Abundance, habitat use, activity patterns and foraging behaviour of Harlequin Ducks breeding in Hebron Fiord, Labrador in 1996

Michael S. Rodway, John W. Gosse Jr., In Fong, William A. Montevecchi, Scott G. Gilland, and Bruce C. Turner

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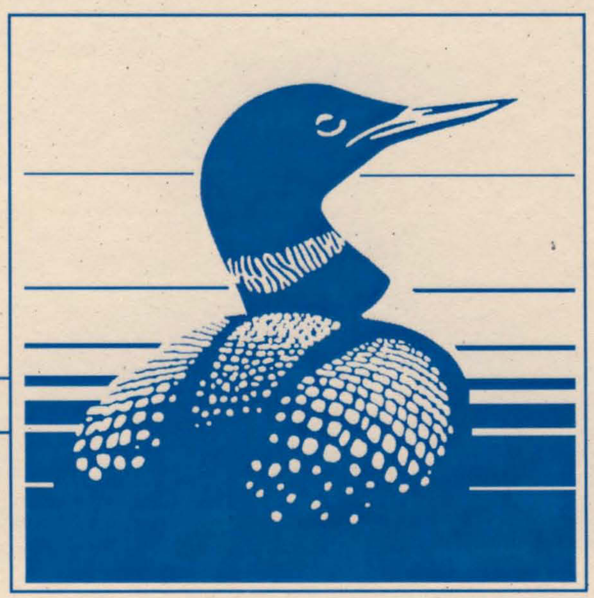

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ABUNDANCE, HABITAT USE, ACTIVITY PATTERNS AND FORAGING EHAVIOUR OF HARLEQUIN DUCKS BREEDING IN HEBRON FIORD, LABRADOR IN 1996

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SUMMARY

Lack of knowledge of breeding habitat distribution and requirements for the endangered eastern North American population of Harlequin Ducks (*Histrionicus histrionicus*) prompted an investigation of a known breeding population in Hebron Fiord, Labrador. Objectives of the study were to: 1) determine which streams are used by Harlequin Ducks and estimate total breeding population in Hebron Fiord; 2) identify habitat requirements for breeding by comparing habitat characteristics and benthic invertebrate species composition between used and unused streams and among strata varying in type and amount of use within a stream; 3) determine breeding phenology, sex ratio, and proportion of females breeding; 4) compare activity patterns of males, females, and broods, especially the proportion of time devoted to feeding; 5) assess diet; 6) find nests and broods to determine habitat use and behaviour; 7) relate phenology, diet, and activity patterns to within-season changes in stream habitat and benthic fauna; and 8) capture, measure, colour band, and obtain blood for genetic analysis from adults. The study was conducted from 8 June to 14 August 1996.

Distribution and abundance was determined by searching the lower 10 km of all larger streams emptying into Hebron Fiord for Harlequin Ducks. Habitat variables and benthic invertebrate composition were measured at random stations on three used and three unused rivers, and within 5 strata on the main study area on "Harlequin Brook" to determine habitat use. Instantaneous scan sampling of focal groups at 30 s intervals was used to establish diurnal activity patterns at four stations on Harlequin Brook during the pre-to-early-laying, incubation, and brood-rearing periods. Diet was determined from fecal samples.

Harlequins were found on 8 of 11 rivers explored in Hebron Fiord. A maximum of 11 males and 13 females occurred on Harlequin Brook of which 6 pairs were considered to have bred. A total

of 69 males and 81 females, with 30-40 pairs breeding, were estimated for the entire fiord. Four broods were observed on Harlequin Brook giving a maximum productivity of 1.2 ducklings/female or 2.7 ducklings per breeding female. Ducklings were 1-2 weeks old when last observed and fledgling productivity was likely lower than these estimates.

Streams used by Harlequin Ducks in the outer portion of Hebron Fiord were narrower, had higher pH and temperature, larger substrate, steeper shorelines, and greater vegetation cover on islands and shorelines than unused streams. Greater numbers of invertebrates were recovered from kick samples in used than unused streams. Simuliidae larvae and Plecoptera nymphs were more frequent, while Chironomidae larvae and Emphemeroptera nymphs were less frequent in used than unused streams. Temperature, pH, and numbers of exposed boulders increased, while flow rate and depth decreased through the season on Harlequin Brook. Stream temperature did not begin to rise until the fourth week in June, while depth generally decreased from mid-June to August with flood peaks in the middle and end of June. Most habitat characteristics varied among strata on Harlequin Brook indicating a complex fluvial and riparian structure on streams used by Harlequin Ducks.

One nest containing 6 eggs was found on 21 July under dense shrub cover on an island 2.5 km upstream from the estuary on Harlequin Brook. The presence of shrub-covered islands was also the main variable related to brood activity. First broods were seen on 29 July and estimated ages of 6 broods indicated clutch initiation in the third week in June and hatching in the last 10 days of July. Persistent snow cover and high water levels precluded nesting in many areas until the end of June.

Diurnal activity patterns varied by habitat and changed through the season. Extensive feeding occurred in slow-moving waters, contrary to expectations. Females spent 40 % of daylight hours feeding during the pre-laying period, more than twice the time spent by males and higher than that reported in other studies. Diurnal feeding patterns showed little variation in the pre-laying period and

major peaks of activity in the morning and evening during incubation and brood-rearing. Larval Diptera Simuliidae were absent in a fecal sample collected in July but were the dominant prey in feces collected in August. Dive times averaged 10-24 s and varied with depth of water. Dive-pause ratios of 1.7 - 2.2 were lower than previously reported. Results support the hypothesis that populations are food-limited on the breeding grounds, and suggest that there may be higher energetic constraints on foraging effort in river specialists than in dabbling or other diving waterfowl.

SOMMAIRE

C'est le manque de connaissances sur la répartition des habitats de nidification et les exigences liées à l'habitat de la population de harlequins plongeurs (*Histrionicus histrionicus*) de l'Est de l'Amérique du Nord, population en danger de disparition, qui a été l'élément déclencheur d'une étude sur une population nicheuse connue du fjord Hebron au Labrador. Cette étude visait à : 1) déterminer quels cours d'eau utilise le harlequin plongeur et évaluer la population nicheuse totale du fjord Hebron; 2) déterminer les exigences liées à l'habitat aux fins de la nidification en comparant les caractéristiques de l'habitat et la composition de la population d'invertébrés benthiques dans les cours d'eau utilisés et ceux qui ne le sont pas, et entre les strates de divers types dans un même cours d'eau et dont l'intensité de la fréquentation est variable; 3) déterminer la phénologie de la reproduction, la proportion des sexes et la proportion de femelles nicheuses; 4) comparer les modèles d'activité des mâles, des femelles et des canetons, en particulier la portion de temps dévolue à l'alimentation; 5) évaluer le régime alimentaire; 6) trouver des nids et des couvées afin d'évaluer l'utilisation de l'habitat et le comportement; 7) établir des liens entre la phénologie, le régime alimentaire et les modèles d'activité, d'une part, et les changements intra-saisonniers

touchant l'habitat que constitue le cours d'eau ainsi que la faune benthique, d'autre part; 8) capturer des adultes, les mesurer, leur poser des bandes de couleur et prélever des échantillons de sang pour l'analyse génétique. L'étude a été menée du 8 juin au 14 août 1996.

La répartition des harlequins plongeurs et leur nombre ont été déterminés le long de la partie inférieure de tous les grands cours d'eau qui se déversent dans le fjord Hebron, sur une distance de 10 km chacun. Les variables de l'habitat et la composition de la population d'invertébrés benthiques ont été mesurées à des emplacements choisis au hasard dans trois rivières utilisées et trois autres non utilisées par le canard, et dans cinq strates de la zone d'étude principale dans le « ruisseau Harlequin » afin de déterminer de quelle façon l'habitat est utilisé. On a effectué des échantillonnages périodiques instantanés de groupes précis à intervalles de 30 secondes afin d'établir les modèles d'activité diurne à quatre endroits le long du ruisseau Harlequin avant la ponte et juste après celle-ci, et pendant la période d'incubation et de soins à la couvée. Le régime alimentaire a été déterminé à partir d'échantillons des matières fécales.

La présence de harlequins plongeurs a été constatée sur huit des onze rivières explorées dans le fjord Hebron. Le nombre maximal de canards a été observé le long du ruisseau Harlequin, soit onze mâles et treize femelles, dont six couples se seraient reproduits. Pour tout le fiord, on a dénombré en tout 69 mâles et 81 femelles, y compris 30 à 40 couples nicheurs. Quatre couvées ont été observées le long du ruisseau Harlequin, la productivité maximale étant de 1,2 caneton par femelle, ou 2,7 canetons par femelle nicheuse. Les canetons étaient âgés de une à deux semaines quand ils ont été observés pour la dernière fois, mais le nombre de jeunes ayant atteint le stade de l'envol était probablement inférieur à ces estimations.

Les cours d'eau utilisés par le harlequin plongeur dans la partie extérieure du fjord Hebron étaient plus étroits et avaient un pH et une température plus élevés; leur substrat couvrait une plus grande superficie, leurs berges étaient plus abruptes et il y avait une meilleure couverture végétale sur les îles adjacentes et les berges, comparativement aux cours d'eau non utilisés. Le nombre d'invertébrés des échantillons prélevés au filet troubleau dans les cours d'eau utilisés était supérieur à celui des échantillons correspondant aux cours d'eau non utilisés. Les larves de simulies et les nymphes de plécoptères étaient plus fréquentes, mais les larves de moucherons et les nymphes d'*Emphemeroptera* étaient moins nombreuses dans les cours d'eau utilisés que dans les autres. Concernant le ruisseau Harlequin, on a enregistré des augmentations de la température, du pH et du nombre de rochers exposés parallèlement à une diminution du débit et de la profondeur du ruisseau pendant la saison. La température des cours d'eau n'a commencé à augmenter qu'à partir de la quatrième semaine de juin, alors que la profondeur a généralement diminué de la mi-juin jusqu'en août, les niveaux maximums de crue ayant été observés au milieu et à la fin du mois de juin. La plupart des caractéristiques de l'habitat ont varié d'une strate à l'autre dans le ruisseau Harlequin, indiquant la complexité de la structure fluviale et riveraine des cours d'eau utilisés par le harlequin plongeur.

Un nid contenant six oeufs a été trouvé le 21 juillet sous une couverture arbustive dense dans une île située à 2,5 km en amont de l'estuaire sur le ruisseau Harlequin. La présence d'îles couvertes d'arbrisseaux a été la principale variable liée aux couvées. Les premières couvées ont été observées le 29 juillet et d'après l'âge estimé de six couvées, la ponte aurait débuté la troisième semaine de juin, l'éclosion se produisant dans les dix derniers jours de juillet. Une couverture de neige persistante et des niveaux d'eau élevés ont empêché la nidification dans bien des secteurs jusqu'à la fin de juin.

Les modèles d'activité diurne variaient d'un habitat à l'autre et ont évolué au cours de la saison. Dans les eaux à débit lent, on a observé une activité d'alimentation intense, contrairement à nos prévisions. Les femelles ont passé 40 % des heures de clarté à se nourrir avant la période de ponte, soit plus du double du temps passé par les mâles, et davantage que la proportion signalée dans d'autres recherches. Dans les modèles d'alimentation diurne, on n'a relevé que peu de variations au cours de la période précédant la ponte, mais des pics d'activité importants le matin et le soir pendant la période d'incubation et de soins aux jeunes. Un échantillon fécal prélevé en juillet ne renfermait pas de larves de diptères simulies, mais ces larves constituaient le principal résidu d'aliments dans les fèces recueillies en août. Le temps de plongée se situait en moyenne entre 10 et 24 secondes et variait selon la profondeur de l'eau. Le rapport entre les temps de plongée et le temps de pause, qui était compris entre 1,7 et 2,2, était inférieur à celui déjà signalé. Les résultats appuient l'hypothèse selon laquelle les populations seraient limitées par la nourriture dans les aires de nidification, laissant supposer que les canards qui préfèrent les rivières dépenseraient plus d'énergie pour se nourrir que les canards de surface ou les autres oiseaux aquatiques plongeurs.

INTRODUCTION

Harlequin Ducks (*Histrionicus histrionicus*) have a disjunct, holarctic distribution with distinct populations in the Pacific (northwestern North America and Asia), Iceland, Greenland, and eastern North America (Palmer 1976, Montevecchi et al. 1995). They are unique among northern hemispheric waterfowl in nesting primarily on swift-flowing streams located in undisturbed forested, montane, and tundra habitats at coastal and inland locations (Bengtson 1966, 1972, Kuchel 1977, Dzinbal 1982, Wallen 1987, Inglis et al. 1989, Cassirer and Groves 1991).

The population in eastern North America is currently considered to consist of 1500 or fewer individuals (Vickery 1988, Goudie 1989) and has been listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; Goudie 1991). Lack of knowledge on breeding habitat distribution and requirements for this population (Montevecchi et al. 1995) prompted an investigation of a known breeding population in Hebron Fiord, Labrador (Goudie et al. 1994, A. Veitch pers. comm.).

Habitat requirements for nesting are known primarily from Iceland. There, most (93%) nests were within 5 m of the water on islands (67 %) and riverbanks (33 %). They were mainly on the ground under dense willow (*Salix* spp.) shrub, and less frequently in rocky cavities and short vegetation and grasses (Bengtson 1972). The few known nest sites in North America have been located on the ground, on woody debris, on cliff ledges, and in rock and tree cavities (Merriam 1883, Bent 1925, Jewett 1931, Thompson 1985, Campbell et al. 1990, Cassirer et al. 1993). Most nest sites were on or between stream banks, but one tree cavity nest was 14 m from the closest bank (Cassirer et al. 1993). One ground nest discovered on a small maritime island in British Columbia (Campbell et al. 1990) suggests that a discredited nesting record on a coastal island in Labrador by Audubon in 1833 (Todd 1963) may merit re-examination.

Data on summer diet and feeding behaviour for the eastern North American population are also lacking. Food availability on the breeding grounds is thought to limit populations (Bengtson and Ulfstrand 1971, Bengtson 1972) and greater understanding of food requirements and activity budgets is vital to recovery plans (Montevecchi et al. 1995). Few studies of feeding ecology have been conducted in Iceland (Bengtson 1966, 1972, Bengtson and Ulfstrand 1971, Inglis et al. 1989), Montana (Wallen 1987), and Alaska (Dzinbal 1982, Dzinbal and Jarvis 1984). Diet in Iceland was predominantly larval Diptera Simuliidae (Bengtson 1972), and Plecoptera and Ephemeroptera nymphs were important in the diet in Wyoming (Cottam 1939 in Breault and Savard 1991) and Montana (Wallen 1987). At coastal streams in Alaska, Harlequin Ducks fed on intertidal marine invertebrates early in the season and later on drifting salmon (*Onchorhynchus* spp.) roe in streams (Dzinbal and Jarvis 1984).

Our objectives in this study were to: 1) determine which streams are used by Harlequin Ducks and estimate total breeding population in Hebron Fiord; 2) identify habitat requirements for breeding by comparing habitat characteristics and benthic invertebrate species composition between used and unused streams and among strata varying in type and amount of use within a stream; 3) determine breeding phenology, sex ratio, and proportion of females breeding; 4) compare activity patterns of males, females, and broods, especially the proportion of time devoted to feeding; 5) assess diet; 6) find nests and broods to determine habitat use and behaviour; 7) relate phenology, diet, and activity patterns to within-season changes in stream habitat and benthic fauna; and 8) capture, measure, colour band, and obtain blood for genetic analysis from adults.

METHODS

Study Site

The study was conducted from 8 June to 14 August 1996. Coastal tundra habitat in Hebron Fiord of rolling moorland rising to 400-700 m elevation with dense, shrub-covered sections along streams is similar to montane habitat in Iceland (Bengtson 1966, 1972, Bengtson and Ulfstrand 1971). Our primary study site was on "Harlequin Brook" (58°09'40"N, 63°04'45"W), a tributary of the Ikarut River in the northwestern arm of Hebron Fiord (Fig. 1). The brook extends 12 km from the estuary to a lake outlet at 200 m elevation. Canyons at 4-6 and 9.5-11 km above the estuary separate it into three distinct sections. Our base cabin was located on Harlequin Brook just above its confluence with the Ikarut and about 1.3 km from the estuary (Fig. 2). The fiord was ice-bound and ice and snow covered river banks and islands when we arrived in early June. By mid-June, much ice and snow was breaking off river banks and islands, but high spring water levels flooded much of the islands through the third week in June. Thus, many areas were not suitable for nesting until the end of June. Ice was retreating from the heads of the fiord by mid-June and the fiord was clear of ice on 27 June.

Capturing Birds

A 24-hour watch was conducted from 1200 h on 10 June to 1200 h on 11 June by the base cabin to determine diurnal movement patterns and the best time to attempt capturing birds. Harlequin Brook was too deep to walk across in June making it impossible to work a mist net set over the brook. To overcome this problem, we suspended, with small stainless steel pulleys, a 10 m mist net stretched between two aluminum poles from a 20 m long high-line strung between two larger poles so that the net could be reeled out and in over the brook like a clothesline. This set-up was erected at 1.4 km from the estuary where the broad, flat gravel shoreline facilitated the operation of the clothesline apparatus.

Water levels had receded enough by the end of June that we could cross the brook in chest waders. We were then able to set two 10 m mist nets tied together across the brook on a sharp bend 1.6 km from the estuary where the shoreline was steeper and partially shrub-covered. Mist-nets were set from 0830-1315, 0315-0638, 0930-2140, 1000-1600 on 13, 15 and 30 June, and 3 July, respectively.

Captured birds were banded with U.S. Fish and Wildlife stainless steel bands on left legs, and with yellow colour bands with black alpha-numeric codes (from Protouch Engraving, Bay 2 - 811 51st, E. Saskatoon, Saskatchewan S7K 0X7) on right legs. Measurements were taken: mass to the nearest g with 1000 g pesola scales, culmen and tarsus to the nearest 0.05 mm with vernier calipers, and flattened wing length to the nearest mm with a stopped ruler. Blood samples were taken from the tarsal vein with 25 gauge needles on 1 ml syringes after swabbing the leg with alcohol.

Distribution and Abundance

The lower 10 km of all larger streams emptying into Hebron Fiord were searched for Harlequin Ducks (Figs. 3-13). Streams shorter than 10 km were searched to the point where they became small, alpine rivulets or outflowed from headwater ponds. Searches were conducted once after ice break-up allowed access and most males had left the area. Three observers, covering both streambanks whenever possible, walked upstream along all accessible sections of each stream. Perimeters of islands were explored whenever water depth allowed us to cross streams. We also spent at least one night camped at the estuary of each stream watching for Harlequin Duck activity. At Primogenitor River we boated up the lower river, across the lake, and then explored a further 10 km upstream on foot, camping at the inflow at the head of the lake (Fig. 6). We kept regular records of Harlequin Ducks in the lower 2 km of Harlequin Brook and explored the upper reaches every 2-3 weeks (Fig. 2). Data presented summarize maximum numbers of males and females counted per day. A total of 48 person-h were spent searching for nests. We focused our search efforts within 5 m of streams on shrub covered banks and islands.

Habitat Characteristics

Three streams with and three streams without sightings of Harlequin Ducks within 10 km of their respective estuaries were chosen to compare habitat characteristics in "used" and "unused" streams. We selected used streams in the same part of the fiord where unused streams were found in order to minimize differences due to location. The lower 5 km of each stream on a 1:50,000 scale topographic map was divided into 200 m intervals, of which 10 were chosen at random (Figs. 4,5,10,11,12,13). If the stream was shorter than 5 km, 20 % of the 200 m intervals were selected so as not to over-represent small streams in the comparison. Random points were located on the stream by measuring from obvious landmarks (e.g., tributaries). Habitat measurements were taken between 22-29 July.

Habitat measurements were also taken at random points selected from 200 m intervals within 5 strata on Harlequin Brook (Fig. 14). Sections of the brook that were subjectively similar were included in the same stratum (Appendix III). Measurements were repeated at monthly intervals to determine changes through the season. Water temperature and depth were also recorded on most days at our Harlequin Brook base camp to further monitor within season changes.

Habitat characteristics recorded at random points included: stream width, depth, surface, substrate, pH, temperature, and flow rate, and, within a distance of 25 m either side of each point, number of exposed boulders, number of islands, width and length of largest island, composition of dominant vegetation cover or substrate on islands, height of island vegetation, slope, width and composition of stream shorelines, slope, composition and vegetation height on streambanks, and distance and height of closest shrub cover from the stream edges. Bottom kick samples for invertebrates (Frost et al. 1971) were also taken at each point, and captured invertebrates were later counted, measured to the nearest mm, and identified in the field to order or family using Pennak (1953). Shorelines were defined as the area immediately adjacent to the water and were distinguished from streambanks by an abrupt change in slope. No streambank characteristics were recorded if a shoreline extended more than 25 m at a constant slope from the water's edge. Coding systems used for discrete habitat variables are given in Table 1. Stream width was estimated to the nearest meter. Temperature was measured to the nearest 0.5EC with a Lamotte Model 545 Enviro-Safe thermometer, and pH was measured using a Oakton Model WD-35624-22 pH Testr2. Flow rate was determined by measuring 10 m along the river with a 30 m tape and then, with an observer stationed at the upstream and downstream ends of the 10 m interval, timing the passage of a plastic fish bobber. The average of three trials was used as the flow rate estimate. Trials were repeated if the bobber became caught in eddies or other obstructions. Some measures could not be taken at inaccessible stations in canyons and where banks were overhung with snow, or where opposite shorelines were not visible past intervening islands. Not being able to measure flow rates in canyons probably resulted in underestimates of average flow rates for those streams with canyon habitat.

We also deployed passive rock samplers (D. Larson pers. comm.) to sample benthic invertebrates at random stations in the lower 2 km of Harlequin Brook and Ikarut River. Samplers consisted of 11 stones tied into a bag made of 35 cm of crab net. Samplers were left in the stream for at least 2 weeks before they were retrieved. Samples were taken 3 times at biweekly intervals on Harlequin Brook, and an additional, paired set was retrieved from Harlequin Brook and Ikarut River on 6 August.

Activity Patterns

Four observation stations were established at 0 (Estuary), 1.7 (J-Kûk), 6.0 (Inukshuk), and 8.3 km (Gooseneck Steadies) from the estuary at sites that were known to be frequented by Harlequin Ducks (Fig. 14). Stations were placed on vantage points elevated above the river, except at the estuary where it was on a broad sandbar, providing views of as much (about 500 m on average) of the river as possible. Habitat measurements (see above) taken in the vicinity allowed us to characterize the habitat at each station.

Diurnal activity patterns were determined during the pre-to-early laying (16-21 June; 0300-2400 h; hereafter called pre-laying), incubation (15-20 July; 0400-2300 h), and early brood-rearing periods (2-6 August; 0430-2230 h). Four-hour observation sessions were staggered over 3-4 days such that combined time blocks were representative of a full daylight period. Additional observations were made from 0200-0300 and 2300-2330 h on 17 June, from 0300-0400 on 16 July, and from 0400-0430 on 3-4 August to attempt to observe ducklings for possible night feeding. Birds at the shoreline or roosting could not be seen at these times but flying birds could be detected and, with a spotting scope, it was possible to determine whether there was activity on the water, especially in the calmer areas at J-Kûk and Gooseneck Steadies.

Behaviour was determined by instantaneous scan sampling of focal groups at 30 s intervals (Altmann 1974). Groups of 1-4 birds (chosen or often the only birds present) were followed throughout the time they were visible from the observation post. Pairs were chosen during the pre-laying period to compare male and female behaviour. Birds were considered present if they were out of sight behind islands or rocks but were known to be in the area, and thus numbers of sightings do not always correspond to the percent of time birds were present (see Results). Total number of bird*hours equalled the number of birds times the length of time they were present during an observation period.

Feeding behaviours were categorized as diving, skimming, and up-ending (Bengtson 1972). Diving included time on the surface as well as under water unless the interval between dives was longer than 30 s, which is close to the maximum recorded dive time for Harlequin Ducks (Bengtson 1966, 1972, Inglis et al. 1989, see Results). Intervals longer than 30 s were coded as swimming. Dive-pause ratios were used to calculate time spent under water to compare to other studies (see Discussion). Dive and pause times were determined by recording to the nearest second when birds dove and resurfaced. Skimming referred to picking drifting prey from off or just under the surface or from streambanks, as well as scraping prey off shallow rocks without submerging. Putting the head under water and peering towards the bottom ("looking") and swimming were not considered feeding behaviours. Other behaviours are described in Bengtson (1966) and Inglis et al. (1989) using terminology from Myers (1959). We called resting with "head-on-back" and "head-low" (Inglis et al. 1989) "rest-tucked" and "rest-up", respectively.

