

Seasonal and Diurnal Abundance of Aquatic Birds on the Drizzle Lake Reserve, Queen Charlotte Islands, British Columbia

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A 112 ha lake on the Argonaut Plain, Queen Charlotte Islands, was surveyed for abundance and movement of birds at weekly intervals from 1978 to 1982. Thirty-six species utilized the lake; species numbers were highest in April and May and total bird-days highest in October and November. The majority of individuals were non-breeding and used the lake for foraging or overnighing. Red-throated Loon, Common Loon, Canada Goose, Mallard and Common Merganser, which moved between nearby marine water and the lake on a daily basis, accounted for the greatest number of yearly bird-days. Estimates of yearly prey consumption by piscivores at the lake range from 0.25 to 0.49 g/m².

Key Words: aquatic birds, seasonal abundance, coastal bog lake, Ecological Reserve, Queen Charlotte Islands.

The Queen Charlotte Islands, 100 km off the coast of British Columbia, lie along a major migratory corridor and provide coastal wintering habitat for many aquatic birds (Bellrose 1980). Although estuaries and near-shore marine waters represent the principal habitats for those species, coastal lakes could be an important alternate habitat for migratory stops, shelter during oceanic storms or foraging. Major use by aquatic species would influence ecological factors such as nutrient levels and distribution and abundance of prey in lakes. Non-breeding Common Loons (*Gavia immer*), which make daily transits between ocean and lakes in this region (Reimchen and Douglas 1980), are suspected of exerting a significant evolutionary pressure on the morphology of freshwater Threespine Sticklebacks, *Gasterosteus aculeatus* (Reimchen 1980, 1983). To determine the extent to which aquatic birds (non-breeding seasonal residents and breeding pairs) use coastal lakes, we documented the numbers and movement of all birds associated with a lake over a period of five consecutive years. The survey is part of a study on biotic interactions between aquatic birds and freshwater fish and serves as baseline data for Drizzle Lake, an area protected under the Ecological Reserves Program of British Columbia as a benchmark for assessing long-term changes in ecosystems (Krajina et al. 1978).

Study Area and Methods

Drizzle Lake (53°56'N, 132°05'W) (112 ha) is located on the Argonaut Plain, an expanse of *Sphagnum* bog and coniferous forest in the northeast corner of Graham Island (Figure 1). The watershed was established as a Reserve in 1971 (Krajina et al. 1978) for its unusual population of Threespine Stickleback (Moodie and Reimchen 1973) and as a representative

High Moor bog. Further habitat description was given by Reimchen and Douglas (1980).

For all aquatic bird species, records were maintained on number, distribution, arrivals and departures and general behaviour (foraging, preening, resting, etc.). Observations (15 min periods) were made with spotting scopes near dawn, mid-day and dusk at least one day per week for some 40 weeks per year from 1978 to 1982. As fog or storms occasionally limited visibility, especially in fall and winter, numbers of individuals may be underestimated for some species. For each month, we present maximum daily numbers observed, averaged over the number of years that a species was present. Total monthly and yearly "bird-days" (number of individuals X number of days present) were calculated for each species, based on weekly, or in some cases, daily records. As some species exhibited regular diurnal movement to and from the lake, we categorized each as day occupant, night occupant or continuous day and night, the latter applicable to species which arrived on the lake and remained continuously for two or more days. Foraging activity was described as absent, occasional (< 10 % of all sightings) or common (> 10 %).

Results

Summarized data for each species are given in Table 1. From 1978 to 1982, 36 species were observed on the lake: loons (3 spp.), grebes (4), cormorant (1), heron (1), swan (1), geese (2), ducks (15), shorebirds (4), gulls (2), murrelet (1), kingfisher (1) and dipper (1). Breeding was confirmed for Red-throated Loon, Canada Goose, Mallard, Green-winged Teal and Hooded Merganser, and suspected for Great Blue Heron and Marbled Murrelet (all scientific names given in Table 1).

