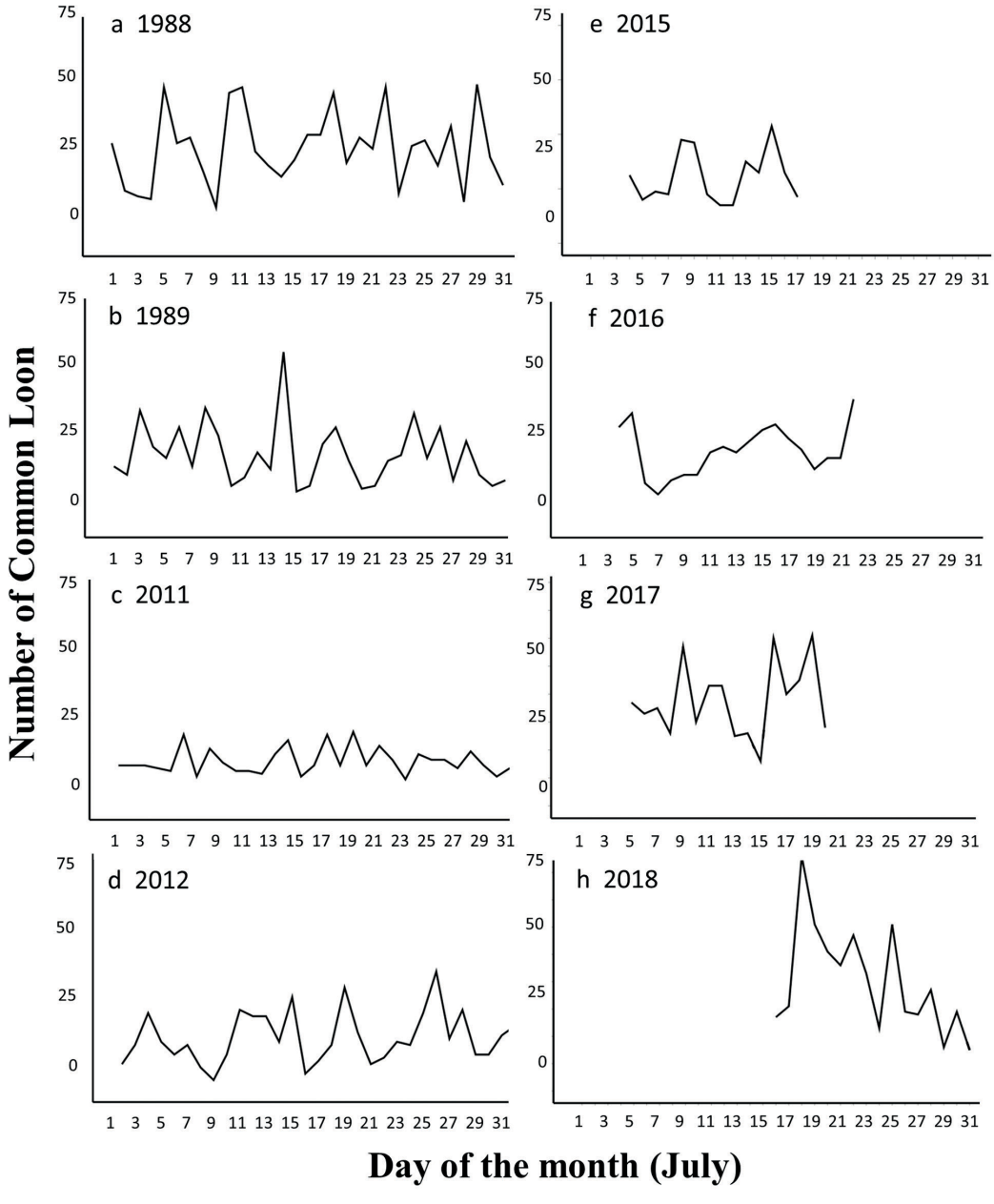

FIGURE 3. July daily oscillations in maximum count of Common Loon (*Gavia immer*) at Drizzle Lake, Haida Gwaii, British Columbia. All years with 14 or more days of continuous loon data (i.e., full tidal cycle) are shown.

daily counts in July for at least a two-week period (a full tidal cycle), there was a single year (2018) in which tidal cycle exhibited a significant correlation (r_s = 0.54, $P < 0.01$) but in none of the remaining years were any trends evident (all $P > 0.1$). However, Common Loon numbers and wind speed were inversely correlated (r_s) in seven of the nine years, two of which were statistically informative ($P < 0.02$). Inclusion of both variables as independent covariates and Common Loon numbers as the dependent response indicated a significant inverse effect for wind speed ($F_{1,188}$ = 5.5, $P < 0.03$) and no effect for tidal cycle ($F_{1,188}$ = 0.2, $P = 0.7$) or wind speed × tidal cycle interaction ($F_{1,188}$ = 0.6, $P = 0.45$).