Diet

Diet was determined from fecal samples collected on 4 August from a roosting site used for much of the previous 3 days by four failed or non-breeding females at the Inukshuk observation area. An additional fecal sample collected from a mist-netted female on 3 July below the J-Kûk observation post gave an indication of diet earlier in the season. Insect parts from feces were sorted and identified to family for Diptera and to order for other taxon. Importance of different prey types is presented as numerical proportions, which will tend to underestimate the relative biomass of larger prey.

Analyses

ANOVA and chi-square tests were used to compare continuous and discrete habitat variables, respectively, between used and unused streams, and among strata on Harlequin Brook. Stream was included as a nested variable in ANOVAs to control for within stream variation. Because measurements taken on either side of the stream for shoreline and bank variables were correlated, I averaged the two to provide single, independent measures at each habitat point. This was done for stream width and distance to nearest shrub cover, and for ranked codes for shoreline slope, bank slope, and shrub height (including that for islands). For nominal cover codes that could not be averaged, I randomly selected one side for each habitat sample. Two-way ANOVA and log-linear analysis by sample date and strata were used to analyze continuous and discrete variables that may have changed through the season on Harlequin Brook (e.g., flow rate, depth).

Stepwise multiple regression was used to relate number of bird*hours recorded during dawn-to-dusk watches at the four observation stations to the habitat variables stream width, depth, surface, substrate, temperature, and flow rate, shoreline width and slope, distance to nearest shrub cover, presence or absence of shrub-covered islands, and total number of invertebrates recovered from kick samples. Average measurements from a minimum of two random points in the vicinity of each observation post were used in regression analyses. The average of codes recorded for discrete variables created continuous variables that could be used in regression models. A separate dummy variable (Hays 1988) was created for the presence or absence of shrub-covered islands.

Non-independent, sequential observations of behaviour and dive and pause times were not appropriate for statistical analyses. As it was not possible to choose random individuals for observations, due to the small numbers of birds present, I randomly picked 10 % of total observations to use in statistical comparisons. Thus, sample sizes for chi-square tests comparing frequencies of observations classed as feeding between groups were 10 % of the total numbers of observations. Dive and pause times were averaged for each diving bout by an individual, and one-way ANOVA was used to compare means of those average dive and pause times among birds of different reproductive status and sex.

Tolerance for type I error was set at 5 % for all tests. Frequency tables were collapsed to fewer categories and chi-square tests were repeated to insure p values were acceptable if more than 20 % of expected cell frequencies from original tables were < 5. Analyses were conducted using SYSTAT (Wilkinson 1990). Means are given ± 1 SD.

RESULTS

Capturing Birds

Most movement up and down the brook occurred at 0300-0600 h, with smaller peaks in activity at 1500-1600 and 2100 h during dawn-to-dusk observations on 10-11 June (Fig. 15).

One male and two female Harlequin Ducks were captured in 26 h of mist-netting. The male was caught in the "clothesline" set-up, but that effort did not work well. The net was visible to the birds in the level, open area where it had to be set, and flying birds avoided it. The simpler set-up on a sharp bend was more effective, but few birds were moving up and down the brook, and most males had left the area by the time we could employ this.

The bottom of the mist nets was difficult to set effectively. If it was in the stream, the net vibrated wildly as the current tugged on it, and so was more visible to the birds. If it was just at the surface, low-flying birds were not well entrapped and sometimes escaped before we could reach them. The three captured Harlequins were banded and measured (Table 2), and blood samples were taken. Handling time was 26 min for the first bird and 16 and 18 min for the next two. The male was difficult to extract from the net because he was pulled under water and tumbled in the bottom of the net. One male Red-breasted Merganser (*Mergus serrator*) was also caught in the mist net at 1932 h on 30 June and was banded with a USFW band.

Distribution and Abundance

Maximum numbers of Harlequin Ducks counted on Harlequin Brook were 11 males and 13 females on 17 June. Females generally outnumbered males throughout the period males were present. Pairs tended to be more dispersed along upper than lower portions of the brook during the pre-laying period. Common sightings in the lower 2 km of the brook were of small groups on or in the vicinity of a well-used roosting site on a small gravel bar in smooth water 1.7 km from the estuary at the J-Kûk observation station (e.g., 7M,7F on 8 June; 8M,10F on 11 June; 6M,10F on 17 June; 5M,7F on 30 June). A maximum of three males and four females (in groups of two pairs, one pair, and one female), and one pair were counted above the first and second canyons, respectively, on 21 June. Similar numbers of males were present throughout June, after which one was seen on 4 July, and the last was seen on 12 July. Throughout July, three to seven females that we concluded were failed or non-breeders frequented roost sites and feeding areas at all times of day.

Harlequins were observed on eight of 11 streams explored in Hebron Fiord (Fig. 3, Table 3). Only females were observed on streams explored only once, except for one pair just below the outlet of Primo Lake (Fig. 6). Most females observed were roosting in small groups along riverbanks or on islands during the middle of the day. Three females on Becca Brook (Fig. 11) and one female on Green Brook (Fig. 13) were roosting in canyons. We also observed females feeding at estuaries, or flying to and from the fiord, especially in the evening (Appendix III).

A group of five males and 12 females was present on 7 July at the shallow, sub-tidal delta, locally known as the "Caribou Rattle" off the mouth of Kame Terrace River (Table 3, Fig. 8). Larger flocks of Barrow's (*Bucephala islandica*) and Common Goldeneyes (*B. clangula*), Red-breasted Mergansers, and Oldsquaw (*Clangula hyemalis*) were also using those shallows (Appendix IV). Three males and 9 females remained in the same area on 9 July, suggesting that some birds were leaving at that time.

We used the number of presumed failed or non-breeding females observed on other streams and the ratio of non-breeding females to the maximum number of males and females observed on Harlequin Brook to estimate the overall abundance of Harlequin Ducks in Hebron Fiord. Females feeding at estuaries or flying to and from the fiord in the evenings were excluded from the non-breeding category because that is when we observed the female leave the known nest site on Harlequin Brook (see below). Females with broods also were excluded. Females roosting in small groups through the middle of the day (Appendix IV) were considered non-breeders. Using these criteria, a total of 21 females were defined as non-breeders on the rivers explored other than Harlequin Brook. Using the ratio of 7 non-breeders to the maximum of 11 males and 13 females on Harlequin Brook gives an estimate of 52 (13 + 21*13/7) females and 44 (52*11/13) males in Hebron Fiord.

This estimate is probably too conservative because the 7 failed or non-breeding females on Harlequin Brook was a maximum estimate based on more extensive observations than the single survey for birds conducted at other rivers. To obtain a less biased estimate, the length of Harlequin Brook was walked on 18 July in a manner similar to that used to explore the other rivers. Four non-breeding females were observed on this survey. Using 4 instead of 7 in the ratio for Harlequin Brook gives an estimate of 81 females and 69 males in Hebron Fiord. Thus we estimate 70 pairs using Hebron Fiord in 1996.

Habitat Characteristics

Streams where no Harlequin Ducks were sighted were located in the Ikarut valley (Ikarut River and Saddle Brook) and in the outer fiord (Barren Brook; Fig. 3). We compared habitat characteristics in those streams to those in three others located in the outer section of the fiord (Winnie, Becca and Green brooks). Used streams were narrower, had higher pH and temperature, larger substrate, steeper shorelines, and greater vegetation cover on islands and shorelines than unused streams (Tables 4 and 5). As with substrate, unvegetated shoreline of used streams was more frequently composed of larger boulders and less frequently of sand or small stones (Table 5).

Greater numbers of invertebrates were recovered from kick samples in used (14 $\pm$ 15, N = 24) than unused (3 $\pm$ 4, N = 24) streams ($F_{1,46}$ = 11.50, P = 0.001). Simuliid larvae (X^2_1 = 5.62, P = 0.018) and Plecoptera nymphs (X^2_1 = 24.71, P < 0.001) were more abundant, while Chironomid larvae (X^2_1 = 3.87, P = 0.049) and Ephemeroptera nymphs (X^2_1 = 29.84, P < 0.001) were less abundant in used than unused streams (Table 6). Ephemeroptera also formed a smaller proportion (X^2_1 = 22.68, P < 0.001) and Plecoptera formed a greater proportion (X^2_1 = 12.69, P < 0.001) of invertebrates recovered from passive rock samplers placed in the lower 2 km of Harlequin Brook than from those placed in the Ikarut River (Table 7). Proportions of Simuliidae were not significantly greater in Harlequin Brook than in Ikarut River (X^2_1 = 0.53, P = 0.467).

At Harlequin Brook, habitat characteristics varied through the season and among strata. Temperature, pH, and numbers of exposed boulders increased, while flow rate and depth decreased through the season (Tables 8 and 9). Stream temperature did not begin to rise until the fourth week in June, while depth generally decreased from mid-June to August with flood peaks in the middle and end of June (Fig. 16). Stream width, temperature and flow rate, numbers of islands and exposed boulders, shoreline width, and distance to shrub cover varied significantly among strata (Table 10), as did depth (G^2_{12} = 47.73, P < 0.001), surface (G^2_8 = 99.50, P < 0.001), and substrate (X^2_{12} = 47.93, P < 0.001; Table 11). Due to small sample sizes (see Table 11), we combined slope codes for shoreline and bank, cover codes for island, shoreline and bank, and vegetation height codes for island and shrub (note that codes for vegetation height on bank were not included because bank vegetation was often the same as nearest shrub cover) to test differences among frequencies. Combined code frequencies were significantly different among strata for slope (X^2_{12} = 49.74, P < 0.001), cover (X^2_{12} = 77.84, P < 0.001), and vegetation height (X^2_8 = 21.48, P = 0.006).

Composition of invertebrate samples also varied through the season and among strata on Harlequin Brook. Proportions in kick samples (Table 12) were highest in June and July for Chironomids ($X^2_2 = 19.77$, $P < 0.001$), in June for Tricoptera ($X^2_1 = 20.06$, $P < 0.001$), and in August for Simuliidae ($X^2_2 = 9.45$, $P = 0.009$) and Plecoptera ($X^2_2 = 31.54$, $P < 0.001$). Similar results were obtained from the passive rock samplers in the lower 2 km of Harlequin Brook: Chironomidae ($X^2_2 = 77.60$, $P < 0.001$) and Tricoptera (not tested due to small sample size) were most frequent early in the season, and proportions of Simuliidae ($X^2_2 = 11.46$, $P = 0.003$) and Plecoptera ($X^2_2 = 77.46$, $P < 0.001$) were highest in August (Table 13).

Among strata on Harlequin Brook, proportions were greatest in strata 1 and 4 for Chironomidae ($X^2_3 = 12.05$, $P = 0.007$), in strata 2 and 4 for Simuliidae ($X^2_3 = 60.05$, $P < 0.001$), and in stratum 1 for Plecoptera ($X^2_3 = 11.32$, $P = 0.010$). Tricoptera were recovered only from stratum 5 (Table 14). Proportions of Ephemeroptera did not vary significantly through the season ($X^2_2 = 4.10$, $P = 0.129$) or among strata ($X^2_3 = 5.74$, $P = 0.125$).

Table 15 summarizes mean lengths of all invertebrates collected from streams in Hebron Fiord in 1996. Simuliidae ($r^2 = 0.27$, $F_{1,128} = 46.95$, $P < 0.001$) and Tricoptera ($r^2 = 0.24$, $F_{1,30} = 9.48$, $P = 0.004$) were the only taxon which showed clear seasonal increases in size.

Stepwise regression of the number of bird*hours recorded during all-day observations at the four observation stations (Table 16) on habitat variables revealed no significant correlations between total use by adult males and females and any habitat variables ($P_s > 0.05$). Numbers of adult bird*hours spent feeding was positively correlated with stream depth ($F_{1,8} = 27.00$, $P = 0.001$) and with substrate size ($F_{1,8} = 23.55$, $P = 0.001$), and negatively correlated with flow rate ($F_{1,8} = 28.19$, $P = 0.001$). Numbers of bird*hours spent swimming was negatively correlated with distance to closest shrub cover ($F_{1,9} = 8.42$, $P = 0.018$), and positively, though not significantly, with depth ($F_{1,9} = 5.00$, P

= 0.052). Bird*hours resting and preening were not significantly related to any habitat variables (P_s > 0.05).

The presence of shrub-covered islands was the only significant predictor of total use by broods ($F_{1,2}$ = 1096.1, P = 0.001), and numbers of duckling*hours spent feeding ($F_{1,2}$ = 1924.7, P = 0.001), and resting and preening ($F_{1,2}$ = 53.50, P = 0.018). Number of duckling*hours spent swimming was related to presence of shrub-covered islands ($F_{1,1}$ = 205.9, P = 0.044) and, negatively, to stream depth ($F_{1,1}$ = 560.3, P = 0.027).

Nests and Broods

A down-lined, 28 cm diameter nest containing 6 eggs was discovered on 21 July on a 12 x 45 m island densely covered with overhanging willow and alder (*Alnus crispa*) shrubs on Harlequin Brook. The incubating female did not flush from the nest until the observer (MSR) approached to within 2 m. The nest was situated among some small stones and a mound of dry leaf litter at the base of a clumped-stem, 2.3 m high alder. It was 0.5 m above water level in the middle of the tapered, upstream, northern end of the island, 4.4, 5.1, and 4.6 m from the north, east and west edges, respectively. Shrub canopy within a 5 m radius around the nest was ~85% and 2.2 m high, and included 5 willow and 19 alder shrubs with an average of 16 (range 7-33) and 13 (range 2-32) stems per shrub, respectively. There was little understorey vegetation adjacent to the nest, and ground cover in a 5 m radius was ~10% moss, 30% herbaceous vegetation, and 60% bare ground and leaf litter. Shrubs overhung the brook by 0-0.6 m. Channels east (to the edge of the brook) and west (to an adjacent island) of the island were 20 and 4.1 m wide, 0.5-1.0 and < 0.5 m deep, with abundant and some riffles, and flow rates of 1.25 and 1.11 m/s over boulder substrates, respectively. The island was one of about 20 similarly vegetated islands in a braided section of the brook with an overall width of

~80 m (including islands) located 2.5 km from the estuary. All islands and adjacent stream banks in this area were searched for nests.

A watch was maintained on the nest site from 2000-2300 and 2045-2313 on 21 and 22 July, respectively. The female emerged from the shrubs surrounding the nest at 2105 on 21 July. She immediately swam to midstream, stayed in an eddy behind a rock for 2 min, swam downstream to perch on a rock and preen for 1 min, then swam further downstream out of sight. A female flying upstream landed within 15 m of the nest site at 2231. She was joined by a second female 3 min later, then both swam across the stream out of sight. A female was not seen leaving the nest on 22 July. Females flew and swam past the nest site at 2152 and 2158, then from 2222-2313, 1-3 females were present in the vicinity swimming up, down, and across the stream, perching briefly on rocks, and engaging in frequent vocalizations, head-nodding, and pursuit behaviours. Eggs had been hatched for a few days when we revisited the nest on 2 August. Down and feathers from the edge of the nest had been carefully folded into the centre completely covering the hatched eggshells.

First broods of 5 and 6 ducklings were seen on 29 July on nearby "Green Brook" (58°11'30"N, 62°47'20"W), and broods of 8, 6, 3 and 1 ducklings were first seen on Harlequin Brook on 2, 3 and 4 August, respectively. All ducklings were small and downy (Ia-Ib) when first observed and estimated ages for those broods (Gollop and Marshall 1954) indicated hatching dates in the last 10 days of July (Fig. 17). All broods were diligently guarded by single females, except the single duckling which was observed feeding as far as 100 m upstream from a "neglecting" female. Other than approaches by this lone duckling, we had no evidence that this female was the parent. We concluded that the lone duckling was from a different brood than the other ducklings because the broods of 6 and 1 ducklings were found 3 km upstream from the other broods beyond an intervening stretch of canyon with many waterfalls and rapids, and the lone duckling was smaller than ducklings in the brood of 6. The lone duckling was not seen again but the female and brood of 6 were observed gradually working their way from 5.2 to 8.4 km upstream from 2-5 August, after which we conducted no further observations. The broods of 8 and 3 ducklings were first observed in the same section of the brook where the nest had been found and we assumed that one of them had hatched from that nest. Those broods were sighted further downstream on 4 August, and the brood of 3 was seen at 1.2 km from the estuary on 5 August. On 10 August, we found only one brood of 10 ducklings with a single female in this area, which was undoubtedly an amalgamation of the 2 broods. They were seen again on 11 and 13 August working their way up and down the lower 2 km of brook, always with only a single female.

Habitat at Observation Posts.

At the estuary (Fig. 14) the brook was tidal with a depth of 1-2 m and a maximum flow rate of about 1.0 m/s over a pebble substrate. Shoreline was low-lying sandbars with little vegetation. J-Kûk was a slower (0.6 m/s), narrow (20-30 m-wide) section with a depth of 0.5-1.5 m over a pebble substrate. It was on a sharp bend just below the braided area of rapids surrounding a number of densely shrub-covered islands where the Harlequin Duck nest was found. Shoreline was high, steep sandbank on one side and low ground with overhanging shrub-cover on the other. There was a small, 10 m-long gravel bar mid-stream. Inukshuk was a relatively level area of rapids, 20-70 m wide, surrounding a few low islands covered with sparse shrubs. Maximum flow rate was 1.8 m/s and depth was generally < 0.5 m over a substrate of large stones and boulders. Gooseneck Steadies was a meandering lake-like area surrounding large, densely shrub-covered islands. Flow rate was <0.2 m/s and depth was 0.5-2.0 m over a silty bottom. Small, rapidly-flowing feeder streams and the main Harlequin Brook entered the steadies from the north and northwest. Ice and snow covered much of the shorelines and overhung portions of the brook at all stations during the first observation period.

Activity Patterns.

Diurnal activity patterns varied by habitat and changed through the season. During the pre-laying period most activity occurred at J-Kûk and Gooseneck Steadies (Fig. 18). J-Kûk was used as a loafing area by a "club" (Bengtson 1966) of up to 6 males and 10 females (Fig. 18) that spent most of the day resting, preening, swimming, and feeding (Table 17, Fig. 19). The small gravel bar in the brook served as the main loafing site. Most feeding behaviour (Table 17) by 1 male and up to 4 females (Fig. 18) was recorded at Gooseneck Steadies, where it was the predominant behaviour, especially for females, throughout much of the day (Fig. 19). Feeding occurred below the inlet of small feeder streams and along the edge of snow and ice overhanging the sides of the brook and islands. Females spent more time feeding than males at all stations ($X^2_1 = 27.4$, $P < 0.001$; Table 17). At Gooseneck Steadies, males often swam alongside diving females, frequently "looking" as if keeping track of the female while she was under water (Table 17).

Inukshuk was the most used area during the incubation period, where groups of up to 5 failed or non-breeding females regularly roosted on the edge of the largest shrub-covered island through much of the day (Fig. 20). Most feeding occurred at Inukshuk and Gooseneck Steadies, although birds were present for only 18% of the observation period at Gooseneck Steadies (Table 18, Fig. 20). Inukshuk and Gooseneck Steadies were also used for brood-rearing (Fig. 21). A brood of six, that were about 1-week old, spent 45% of their time feeding in both areas compared to an average of 15% for their parent female. Females without broods fed more than those with broods ($X^2_1 = 10.34$, $P = 0.001$; Table 19). The "Willows" area where the nest was found above J-Kûk was also used for brood-rearing and females periodically escorted their broods up and down the brook past the J-Kûk observation area (Table 19; Fig. 21).

Little use was made of the estuary throughout the season (Figs. 18, 20, and 21). Main activities there were swimming and flying, often of birds in transit between the higher brook and offshore in the fiord (Tables 17-19). Birds sometimes roosted and preened on the shoreline or on gravel bars, and spent a small proportion of time feeding.

Females spent more time feeding in the pre-laying period than in the incubation ($X^2_1 = 71.8$, $P < 0.001$) and brood-rearing periods ($X^2_1 = 35.2$, $P < 0.001$; Table 20). Females during incubation and accompanying broods had the lowest and similar feeding rates ($X^2_1 = 2.73$, $P = 0.098$), and ducklings had the highest (though not significantly higher than pre-laying females; $X^2_1 = 1.18$, $P = 0.227$). Aggressive and courtship behaviours occurred primarily during the pre-laying period (Table 20) at J-Kûk and Gooseneck Steadies (Table 17). Aggressive encounters were observed at Inukshuk, as females attending broods chased off closely approaching failed or non-breeding females (Table 19). Alert behaviour by females was most frequent during the brood-rearing period (Table 20) and at Inukshuk (Tables 18 and 19).

Diurnal feeding patterns also changed through the season. Males and females in the pre-laying period fed through most daylight hours with no obvious peaks (Fig. 22). Females during the incubation period and females with broods fed mostly in the morning and evening. Failed or nonbreeding females fed more through the middle of the day during the brood-rearing period (Fig. 22). Birds were not seen feeding when it was dark at the beginning or end of diurnal observation periods, and no evidence of feeding was observed during nocturnal observations. Harlequins were occasionally sighted flying and swimming by the estuary and J-Kûk observation posts as early as 0200 on 17 June and 0320 on 17 July.

Feeding Efficiency

Most diving was observed at Gooseneck Steadies during the pre-laying period and at Inukshuk during the incubation period (Tables 17 and 18). Samples of dive times from paired males and females and from unpaired females at Gooseneck Steadies during the pre-laying period (Table 21) showed significant differences in dive times ($F_{2,114} = 4.55$; $P = 0.013$) and pause times ($F_{2,85} = 3.73$; $P = 0.028$), but not in dive-pause ratios ($F_{2,85} = 0.90$; $P = 0.410$). Unpaired females made longer dives than paired females (Tukey: $P = 0.009$) and paired males ($P = 0.041$), and took longer pauses than paired females ($P = 0.041$) but not paired males ($P = 0.634$). In the shallower water at Inukshuk, females made shorter dives ($F_{2,96} = 20.6$; $P < 0.001$) with similar dive-pause ratios ($F_{2,68} = 0.28$; $P = 0.757$) during the incubation period compared to all those recorded at Gooseneck Steadies during the pre-laying period and at J-Kûk during the brood-rearing period (Tukey: $P_s < 0.001$; Table 21; Fig. 23). Maximum dive times were 35, 21 and 34 s at Gooseneck Steadies, Inukshuk and J-Kûk, respectively.

Diet

Diptera Simuliidae constituted 98% of remains found in feces collected on 4 August (Table 22). No simuliidae were present and Tricoptera larvae were the most common prey item in feces collected on 3 July.

DISCUSSION

Capturing Birds

One male and two females were captured and measured. Male and female mass, wing length, tarsus, and culmen measurements were within the range of those recorded for Pacific birds, although some measurements differed from those reported in individual studies (Kuchel 1977, Dzinbal 1982, Wallen 1987, Cassirer and Groves 1991). Mass and culmen measurements for the single male we caught were greater than maximum measurements taken from 40 birds captured in Alaska (Dzinbal 1982). Culmen length was also greater than, and mass was equal to the maximum recorded for 7 birds in Idaho (Cassirer and Groves 1991). In contrast, male mass was equal to the minimum recorded for 12 males in Montana (Kuchel 1977). Small sample sizes in most studies may contribute to variation in mean values reported. Female measurements show more overlap among studies.

Capture methods were handicapped by high water level and flow rate early in the season. Nets strung across open areas were visible to flying birds and better locations were on bends with high banks. Mist-netting would be more effective on smaller streams that can be waded across in June. Netting also may be more effective in forested areas where nets would not be visible against the sky. Netting over calm water may allow the net to be set into or very close to the water and alleviate the problem of low-flying birds escaping under the net.

Most movement up and down the lower brook occurred in the early morning and highest capture rates could be expected at that time. However, flights of larger groups of birds (we had one flock of 13 birds fly around, through, and over the "clothesline" set-up) could result in chaotic situations and potential injuries and fatalities. Blood samples from mist-netted birds have been analyzed by K. Schrifner.

