Harlequin Duck Breeding Distribution and Hydroelectric Operations on the Bridge River, British Columbia

Edward L. Hill
BC Hydro
6911 Southpoint Drive, Burnaby, BC, V3N 4X8, Canada
ed.hill@bchydro.bc.ca

Kenneth G. Wright
Harlequin Conservation Society
Site 12 Comp 15, Galiano Island, BC, V0N 1P0, Canada

ABSTRACT

Studies about impacts of hydroelectric operations on riverine-dependent birds are limited to date. We present data on the distribution of a breeding population of harlequin ducks (*Histrionicus histrionicus*) on a river system in the Southern Interior of British Columbia that has been developed for hydroelectric generation. Pair surveys revealed 17 ± 5 (SD) birds occurring on the Bridge and Yalakom rivers, downstream of Terzaghi Dam. Four broods were observed in the lower Bridge River below Terzaghi Dam in 1997 and 1998. Mean brood size was 2.25 ducklings ± 1.26 (SD) in 1997 and 2.0 ± 1.15 in 1998. Only 2 broods were observed on the upper Bridge River. Physical habitat features are described. Our preliminary data indicate that harlequin ducks react to habitat changes resulting from hydroelectric operations. Increased flows below Terzaghi Dam in May, June, and July may reduce harlequin duck productivity.

Key words: breeding distribution, Bridge River, habitat characteristics, harlequin duck, *Histrionicus histrionicus*, hydroelectric operations, impact assessment, population.

Harlequin ducks (*Histrionicus histrionicus*) are known mostly from their coastal haunts where they inhabit rocky intertidal shorelines (Palmer 1976). Breeding occurs primarily along fast flowing rivers and streams (American Ornithologists' Union 1983). Presently, only scant information exists on the breeding abundance and distribution of harlequin ducks in British Columbia (Campbell et al. 1990, Wright and Goudie 1998). Virtually no information exists on the impacts of hydroelectric development or operations on harlequin ducks or mitigative measures. Alteration of rivers by hydroelectric dams and other anthropogenic disturbances threaten the globally endangered torrent duck (*Merganetta armata*; Callaghan 1997), which occupies the ecological niche of the harlequin duck in South America. In this paper, we examine nesting phenology, distribution and the physical habitat characteristics of a breeding population of harlequin ducks that occur within a hydroelectric system.

The Bridge River Hydroelectric System, located about 200 km northeast of Vancouver, includes Downton Reservoir and the La Joie Generating Station; Carpenter Reservoir and the 2 Bridge River Generating Stations on the northwestern shore of Seton Lake; and the Seton Generating Station on the west bank of the Fraser River near Lillooet. Hydroelectric development in the Bridge River System began in the 1920s.

Carpenter Reservoir was impounded in 1948. Terzaghi Dam, located about 41 km upstream from the confluence of the Bridge and Fraser rivers, diverts water into Seton Lake from Carpenter Reservoir. Consequently, the river channel is normally dry for approximately 4 km below the dam. Flows in the lower Bridge River are maintained by groundwater and tributary inflows. Water is rarely released directly into the Bridge River at Terzaghi Dam, except during the spills for testing or reservoir management. Spills have occurred 17 times from 1960 to 1997 (flow range during spills: 0.5–347.6 m^3/s).

Normally, water is not discharged past Terzaghi Dam. However, inflows to the Bridge River System were higher than average in May 1997 because of an increased snowpack and precipitation. This resulted in the need to manage water levels in the Downton, Carpenter, and Seton Reservoirs to minimize environmental impacts. With the agreement of regulatory agencies and other stakeholders, a controlled spill occurred at Terzaghi Dam from 13 July to 2 September 1997, with a peak discharge of approximately 27 m^3/s. Prior to initiating the spill, an environmental management plan (British Columbia Hydro 1997) was prepared to assess potential environmental impacts, and to identify possible mitigative and monitoring activities. The harlequin duck was identified as a species of concern, and inventory-level surveys in 1997 confirmed a breeding population using the Bridge River System.

In 1998 additional information on population size, habitat utilization, and nesting biology of harlequins in the Bridge River System was obtained to better define operational impacts and possible mitigative measures. Because no spill

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occurred at Terzaghi Dam in 1998, we were able to collect baseline data below the dam. Control data were also collected from the unregulated upper Bridge River which flows into Downton Reservoir.