Common Loon numbers ranged from solitary birds to large groups (20–60 individuals). Both solitary and group foraging were common. On most days, we observed loons that were initially scattered over the lake surface converge towards shoreline disturbances such as the arrival of a Black-tailed Deer (*Odocoileus hemionus)*, American Black Bear (*Ursus americanus*), Sandhill Crane (*Antigone canadensis*), and even the authors when we arrived at the lake to make observations. This behaviour also occurred when a Bald Eagle (*Haliaeetus leucocephalus*) arrived from adjacent marine waters, perched in lakeside trees, or bathed in the shallows. Loon aggregations remained in close proximity (10–50 m) to the eagle. This stereotyped behaviour of converging on shoreline disturbances was observed multiple times every year.

Common Loon were highly vocal and used calls in three different contexts. The most common was the Tremolo flight call used by single or multiple birds following take-off from the lake; the call appeared to encourage flight from other birds on the surface. Vocalizations did not occur during any flight arrivals to the lake. The Tremolo was also voiced following a 'splash dive' and loons appeared to maintain elevated alertness for several minutes. The second call—the Wail—was heard only in association with over-flights or proximity of a Bald Eagle and was usually followed by Tremolos and convergence and aggregation of other loons towards the shoreline position of the eagle.

Red-throated Loon

Baseline surveys (1976–1982) showed an average of 13.5 loons each summer with a maximum of 19 individuals in 1979 (Figure 4). Average numbers from 1983 to 1989 declined to 10 ($F_{1,58} = 21.3$, $P < 0.001$) with lowest numbers (six) at the end of the decade. The 2011–2019 surveys showed a further reduction in average counts (average = 6.2) relative to both the 1983–1989 period ($F_{1,83} = 64.2$, $P < 0.001$) and to the baseline surveys ($F_{1,63} = 125.3$, $P < 0.001$). Maximum counts from 2011 to 2019 did not exceed 10 birds. Of the 22 years of observation involving 485 survey days, there were only 14 days with no Red-throated Loon on the lake during summer and all of these occurred in 2017. We did not quantify the soundscape, but an additional change evident relative to the baseline surveys was the major decline in the vocalizations of the Red-throated Loon during the frequent intra-specific encounters from dusk into darkness.

The four Red-throated Loon nesting territories identified on the reserve varied in their occupancy over time (Figure 5). Territory #1, monitored for 32 years, had chicks in 20 years, but this territory has not been occupied in any of the last ten years (2011–2020). Territory #2, on the inlet stream to the lake, was occupied in all of the 23 survey years, although no chicks have been observed since 1986. Territory