Distribution and Abundance

A maximum of 11 males and 13 females were observed on Harlequin Brook in 1996. Our observations of greater numbers of females than males is contrary to the dominance of males reported in other studies (Bengtson 1966, 1972, Kuchel 1977, Inglis et al. 1989). As males depart the breeding areas when the females start to nest, the difference may be related to the lateness of the breeding population survey. However sources of differential mortality should be explored. Assuming that the number of males correspond to the number of breeding pairs yields a density estimate of 0.92 pairs/km, slightly less than the mean of 1.3 pairs/km reported for streams in Iceland (Bengtson 1972). The number of pairs actually initiating breeding was probably lower because of the typically high incidence (15-89%) of non-breeding in females (Bengtson and Ulfstrand 1971, Dzinbal 1982, Wallen 1987). Regular observations of 3-7 non-breeding females during July suggest that only 46% of the females present bred in 1996. Aerial surveys in Labrador also indicate high incidence of non-breeding (Goudie et al. 1994).

Adults tended to gather, especially before egg-laying, at a communal loafing site or "club" (Bengtson 1966) located just downstream from where the nest was found (see also Kuchel 1977). Pairs were more dispersed along the upper brook at that time. Later, in July and early August, small groups of non-breeding females were common at Inukshuk in the upper brook and fewer birds were seen in the lower brook.

Harlequins were observed on 8 of 11 streams explored in Hebron Fiord. This is a conservative estimate of the number of streams used by Harlequin Ducks because streams were checked only once and because only the lower 10 km of each stream were searched. However, we are quite confident that Harlequin Ducks were not present on "unused" streams, especially Barren Brook and on the lower 10 km of Ikarut River, because they were accessible along the entire lengths that were searched and they had little shoreline vegetation to obscure birds. Harlequin Ducks may use upper portions of the Ikarut River because we occasionally observed birds heading up that river (1 female at 2153 h on 10 June, 1 pair at 0518 on 15 June) during observations on lower Harlequin Brook.

Caribou Rattle appears to be an important waterfowl feeding and staging area. Earliest spring arrivals of Harlequin Ducks in Hebron Fiord have been reported there (A. Veitch pers. comm.). We suspected that it was a staging area used by males and non-breeding females before departure to other coastal areas.

We estimated 150 adults using Hebron Fiord in 1996. This constitutes a substantial proportion of the estimated eastern North American population (Goudie 1991), making Hebron Fiord a priority area for conservation measures. If a similar rate of non-breeding occurred in all streams surveyed, then 30-40 pairs bred in 1996.

Production on Harlequin Brook was four broods from a maximum of 13 females. Sixteen ducklings were alive when last observed, representing a maximum productivity of 1.2 ducklings per female present, or 2.7 ducklings per breeding female (assuming that 6 females bred in 1996). Ducklings were 1-2 weeks old when last observed and fledgling production was undoubtedly lower, although mortality is highest during the first 2 weeks (Bengtson 1972). We observed no incidents of predation, but Gyrfalcons (*Falco rusticolus*) nested in the lower canyon on Harlequin Brook and were observed stooping on female Harlequins at J-Kûk on 2 August. Peregrine Falcons (*F. peregrinus*) and red foxes (*Vulpes vulpes*) also frequented the area (Appendix IV).

Habitat Characteristics

Streams used by Harlequin Ducks in the outer portion of Hebron Fiord were narrower, had higher pH and temperature, larger substrate, steeper shorelines, and greater vegetation cover on islands and shorelines than unused streams. We suspected that differences in width may represent a bias due to the fact that larger streams used by Harlequin Ducks (i.e., Primogenitor, Caribou, Kame Terrace, and Golden Eagle) were not included in the habitat comparison, while the unused section of Ikarut

River, which is similar in size to excluded streams, was included in the comparison. However, differences in width were still substantial (22 ± 21 and 40 ± 41 for used and unused, respectively), though not significant ($F_{1,40} = 3.24$, $P = 0.079$), when Ikarut River was excluded from the comparison. Narrower width of used streams probably relates to their steeper shorelines, and thus more constricted stream flow. Higher frequency of very steep shorelines represents a greater incidence of canyon habitat on used streams. Harlequin Ducks were observed roosting in canyons and may use cavities and ledges in canyons for nest sites (Bengtson 1972, Campbell et al. 1990, Cassirer et al. 1993). Canyons were used preferentially in Montana and were thought to provide good loafing sites and abundant insect populations (Kuchel 1977).

Lower temperatures, and possibly lower pH as well, probably indicates later retention of snow cover on unused streams. Banks were covered with snow and ice at the upper two stations on Saddle Brook on 23 July (see Appendix II), and Barren Bay was located in the outer section of Hebron Fiord where snow melt was later in general than in the inner fiord. Ice and snow were also recorded on Becca Brook, which had the coldest temperatures of the used streams (see Appendix II) and was located towards the outer fiord. Colder temperatures probably reduce invertebrate productivity (Colbo and Porter 1981), and later snow cover may delay access to potential nest sites.

Vegetation on islands and shorelines appears to be important for Harlequin Ducks. Nest sites are located in dense vegetation on islands and close to shore (Bengtson 1972, this study) and adults with broods make frequent use of vegetation cover along the edge of the stream for concealment (Bengtson 1966, Kuchel 1977, MSR pers. obs.). Presence of shrub-covered islands was the main variable related to brood activity, and the proximity of shrub cover was related to time spent swimming by adults on Harlequin Brook.

Numbers of invertebrates captured in kick samples, and frequency of Simuliidae and Plecoptera were higher in used than unused streams. Higher frequency of Simuliidae and Plecoptera in used streams and Chironomidae in unused streams is consistent with their relative importance in the diet as determined by fecal analysis. Changes in relative abundance of invertebrate taxa through the season and among strata on Harlequin Brook were also consistent with their occurrence in the diet and the distribution of feeding birds. Tricoptera were frequent in the fecal sample collected and were abundant only at Gooseneck Steadies where most feeding occurred in June. Simuliidae were not present in kick samples taken in June and were most abundant in early August, especially in strata 2 and 4 which corresponded to the Willows and Inukshuk areas used for brood-rearing.

Larger substrate in used streams may reflect a preference for faster water and relate to Harlequin's dietary dependence on Simuliidae larvae which concentrate on cobble or boulder substrates in fast-flowing water (McCreadie and Colbo 1993). Flow rates did not differ between used and unused streams, but the greater incidence of canyon habitat, where flow rate often could not be measured, probably resulted in an under-estimate of mean flow rates on used streams. Substrate size was an important predictor of time spent feeding by adults on Harlequin Brook. The positive relationship between number of adult bird*hours spent feeding and substrate size appears contradictory to the negative relationships found between feeding activity and depth and flow rate. However, changing patterns of habitat use through the season may account for these apparently anomalous results. High use of the slow-moving, deeper waters at Gooseneck Steadies early in the season and for brood-rearing explains the relationships with depth and flow rate, while intense feeding in the shallow rapids over boulder substrate at Inukshuk in July and August probably accounts for the relationship with substrate size. These results indicate a complex use of variable habitats.

Variation in most habitat characteristics among strata on Harlequin Brook also suggests that streams used by Harlequin Ducks have a complex fluvial and riparian structure. Different requirements for nesting, feeding, resting, and brood-rearing may result in preferences for streams with variable structure. Future comparisons of within stream variation in habitats between used and unused streams could address this hypothesis.

Seasonal changes in temperature, pH, flow rate, depth, and numbers of exposed boulders were probably primarily a function of the recession of water levels and the reduction in melt water input. Low water temperatures would maintain low benthic invertebrate productivity (Colbo and Porter 1981) until near the end of June and undoubtedly affects timing of breeding by Harlequin Ducks (see below). Flood peaks in the middle and end of June would limit access to nest sites and can affect breeding success (Kuchel 1977, Wallen 1987).

Phenology

Timing of hatching in the last week of July is 2-4 weeks later than dates reported for Idaho (Cassirer and Groves 1991), Montana (Kuchel 1977), and Alaska (Dzinbal 1982), and is similar to median dates in Iceland (Bengtson 1972) and Wyoming (Wallen 1987). Differences may be due to spring conditions and altitudinal and latitudinal effects on timing of snow melt (Bengtson 1972, Wallen 1987, Cassirer and Groves 1991). Laying (assuming a 28 day incubation period - Bengtson 1972) apparently peaked just after snow melt and recession of flood waters near the end of June on Harlequin Brook (see Fig. 17). Protracted laying and hatching periods, with egg-laying beginning at the end of May, observed by Bengtson (1972) would not be feasible in the spring conditions at northern Labrador in 1996. Two Ic broods (see Gollop and Marshall 1954) observed in Harlequin

Brook at the end of July 1988 (Goudie et al. 1994) suggest interannual variation in breeding chronology.

Nest Site and Brood Behaviour

The nest site and clutch size were similar to most described in Iceland (Bengtson 1972). Difficulties of searching through dense shrubbery, cryptic coloration of incubating females, and their tenacious behaviour on the nest (Bengtson 1966, this study) make nest finding a time-consuming, artful endeavour. Although our single nest find supports the merit of searching through dense shrub habitat, other possible nest sites, such as rock cavities and cliff ledges, should not be ignored.

Behaviour of broods differed in the upper and lower brook. The canyon presented a barrier to broods hatched above and below and probably accounted for the opposite upstream and downstream movements observed. Broods below the canyon worked their way up and down the lower 2-3 km of brook and appeared to make some use of the estuary for feeding.

We are unsure whether the lone duckling we observed was a result of early brood abandonment, parental neglect, or simply a lost duckling. Abandonment of older broods is common (Bengtson 1972, Wallen 1987, Cassirer and Groves 1991) but we know of no other cases where few-day-old ducklings have been abandoned. Movements of the female in the vicinity of that duckling were very sluggish when we disturbed her, unlike all other birds that we observed, suggesting that she may have been unwell, and, if she was the parent, unable to guard her ducklings.

Brood amalgamation is common in waterfowl when broods hatch synchronously and brood-rearing habitats overlap (Afton and Paulis 1992), as was the case in the lower section of Harlequin Brook. Brood amalgamation in Harlequin Ducks has been observed in Iceland (Bengtson 1966) and Montana (Miller 1990 cited in Cassirer and Groves 1991) and has important implications for brood surveys designed to measure breeding success and productivity. Brood amalgamation following abandonment of older ducklings, and groups of 2-3 females sharing mixed-age younger broods with no indications of one female "robbing" ducklings from another was reported in Iceland (Bengtson 1966, 1972). Only one female accompanied the amalgamated brood of 10 downy ducklings over the 3 days that we observed them. No interactions with other females in the area were observed. We suspected partial amalgamation had occurred when we first observed the broods of 3 and 8 ducklings because one probably came from the known nest with 6 eggs and hatching success is normally high (87% - Bengtson 1972).

The possibility that one of the amalgamated broods and the lone duckling were abandoned at young ages raises concerns for the body condition of breeding females. Harlequin Ducks show adaptations to impoverished and ephemeral food supplies (Bengtson 1972) and appear to be poorly buffered against variation in food supplies. This leads to high rates of non-breeding in poor years (Bengtson and Ulfstrand 1971), and possibly to clutch and brood abandonment as well (see Afton and Paulis 1992). Adults in the lower portion of Harlequin Brook exhibited regular movements to and from the estuary, and proximity to intertidal food resources may have supplemented food availability in the brook. Frequency of non-breeding was high and productivity was low in coastal streams in Alaska (Dzinbal 1982), suggesting that even with intertidal resources, Harlequin Ducks may still be food limited (Bengtson 1972).

Activity Patterns

Streams used by Harlequin Ducks for breeding in boreal, subarctic and montane areas have relatively low mean benthic animal standing crops and low productivity (Ulfstrand 1968, Bengtson and Ulfstrand 1971, Bengtson 1972). Low breeding density and high frequency of non-breeding, especially when productivity is reduced (Bengtson and Ulfstrand 1971), indicate that harlequins are poorly buffered against variation in food supplies. Females spent 40% of daylight hours feeding during the pre-laying period at Harlequin Brook, more than twice the time spent by males and higher than that reported in other studies. Pre-laying females fed 21% (including only time spent under water during dives) and 7% of diurnal time in Alaska (Dzinbal 1984) and Iceland (Inglis et al. 1989), respectively. Excluding pause times during diving bouts, as did Dzinbal and Jarvis (1984), yields an estimate of 28% of diurnal time spent feeding by pre-laying females at Harlequin Brook. High food availability was thought to account for low feeding rates in Iceland (Inglis et al. 1989). It probably also contributed to the lack of difference in the percentage of time spent feeding by males and females (Inglis et al. 1989), in contrast to the results of this study, those of Bengtson (1972) and Dzinbal (1984), and the difference typically observed in other waterfowl (Krapu and Reinecke 1992). Higher feeding rates and greater differences between males and females in this study than those of Bengtson (1972) and Dzinbal (1984) suggest that females at Harlequin Brook may have been stressed to obtain sufficient food to meet the demands of egg production. We estimated that less than half of the females present at Harlequin Brook initiated breeding in 1996.

Changes in diurnal feeding patterns through the season may explain differences in feeding patterns observed in previous studies. Observations revealed little variation in the pre-laying period, as found by Inglis et al. (1989) during the same period, and major peaks of activity in the morning and evening during incubation and brood-rearing, similar to the overall summer patterns reported by Bengtson (1966, 1972) and Kuchel (1977). However, in contrast to Inglis et al. (1989), continuous feeding throughout daylight hours during the pre-laying period could indicate low food availability at that time, resulting in the high proportion of time spent feeding by pre-laying females. No evidence of nocturnal feeding was obtained, although sightings of flying and swimming birds at the estuary and J-Kûk indicated that some activity does occur in the pre-dawn hours.

Extensive feeding in the slow-moving waters at Gooseneck Steadies was unexpected. Harlequin Ducks have rarely been sighted on lakes in Iceland (Bengtson 1966), and confine most of their feeding activity to swiftly running waters (Bengtson 1972, Kuchel 1977, Inglis et al. 1989). However, Kuchel (1977) reported frequent use of calm water and ponds during periods of high water and for brood-rearing in Montana, and dense shrub cover was thought to attract harlequins to a lake where a brood was successfully raised in Alaska (Dzinbal 1982). We suspected that harlequins may have been nesting in the dense shrubs covering the islands in Gooseneck Steadies, which had similar vegetation to the islands where the nest was found above J-Kûk. Tricoptera were abundant only at Gooseneck Steadies in June and were frequent in the fecal sample collected at that time. Alternative foods in other habitats may have been less available.

Diving was the predominant feeding behaviour for all classes of harlequins, and for ducklings formed a similar proportion of their feeding activity as skimming. In contrast, young ducklings fed mostly by skimming in Iceland (Bengtson 1972) and rarely fed by diving until 3-4 weeks old in Montana (Kuchel 1977). Adult insects picked from the surface formed a larger part of ducklings diet in Iceland (Bengtson 1972) and type of feeding behaviour probably relates to timing of insect emergence (Sedinger 1992). Much of the skimming behaviour recorded at Inukshuk was of ducklings scraping prey, possibly simuliid larvae or pupae, off shallow rocks. Adult black flies were also available at that time as they were emerging in large numbers for the first time in 1996 on 2-3 August (MSR pers. obs.), coincidental with the brood-rearing behavioural observations. Greater handling time for adult insects (Sedinger 1992) may have made it advantageous for ducklings to feed on the more concentrated larvae and pupae still attached to the substrate. At Gooseneck Steadies, ducklings spent considerable time picking prey off the edge of the streambank. Numerous Plecoptera were observed emerging along the stream edges at that time and may have been an important prey. We have no information on the proportion of time spent feeding by harlequin ducklings elsewhere, but the 45% we observed is similar to that reported for other diving species (Sedinger 1992).

Mean dive times of 22-24 s at Gooseneck Steadies and J-Kûk were longer than the means of 16 and 20 s reported by Bengtson (1972) and Kuchel (1977). Shorter dive times in the shallower and faster water at Inukshuk were similar to those measured by Inglis et al. (1989). Maximum dive time was 35 s in this study and in Bengtson's (1972). Longer dives of 39 and 40 s have been recorded (Bengtson 1966, Kuchel 1977).

Dive-pause ratios of 4.0 (Bengtson 1966, Kuchel 1977) implicated harlequins as the most efficient of sympatric diving ducks (Bengtson 1966, 1972). Lower ratios of 1.7-2.2 found in this study are similar to those reported for Oldsquaw, Red-breasted Merganser and Barrow's Goldeneye in stream habitats in Iceland (Bengtson 1966). Similar dive-pause ratios at Gooseneck Steadies, Inukshuk and J-Kûk imply that differences are not a function of habitat, water depth, or flow rate. There are no obvious methodological differences among studies, and reasons for the large discrepancy between our results and those of Bengtson (1966) and Kuchel (1977) are not apparent.

Low feeding rates of parents with broods, and higher rates for birds without broods have been reported for other species (Afton and Paulus 1992). Kuchel (9177) reported that females rarely fed until their broods were several weeks old, but this seems unlikely given the energy requirements of laying and incubation (Alisauskas and Ankney 1992). Alert behaviour by parent females was most common at Inukshuk and not recorded at Gooseneck Steadies probably because of differences in habitat and feeding behaviour. At Inukshuk, where most feeding occurred towards the exposed centre of the brook, the female often stood in alert posture on an exposed rock while her ducklings were foraging. Most feeding by ducklings at Gooseneck Steadies occurred close to shore while the female maintained a guarding position, swimming so as to keep her ducklings between her and the shelter of the shrub-covered streambank.

Females with broods exhibited social tendencies in Iceland, forming mixed groups of 2-3 females with different aged young, and allowing unsuccessful females to participate in brood-rearing (Bengtson 1966). In contrast, unsuccessful females were not tolerated near broods, and females with broods were aggressive to other females and broods, even rejecting abandoned broods in Montana (Kuchel 1977). We observed females with broods chase off failed or non-breeding females at Inukshuk, but two females freely mixing with a female and brood of 3 ducklings at J-Kûk, and the amalgamation of that brood with another brood of 8 ducklings that were also observed, indicated that females will at times accept other females and ducklings. Differences in aggressive behaviour may relate to food availability (Kuchel 1977), but differences between females on Harlequin Brook suggest that other factors are involved.

Diet

Fecal remains collected in August were composed primarily of Diptera Simuliidae larvae in similar proportion to that reported for May to August in Iceland (Bengtson 1972). The fecal sample collected in early July differed most notably by the complete absence of simuliidae. Many simuliidae overwinter as larvae in Iceland streams (Bengtson and Ulfstrand 1971) and are abundant there through May and the first half of June and in August (Bengtson 1972, Gíslason and Gardarsson 1988). This food resource early in the season may be lacking in northern Labrador. Simuliidae were not present in invertebrate samples taken in Harlequin Brook at the end of June and were most abundant in August. In Iceland, turbulent streams stay open throughout the winter and water temperatures show a rapid rise in May and June (Bengtson 1966, Ulfstrand 1968, Gíslason and Gardarsson 1988). In contrast, persistent winter snow and ice cover and low water temperatures through May and June may hinder overwintering of larvae and limit production early in the season in northern Labrador (Colbo and Porter 1981, M. Colbo pers. comm.). Hebron Fiord lies close to the northern limit of simuliid distribution (M. Colbo pers. comm.) and dependence on simuliid larvae during the brood-rearing period may limit the northern breeding distribution of Harlequin Ducks (Bengtson 1966, Goudie 1991).

Chironomids were the most frequent taxon recovered from kick and passive rock samplers but were not found in the diet. Most were small and, unless concentrated and accessible, are probably a poor food resource. They formed a small proportion (1%) of the diet in Iceland (Bengtson 1972).

Conclusions and Recommendations

Low reproductive potential of Harlequin Ducks due to deferred maturity, small clutch size, and high frequency of non-breeding when food supplies decrease (Bengtson 1972, Bengtson and Ulfstrand 1971) means that endangered populations will be slow to recover even if other impacts on the population are minimal (Montevecchi et al. 1995). Historical records from Hebron Fiord indicate that productivity is variable and that few or no ducklings are produced in some years (Goudie et al. 1994, A. Veitch pers. comm.). Relationships between time budgets, breeding success, and factors that affect stream productivity, such as low spring temperatures (Gíslason and Gardarsson 1988), low water levels (Goudie et al. 1994), and increased turbidity from flood waters or human disturbance need investigation. The degree to which Harlequin Ducks can increase foraging effort in response to food shortage is unknown. Although feeding rates of pre-laying Harlequin Ducks at Harlequin Brook were not high compared to some other waterfowl (cf. Krapu and Reinecke 1992), they were higher than rates reported in other Harlequin Duck studies, and were similar or higher than those observed in other river ducks (Eldridge 1986a, b). Energetic constraints on foraging effort may be higher among river specialists than among dabbling or other diving species. The higher pre-laying feeding rate we observed in calm waters at Gooseneck Steadies than in faster waters in other studies provides some support for this idea. Implications for survey times in northern Labrador indicate that pair counts are probably best carried out in mid-June before egg-laying and the departure of males at the end of June. Brood counts should be conducted in early August.

Open tundra habitat at Hebron Fiord facilitates observational studies and makes it relatively easy to follow movements of adults and broods. Most river areas are easily accessed on foot. Thus it is an excellent site for studies of activity patterns, feeding behaviour, movement, and habitat use by adults and broods. Difficulties we encountered attempting to capture birds could undoubtedly be overcome with more time and preparation, and thus studies requiring marked birds are also practical and recommended. Open visibility and ease of observing birds would likely yield high probabilities of resighting marked birds. The large number of used streams within a small area in Hebron Fiord that vary considerably in size, temperature profiles, and many other habitat variables lend themselves well to comparative studies to examine habitat requirements, spacing, activity patterns, and breeding success. However, persistent ice cover in the fiord until late June and typically strong winds in August hampers movement between rivers and could limit comparative studies at those times if researchers are dependent on boat travel to reach study sites. Travel between rivers may be possible over the ice earlier in the season.

The relatively large breeding population in Hebron Fiord warrants further study and we recommend continued research effort in the area. Costs of conducting studies in northern Labrador could be substantially reduced by starting work early in the season when it is possible to access the area by charter plane on skiis, and by stock-piling supplies with the assistance of Coast Guard or other vessels that visit the area in the summer. Inclusion of Hebron Fiord in the proposed Torngat National Park should be reconsidered given its importance to the endangered eastern population of Harlequin Ducks and its use by other wildlife.

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TABLE 1. Codes for discrete stream habitat variables.

DEPTH	1 - < 0.5 m
	2 - 0.5 - 1 m
	3 - 1 - 2 m
	4 - > 2 m
SURFACE	1 - steady
	2 - some riffles
	3 - riffles abundant
SUBSTRATE	1 - sand/silt
	2 - gravel (<5 cm)
	3 - cobble (5-30 cm)
	4 - boulders (>30 cm)
	5 - bedrock
COVER	1 - shrubs
	2 - grass/ forbes
	3 - sand/silt
	4 - stones
	5 - boulders
	6 - bedrock
	7 - snow/ice
VEGETATION HEIGHT	1 - < 0.5 m
	2 - 0.5 - 1 m
	3 - > 1 m
SLOPE	1 - < 10°
	2 - 10 - 30°
	3 - 30 - 60°
	4 - 60 - 90°

TABLE 2. Measurements of Harlequin Ducks captured in mist nets on Harlequin Brook, Hebron Fiord, Labrador in 1996.

Date	Time	Flight direction On brook	Sex	Mass (g)	Wing (mm)	Culmen (mm)	Tarsus (mm)	USFWC band #	Colour band #
15 Jun	0521	Down	M	659	208	30.05	38.65	70555801	A1
30 Jun	1740	Up	F	571	202	25.50	37.15	70555802	A2
3 Jul	1026	Down	F	556	204	24.85	34.95	70555803	A3

TABLE 3. Maximum numbers of Harlequin Ducks sighted on the lower 10 km of streams emptying into Hebron Fiord, Labrador in 1996. Stream locations are shown in Fig. 3.