Before the 1997 harlequin duck study (Wright 1998), little information was available on wildlife within the Bridge River watershed aside from anecdotal observations. We now know that the Bridge River supports a rich riverine bird community. The Bridge River also supports populations of several resident and anadromous fish species (Riley et al. 1998).

In the past, spills of water at Terzaghi Dam caused conflicts between the management of water and fisheries. Recognizing the need to collaborate on existing programs and/or initiate new fisheries improvement programs as well as to responsibly manage spills, British Columbia (BC) Hydro, the Stl'atl'imx Nation, the Department of Fisheries and Oceans, and the Ministry of Environment, Lands and Parks have agreed to implement the Bridge Seton Interim Cooperative Fisheries Project, and will shortly be implementing a Water Use Plan. The fisheries project is interesting for wildlife perspective because it includes the following components:

1. the design and construction of a water release structure at Terzaghi Dam;
2. the development and implementation of a water release strategy by 1 August 1999;
3. habitat improvement in the 4 km of dry river channel immediately below Terzaghi Dam; and
4. the Bridge River aquatic monitoring program (adaptive management).

The release of water from Terzaghi Dam (a fisheries-related commitment), and the subsequent permanent wetting of the presently dry channel will affect the ecology of riverine wildlife species such as harlequin ducks. Wright (1998) observed 1 brood of harlequins in the upstream section of the lower Bridge River that was wetted by the 1997 spill. Determination of the appropriate levels of flow below Terzaghi Dam will allow evaluation of the impacts of various flow regimes on harlequins and other wildlife, and collaboration with fisheries researchers on the interaction between fish and wildlife (e.g., predation) during the flow release experiment. This work will also be useful for wildlife-sensitive water use planning in other watersheds.

STUDY AREA

This study was conducted within the Bridge River watershed (a tributary of the Fraser River), British Columbia (Fig. 1). The Bridge River originates from a glacier in the Coast Mountain Range about 50 km west of Gold Bridge.

The upper Bridge River includes the Interior Douglas-fir (900–1100 m) and Montane Spruce (>1100 m) biogeoclimatic zones in its lower reaches. At higher elevations and westward, precipitation (mainly snow) increases, and the Engelmann Spruce–Subalpine Fir zone dominates. Most of the lower Bridge River occurs in the hot and dry (rainshadow conditions) Ponderosa Pine zone, whereas the Yalakom River and the Bridge River upstream of Hell Creek are within the Interior Douglas-fir zone.

Our surveys in 1998 were conducted on the upper Bridge River from Downton Reservoir to the glacier, the lower Bridge River from the Fraser River confluence to the upstream limit of water (about 4 km below Terzaghi Dam), and the Yalakom River from its confluence with the lower Bridge River to upstream of Shulaps Creek (Figs. 2, 3).

METHODS

Breeding Population, Phenology, and Distribution

We inventoried harlequin ducks by helicopter and by hiking surveys using techniques proposed by the Resources Inventory Committee (Resources Inventory Committee 1997).

Two methods were used to estimate the breeding population: (1) a pair of replicate surveys conducted 10 days apart during the prenesting period, and (2) capture–mark–recapture (CMR). The CMR method is based on Chapman (1951) with recent revisions (Seber 1977), and is generally the preferred method in a closed population. Birds were captured by flushing them into a mist net strung across the river, and were subsequently banded and released.

Approximate timing of nest initiation was investigated by comparing the frequency of single males to total birds observed. Chi-square goodness-of-fit tests with $P = 0.05$ significance level were used for this comparison. We aged broods according to Gollop and Marshall (1954), with modifications (Kuchel 1977). Back-dating provided approximate dates of clutch initiation and hatching. Fledging dates were estimated from brood age.

Locations of harlequin sightings during pair (prenesting; May–June) and brood (July–August) periods were plotted on field maps and are discussed in the following section.

Habitat Characteristics

All sites where ground observations were made were described. We recorded the following variables: bank type (vertical or horizontal), bottom type, channel form, bank composition, vegetative cover, water clarity, loafing site availability, channel width, stream width, gradient, and depth. Loafing sites are usually rocks and instream islands surrounded by moving water (Bengtson 1972); however, harlequins will also use logs and stream banks in some situations. All sites where birds were observed during ground surveys were photographically documented; stream gradient was measured using a clinometer; channel widths were estimated visually; and maximum water depth was recorded. We also described some general physical habitat attributes of sites occupied during the pair and brood cycles and at randomly chosen sites throughout the study area.