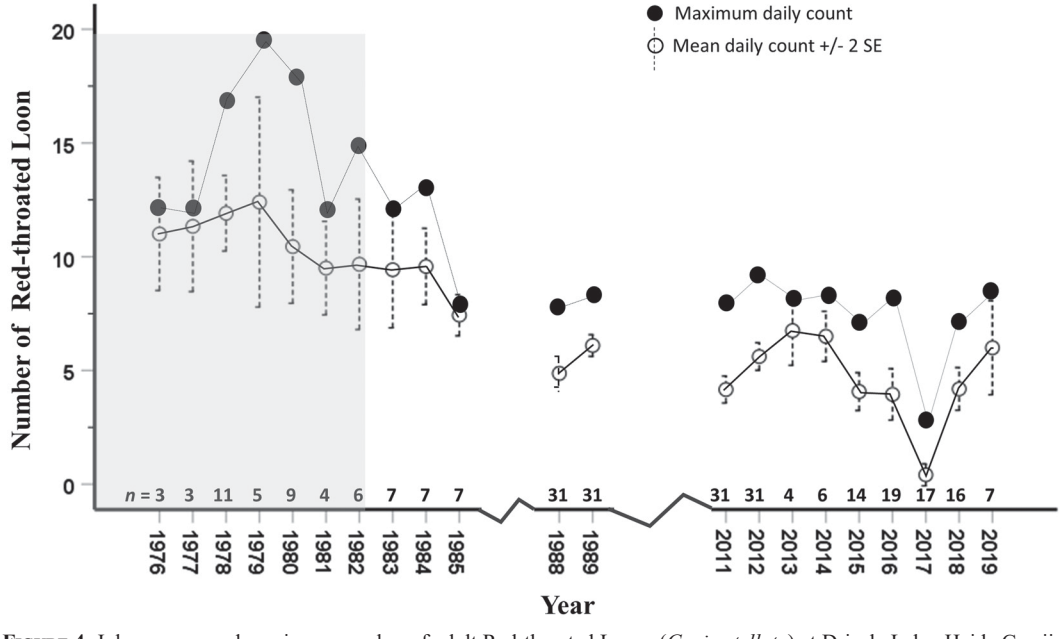

FIGURE 4. July average and maximum number of adult Red-throated Loons (*Gavia stellata*) at Drizzle Lake, Haida Gwaii, British Columbia, 1976–2019. *n* = number of census days. Shaded area shows baseline surveys (1977–1982).

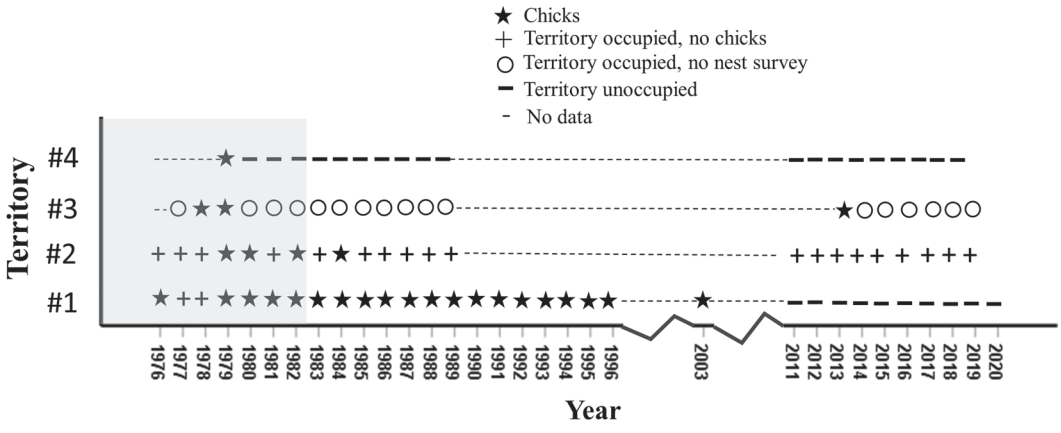

Figure 5. Yearly activity at the four Red-throated Loon (*Gavia stellata*) nesting territories at Drizzle Lake, Haida Gwaii, British Columbia. Shaded area shows baseline surveys (1977–1982).

#3, a small pond, was occupied in all years while Territory #4, an additional small pond, was occupied only in 1979.

Discussion

Our extended surveys at the Drizzle Lake Ecological Reserve showed that numbers of adult Common Loon, although variable among years, exhibited a similar average and maximum within each of the three time blocks from 1976 to 2020. The only evidence of a consistent yearly change in numbers occurred recently, from the lowest count of 16 in 2011 to the highest count of 83 in 2020. Low numbers in 2011 correspond to marine waterbird surveys (1999–2011) of inner coastal regions of eastern Vancouver Island that also showed lowest Common Loon counts in 2011 (Crewe *et al*. 2012). As well, the increase we observed during 2011–2020 is also consistent with an increase in Common Loon in additional marine waterbird surveys (1999–2019) from outer coastal waters including Haida Gwaii (Ethier *et al*. 2020). Fluctuations in average or maximum numbers of birds between successive years strongly suggest that these fluctuations are not the result of broader demographic trends but reflect yearly differences in the extent of coastal movement of Common Loon in marine waters around Haida Gwaii. Common Loon in Alaska have had a stable or increasing population from 1985 to 2015 (McDuffie *et al*. 2019) while those in Ontario and Wisconsin show declining reproductive success and abundance from anthropogenic influences (Tozer *et al.* 2013; Bianchini *et al.* 2020; Piper *et al.* 2020). Currently, continental trends in Common Loon abundance appear stable (Evers *et al*. 2020).