Name	Date	Male	Female	Ducklings
Harlequin	8 Jun-14 Aug	11	13	18
Ikarut	2 Jul	0	0	0
Saddle	2 Jul	0	0	0
Primogenitor				
- below lake	4 Jul	1	1	0
- above lake	4 Jul	0	7	0
Caribou	7 Jul	0	2	0
Kame Terrace	10 Jul	0	4	0
- offshore	7 Jul	5	12	0
Golden Eagle	12 Jul	0	2	0
Winnie	25 Jul	0	2	0
Becca	27 Jul	0	6	0
Barren	28 Jul	0	0	0
Green	29 Jul	0	3	11
Total		17	48	29

TABLE 4. Comparison of mean (SD) habitat measurements for streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador on 22-29 July 1996. Within-stream variance has been accounted for by including stream as a nested variable in ANOVA models.

Variable	Used	Unused	F	Error df	P
Width (m)	22 (21)	48 (40)	7.38	46	0.009
pH	7.4 (0.1)	7.1 (0.1)	49.17	46	0.000
Temperature (^oC)	12.9 (2.2)	10.7 (2.8)	320.26	42	0.000
Flow rate (m/s)	1.1 (0.6)	1.0 (0.3)	1.26	46	0.267
Number of islands	1.4 (2.7)	1.0 (1.3)	0.17	46	0.678
Exposed boulders	41 (96)	60 (140)	2.71	46	0.106
Shoreline width (m)	5 (8)	7 (9)	0.60	46	0.443
Shoreline slope[1]	3.0 (0.6)	2.5 (0.5)	13.82	46	0.001
Bank slope[1]	2.1 (0.7)	2.2 (0.7)	0.59	41	0.448
Distance to shrub cover (m)	18 (39)	20 (46)	0.14	46	0.715
Shrub height[1]	1.6 (0.6)	1.3 (0.7)	2.38	46	0.130

[1] Means of average codes (see Methods and Table 1) at each sample point.

TABLE 5. Frequency distributions of habitat variable codes for streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador on 22-29 July 1996. Single values for shoreline and bank cover were chosen randomly for each sample point if they were recorded for both sides of the stream. See Table 1 for code definitions.

	Used						Unused							
Variable	1	2	3	4	5	6	1	2	3	4	5	6	X^2	P
Depth	11	14	2				11	10	4				1.26	0.533
Surface	1	10	16				0	15	10				3.31	0.191
Substrate	0	1	9	16			6	4	11	4			15.19	0.002
Cover														
- island	3	5	0	0	3	1	1	0	4	4	3	0	8.71	0.003[1]
- shoreline	3	9	0	0	10	5	3	3	2	9	8	0	15.08	0.001[2]
- bank	9	7	0	0	4	4	12	6	1	2	2	0	6.70	0.035[2]

[1] Due to low cell frequencies, contingency table was collapsed to 2 X 2 comparing frequencies of codes 1-2 (vegetated) to codes 3-6 (non-vegetated).

[2] Due to low cell frequencies, contingency table was collapsed to 2 X 3 comparing frequencies of codes 1-2, 3-4 and 5-6.

TABLE 6. Numbers and percentages in parentheses of invertebrates recovered from kick samples taken at random stations on streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador, 22-29 July 1996.

Order	Used	Unused
Acari	21 (6)	4 (5)
Coleoptera	2 (0.6)	0
Diptera	186 (56)	51 (68)
Chironomid	154 (46)	44 (59)
Simuliid	32 (10)	1 (1)
Ephemeroptera	14 (4)	17 (23)
Nematoda	2 (0.6)	1 (1)
Plecoptera	101 (30)	2 (3)
Tricoptera	4 (1)	0
Unknown	4 (1)	0
Total	334	75
No. of samples	24	24

TABLE 7. Numbers and percentages in parentheses of invertebrates recovered on 6 August from 2-week passive rock samplers placed at random stations on the lower 2 km of Harlequin Brook and Ikarut River, Hebron Fiord, Labrador in 1996.

Order	Harlequin Brook	Ikarut River
Acari	11 (5)	1 (1)
Diptera	176 (78)	83 (80)
Chironomid	162 (72)	79 (76)
Simuliid	13 (6)	4 (4)
Ephemeroptera	6 (3)	18 (17)
Nematoda	0	1 (1)
Plecoptera	30 (13)	1 (1)
Tricoptera	3 (1)	0
Total	226	104
No. of samples	5	4

TABLE 8. Seasonal changes in mean (SD) habitat measurements taken at random stations on Harlequin Brook in Hebron Fiord, Labrador in 1996. Means are least squares means from 2-way ANOVA by sample date and stratum (see Table 10).

	Sample date					
Variable	23-24 Jun	18 Jul	5-6 Aug	F	df	P
pH	7.0 (0.2)	7.1 (0.1)	7.2 (0.1)	6.12	35	0.005
Temperature (^{o}C)	3.9 (1.0)	10.7 (0.9)	15.5 (1.9)	425.52	55	0.000
Flow rate (m/s)	1.6 (0.9)	1.0 (0.5)	0.9 (0.5)	11.42	42	0.000
Exposed boulders	<1 (2)	16 (33)	35 (53)	6.65	60	0.002

TABLE 9. Seasonal changes in frequency distributions of depth and surface codes recorded at random stations on Harlequin Brook in Hebron Fiord, Labrador in 1996. See Table 1 for code definitions.

	Sample date														
	23-24 Jun				18 Jul				5-6 Aug				G^2	df	P
	1	2	3	4	1	2	3	4	1	2	3	4			
Depth	1	11	10	2	9	15	1	0	7	17	1	0	26.30	6	0.000
Surface	4	4	17		4	10	11		7	9	9		6.85	4	0.144

TABLE 10. Comparison of mean (SD) habitat measurements taken at random stations in 5 strata on Harlequin Brook in Hebron Fiord, Labrador in 1996. For the variables pH, temperature, flow rate, and numbers of boulders that changed through the season, least squares means from 2-way ANOVA by sample date (see Table 8) and stratum are presented. For width, numbers of islands, shoreline width, and distance to shrub cover, means are from measurements taken on 18 July.

	Stratum							
Variable	1	2	3	4	5	F	df	P
Width (m)	49 (41)	73 (29)	19 (9)	36 (24)	75 (83)	5.07	61	0.001
pH	7.2 (0.1)	7.1 (0.1)	-	7.1 (0.1)	7.1 (0.1)	2.28	35	0.097
Temperature (^oC)	9.4 (3.9)	10.2 (5.3)	9.3 (0.3)	10.5 (5.7)	10.8 (5.4)	2.99	55	0.026
Flow rate (m/s)	1.1 (0.5)	1.5 (0.7)	2.0 (0.8)	1.1 (0.4)	0.1 (0.1)	12.19	42	0.000
No. of islands	1.0 (0.7)	4.0 (2.8)	0.2 (0.4)	0.5 (0.6)	1.3 (1.9)	5.10	20	0.005
Exposed boulders	1 (3)	21 (38)	20 (36)	42 (62)	0	3.43	60	0.014
Shoreline width (m)	10 (11)	2 (1)	4 (4)	5 (8)	2 (1)	2.59	44	0.050
Meters to shrub cvr	58 (81)	2 (3)	19 (33)	10 (17)	3 (3)	3.35	46	0.017

TABLE 11. Frequency distributions of habitat variable codes recorded at random stations in 5 strata on Harlequin Brook in Hebron Fiord, Labrador in 1996. For the variables depth and surface that changed through the season, comparisons are from log-linear analysis by sample date (see Table 9) and stratum. Frequencies for other variable codes are from measurements taken on 18 July. See Table 1 for code definitions.

	Stratum and variable code				
	1	2	3	4	5
Variable	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Depth	0 8 6 1	7 9 1 0	412 2 0	6 6 0 0	0 8 3 1
Surface	310 2	0 315	0 216	0 8 4	12 0 0
Substrate	0 5 0 0	0 1 3 2	0 0 0 6	0 0 3 1	3 1 0 0
Island					
- cover	0 0 0 4 0	5 1 0 0 0	0 0 0 0 1	1 1 0 0 0	1 0 1 0 0
- veg. height	0 0 0	1 0 5	0 0 0	1 1 0	0 0 1
Shoreline					
- slope	5 2 3 0	2 3 6 0	0 2 5 5	0 6 2 0	0 6 1 1
- cover	1 3 1 5 0 0 0	0 7 0 4 0 0 0	3 0 0 1 3 4 1	0 5 0 2 1 0 0	1 5 0 2 0 0 0
Bank					
- slope	1 4 2	5 5 1	0 210	2 6 0	0 8 0
- cover	4 1 2 0 0	8 2 1 0 0	5 2 0 2 3	3 5 0 0 0	7 1 0 0 0
- veg. height	1 2 2	3 5 2	2 2 3	5 3 0	2 3 3
Height of shrub	6 4 0	4 4 4	5 2 6	3 5 0	0 5 3

TABLE 12. Within season changes in numbers and percentages in prentheses and types of invertebrates recovered from kick samples taken at random stations on Harlequin Brook, Hebron Fiord, Labrador in 1996.

Order	20-24 Jun	19 Jul	5-6 Aug
Acari	5 (6)	14 (9)	4 (3)
Amphipoda	1 (1)	0	0
Annelida	0	0	17 (13)
Cladocera	0	1 (0.6)	1 (0.8)
Coleoptera	0	1 (0.6)	1 (0.8)
Copepoda	1 (1)	2 (1)	1 (0.8)
Diptera	54 (67)	121 (79)	76 (58)
Chironomid	54 (67)	108 (70)	60 (46)
Simuliid	0	13 (8)	15 (11)
Ephemeroptera	9 (11)	7 (5)	7 (5)
Nematoda	0	4 (3)	1 (0.8)
Plecoptera	1 (1)	2 (1)	22 (17)
Tricoptera	8 (10)	1 (0.6)	1 (0.8)
Turbellaria	0	1 (0.6)	1 (0.8)
Unknown	2 (3)	0	0
Total	81	154	132
No. of samples	19	19	19

TABLE 13. Within season changes in numbers and percentages in parentheses and types of invertebrates recovered from passive rock samplers placed at random stations on the lower 2 km of Harlequin Brook, Hebron Fiord, Labrador in 1996.

	Date and length of time samplers were in stream		
	28 Jun	13 Jul	31 Jul
Order	2-week	2-week	5-week
Acari	4 (2)	17 (6)	28 (8)
Amphipoda	0	0	7 (2)
Coleoptera	0	1 (0.4)	1 (0.3)
Copepoda	0	0	1 (0.3)
Diptera	167 (95)	270 (92)	263 (71)
Chironomid	167 (95)	249 (84)	239 (64)
Simuliid	0	15 (5)	24 (7)
Ephemeroptera	0	5 (2)	10 (3)
Nematoda	0	2 (0.7)	1 (0.3)
Plecoptera	0	0	57 (15)
Tricoptera	4 (2)	0	3 (0.8)
Total	175	295	371
No. of samples	2	5	5

TABLE 14. Differences among habitat strata in numbers and percentages in parentheses and types of invertebrates recovered from kick samples taken at random stations on Harlequin Brook, Hebron Fiord, Labrador on 20-24 June, 19 July, and 5-6 August 1996.

	Stratum			
Order	Sand/silt	Gravel (< 5 cm)	Boulders (> 30 cm	Bedrock
Acari	14 (8)	6 (8)	1 (2)	2 (2)
Amphipoda	1 (0.6)	0	0	0
Annelida	9 (5)	0	0	8 (9)
Cladocera	0	0	0	2 (2)
Coleoptera	0	0	0	3 (4)
Copepoda	0	0	0	3 (4)
Diptera	116 (69)	51 (70)	38 (91)	47 (55)
Chironomid	115 (69)	34 (47)	27 (64)	46 (54)
Simuliid	0	17 (23)	10 (24)	1 (1)
Ephemeroptera	8 (5)	9 (12)	2 (5)	4 (5)
Nematoda	1 (0.6)	0	0	4 (5)
Plecoptera	17 (10)	7 (10)	1 (2)	0
Tricoptera	0	0	0	10 (12)
Turbellaria	1 (0.6)	0	0	1 (1)
Unknown	1 (0.6)	0	0	1 (1)
Total	168	73	42	85
No. of samples	15	18	12	12

TABLE 15. Mean lengths (mm) of invertebrates recovered from kick and passive rock samplers placed at random stations on rivers in Hebron Fiord, Labrador in 1996.

Order	N	Length	Min	Max
Acari	111	1.7± 0.5	1	3
Amphipoda	8	12.8± 2.5	10	16
Annelida	17	8.9± 2.9	5	13
Cladocera	2	1.5± 0.7	1	2
Coleoptera	6	3.7± 1.0	2	5
Copepoda	5	1.8± 0.8	1	3
Diptera				
Chironomid	1646	3.2± 1.4	1	16
Ephydrid	6	4.8± 1.7	3	8
Simuliid	133	3.6± 1.3	2	8
Tipulid	5	20.8± 7.5	12	30
Ephemeroptera	118	11.0± 5.4	2	27
Nematoda	12	6.9± 3.2	5	17
Plecoptera	227	4.7± 3.6	1	31
Tricoptera	32	8.1± 3.8	2	18
Turbellaria	2	2.5± 0.7	2	3

TABLE 16. Total activity by Harlequin Duck adults and broods at four observation stations during the pre-to-early-laying (sample 1), incubation (sample 2), and brood-rearing (sample 3) periods on Harlequin Brook, Labrador in 1996. Percent of time spent in each activity by focal individuals during dawn-to-dusk observations was weighted by the number of birds and amount of time they were present at each of the four stations to calculate total bird*hours for each activity (see Tables 17-19).

		Adult activity (bird*hours)				Brood activity (bird*hours)			
Sample	Station	Feeding	Swimming	Resting	Total	Feeding	Swimming	Resting	Total
1	Estuary	0.2	1.1	0.7	2.4	-	-	-	-
1	J-Kûk	15.7	19.2	49.9	88.4	-	-	-	-
1	Inukshuk	0.2	0.7	0.8	1.8	-	-	-	-
1	Gooseneck	35.7	12.3	4.5	53.4	-	-	-	-
2	Estuary	0.1	0.4	<0.1	0.7	-	-	-	-
2	J-Kûk	0.4	7.5	0.9	9.3	-	-	-	-
2	Inukshuk	10.7	4.0	23.0	40.4	-	-	-	-
2	Gooseneck	3.7	2.4	1.0	6.8	-	-	-	-
3	Estuary	0.2	1.3	0.7	2.2	0	0	0	0
3	J-Kûk	2.8	3.2	0.1	6.1	0.9	2.1	0	3.0
3	Inukshuk	10.5	7.5	28.1	46.9	23.1	9.8	17.3	51.4
3	Gooseneck	1.0	3.7	3.8	8.6	23.6	5.1	22.7	51.8

TABLE 17. Comparison of time budgets of male and female Harlequin Ducks determined during dawn-to-dusk (0300-2400 h) observations of focal individuals in the pre-to-early-laying period at four stations on Harlequin Brook, Labrador in 1996.

	Estuary		J-Kûk		Inukshuk		Gooseneck	
	Male	Female	Male	Female	Male	Female	Male	Female
% of time present:	5.1	5.4	70.3	71.9	4.2	4.2	65.0	71.9
# of bird*hours:	1.2	1.2	37.7	50.7	0.9	0.9	13.7	39.7
# of sightings:	121	128	1655	1696	93	101	988	1048
Percent of sightings:								
Diving	5.8	12.5	9.5	14.3	2.2	3.0	42.9	70.6
Skimming	0	0	2.7	7.5	0	17.8	0.3	4.3
Upending	0	0	0	0.1	0	0	0	0
Looking	0.8	0	0	0	0	0	4.3	0.4
Swimming	47.1	44.5	26.5	18.2	48.4	24.8	34.7	17.2
Chasing	0	0	0.8	0.1	0	0	0.4	0
Fleeing	0	0	0	0.2	0	0	0	0.3
Head-nodding	0	0	2.3	1.5	0	0	0.9	1.3
Alert	0	0	1.0	0.4	0	0	0	0
Walking	0	0	0.7	0.7	0	0	0.3	0.2
Preening	14.1	1.6	5.1	6.2	0	7.9	6.5	5.1
Rest-up	12.4	17.2	6.5	7.3	43.0	12.9	5.4	0.6
Rest-tucked	2.5	9.4	44.6	43.2	0	27.7	4.4	0.1
Flying	17.4	14.9	0.4	0.4	6.5	5.9	0	0

TABLE 18. Comparison of time budgets of female Harlequin Ducks determined during dawn-to-dusk (0400-2300 h) observations of focal individuals in the incubation period at four stations on Harlequin Brook, Labrador in 1996.

	Estuary	J-Kûk	Inukshuk	Gooseneck
% of time present:	3.1	20.5	71.7	17.9
# of bird*hours:	0.7	9.3	40.4	6.8
# of sightings:	69	467	1555	81
Percent of sightings:				
Diving	13.0	4.5	25.1	42.0
Skimming	0	0	1.3	12.3
Upending	0	0	0.1	0
Looking	8.7	1.5	0	6.2
Swimming	52.2	79.0	10.0	29.6
Head-nodding	0	0	1.0	0
Alert	1.4	2.1	4.9	0
Preening	1.4	1.1	1.3	6.2
Rest-up	2.9	7.1	12.0	1.2
Rest-tucked	0	1.9	43.5	0
Flying	20.3	2.8	0.8	2.5

TABLE 19. Comparison of time budgets of Harlequin Duck females with broods and failed or non-breeding females during dawn-to-dusk (0430-2230 h) observations of focal individuals in the brood-rearing period at four stations on Harlequin Brook, Labrador in 1996.

	Estuary	J-Kûk			Inukshuk			Gooseneck	
	Female	Female	Ducklings	Failed female	Female	Ducklings	Failed female	Female	Ducklings
% of time present:	6	6	6	15	48	48	98	48	48
# of bird*hours:	2.2	1.0	3.0	5.1	8.4	51.3	38.4	8.6	51.8
# of observations:	99	108	108	289	779	4410	1259	348	2070
Percent of observations:									
Diving	10	10	10	49	9	23	19	9	25
Skimming	0	16	20	0	8	22	4	3	20
Upending	0	0	0	0	0	0	0	0	0.3
Looking	5	2	0	1.4	0	0	0	0	0
Swimming	53	70	69	46	25	19	14	43	10
Chasing	0	0	0	0	0.1	0	0	0	0
Fleeing	0	0	0	0	0	0	0.1	0	0
Head-nodding	0	0	0	0	0	0	0.1	0	0
Alert	0	0	0	2	16	0	0.8	0	0
Running	0	0	0	0	0.1	0	0	0.6	0.4
Walking	0	0	0	0	0	2	0	0	0.2
Preening	2	2	0	0.7	4	4	7	0.6	0.1
Rest-up	27	0	0	0	26	16	33	44[a]	44[a]
Rest-tucked	3	0	0	0	12	14	21	0	0
Flying	0	0	0	1	0	0	0	0	0

[a] Proportions of resting behaviour in tucked or head-up position could not be determined.

TABLE 20. Comparison of time budgets of Harlequin Ducks in the pre-to-early-laying, incubation, and brood-rearing periods on Harlequin Brook, Labrador in 1996. Data are weighted by the number of birds and the percent of time they were present at each of the four stations to calculate overall percentages.

	Pre-laying		Incubation	Brood-rearing		
	Male	Female	Female	Parent female	Duckling	Failed female
# of sightings:	2857	2973	2172	1235	6588	1647
% of total activity:						
Feeding:						
Diving	14	32	16	9	23	22
Skimming	2	7	1.3	7	22	4
Upending	0	<0	0.1	0	0.1	0
Total	17	40	17	16	45	25
Locomotion:						
Looking	0.8	0.1	0.5	0.2	0	0.2
Swimming	29	19	24	34	19	22
Running	0	0	0	0.2	0.4	0
Walking	0	0	0	0.1	2	<0.1
Flying	0.8	1	1.0	0	0	0.1
Total	31	20	26	35	21	22
Social interaction:						
Chasing	0.5	<0.1	0	0.1	0	0
Fleeing	0	0.2	0	0	0	<0.1
Head-nodding	2	2	0.8	0	0	0.1
Total	3	2	0.8	0.1	0	0.1
Maintainance:						
Alert	0.6	0.2	4	10	0	1
Preening	4.6	5	0.8	3	3	4
Resting	45	34	52	36	32	47
Total	50	39	57	49	35	52

TABLE 21. Comparison of mean ± SD dive and pause times in seconds and dive-pause ratios of paired male and female and unpaired female at Gooseneck Steadies on 19-21 June in the early-laying period, of females at Inukshuk on 15-18 July in the incubation period, and females at J-Kûk on 2-4 August in the brood-rearing period. Sample sizes given in parentheses.

	Dive time (N)	Pause time (N)	Dive-pause ratio (N)
Gooseneck			
Paired male	22.8± 4.5 (278)	13.7± 7.0 (228)	2.0± 0.8 (228)
Paired female	21.5± 5.9 (233)	11.9± 5.8 (181)	2.2± 1.0 (181)
Unpaired female	24.7± 4.4 (85)	16.5± 7.1 (73)	1.7± 0.8 (73)
Inukshuk			
Female	10.0± 4.3 (104)	7.6± 5.3 (83)	2.2± 1.9 (61)
J-Kûk			
Female	23.3± 7.1 (178)	13.3± 7.9 (155)	2.2± 0.9 (155)

TABLE 22. Presence (+) and percent composition of prey remains in composite fecal samples collected on 3 July and 4 August 1996 at Harlequin Brook, Labrador.

	3 July	4 August
Number identified[a]	30	4493
Diptera Simuliidae	0	98
Tricoptera	+	0.7
Plecoptera	+	0.4
Ephemeroptera	+	0.1
Coleoptera	0	0.1
Acari Hydracarina	0	<0.1
Unknown	0	0.7

[a] Numbers of simuliid individuals were accurately determined by counting heads. Remains of other prey types were mostly leg parts and numbers of individuals were more difficult to estimate.

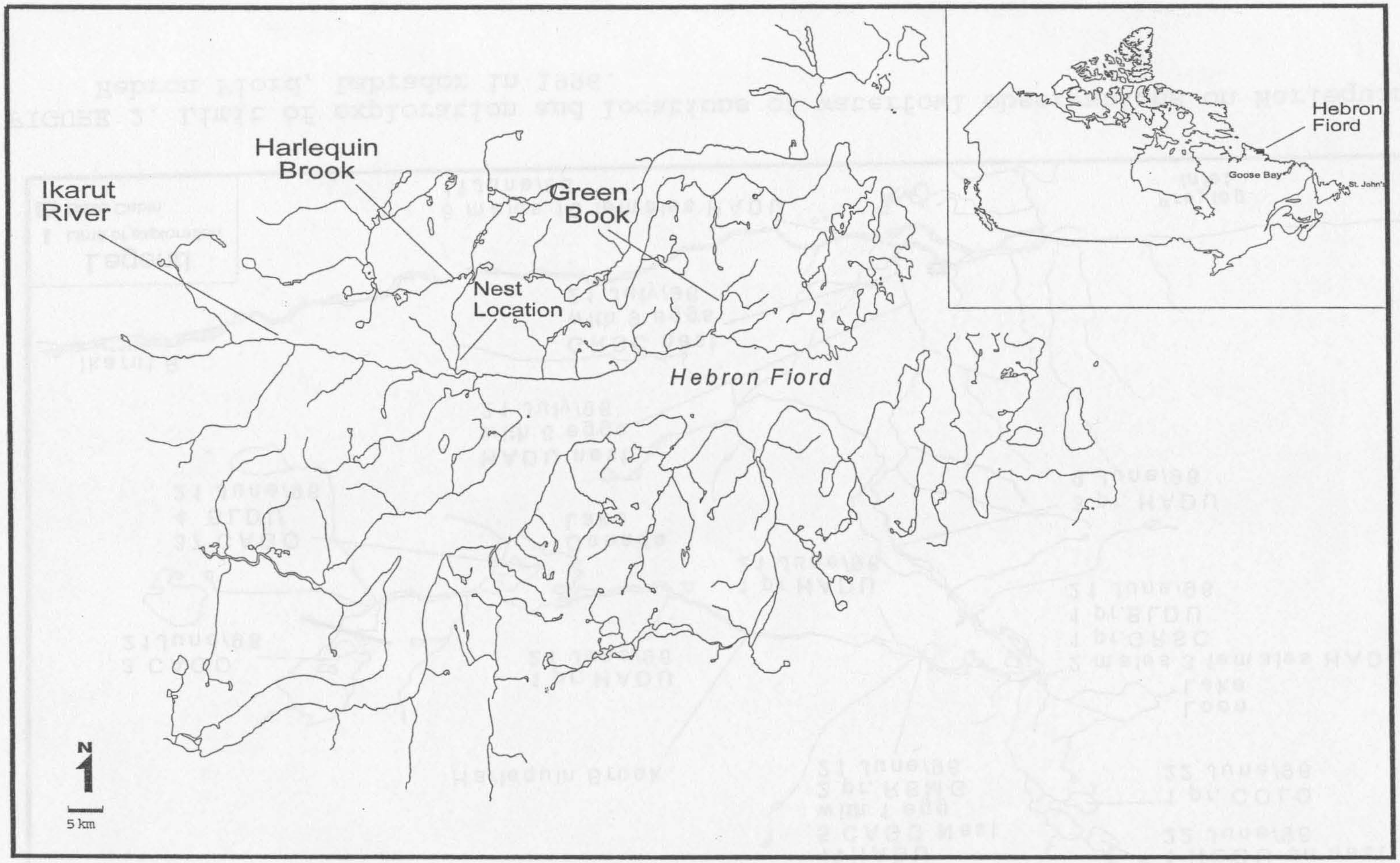

FIGURE 1. Location of study area and Harlequin Duck nest site on Harlequin Brook, Hebron Fiord, Labrador.