RESULTS

Breeding Population, Phenology, and Distribution

Lower Bridge and Yalakom Rivers

An estimated breeding population of 17 ± 5.5 (SD) birds in 1998 was found on the lower Bridge and Yalakom rivers. This was similar to our maximum count for the same area (15 individuals, including 5 pairs).

The proportion of single males to total birds observed on the Yalakom and lower Bridge rivers did not differ significantly between hiking surveys on 3–6 May and 14–17 May ($\chi^2_1 = 0.741$, $P > 0.25$, Yates corrected). This result indicates that laying was not completed by mid-May 1998.

During the prenesting period, most pairs were observed on the Yalakom River and at its confluence with the lower Bridge River (Fig. 3). Apart from birds in the Bridge River/Yalakom River confluence area, very little use of the lower Bridge River was observed. No birds were observed downstream of the confluence of the lower Bridge and Yalakom rivers in either year, except a broodless female on 17 July 1998. Nesting on the lower Bridge and Yalakom rivers occurred from early May to late June (Table 1).

Four broods were documented on the lower Bridge River in both years in the reach upstream of the Yalakom River. Mean brood sizes were 2.25 ± 1.26 (SD) in 1997 (spill year) and 2.0 ± 1.15 in 1998 (normal year), and did not differ significantly ($U = 7$, $P > 0.05$; Mann-Whitney U-test). Broods in 1997 were distributed closer to Terzaghi Dam than in 1998, presumably because of the increased flow. We observed little movement of known broods (maximum 4 stream km). No broods were found using the Yalakom River in 1997 or 1998.

We banded 15 harlequin ducks throughout the 1998 season (adults = 7, young of year = 8). A male banded on the lower Bridge River on 3 May was subsequently resighted alone on 16 May on the Yalakom River, 6 km above the lower Bridge River confluence. Of the 3 females banded during the prenesting period, 2 were later recaptured with young on the lower Bridge