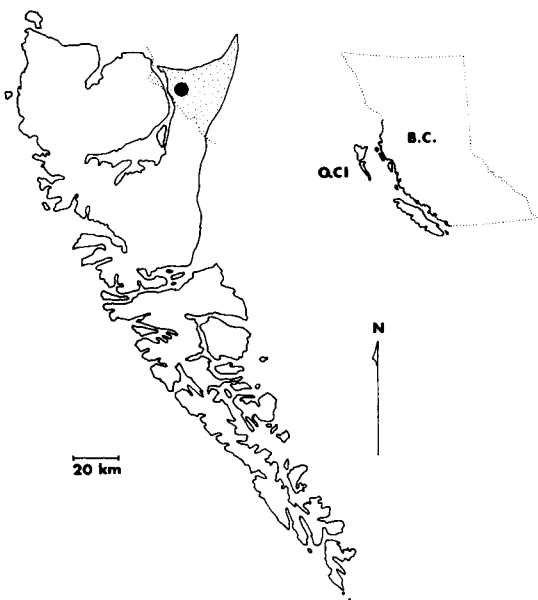


FIGURE 1. Queen Charlotte Islands showing Argonaut Plain (stippled) and Drizzle Lake Ecological Reserve (solid circle). Inset — British Columbia.

Most species exhibited a consistent seasonal occurrence and numerical abundance between years. Common Loons were at peak abundance in July, with maximum daily numbers ranging from 27 to 60 during the five years. In spring, approximately 30 (range between years, 15-75) male and female Common Mergansers occupied the lake daily; in fall, maximum numbers ranged from 85 to 124 between years, with the majority of birds in immature plumage. Mallards showed seasonal peaks similar to mergansers, with November maxima of 100-200 birds. From one to five Red-necked Grebes, Horned Grebes and Buffleheads were present from October to April of each year, with numbers increasing slightly in April, prior to their departure from the lake. The Double-crested Cormorant occurred between February and April, with only one to three individuals present at any time.

Canada Geese included breeding pairs, sub-adult congregations during molt, small resident flocks which moved irregularly between the lake or bog and the ocean, and migratory flocks. The latter (which are not included in total bird-day calculations) were frequent from mid-September to early November in south-east migration over the lake. On 2 October 1981, 22 flocks (40-270 birds/flock) were observed between 1200 and 1900 PST, with additional flocks heard throughout the night. Similar movements were observed on 12 October 1978, 12 October 1980 and 15

October 1982. Flocks in September and early October never stopped at the lake, but in three of the five years, several flocks in late October and early November landed and remained for several days. Resident geese did not join the migrants.

Species numbers were highest in April and lowest in December and January (Figure 2). Total numbers of individuals (bird-days) generally increased to a maximum in October, with minor peaks in April and July (Figure 2). The major contributors to those fluctuations were Mallard (7820 bird-days), Canada Goose (4858), Common Merganser (3553), Red-throated Loon (1884) and Common Loon (1626). Large flocks of Mallards and Common Mergansers accounted for the increase in bird-days during late fall.

There were regular diurnal movements between the lake and nearby marine waters. Red-throated Loons, Common Mergansers and Glaucous-winged Gulls were primarily night residents, arriving on the lake near dusk and departing again the following morning, mergansers usually at dawn and loons 1-3 h after sunrise. Common Loons and Mallards were principally day occupants; the former arrived near dawn, reaching peak abundance by mid-morning, whereas the latter species generally were present from mid-day to dusk. Other species, such as Double-crested Cormorant, Canada Goose, Scaup, White-winged Scoter and Belted Kingfisher also made daily transits between ocean and lake but at irregular times.