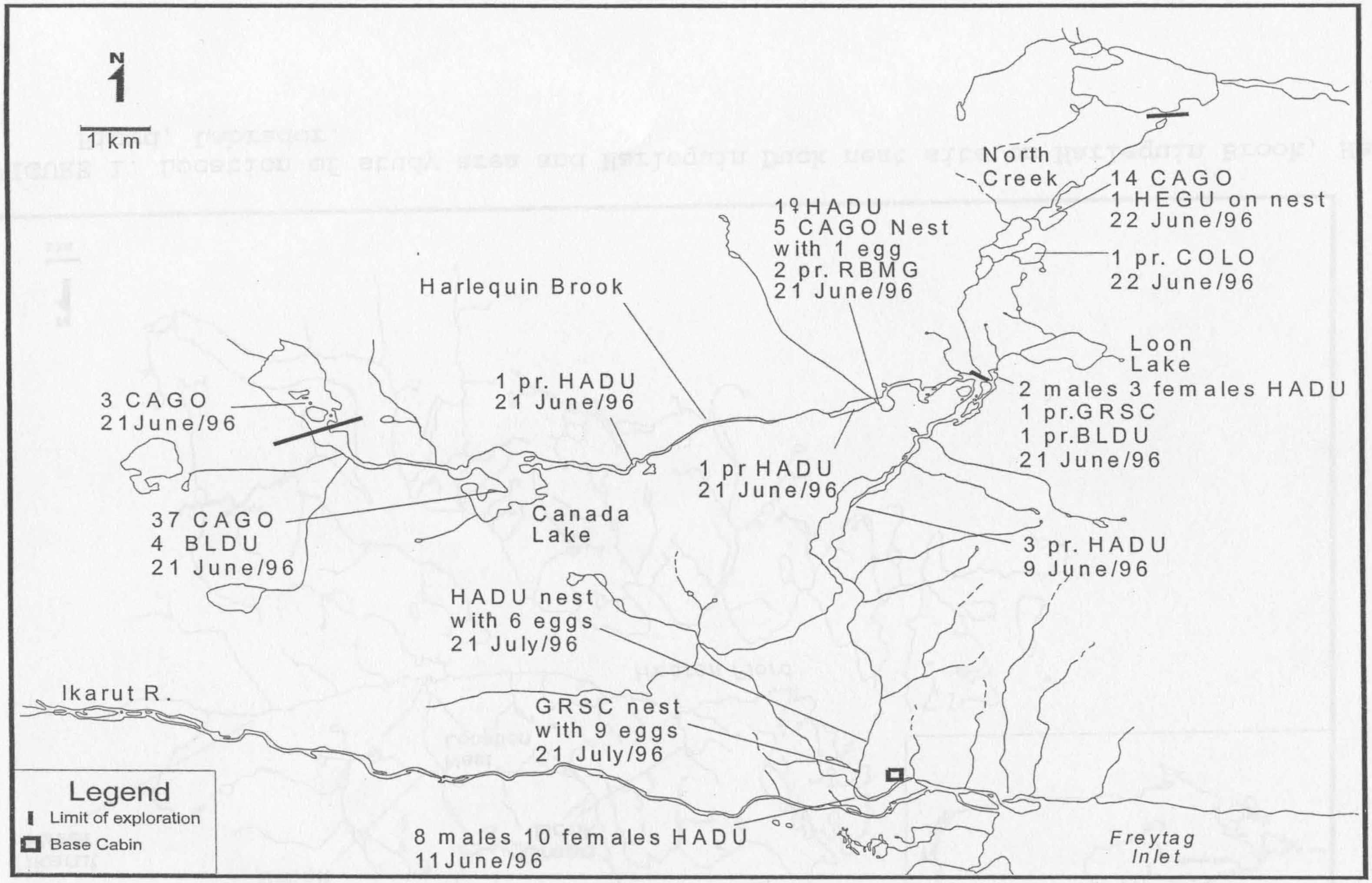

FIGURE 2. Limit of exploration and locations of waterfowl observations on Harlequin Brook, Hebron Fiord, Labrador in 1996.

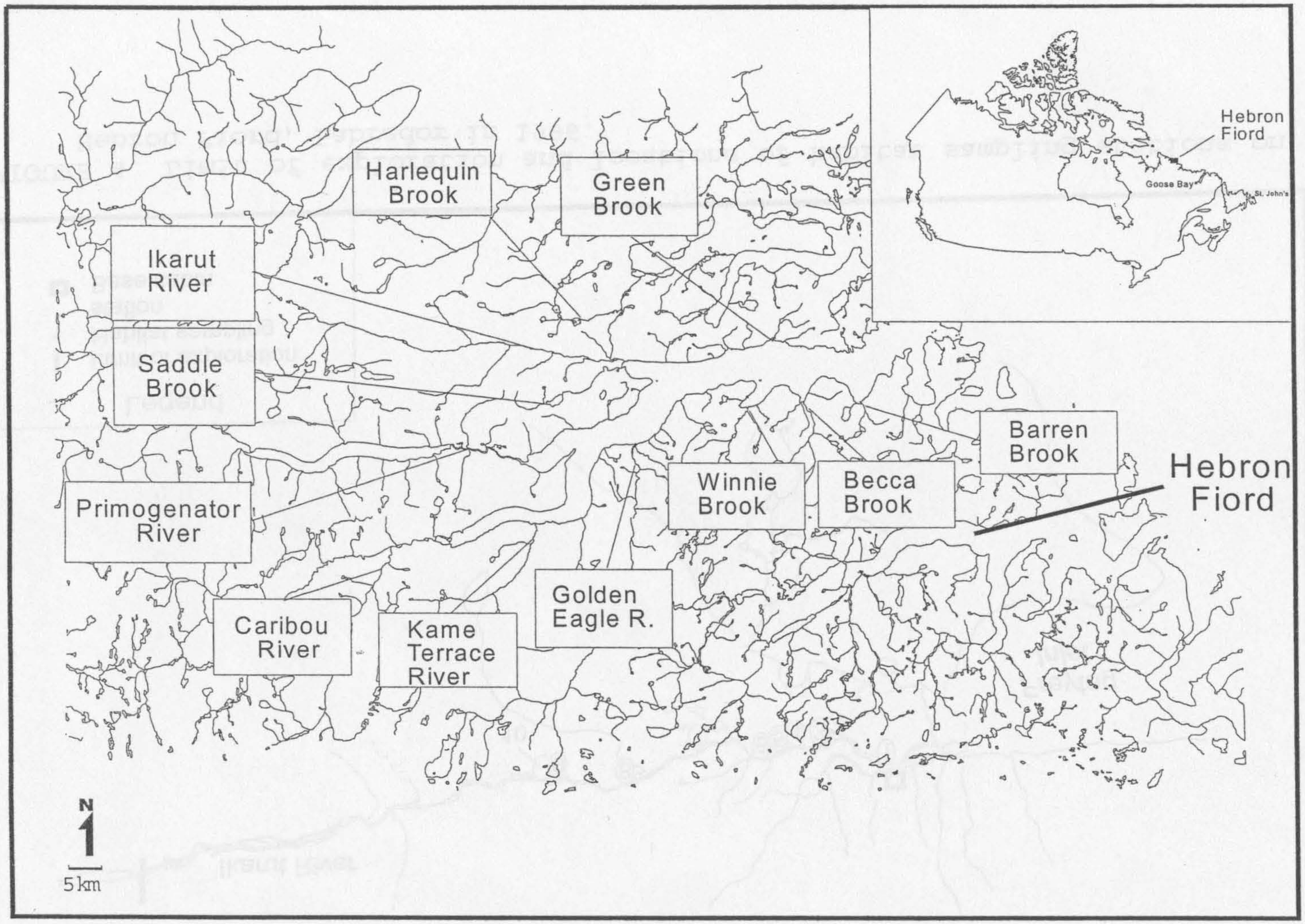

FIGURE 3. Locations of rivers explored for Harlequin Ducks in Hebron Fiord, Labrador in 1996.

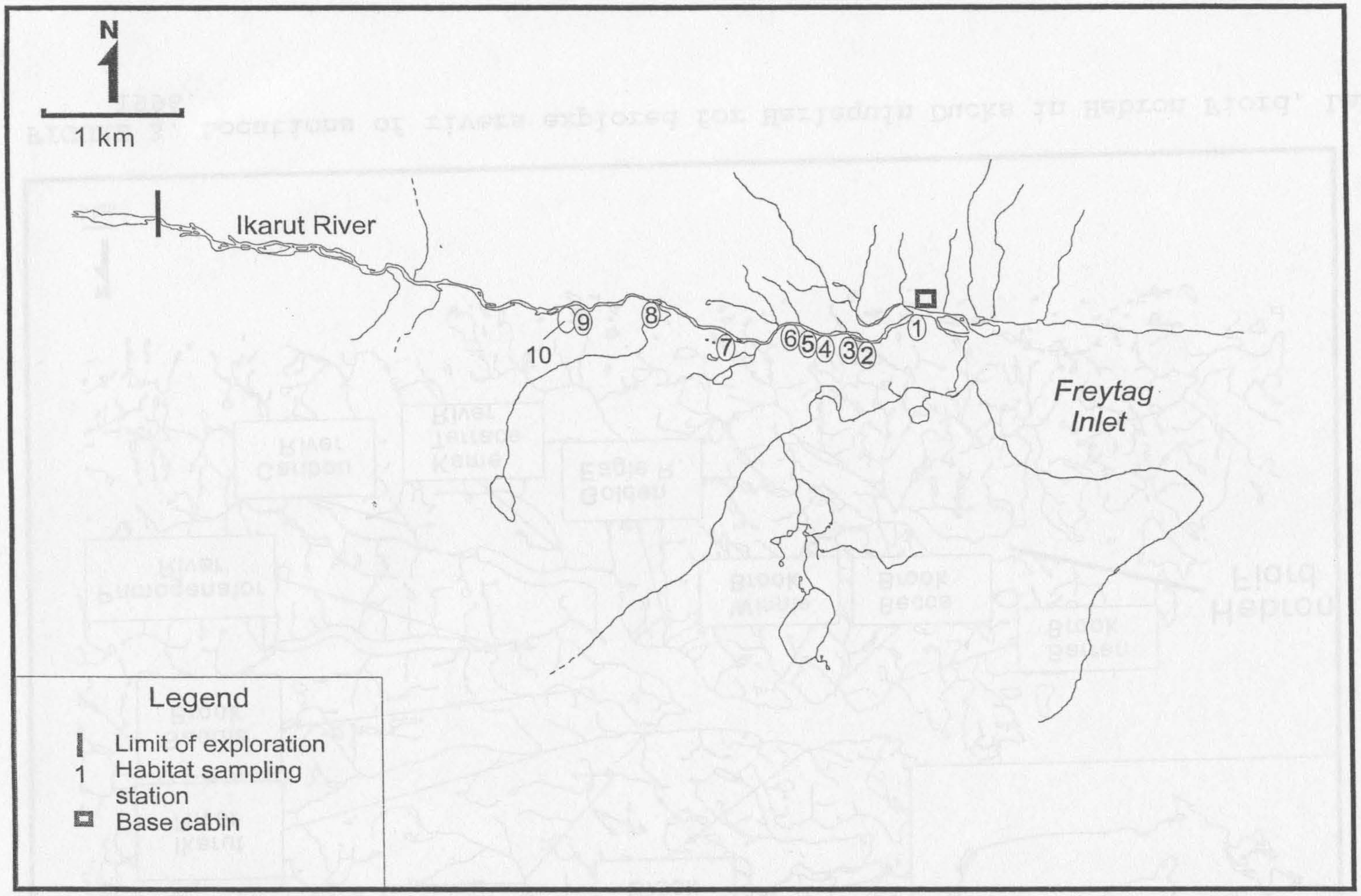

FIGURE 4. Limit of exploration and locations of habitat sampling stations on Ikarut River, Hebron Fiord, Labrador in 1996.

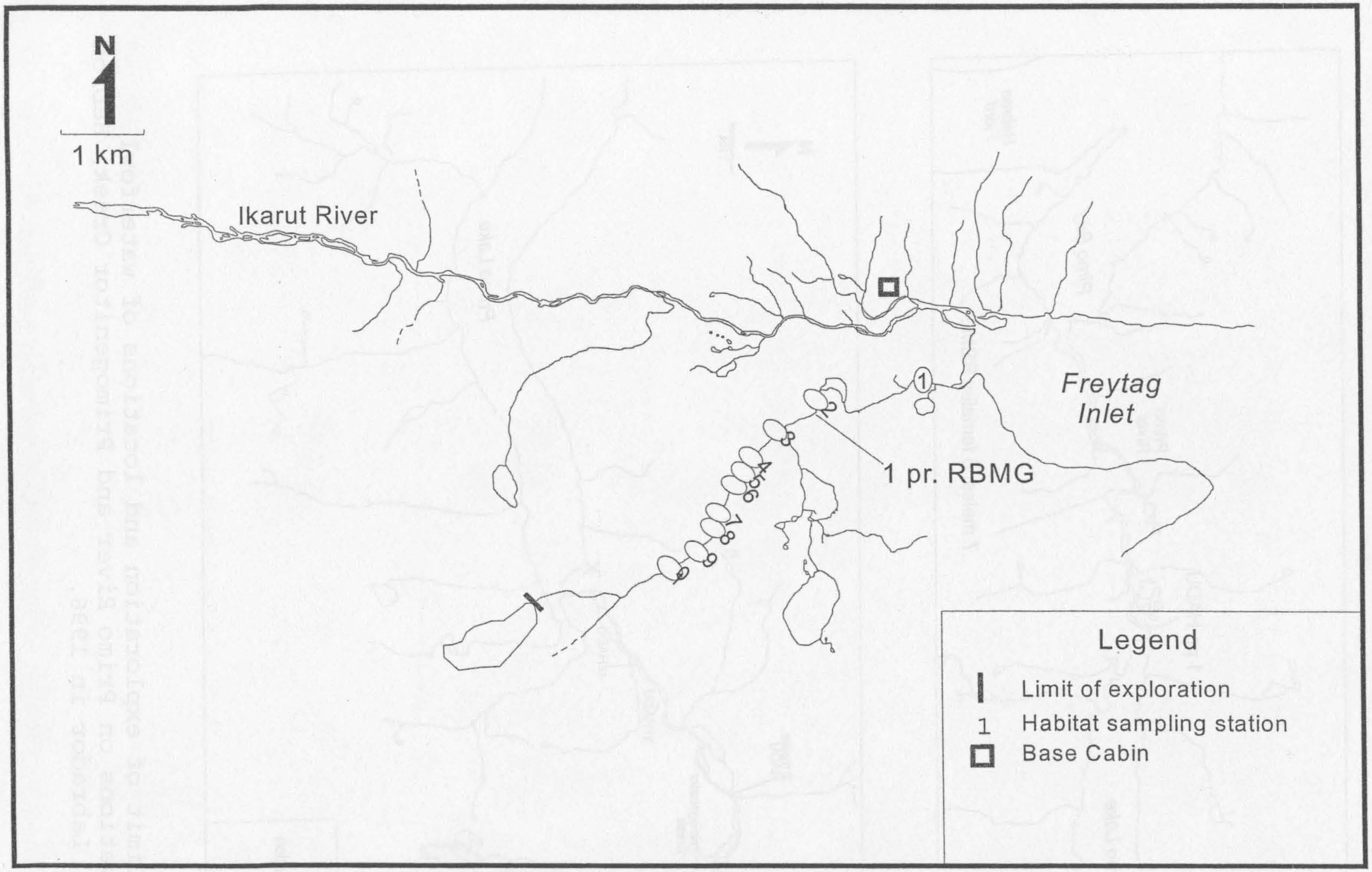

FIGURE 5. Limit of exploration and locations of habitat sampling stations and waterfowl observations on Saddle Brook, Hebron Fiord, Labrador in 1996.

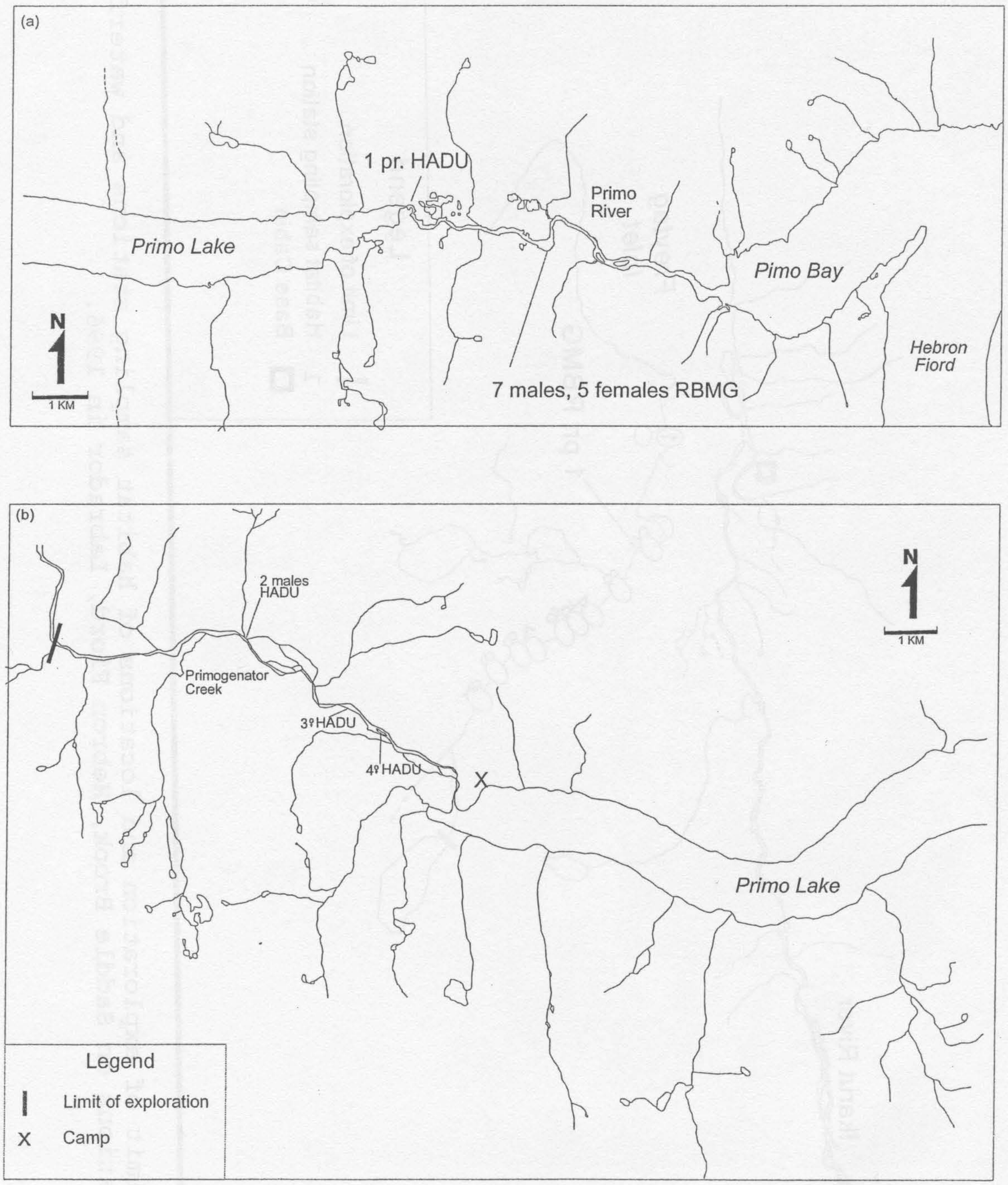

FIGURE 6. Limit of exploration and locations of waterfowl observations on Primo River and Primogenitor Creek, Hebron Fiord, Labrador in 1996.