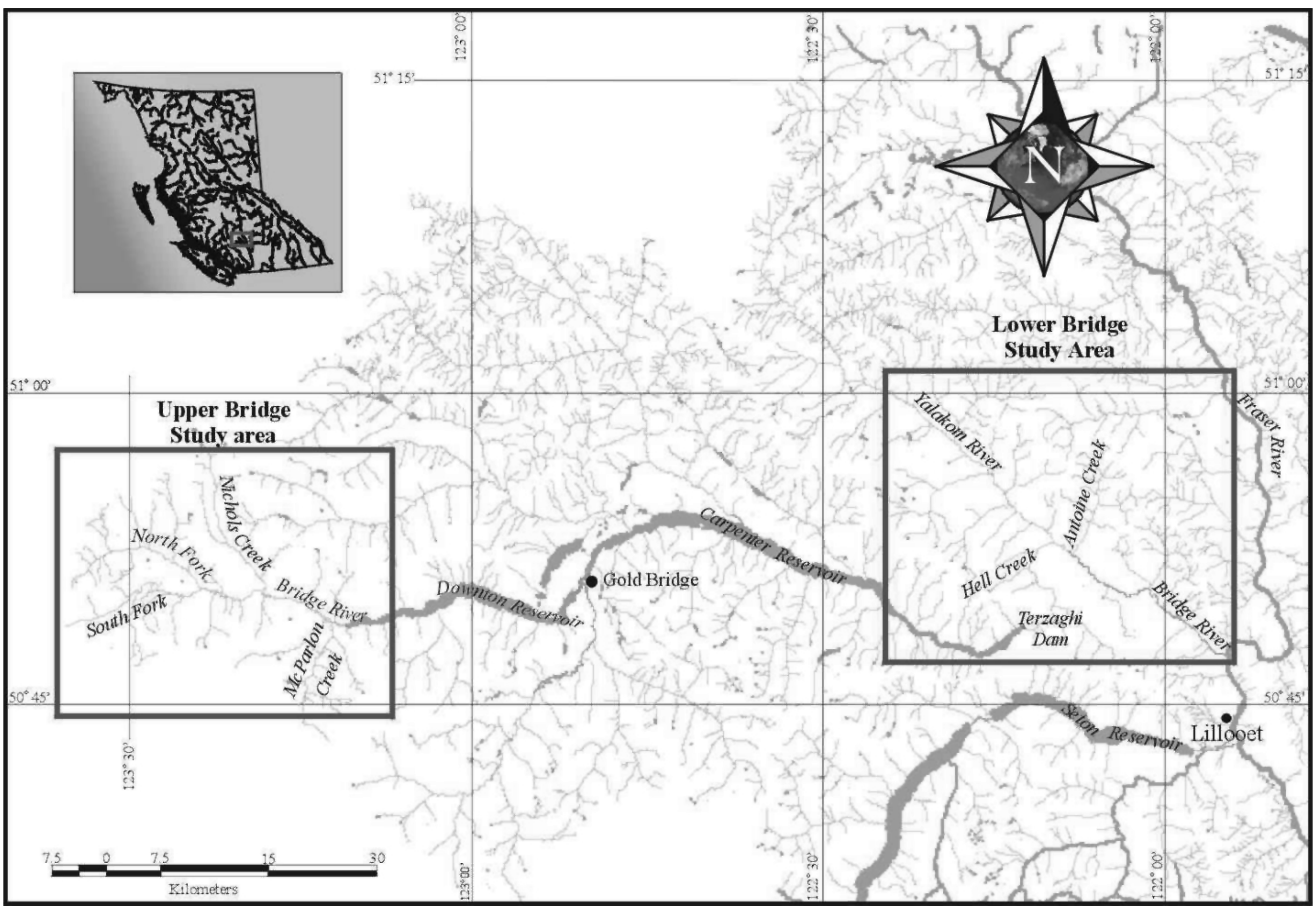

Figure 1. Study area map of the Bridge River System, British Columbia.

River, only a few kilometres upstream of the pair banding site.

Three birds previously banded elsewhere were resighted in the Yalakom River and lower Bridge River study area, linking this breeding population with coastal wintering areas in British Columbia and Washington State. These birds consisted of a female and male banded at coastal moulting areas in the Strait of Georgia in 1994–1996, and a male that moulted at Protection Island, Washington, in 1994 (G. Schirato, Washington Dep. Fish and Wildl., 1988, pers. comm.).

Upper Bridge River

A CMR estimate was not possible on the upper Bridge River due to high water levels. A maximum count of 24 birds (11 pairs and 2 single males) was obtained for the upper Bridge River on the 13 May 1998 helicopter survey. Pairs were distributed relatively evenly from McParlon Creek upstream to the confluence of the forks (Fig. 2). The count from the 2 June 1998 helicopter survey was significantly lower (i.e., 7 birds; $\chi^2_1 = 9.36$, $P < 0.005$). This observed decrease was most likely attributable to the onset of nesting. We noted a significant difference in the proportion of single males observed between the 13 May helicopter survey and the 3–7 June hiking survey ($\chi^2_1 = 14.98$, $P < 0.01$), indicating that nesting began in late May–early June 1998.

Only 2 broods were observed on the upper Bridge River (mean brood size 2.5 ± 0.71) which precluded discussion on distribution. High water levels and increased turbidity may have caused broods to move into clear water tributaries of the upper Bridge River. The upper Bridge River is now considered an unsuitable control site for the lower Bridge River due to habitat differences (higher elevation, reduced sightability, significantly higher flows).

HABITAT CHARACTERISTICS

Twenty-four occupied sites and 10 random sites were assessed. Channel gradient was consistently higher at occupied