While our data confirm the distinctive July influx of adult non-breeding loons to this coastal lake seen during the baseline surveys (1976–1982), they give limited insight as to why these birds should leave marine waters daily in July and fly to Drizzle Lake. The birds commonly forage on the lake and it is possible that prey capture rates during July exceed those from marine habitats. Rather than clear oceanic waters, Drizzle Lake is situated on a large expanse of *Sphagnum* bog that results in deep tannin staining of the lake. This staining greatly limits the amount and the spectrum of light penetration that reduces the detection and reaction distances of subsurface interactions (Reimchen 1989). Despite the challenges of low light, we suspect that diving loons are able to exploit these restricted and unusual photic conditions allowing improved prey capture rates (http://web.uvic.ca/~reimlab/stickleloonvoice640.mp4). An additional piscivore in Drizzle Lake is Cutthroat Trout (*Oncorhynchus clarkii*), which exhibits their highest predation rates on stickleback during summer months (Reimchen 1990) when loons are present. How these piscivores interact behaviourally or trophically is currently unknown. Furthermore, as loons are long-lived, exceeding 30 years (Evers *et al*. 2020), some or many of the adult birds may be the same individuals that return to these lakes each year. As such, these may represent long-term 'information centres' (Galef and Wigmore 1983; Harel *et al.* 2017) that, in addition to foraging, are used for social interactions or pre-migratory grouping (McIntyre and Barr 1983; Paruk 2006). That the loons arrived at the lake as singles or small groups but left in large groups is consistent with a combination of these processes. These aggregations in July occur several months before successful completion of reproduction by loons in western Canada, Alaska, or the Arctic and several months prior to the southerly migration of both successful

and unsuccessful nesters from the Arctic (Evers *et al.* 2020); this suggests a novel component of the life history in Common Loons in western North America. Satellite tracking, as well as other markers such as banding or genomic data, would yield insight into the origin of lake aggregations on Haida Gwaii.

We detected substantial daily variability in numbers of Common Loon using the lake in July of each year. Rather than gradual increases or decreases over the month, there were peaks in abundance, separated by three or more days of low abundance. We suspected that this periodicity, with a mode at seven days, could be associated with conditions in marine waters that reduced foraging opportunities for the loons. For example, neap and spring tidal cycles are separated by seven days, with associated current conditions being much stronger during spring tides. Such currents could be expected to alter fish activity and foraging opportunities for avian piscivores that, in turn, could increase or decrease prospects for movement to alternate foraging habitats in lakes. However, we found limited support for any association between tidal cycle and lake visits. We also examined average daily wind speed, suspecting that the high wing loading of Common Loon (Savile 1957; Gray *et al*. 2014) would result in significant flight constraints during take-off in very calm conditions or during flight in strong winds. We observed that on windless days at Drizzle Lake, loons required greater take-off distance in flat surface waters and typically did not leave the lake until local winds increased, usually by midday. As well, large surface waves limited take-off and strong winds compromised aerial flight for the loons. Our data are consistent with this suggestion as they show a significant inverse relationship between daily Common Loon arrivals on the lake and daily wind speed. Assuming that this is a causal explanation for the within month periodicity, perhaps it also contributes to why loon visitations are largely restricted to the month of July because this month, specifically its third week, has the lowest average wind speed throughout the year (Sandspit Airport; Environment and Climate Change Canada 2020). Although suggestive, over the 22 years of our surveys, we did not detect any relationship between average July winds each year and abundance of Common Loon and infer that average monthly wind speed is not an important factor in year-to-year variation in lake visitation.

Consistent with the trends seen during the baseline surveys (Reimchen and Douglas 1980), we found that Red-throated Loon are generally not on the lake during the day but arrive at dusk, spend the night, and then depart for marine waters at dawn, a recurring behaviour from late-April to August. Although they arrive at the lake as pairs, these often congregate in groups during which there is extensive agonistic displays and vocalizations (Douglas and Reimchen *in press*). Foraging activity is much less prevalent than with Common Loon (Reimchen and Douglas 1980). We observed an approximate 50% reduction in average and maximum evening counts of Red-throated Loon between 1976 and 2019, and while most of this reduction happened by the end of the 1980s, the lowest counts occurred in 2017 when on the majority of evenings, no Red-throated Loon were present on the lake. There has been no successful nesting on the lake over the last decade and the most consistently used territory (#1, Figure 1) has not been occupied since 2011 although lake and shoreline conditions appear similar to those in the previous decades.