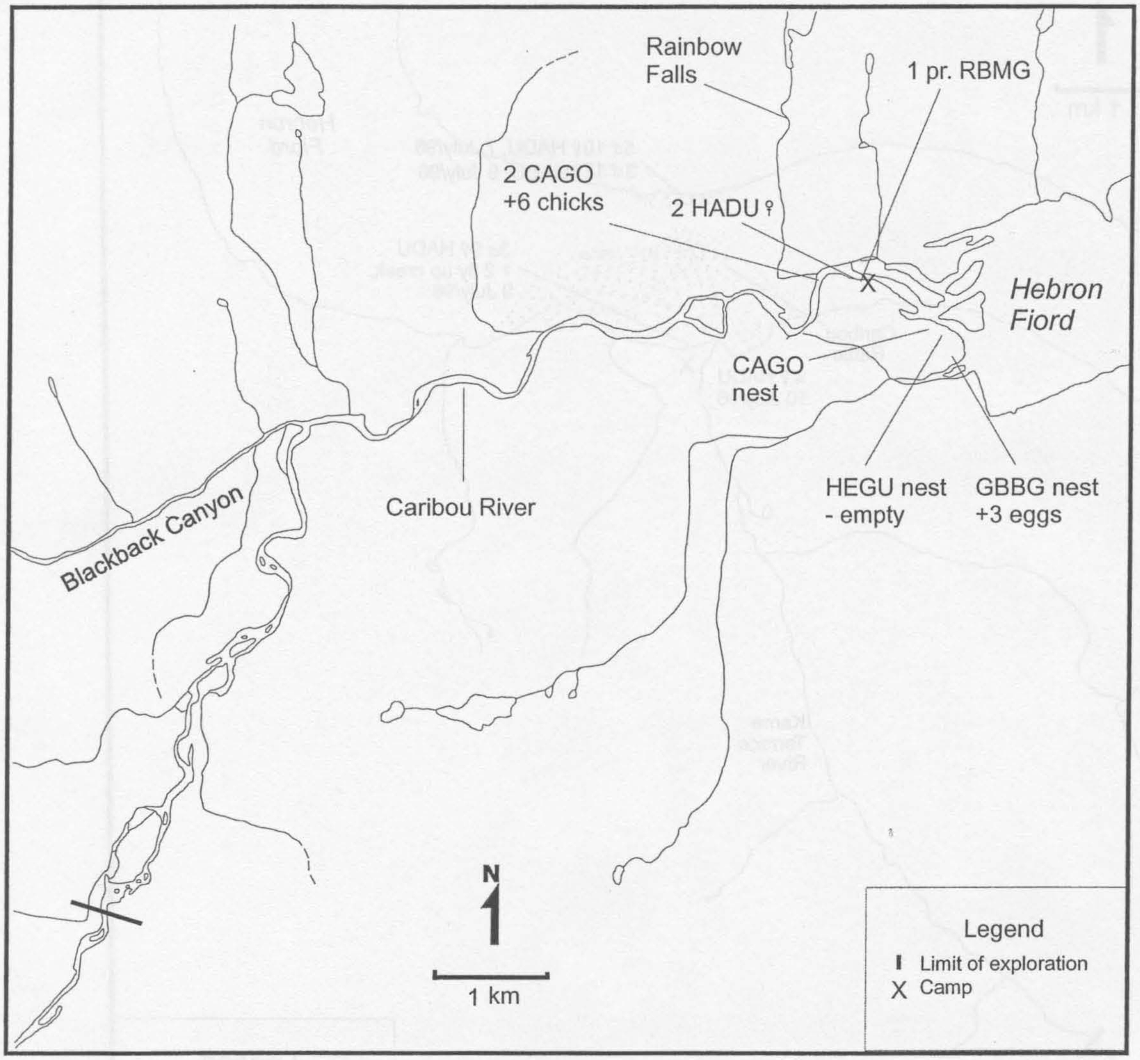

FIGURE 7. Limit of exploration and locations of waterfowl observations on Caribou River, Hebron Fiord, Labrador in 1996

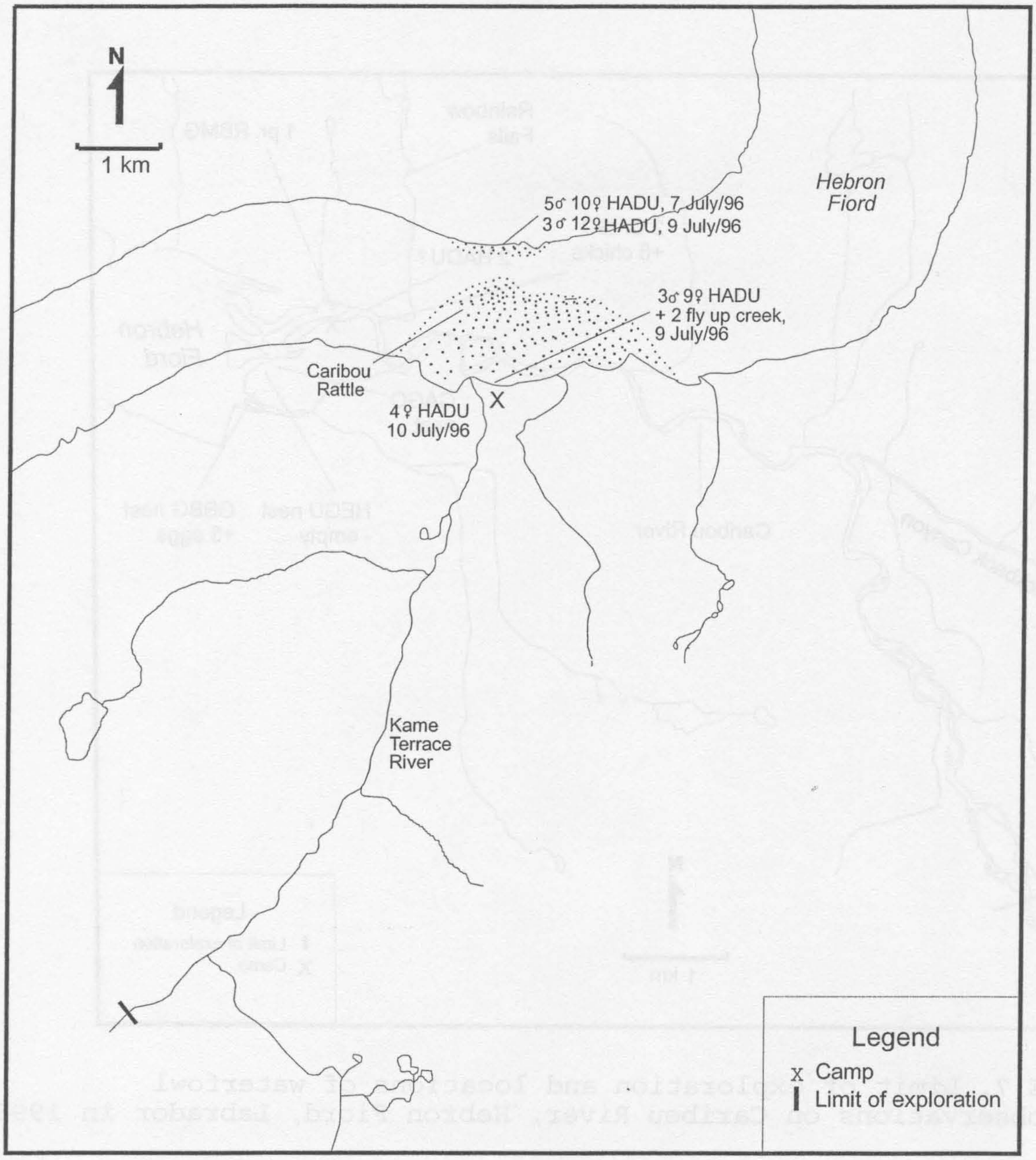

FIGURE 8. Limit of exploration and locations of waterfowl observations on Kame Terrace River and at Caribou Rattle, Hebron Fiord, Labrador in 1996.

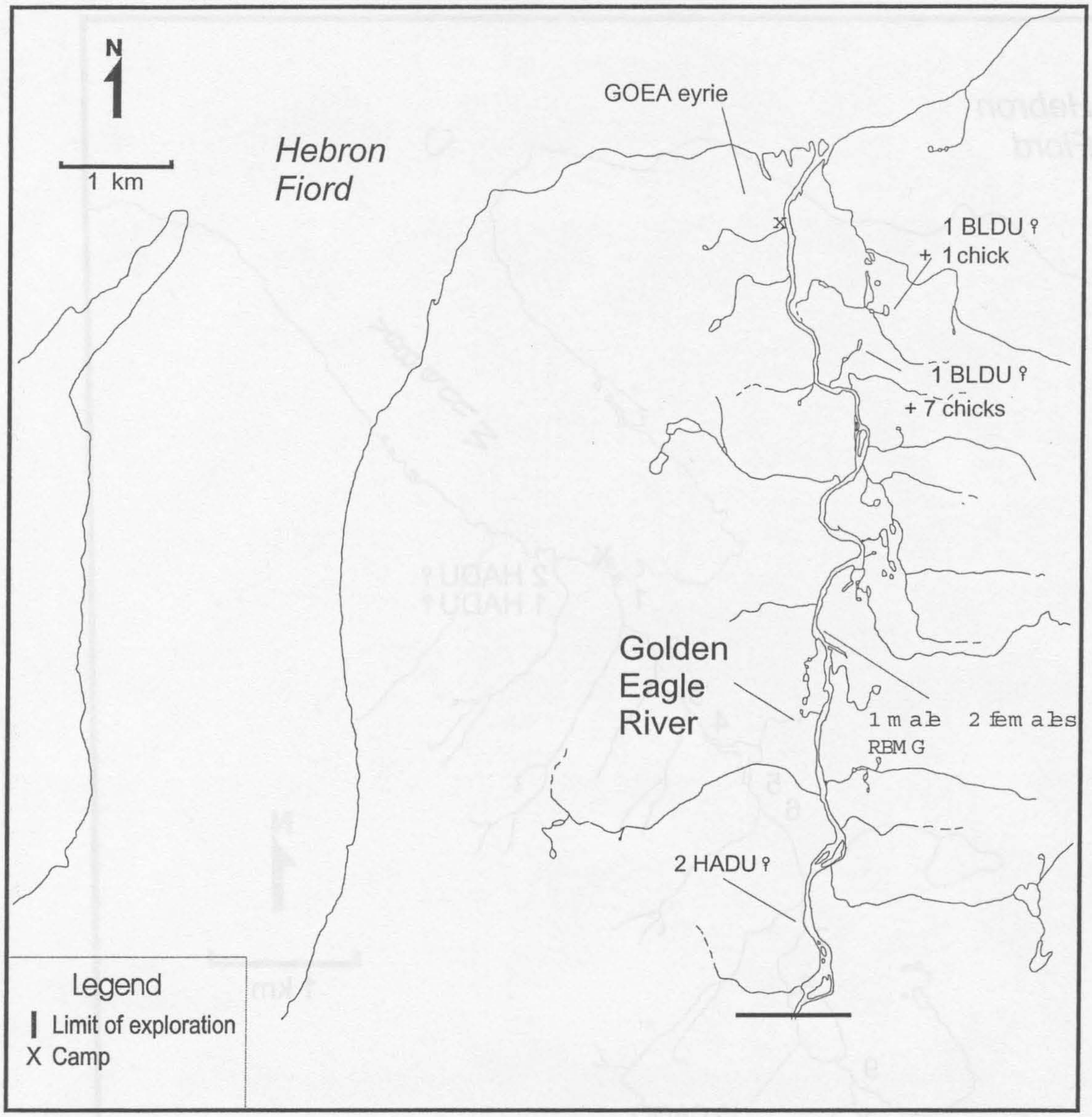

FIGURE 9. Limit of exploration and locations of waterfowl observations on Golden Eagle River, Hebron Fiord, Labrador in 1996.

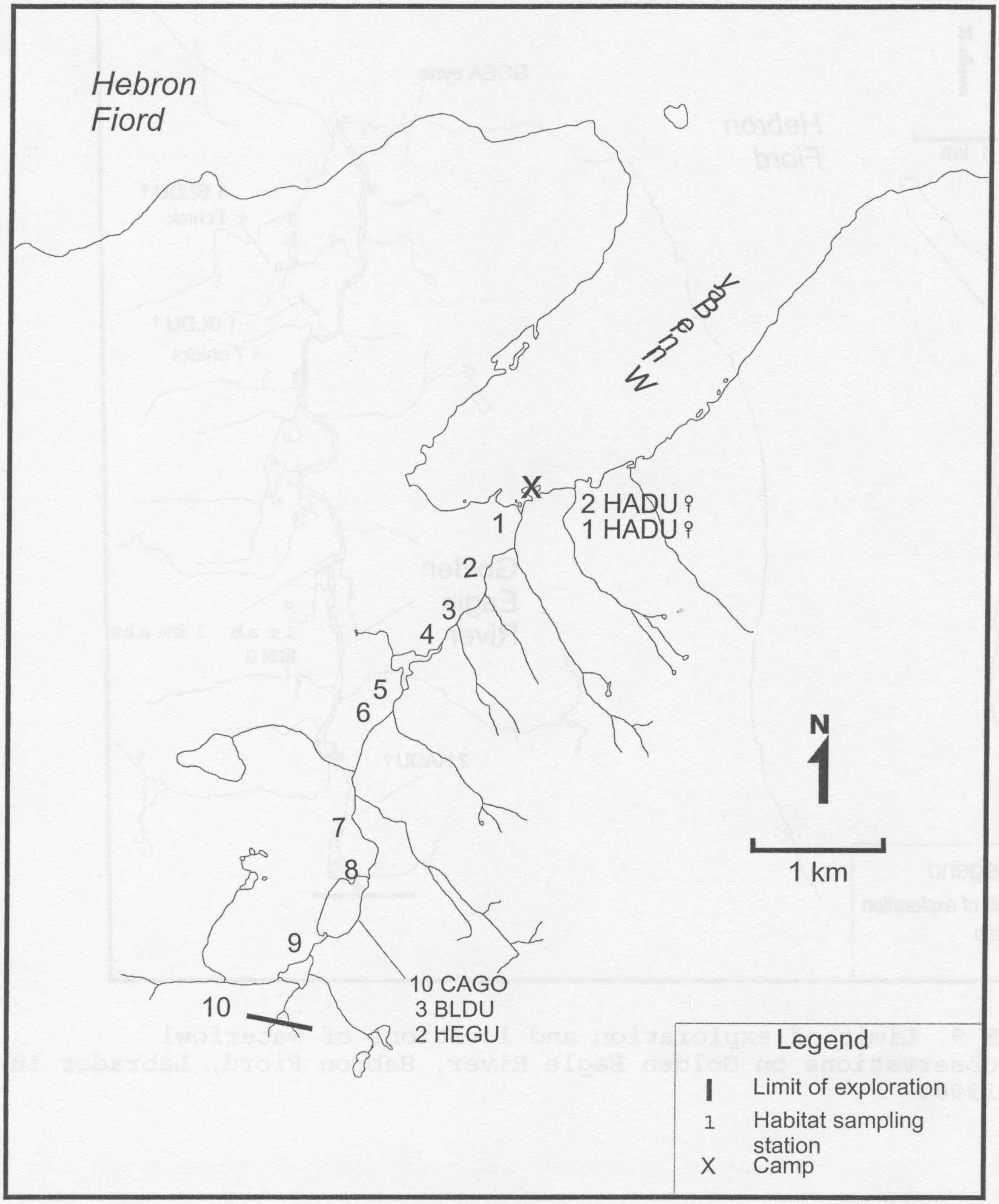

FIGURE 10. Limit of exploration and locations of habitat sampling stations and waterfowl observations on Winnie Brook, Hebron Fiord, Labrador in 1996.

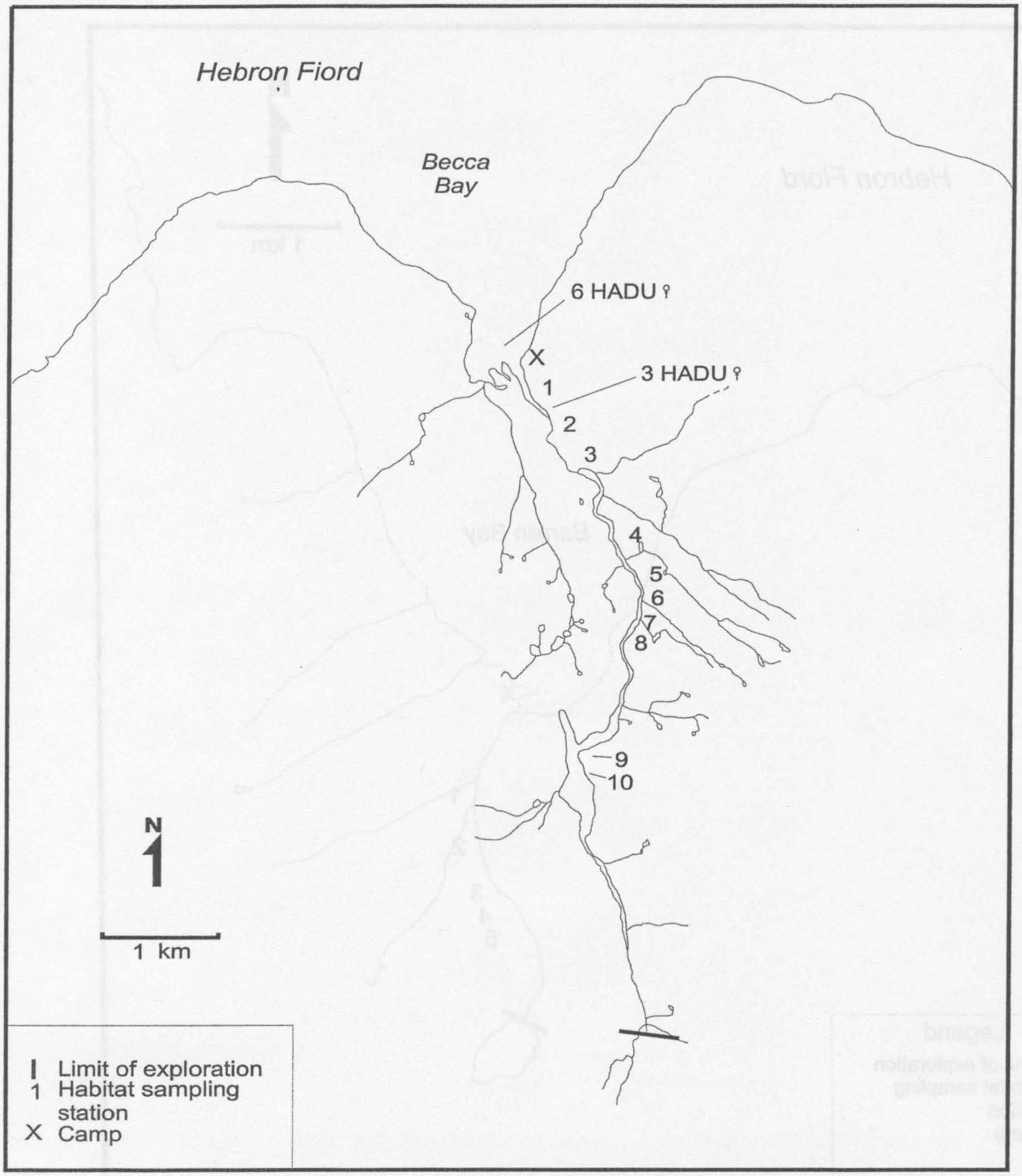

FIGURE 11. Limit of exploration and locations of habitat sampling stations and waterfowl observations on Becca Brook, Hebron Fiord, Labrador in 1996.

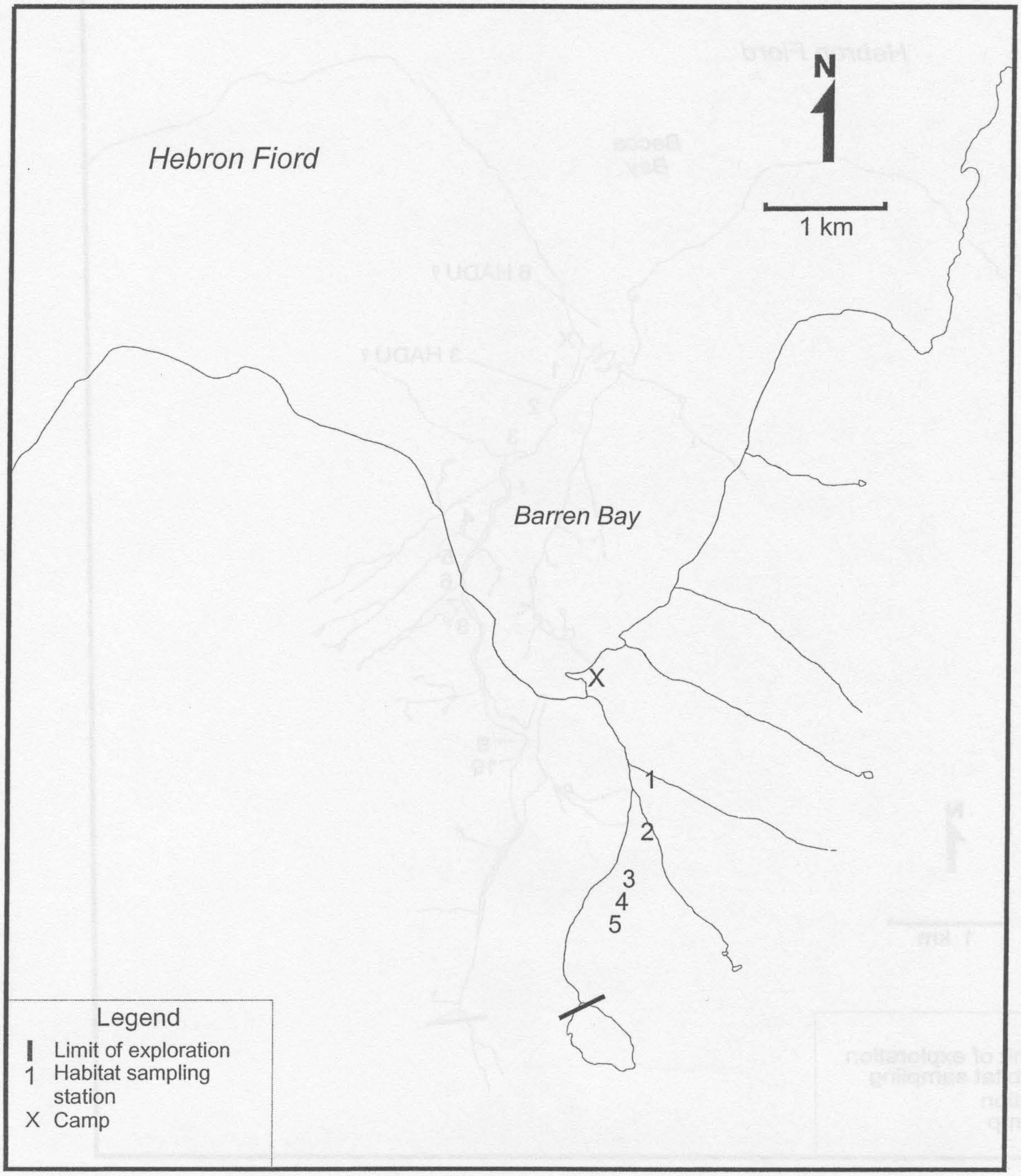

FIGURE 12. Limit of exploration and locations of habitat sampling stations on Barren Brook, Hebron Fiord, Labrador in 1996.

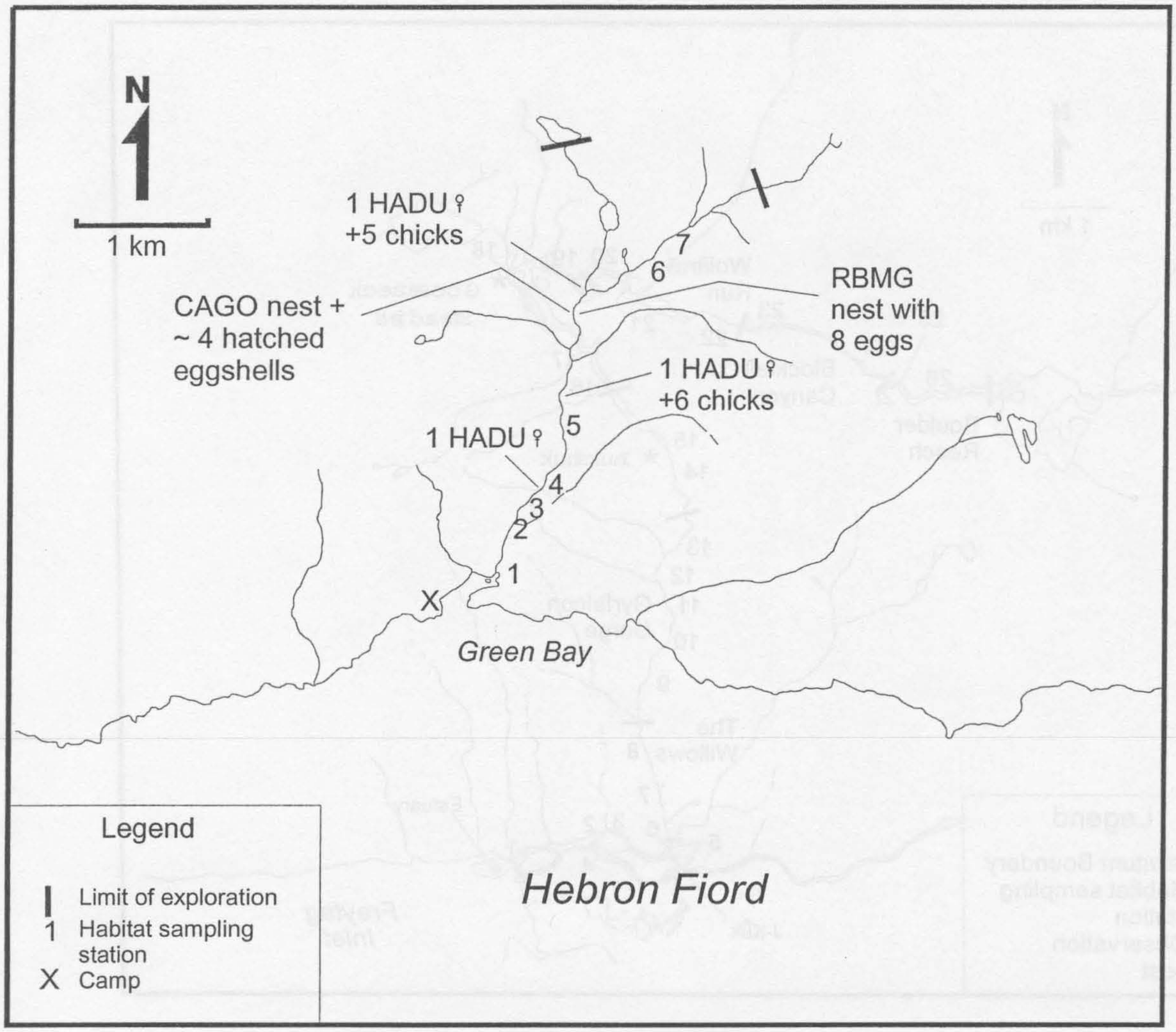

FIGURE 13. Limit of exploration and locations of habitat sampling stations and waterfowl observations on Green Brook, Hebron Fiord, Labrador in 1996.