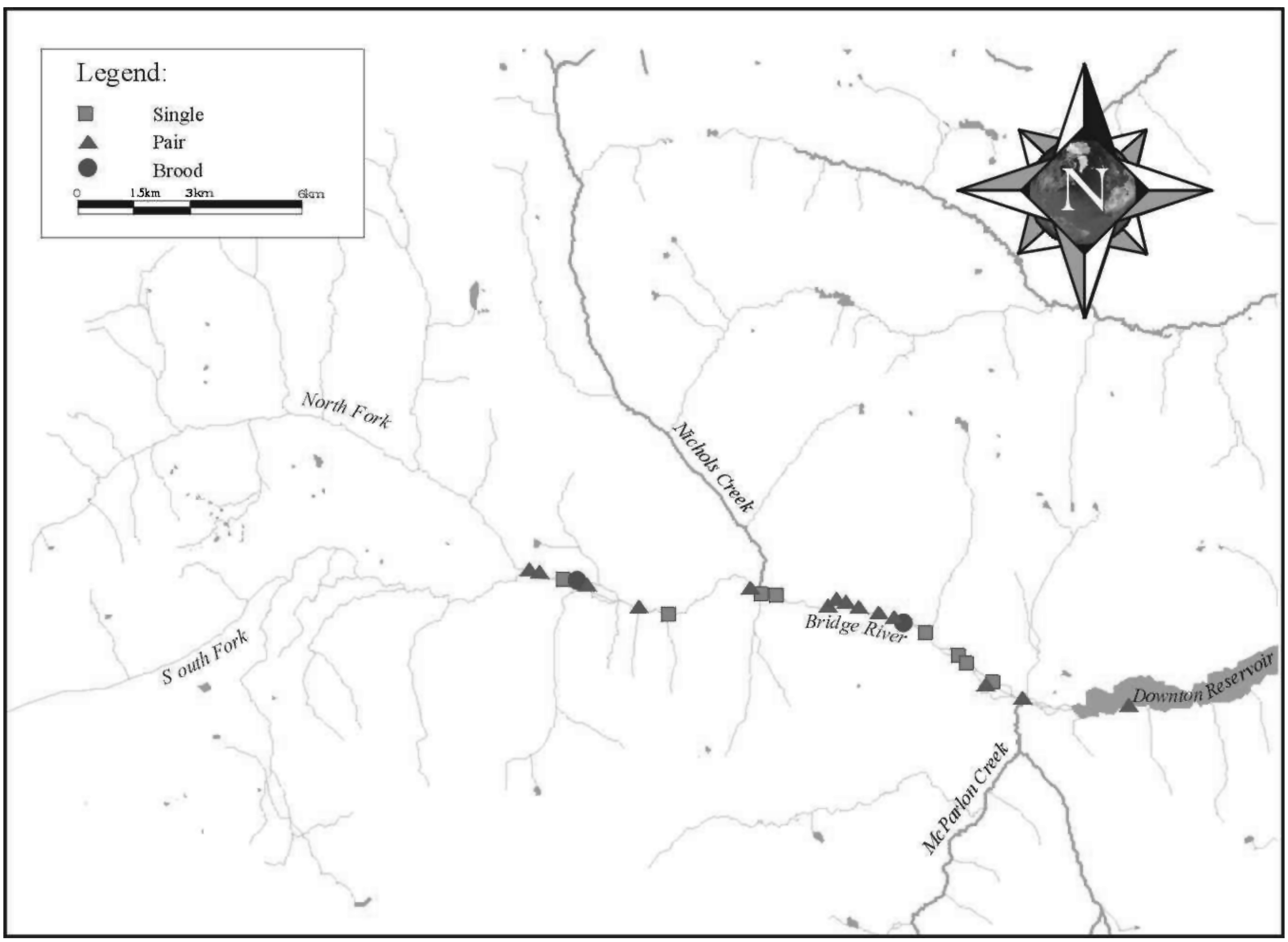

Figure 2. Distribution of harlequin ducks (May–July 1998) on the upper Bridge River, British Columbia.

sites than random sites (mean = 2.3% ± 1.7 SD and 1.6% ± 0.9, respectively). Water clarity was variable and reach specific. The upper Bridge River was turbid with glacial till during the pair/prenesting period while the lower Bridge River above the Yalakom River was clear. The Yalakom River, and the Bridge River downstream of the Yalakom River confluence were moderately turbid. Channel width at sites occupied by harlequin ducks was wider on the lower Bridge River (14.9 m ± 5.2) than the Yalakom River (10.0 m ± 3.0); however, random sites barely differed. Stream width was similar among occupied and random sites. Bottom substrate mostly consisted of cobbles with some sites having predominately boulders. Harlequins