Among the 13 species that foraged regularly on the lake, 9 were piscivores. Where fish could be identified (for loons, grebes, mergansers and kingfisher), Threespine Stickleback was the only prey. Resident Green-winged Teals, Mallards and Buffleheads occurred primarily in shallow bays and are suspected of taking trichoptera larvae and vegetation. Canada Geese seldom foraged on the lake, but rather fed on shoreline vegetation and in adjacent bogs.

Species were assigned to one or more of three categories: migrants, which were present for < 5 days per year during the major migrations, seasonal residents, both breeding and non-breeding, which remained on the lake for one week to three months, and daily itinerants, which travelled to and from the ocean on a daily basis. Summarized data (Table 2) showed that half of the species used the lake as a migratory stop-over. Those species, which rarely foraged, accounted for only 1% of the total yearly bird-days. The 12 species of resident birds contributed 20% to the total bird-days. By far the greatest use of the aquatic habitat (79%) was by itinerants, principally Red-throated Loon, Common Loon, Canada Goose, Mallard, Common Merganser and Glaucous-winged Gull. Of those, only the Common Loon and Canada Goose were regular foragers.

TABLE 1. Seasonal abundance and occurrence of aquatic birds on the Drizzle Lake Ecological Reserve, Queen Charlotte Islands, 1978-1982. Figures show, for each month, daily maximum counts averaged over number of years present and maximum observed per day (in brackets). TBD — total bird days; Y — number of years present (Max. 5); Di — diurnal occupation by aquatic species, principally in daylight (D), principally twilight and darkness (N), full day and night occupancy (DN) and variable (V); F — foraging activity, not observed (0), occasional (1) and common (2). December data limited to 1979, showing maximum observed. No data (—). Nomenclature follows A.O.U. (1982).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TBD	Y	Di	F
1. Red-throated Loon <i>Gavia stellata</i>	0	0	0.4 (1)	8.4 (12)	11.8 (15)	11.0 (16)	14.6 (19)	13.2 (20)	2.6 (5)	0	0	0	1 884	5	N	1
2. Arctic Loon <i>G. arctica</i>	0	0	0	0	0	1	1	0	0	0	0	0	30	1	DN	2
3. Common Loon <i>G. immer</i>	0	0.2 (1)	0.2 (1)	0.6 (1)	1.0 (3)	14.0 (24)	43.4 (60)	12.8 (24)	1.2 (3)	1.8 (5)	0.8 (2)	0	1 626	5	D	2
4. Pied-billed Grebe <i>Podilymbus podiceps</i>	0	0	0	0	1	0	0	0	0	0	0	0	17	1	DN	2
5. Horned Grebe <i>Podiceps auritus</i>	0	0.2 (1)	0.2 (1)	0.6 (2)	0.2 (1)	0	0	0	0.4 (1)	1.2 (4)	0.2 (1)	0	91	5	DN	2
6. Red-necked Grebe <i>P. grisegena</i>	0.2 (1)	0.2 (1)	0.4 (1)	1.8 (8)	1.6 (7)	0	0.2 (1)	0.4 (1)	1.8 (2)	3.0 (4)	0.8 (2)	1	341	5	DN	2
7. Western Grebe <i>Aechmophorus occidentalis</i>	0	0	0	0	0	0	0	0	1	0	0	0	2	1	DN	1
8. Double-crested Cormorant <i>Phalacrocorax auritus</i>	0	0.3	1.5	1.0	0	0	0	0	0	0	0	0	85	5	V	2
9. Great Blue Heron <i>Ardea herodias</i>	0	0	0.6 (1)	0.2 (1)	0	0.4 (1)	0.2 (1)	0	0	0	0	0	43	4	N	1
10. Trumpeter Swan <i>Cygnus buccinator</i>	0.2 (1)	0	1.4 (5)	7.2 (22)	0	0	0	0	0	0	2.4 (9)	0	11	5	V	0
11. Greater White- fronted Goose <i>Anser albifrons</i>	0	0	0	0	0	0	0	0	1	0	0	0	1	1	—	0
12. Canada Goose <i>Branta canadensis</i>	6.0 (12)	4.0 (12)	4.2 (12)	4.8 (12)	6.6 (13)	17.0 (47)	26.6 (52)	30.8 (52)	21.2 (32)	14.4 (24)	16.5 (33)	15.0	4 858	5	DN	2
13. Green-winged Teal <i>Anas crecca</i>	0	0	0	6.0 (20)	1.8 (2)	1.6 (8)	1.4 (7)	2.5 (6)	2.2 (4)	2.0 (6)	0	0	425	4	DN	2
14. Mallard <i>A. platyrhynchos</i>	0.6 (2)	15.8 (50)	1.6 (6)	6.0 (20)	2.5 (4)	6.8 (30)	0.2 (1)	1.0 (3)	7.4 (15)	56.8 (110)	112.5 (202)	100.0	7 820	5	D	0
15. Northern Pintail <i>A. acuta</i>	0	0	0	15.0 (30)	0	0	0	0	3.0	0	0	0	33	2	V	0
16. Northern Shoveler <i>A. clypeata</i>	0	0	0	1.3 (4)	3.0 (6)	0	0	0	0	0	0	0	17	3	V	0
17. American Wigeon <i>A. americana</i>	0	0	0	7.5 (15)	0	0	0	0	2.0 (4)	2.5 (5)	0	0	31	2	V	0
18. Ring-necked Duck <i>Aythya collaris</i>	0	0	1.0 (2)	3.5 (7)	0	0	0	0	0	0	0	0	14	2	V	0