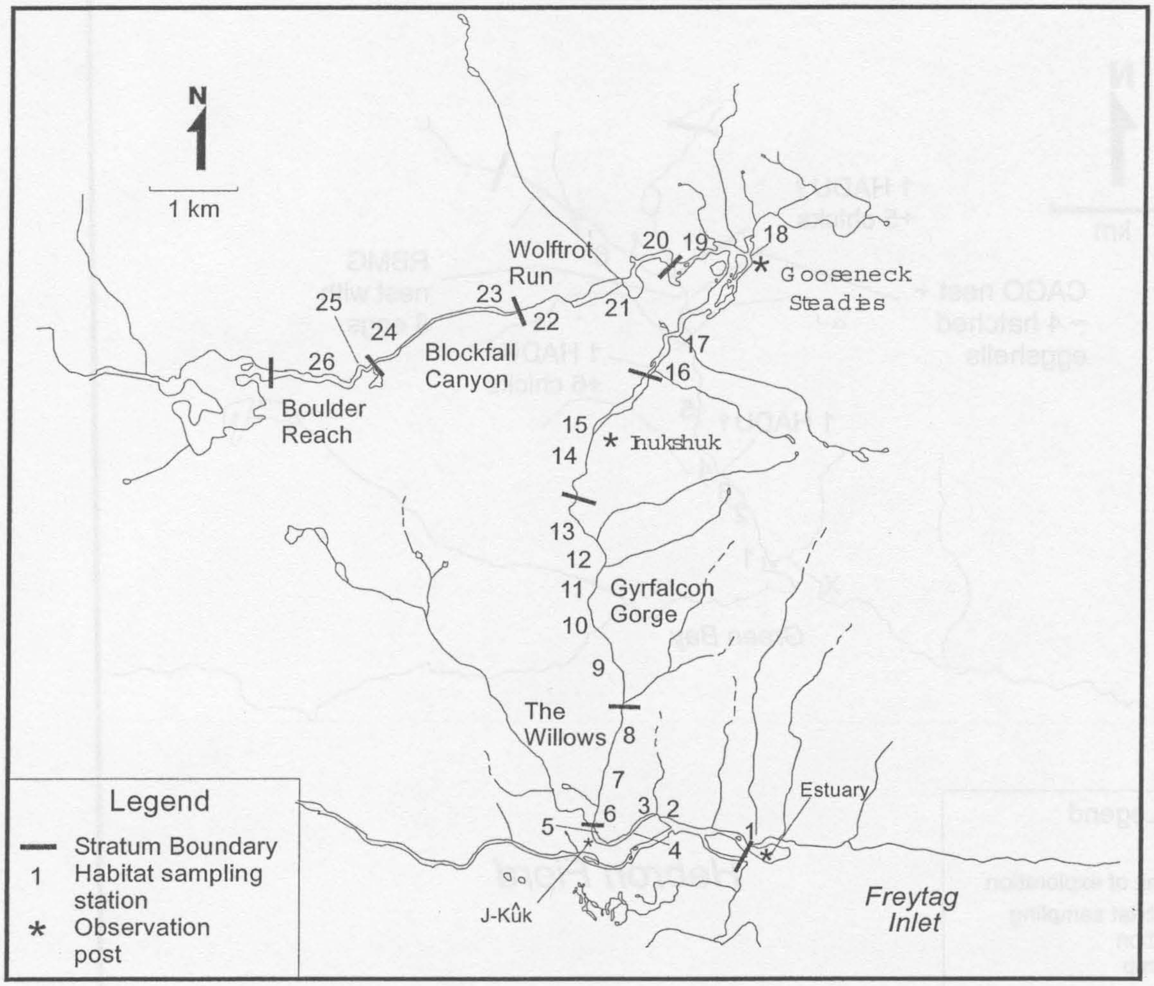

FIGURE 14. Location of habitat sampling stations, stratum boundaries, and observation posts on Harlequin Brook, Hebron Fiord, Labrador in 1996. Strata 1-5 corresponded to the "Flyway" (stratum 1), the "Willows" and "Wolftrot Run" (stratum 2), "Gyrfalcon Gorge" and "Blockfall Canyon" (stratum 3), "Inukshuk" and "Boulder Reach" (stratum 4), and "Gooseneck Steadies" (stratum 5), respectively.

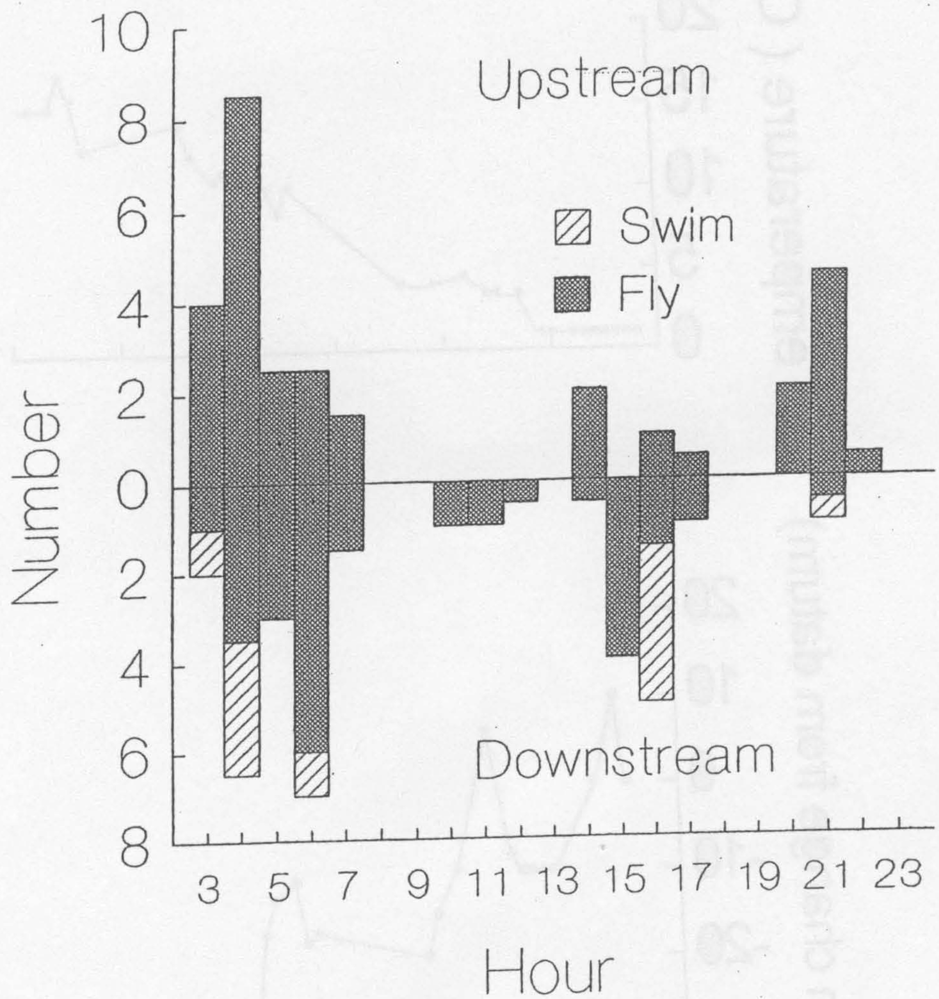

FIGURE 15. Diurnal upstream and downstream movements of Harlequin Ducks past the base cabin on Harlequin Brook, Hebron Fiord, Labrador on 10-11 June 1996

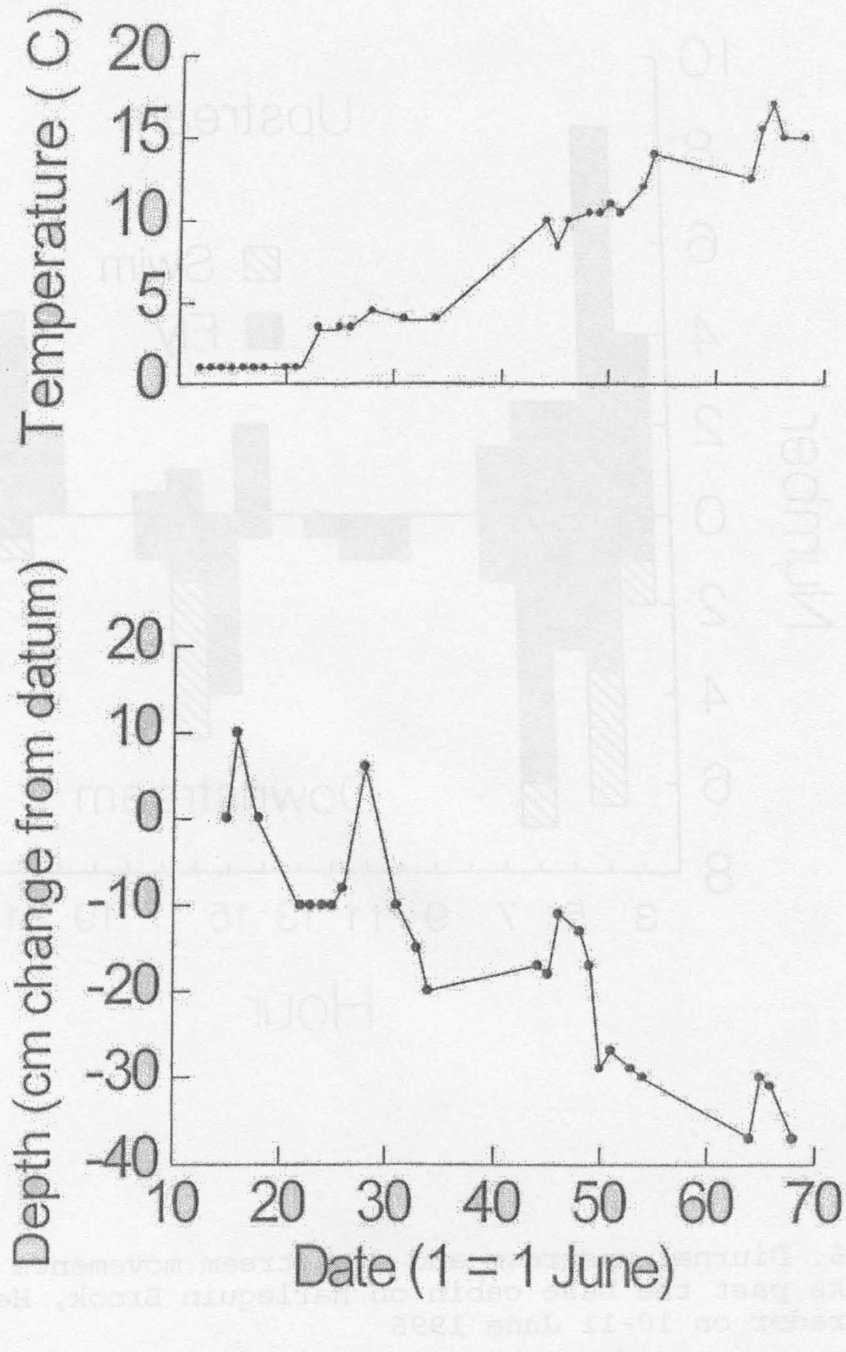

FIGURE 16. Within season changes in water temperature and depth measured in front of the base cabin on Harlequin Brook Hebron Fiord, Labrador in 1996.

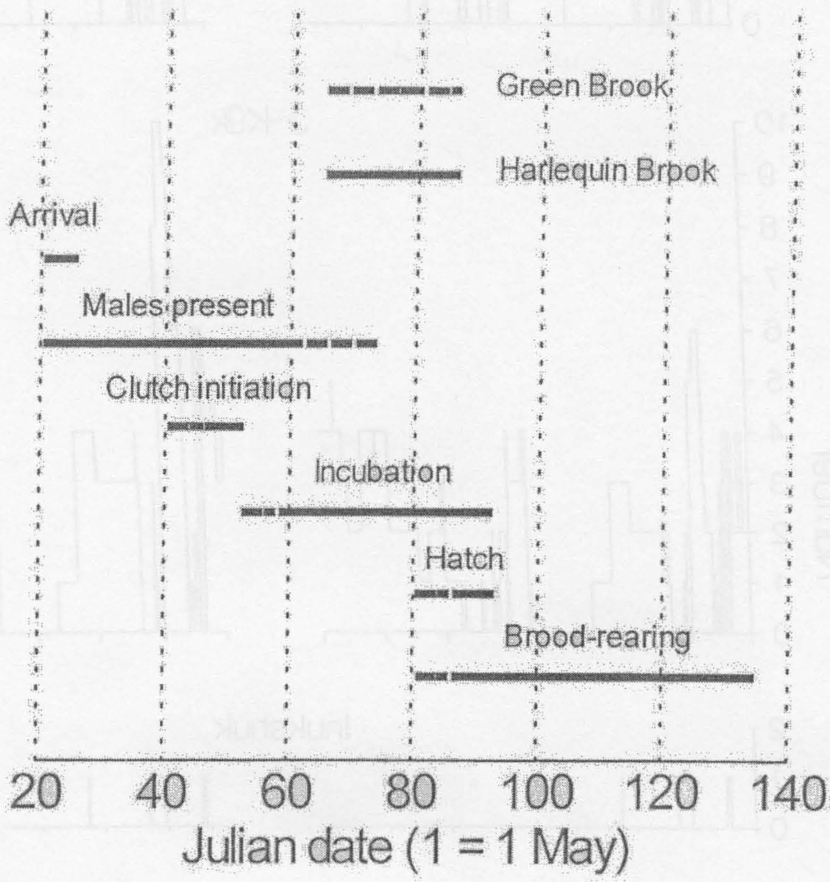

FIGURE 17. Breeding phenology of Harlequin Ducks in Hebron Fiord, Labrador. Timing was estimated from ages of 6 broods observed in 1996 and assuming a 28 day incubation period (Bengtson 1972), a mean clutch size of 6 eggs (Bengtson 1972, this study), an egg-laying rate of 0.5 eggs/day (Alisauskas and Ankney 1992), and a fledging period of 6 weeks (Bengtson 1972). Arrival dates are based on first sightings of Harlequin Ducks at Caribou Rattle by A. Veitch (pers. comm.) in 1989-1992.

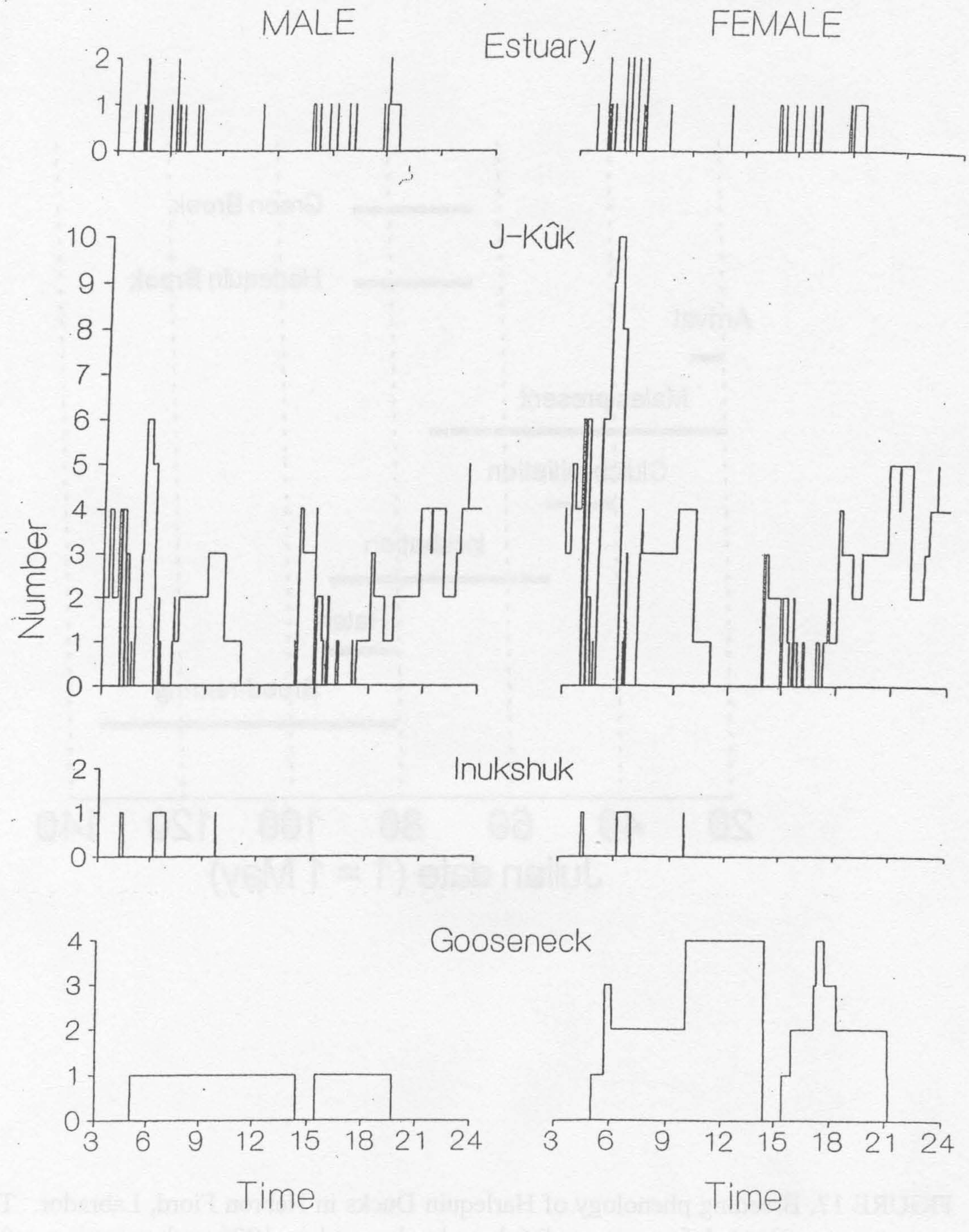

FIGURE 18. Diurnal abundance of male and female Harlequin Ducks at four stations on Harlequin Brook, Hebron Fiord, Labrador in the pre-laying period, 16-21 June 1996.

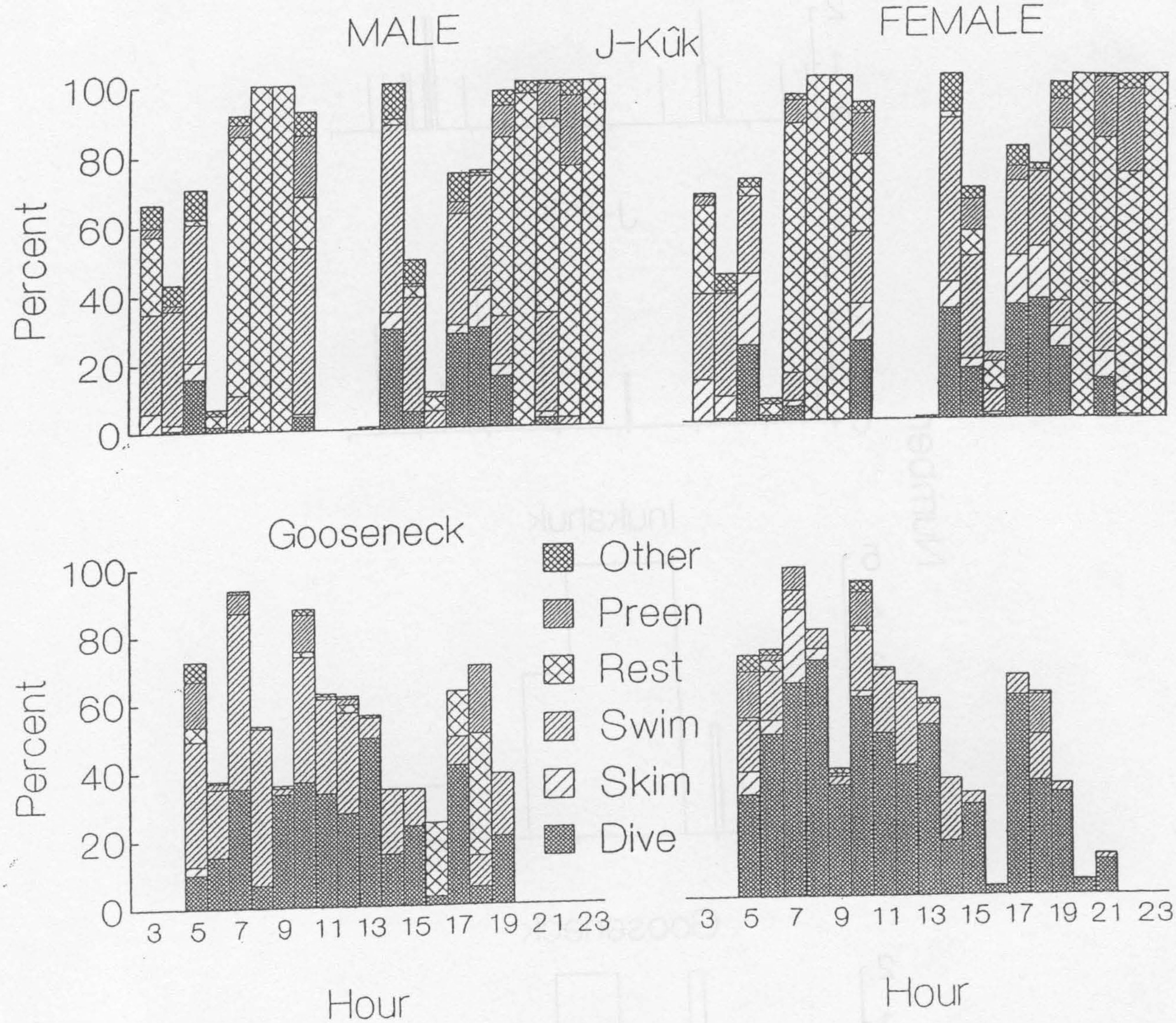

FIGURE 19. Diurnal activity patterns of male and female Harlequin Ducks at J-Kûk and Gooseneck Steadies on Harlequin Brook, Hebron Fiord, Labrador in the pre-laying period, 16-21 June 1996.

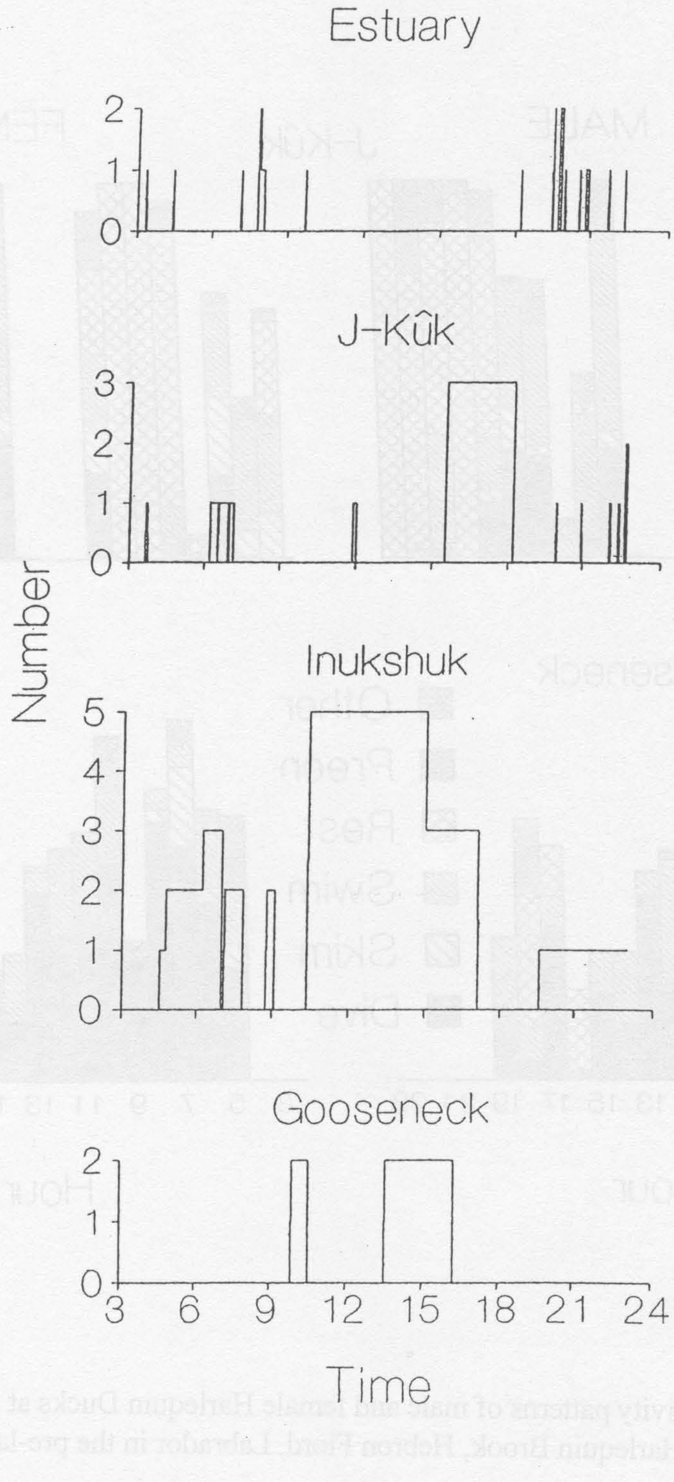

FIGURE 20. Diurnal abundance of female Harlequin Ducks at four stations on Harlequin Brook, Hebron Fiord, Labrador in the incubation period, 15-20 July 1996. Most observations are assumed to be of failed or non-breeding females.