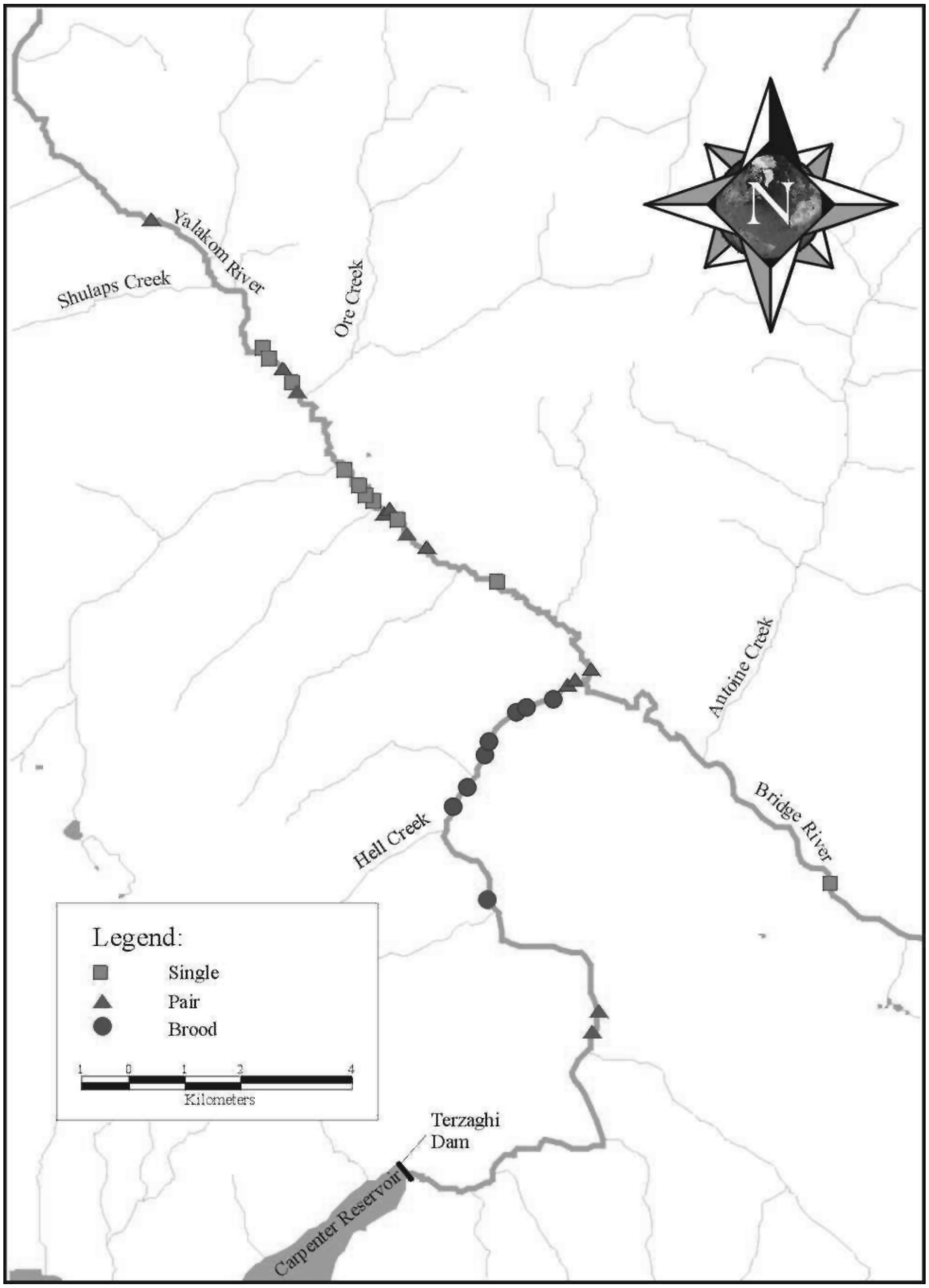

Figure 3. Distribution of harlequin ducks (May–August 1998) on the lower Bridge and Yalakom rivers, British Columbia.

Table 1. Brood class, age, and breeding phenology of harlequin ducks captured July–August 1998, lower Bridge River, British Columbia.

Date banded	Brood size	Class[a]	Age (days)	Estimated hatch date	Clutch initiation[b]	Fledgling[c]
18 July	3	IIb	26–38	10–22 June	1–13 May	25 Jul–6 Aug
20 July	1	IIb	26–38	12–26 June	3–15 May	27 Jul–8 Aug
2 Aug	1	IIa	21–25	8–12 July	29 May–2 June	22–26 Aug
3 Aug	3	IIa	21–25	10–14 July	3 May–3 June	23–27 Aug

[a] Follows Gollop and Marshall (1954) as modified by Kuchel (1977).
[b] Estimated by backdating from estimated hatch date, allowing 28 days for incubation and a 6 egg clutch with a laying interval of 1 egg /2 days (Bengtson 1972).
[c] Estimated as 45 days from hatching.

showed a preference for areas with numerous instream boulders and logs for loafing.