The reduced abundance and activity of Red-throated Loon on Drizzle Lake parallels that in other geographical areas. In the Arctic Coast Plain, northern Alaska, there was a 40% reduction in Red-throated Loon from 1992 to 2000, but then stability thereafter (Larned *et al.* 2012). In the Baltic Sea, northern Europe, an important overwintering habitat of aquatic birds, there was an 85% reduction of Red-throated Loon and Arctic Loon (*Gavia arctica*) from 1987 to 2000 (Skov *et al.* 2011), declines generally considered to originate from increased mortality in marine habitats (Schmutz 2014), but also from ecological disturbance to nesting ponds in Swedish populations (Eriksson 1994). Red-throated Loon from Haida Gwaii are thought to overwinter on inshore marine waters in southern British Columbia (Campbell *et al*. 1990) and possibly further south, as recent satellite-tracking of Alaskan birds (McCloskey *et al*. 2018) indicates that some adults overwinter in coastal waters of Mexico. Inshore habitats impose the highest risk to overwintering seabirds (Croxall *et al*. 2012).

Apart from the possible marine influences, are there ecological changes that have occurred in the Drizzle Lake Ecological Reserve during 1976–2020 that could influence the abundance or activity pattern of the loons? There is no clear evidence for any long-term shifts in water levels, pH, water spectra, and fish community (Reimchen 1990, 1994; Reimchen unpubl. data). Raccoon (*Procyon lotor*), an invasive species on Haida Gwaii, is a predator on Red-throated Loon nests (Douglas and Reimchen 1988) and while uncommon, could be associated with the reduced nesting success over the last two decades. Additionally, number of daily helicopter flights directly over the lake has increased over the last two decades during summer months when Common Loon and nesting Red-throated Loon are on the lake surface or in flight. The brief and intense engine noise from the low-flying aircraft has no counterpart in this remote reserve and may contribute to the failed reproduction of the

Red-throated Loon. Although it appears not to have affected the visiting Common Loons, the numbers of which have not declined over the same period. Perhaps nesting loons are more vulnerable to this potential disturbance than visiting loons. Loons are considered a high-risk species for aircraft collisions (Pfeiffer *et al.* 2018) and the probability of collisions could be substantial at Drizzle Lake given the daily movement of groups of 10–30 loons in perpendicular flight paths, at similar elevation and at the same time of day as north-south aircraft flight paths. Apart from the potential human cost and loon mortality, the ecological impact of such an event could seriously compromise the integrity of the reserve.

The Drizzle Lake Ecological Reserve was originally established in 1973 primarily for the protection of the endemic Giant Threespine Stickleback (Krajina *et al.* 1978). Long term studies on this reserve showed that avian piscivores, of which Common Loon is the most prevalent, are the dominant predators on the sub-adult and adult sticklebacks in this lake (Reimchen 1988, 1994). Yearly and seasonal shifts in the amount of loon predation observed in the baseline surveys are linked to the frequency of defensive armour phenotypes of the stickleback (Reimchen 1995) and, as such, it seems probable that the prevalence of Common Loon, evident in most years from 1977 to 2020, represents post-glacial continuity of the major selective pressure that has led to the evolution of gigantism and the distinct defense morphology of this endemic stickleback population. A reduction in the predation pressure from Cutthroat Trout and/or Common Loon was identified as a potential threat to the stickleback (COSEWIC 2013).

In summary, our surveys of the Drizzle Lake Ecological Reserve encompass numerical data on loon abundance for 22 years between 1976 and 2020. We confirm exceptionally high abundance of Common Loon on this small lake, substantial variation among years, and no current indication of any long-term changes. In contrast, Red-throated Loon show an approximately 50% decline in both breeding and non-breeding pairs, trends that are similar to those in Alaska and Northern Europe. Our data provide a broad baseline for future biophysical surveys at this reserve.

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Author Contributions

Writing – Original Draft: T.E.R.; Writing – Review & Editing: T.E.R. and S.D.D.; Conceptualization: T.E.R. and S.D.D.; Investigation: T.E.R. and S.D.D.; Methodology: T.E.R.; Formal Analysis: T.E.R.; Funding Acquisition: T.E.R.

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