19. Scaup <i>Aythya</i> spp.	0	0	0	0.4 (2)	6.0 (10)	3.6 (8)	0.3 (1)	0.3 (1)	1.6 (5)	0.3 (1)	1.6 (5)	2.0	208	5	V	1
20. Oldsquaw <i>Clangula hyemalis</i>	0.2 (1)	0.2 (1)	0.6 (1)	0.4 (1)	0.2 (1)	0	0	0	0	0	0.2 (1)	1.0 1.0	61	4	DN	2
21. Surf Scoter <i>Melanitta perspicillata</i>	0	0	0	0.7 (1)	0	0	0.7 (1)	0	1.3 (3)	0	0	0	8	3	V	0
22. White-winged Scoter <i>M. fusca</i>	0	0.2 (1)	0.2 (1)	1.0 (3)	2.0 (2)	0.4 (2)	1.0 (2)	0.4 (2)	0.6 (1)	11.4 (50)	3.2 (15)	0	207	5	V	—
23. Common Goldeneye <i>Bucephala clangula</i>	0	0	0.6 (2)	0	0	0	0	0	0.3 (1)	0	1.0 (3)	0	11	3	V	0
24. Bufflehead <i>B. albeola</i>	0.6 (2)	1.0 (2)	3.0 (5)	6.4 (12)	3.0 (5)	0	0	0	0	3.0 (6)	1.0 (2)	2.0	608	5	DN	2
25. Hooded Merganser <i>Lophodytes cucullatus</i>	0	0	0	0.5 (2)	0.3 (1)	0.5 (1)	0.5 (1)	0.5 (7)	3.3 (6)	4.0 (4)	1.5 (4)	0	322	4	DN	2
26. Common Merganser <i>Mergus merganser</i>	0.8 (3)	1.2 (3)	6.8 (22)	10.2 (12)	30.0 (75)	0.5 (1)	0.2 (1)	0	56.5 (104)	88.5 (124)	0.8 (2)	4.0	3 553	5	N	1
27. Red-breasted Merganser <i>M. serrator</i>	0	0	1.0	0	0	0	0	0	0	0	0	0	1	1	N	0
28. Greater Yellowlegs <i>Tringa melanoleuca</i>	0	0	0	0	0	0	1	1	1	0	0	0	84	3	V	2
29. Wandering Tattler <i>Heteroscelus incanus</i>	0	0	0	0	1	0	0	0	0	0	0	0	2	1	—	2
30. Spotted Sandpiper <i>Actitis macularia</i>	0	0	0	0	0	0	0	1	1	0	0	0	55	2	V	2
31. Red Phalarope <i>Phalaropus fulicaria</i>	0	0	0	0	0	0	0	0	0	0	1	0	4	2	—	2
32. Bonaparte's Gull <i>Larus philadelphia</i>	0	0	0	0	0	0	1	0	0	0	0	0	1	1	D	0
33. Glaucous-winged Gull <i>L. glaucescens</i>	0	0	0.4 (2)	3.8 (5)	2.0 (2)	3.4 (8)	3.6 (6)	3.5 (5)	2.0 (2)	0	0.4	0	581	5	N	0
34. Marbled Murrelet <i>Brachyramphus marmoratus</i>	0	0	0	0	0	0	2	0	0	0	0	0	2	2	N	0
35. Belted Kingfisher <i>Ceryle alcyon</i>	0.2 (1)	0.5 (1)	1.2 (2)	1.8 (2)	1.2 (2)	1.0 (1)	1.2 (2)	1.0 (1)	1.0 (1)	1.2 (2)	1.3 (4)	2	353	5	D	2
36. American Dipper <i>Cinclus mexicanus</i>	0	0	0	0	0	0	0	0	0	0	1	0	1	1	—	—