DISCUSSION

Little information presently exists on harlequin duck breeding populations in British Columbia (Campbell et al. 1990, Wright and Goudie 1998). Therefore, it is difficult to identify significant breeding concentrations and any regional patterns of distribution. In much of its range, the harlequin duck exhibits low breeding densities. Populations have been documented in the Canadian Rockies: 41 ± 8, Kananaskis River, Alberta, Smith 1999; 150 ± 18, Bow River, Alberta, Smith 1998; 58 ± 7, McLeod River/Whitehorse Creek System, Alberta, MacCallum 1997. The upper Bridge River seems to support a significant breeding population with 11 pairs and 2 single males (24 individuals) observed on 13 May 1998, and may have supported twice that (i.e., 22 pairs or 48 birds) based on 50% sightability, as found on helicopter surveys conducted in Alaska in similar or better visibility conditions (McCaffery and Harwood 1996). The lower Bridge and Yalakom rivers, also support a relatively large breeding population (17 ± 5 birds). In the larger Nahatlatch River watershed west of the Fraser River near Boston Bar, a breeding population of 39 ± 8.9 birds was reported (Freeman and Goudie 1998). Estimates of density would be required to compare the reported populations because of differences in the sizes of study areas.

Harlequin ducks breed in both treeless (Bengston 1972) and forested areas. In the forested breeding range, harlequins show a preference for areas with an intact riparian reserve over logged stream banks (Freeman and Goudie 1998). They exhibit a preference for fast flowing (gradient 1–5%), shallow rivers and streams (Palmer 1976) that support available macro-invertebrates populations (e.g., larval stonefly *Plecoptera* spp.). Breeding streams in Alaska had significantly greater discharge volume, stream width, and riparian width than unoccupied streams (Crowley 1993). Rodway (1998) found that occupied streams were narrower than unoccupied streams, and had larger substrate and higher vegetation cover.

The results of the field work in 1997 and 1998, along with an inventory survey of Downton Reservoir in 1997 (Robertson et al. 1998), have substantially contributed to our knowledge of wildlife in the Bridge River System, and therefore to our understanding of the effects of hydroelectric operations on the system. A breeding population of harlequin ducks that uses the Bridge River below Terzaghi Dam has been documented. Furthermore, in 1997, a brood was observed using the section of river below the dam that was wetted by the controlled spill. In addition, 94 species of birds, 15 mammalian species, and 2 species of reptiles were documented.

Four broods were present in both years on the lower Bridge River upstream of the Yalakom River and average brood size was not significantly different between years. However, broods tended to occur closer to Terzaghi Dam in 1997 (during the spill) than in 1998. This difference in distribution probably resulted from increased water flows and possibly more favourable upstream habitat conditions.

MANAGEMENT IMPLICATIONS

The original objective of the harlequin studies in 1997 and 1998 was to obtain sufficient information to assess potential operational (controlled spill) impacts (e.g., direct mortality through loss of nests, drowning or habitat alteration, changes in productivity resulting from habitat alteration), and to identify possible mitigation and/or compensation (e.g., timing of controlled spills to avoid critical periods, habitat improvement). A staged approach to accomplish this objective was planned:

- determine presence of harlequins (and other species) in 1997;
- determine general habitat use and phenology in 1998;
- evaluate habitat use and phenology as directly related to BC Hydro's operations and modified flows (e.g., within spill channel) - future studies; and
- evaluate impacts/mitigation/compensation in cooperation with other stakeholders - future studies.

The original objectives have been partially met. We now know that harlequins nest within the lower Bridge River System (probably along the Yalakom and other tributaries) and raise their broods on the main stem of the Bridge River. However, we do not know whether harlequins nest along the section of river immediately below Terzaghi Dam during spill years. Radiotelemetric studies are required to more accurately determine the nesting period, nesting locations, and habitat use by broods.

At present, we can say only that losses of nests and young broods may be reduced by keeping flows below Terzaghi Dam relatively constant from May through July.

The scope of proposed wildlife studies (particularly on harlequin ducks) has been altered by agreement on the Bridge Seton Interim Cooperative Fisheries Project and Water Use Planning. The decision to maintain a flow below Terzaghi Dam requires a broader scope to include wildlife in the instream flow needs assessment, planning of channel shaping, and adaptive management. Future work on harlequin ducks and other wildlife on the Bridge River will reflect these broader needs.

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