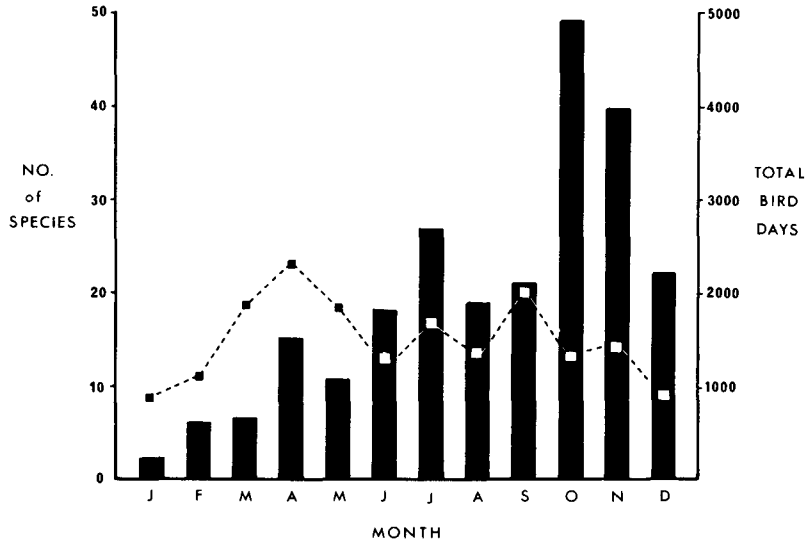


FIGURE 2. Monthly abundance of aquatic species (dashed), and total bird-days (histogram).

Discussion

Most birds observed on Drizzle Lake are within their known breeding, migratory or winter ranges (Godfrey 1966; Bellrose 1980), and had been noted during earlier coastal surveys on the Queen Charlotte Islands (Osgood 1901; Patch 1922; Darcus 1930; Cumming 1931). Green-winged Teals had not been reported as breeding on the Islands (Godfrey 1966); it is unlikely that our records represent a recent extension of their breeding range, as "juvenile" teal were observed on an adjacent lake in 1919 (Patch 1922). Pied-billed Grebe and Ring-necked Duck were north of their known coastal ranges. The assemblage of species and their seasonal occurrence is probably representative of many lakes on the Argonaut Plain

although numbers of individuals will vary according to lake size and limnological conditions. Most species were also observed on a 18 ha lake 30 km south (Reimchen 1980 and unpublished data).

Despite its location along a major Pacific flyway and proximity to the ocean, Drizzle Lake was not a feeding area for migratory geese, ducks or shorebirds; it was used only for short periods by small numbers of migrants. Seabirds, such as alcids and petrels, which breed in large colonies on the coast of the Queen Charlotte Islands (Summers 1974; Sealy 1976), did not frequent the lake during any period of the year, with the exception of the occasional Marbled Murrelet, which probably nests in adjacent forests.

There was regular seasonal habitation of the lake by

TABLE 2. Principal utilization of aquatic habitat observed at Drizzle Lake from 1978 to 1982. See Table 1 for species. *migrants present for less than 5 d/y.

Category	Species	No. of species	Total Bd. Days	% of total Bd. Days
Migrant*	7,10,11,12,13,15 16,17,18,21,22,23 27,28,29,30,31,32,36	19	170	0.7
Seasonal Resident				
Breeding	1,12,13,14,25	5	1 710	7.3
Non-breeding	2,3,4,5,6,12,24	7	3 068	13.1
Ocean/Lake Daily Itinerants				
Foraging frequent	3,8,12,20,28,35	6	4 899	21.0
Foraging absent or uncommon	1,9,14,19,21,22 26,33,34	9	13 537	57.9

both foraging and non-foraging birds. Major utilisation, in total bird-days, was by individuals which moved to and from the ocean on a daily basis, doing the majority of their feeding in nearshore marine waters. That individuals leave their foraging habitat and return to an inland lake suggests a requirement of fresh water in the diet or for plumage maintenance, since each species drinks and preens extensively following its arrival. Lakes also lack disturbance from tidal movement and probably have lower densities of predators (mammals, raptors and large fish) than the coastline or open ocean.

Foraging piscivores occurred on the lake throughout the year, usually in small numbers. For those species which foraged throughout the day (resident Common Loon, Red-necked Grebe, Horned Grebe, Double-crested Cormorant, Hooded Merganser, Oldsquaw and Belted Kingfisher), yearly weight of fish consumed may be estimated from the equation $\log F = -0.293 + 0.850 \log W$, where F is the g fish consumed per day and W is the weight of the bird (g) (Nilsson and Nilsson 1976) (mean bird weights obtained from Terres 1980 and R. W. Campbell, British Columbia Provincial Museum, personal communication). This yields a total of 295 kg or 0.26 g/m² of fish consumed yearly, which is a minimum estimate, as it includes only consumption by seasonal residents. Food consumption by itinerants such as summering Common Loons is more difficult to estimate as they remain approximately 4 h per day on the lake and only about 50 % of the birds forage (Reimchen and Douglas 1980). Only 15 % of the Red-throated Loons foraged during their nightly occupation of the lake, generally for less than 1 h. On the (unrealistic) assumption that the loons obtained all their caloric requirements during those short periods, prey consumption by itinerants could equal 278 kg/y. That would increase the total fish consumption to 573 kg/y for all species or 0.51 g/m²/y and would represent a maximum estimate. Common Loons accounted for 59 % of the total. Although comparable data are not available for other coastal lakes in British Columbia, analysis of prey consumption by birds at a large oligotrophic lake (4400 ha) in Sweden yielded a total of 0.78 g/m²/y (Nilsson and Nilsson 1976); Common Mergansers accounted for 62 % of total fish consumption there. At Drizzle Lake, this species was the most common piscivore, yet it rarely foraged. In coastal marine waters of the north Pacific, values for food consumption by birds (including non-piscivores) range from 0.7 to 8.0 g/m²/y (Schneider and Hunt 1982).

The relatively consistent numerical and seasonal occurrence of the aquatic species observed in this survey provides a useful baseline for assessing tem-

poral changes in the habitat. It is not possible to determine whether the data are representative as equivalent surveys have not been made at other lakes in British Columbia. Major nocturnal habitation by some species must be considered if future surveys of this and other systems are to be comparable.

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