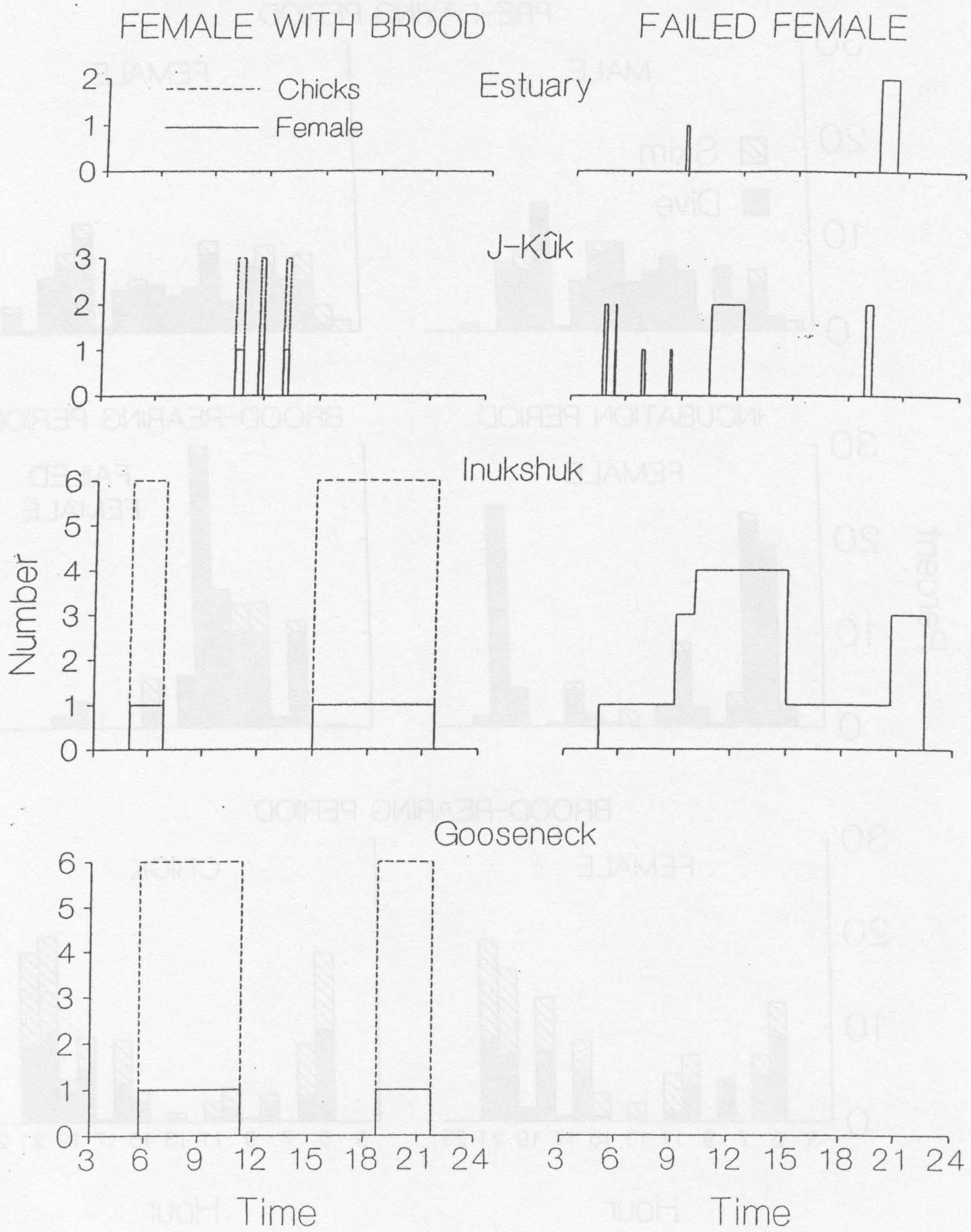

FIGURE 21. Diurnal abundance of Harlequin Duck females with broods and failed or non-breeding females at four stations on Harlequin Brook, Hebron Fiord, Labrador in the brood-rearing period, 2-6 August 1996.

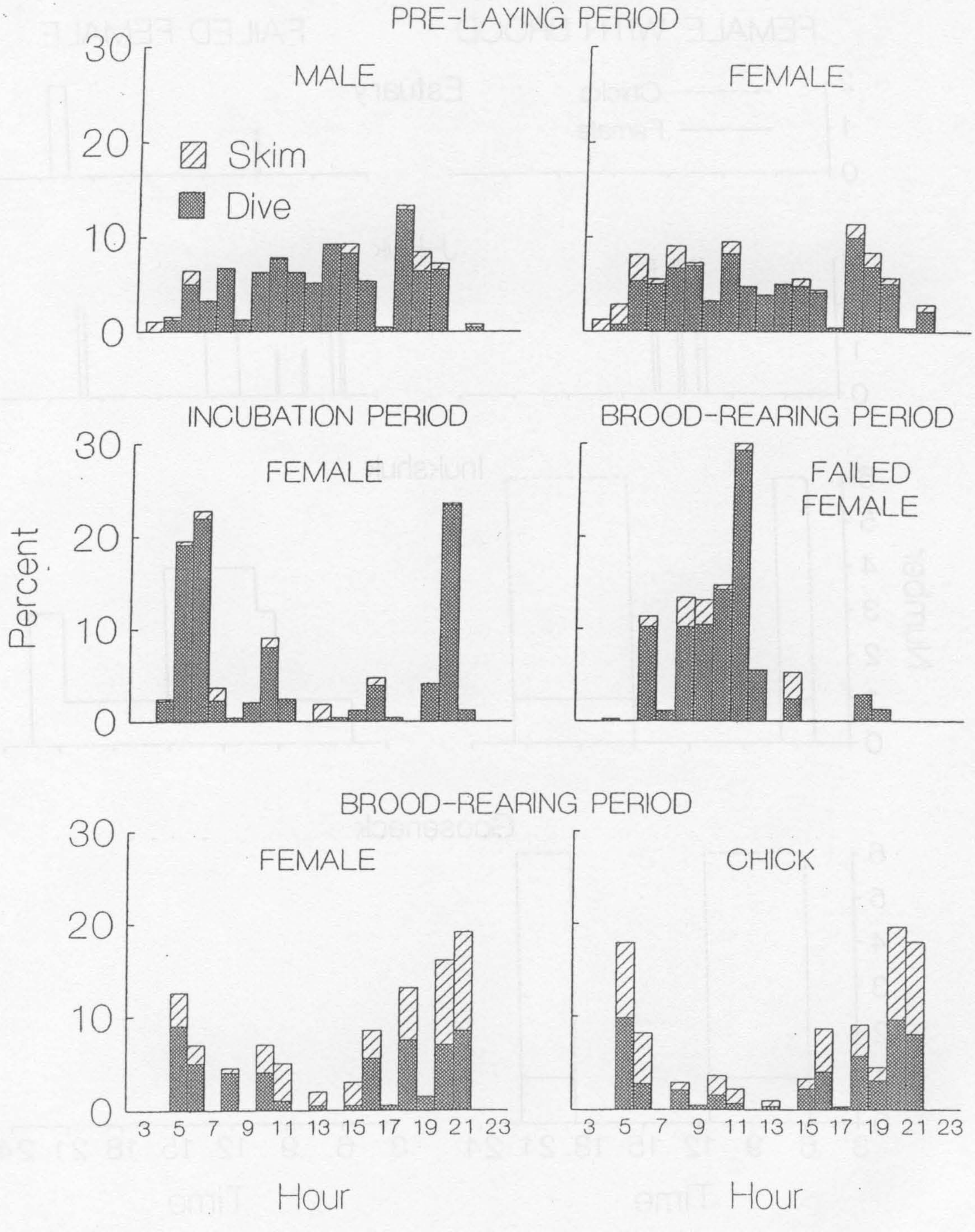

FIGURE 22. Diurnal feeding patterns of Harlequin Ducks in the pre-laying, incubation, and brood-rearing periods on Harlequin Brook, Hebron Fiord, Labrador in 1996.

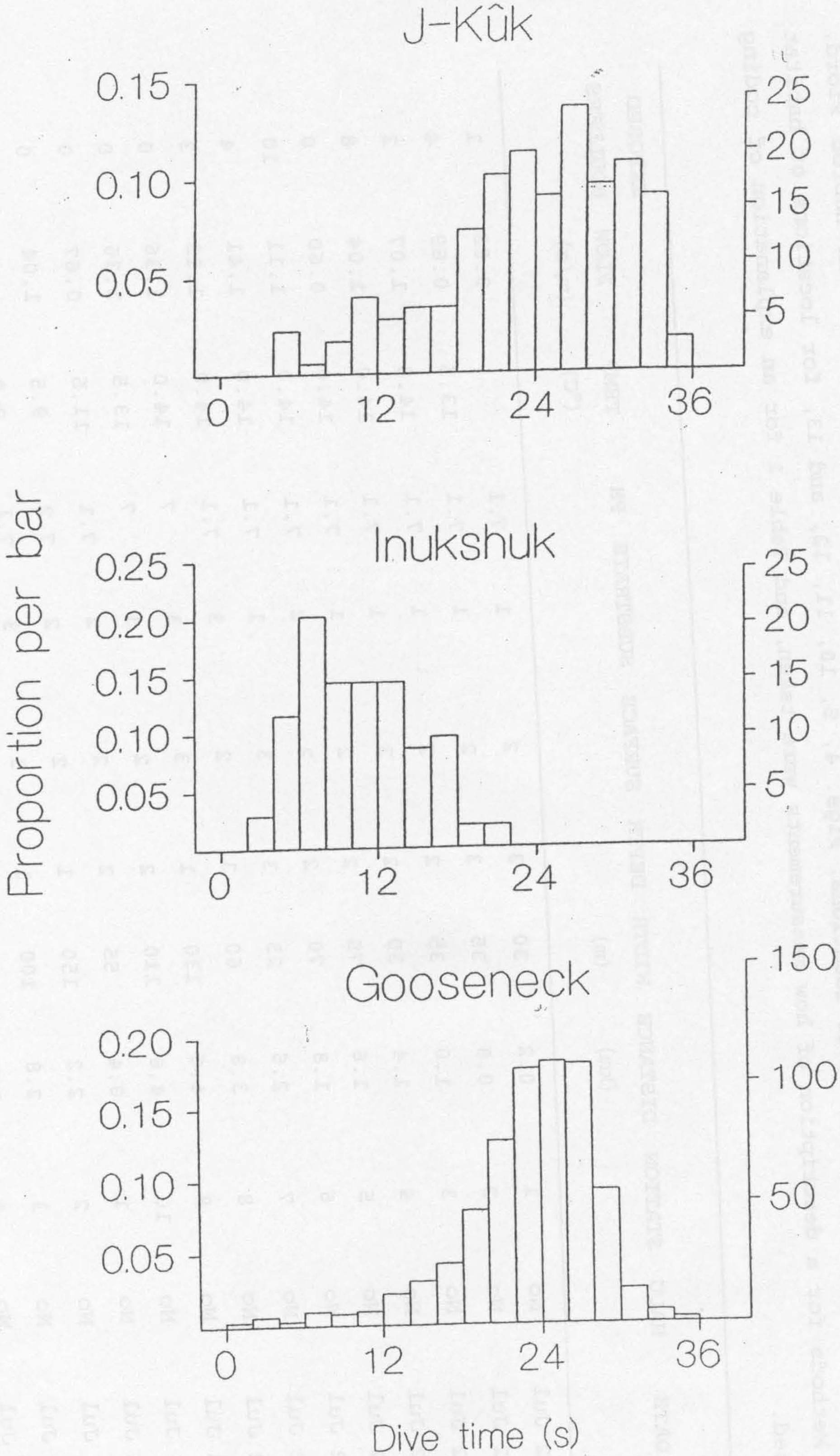

FIGURE 23. Comparison of Harlequin Duck dive times in three different habitats on Harlequin Brook, Hebron Fiord, Labrador in 1996.

APPENDIX I. Habitat measurements taken at random 200 m intervals in the lower 5 km of three rivers with and 3 rivers without sightings of Harlequin Ducks within 10 km of their respective estuaries in Hebron Fiord, Labrador in 1996. See Fig. 3 for river locations, Figs. 4, 5, 10, 11, 12, and 13, for locations of habitat stations, Methods for a description of how measurements were taken, and Table 1 for an explanation of coding systems used.

RIVER	DATE	HADU	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)	EXPOSED BOULDERS
Ikarut	22 Jul	No	1	0.2	30	3	2	1	7.1		0.88	1
Ikarut	22 Jul	No	2	0.8	35	3	2	1	7.1	13.5	0.69	4
Ikarut	22 Jul	No	3	1.0	35	2	2	1	7.1	14.0	1.07	2
Ikarut	22 Jul	No	4	1.4	30	2	3	1	7.1	14.0	1.04	8
Ikarut	22 Jul	No	5	1.6	75	2	2	1	7.1	14.0	0.60	0
Ikarut	22 Jul	No	6	1.8	70	2	2	2	7.1	14.0	1.11	10
Ikarut	22 Jul	No	7	2.6	25	3	3	1	7.1	14.0	1.41	4
Ikarut	22 Jul	No	8	3.8	60	3	2	3	7.1	14.0	1.13	3
Ikarut	22 Jul	No	9	4.6	130	1	3	3	7	14.0	1.36	0
Ikarut	22 Jul	No	10	4.8	110	2	2	3	7	13.5	1.36	0
Saddle	23 Jul	No	1	0.4	55	2	2	2	7.1	11.5	0.67	0
Saddle	23 Jul	No	2	2.2	150	1	2	2	7.2	9.5	1.04	0
Saddle	23 Jul	No	3	2.8	100	1	3	3	7.1	9.0	0.81	0
Saddle	23 Jul	No	4	3.2	25	1	2	2	7.1	9.0	0.59	50
Saddle	23 Jul	No	5	3.4	10	1	2	3	7.1	9.0	0.83	1

Appendix I (cont'd)

RIVER	DATE	HADU	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)	EXPOSED BOULDERS
Saddle	23 Jul	No	6	3.6	10	1	3	3	7.1	8.5	1.21	5
Saddle	23 Jul	No	7	4.0	4	2	3	3	7.1		1.48	20
Saddle	23 Jul	No	8	4.2	15	2	3	4	7.1	8.5	1.66	60
Saddle	23 Jul	No	9	4.6	10	2	2	3	7.1	8.5	0.68	10
Saddle	23 Jul	No	10	5.0	30	1	3	3	7.1	8.5	0.47	100
Winnie	25 Jul	Yes	1	0.2	15	2	3	3	7.6	15.0	1.57	3
Winnie	25 Jul	Yes	2	0.6	25	2	3	4	7.6		1.26	50
Winnie	25 Jul	Yes	3	1.0	5	2	3	4	7.5		0.99	10
Winnie	25 Jul	Yes	4	1.4	40	2	1	3	7.5	16.0	0.61	50
Winnie	25 Jul	Yes	5	2.2	30	2	3	3	7.3	14.5	0.90	20
Winnie	25 Jul	Yes	6	2.4	12	1	3	4	7.4	15.0	1.25	5
Winnie	25 Jul	Yes	7	3.0	4	2	2	4	7.3	15.0	1.16	4
Winnie	25 Jul	Yes	8	3.4	50	1	2	4	7.3	14.5	0.53	30
Winnie	25 Jul	Yes	9	4.2	10	2	2	4	7.3	15.0	0.66	0
Winnie	25 Jul	Yes	10	4.8	3.5	1	3	4	7.4	14.5	1.26	5
Becca	27 Jul	Yes	1	0.2	30	2	3	4	7.5	10.0	1.28	30
Becca	27 Jul	Yes	2	0.6	10	3	3	4	7.4	10.5	1.16	0
Becca	27 Jul	Yes	3	1.0	80	1	2	3	7.4	10.5	0.93	30
Becca	27 Jul	Yes	4	2.0	30	1	3	4	7.3	10.5	2.50	0

Appendix I (cont'd)

RIVER	DATE	HADU	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)	EXPOSED BOULDERS
Becca	27 Jul	Yes	5	2.4	12	2	3	4	7.4	10.5	2.00	4
Becca	27 Jul	Yes	6	2.6	15	2	3	4	7.3	10.5	0.98	12
Becca	27 Jul	Yes	7	2.8	10	3	3		7.3	10.0	2.50	0
Becca	27 Jul	Yes	8	3.0	20	2	3	4	7.3	10.5	2.18	15
Becca	27 Jul	Yes	9	4.2	25	2	2	4	7.3	10.0	0.79	10
Becca	27 Jul	Yes	10	4.4	90	1	2	4	7.3	10.5	0.81	500
Barren	28 Jul	No	1	0.8	60	1	2	3	7.3	8.5	0.62	500
Barren	28 Jul	No	2	1.2	65	1	2	4	7.3	7.5	1.00	500
Barren	28 Jul	No	3	1.6	15	2	3	4	7.3	7.5	1.10	6
Barren	28 Jul	No	4	1.8	20	1	3	4	7.3	7.0	1.09	10
Barren	28 Jul	No	5	2.0	25	1	2	3	7.2	7.5	0.59	200
Green	29 Jul	Yes	1	0.2	12	1	3	3	7.4	14.5	0.75	100
Green	29 Jul	Yes	2	0.6	15	1	3	3	7.3	14.5	0.76	100
Green	29 Jul	Yes	3	0.8	10	2	2	3	7.5	15.0	0.80	15
Green	29 Jul	Yes	4	1.0	6	2	3	4	7.1	15.0	1.16	10
Green	29 Jul	Yes	5	1.6	20	1	2	3	7.2	14.5	0.63	50
Green	29 Jul	Yes	6	3.2	20	1	2	3	7.1	13.5	0.71	50
Green	29 Jul	Yes	7	3.6	7	1	2	2	7.1	13.5	0.54	8

Appendix 1 (cont'd)

RIVER	NUMBER	Stn.	ISLANDS: WIDTH OF LARGEST (m)	ISLANDS: LENGTH OF LARGEST (m)	ISLANDS: COVER	ISLANDS: VEGETATION HEIGHT	SHORELINE RIGHT: SLOPE	SHORELINE RIGHT: WIDTH (m)	SHORELINE RIGHT: COVER	SHORELINE LEFT: SLOPE	SHORELINE LEFT: WIDTH (m)	SHORELINE LEFT: COVER
Ikarut	0	1					1	>25	4	1	>25	4
Ikarut	0	2					2	>25	4	2	3	4
Ikarut	1	3	3	10	3		2	4	4	2	5	4
Ikarut	0	4					2	2	4	2	3	4
Ikarut	2	5	5	20	3		2	20	4	3	1	4
Ikarut	4	6	5	15	3		3	2	1	2	>25	4
Ikarut	0	7					2	>25	4	2	1	4
Ikarut	1	8	20	50	4		3	1	4	1	7	4
Ikarut	3	9	20	100	4		4	1	1	3	2	2
Ikarut	2	10	10	100	4		3	1	1	3	1	4
Saddle	2	1	20	60	3		2	>25	3	3	2	3
Saddle	1	2	100	400	4		3	1	4	3	6	3
Saddle	2	3	50	100	1	1	3	1	1	3	5	4
Saddle	0	4					3	2	4	2	>25	5
Saddle	0	5					3	>25	1	2	>25	5
Saddle	0	6					3	0.5	2	2	4	5
Saddle	0	7					3	4	5	3	4	5
Saddle	0	8					3	1	5	3	5	5
Saddle	0	9					3	2	5	2	4	5
Saddle	0	10					3	2	2	1	1	4

Appendix I (cont'd)

RIVER	NUMBER	Stn.	ISLANDS: WIDTH OF LARGEST (m)	ISLANDS: LENGTH OF LARGEST (m)	ISLANDS: COVER	ISLANDS: VEGETATION HEIGHT	SHORELINE RIGHT: SLOPE	SHORELINE RIGHT: WIDTH (m)	SHORELINE RIGHT: COVER	SHORELINE LEFT: SLOPE	SHORELINE LEFT: WIDTH (m)	SHORELINE LEFT: COVER
Winnie	0	1					2	0	1	2	0	1
Winnie	1	2	10	60	5		3	1	5	3	0.5	2
Winnie	0	3					4	2	5	2	3	5
Winnie	10	4	5	20	2	1	2	0.5	2	2	0.5	2
Winnie	7	5	5	10	2	1	2	>25	2	2	0.5	2
Winnie	1	6	15	15	5		3	2	6	3	1	5
Winnie	0	7					3	2	5	3	0.5	5
Winnie	8	8	10	20	2	2	3	1	2	3	1	1
Winnie	1	9	20	50	1	3	2	>25	2	2	>25	2
Winnie	0	10					2	>25	5	2	>25	1
Becca	0	1					2	>25	2	3	>25	5
Becca	0	2					4	1	6	4	4	6
Becca	1	3	10	40	5		3	1	2	3	3	2
Becca	1	4			6		4	10	6	3	2	5
Becca	0	5					4	10	6	3	2	5
Becca	0	6					3	2	5	4	12	7
Becca	0	7					4	5	6	4	4	6
Becca	0	8					3	5	5	4	12	6
Becca	0	9					4	0.5	6	3	0.5	6
Becca	0	10					3	1	5	3	0.5	2

Appendix I (cont'd)

		ISLANDS				SHORELINE RIGHT			SHORELINE LEFT		
RIVER	NUMBER	WIDTH OF LARGEST (m) Stn.	LENGTH OF LARGEST (m)	COVER	VEGETATION HEIGHT	SLOPE	WIDTH (m)	COVER	SLOPE	WIDTH (m)	COVER
Barren	3	10	40	5		2	1	5	2	1	2
Barren	4	20	50	5		2	0.5	2	3	3	5
Barren	0					3	8	5	3	2	5
Barren	1	10	20	5		2	15	7	3	3	5
Barren	0					4	2	5	2	1	5
Green	1	10	30	1	2	2	0.5	2	3	0.5	1
Green	1	10	30	1	2	3	1	5	3	2	5
Green	0					3	4	5	4	3	6
Green	0					4	4	6	3	4	6
Green	0					3	0.5	2	3	0.5	2
Green	5	10	35	2	1	3	1	5	3	0.5	2
Green	1	2	3	2	1	4	0.5	2	4	0.5	2

Appendix I (cont'd)

		BANK						CLOSEST SHRUB COVER TO STREAM			
		RIGHT			LEFT			RIGHT		LEFT	
RIVER	Stn	SLOPE	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT	DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Ikarut	1							100	1	300	1
Ikarut	2				2	2	1	30	1	3	1
Ikarut	3	3	1	2	2	2	1	4	2	5	1
Ikarut	4	1	4		1	2	1	50	1	3	1
Ikarut	5	2	1	1	3	1	3	20	1	1	2
Ikarut	6	1	1	1				1	2	60	2
Ikarut	7				3	1	2	30	2	1	2
Ikarut	8	1	1	1	3	1	3	1	1	6	3
Ikarut	9	2	2	1	1	2	1	1	1	0	1
Ikarut	10	2	1	1	1	1	1	0.5	1	1	1
Saddle	1				1	3		50	1	4	1
Saddle	2	2	1	2	1	1	1	1	2	6	1
Saddle	3	1	1	1	2	4		0	2	10	1
Saddle	4	2	1	3				2	3	1	2
Saddle	5							1	1	30	2
Saddle	6	3	1	3	2	5		2	3	1	2
Saddle	7	3	2	1	2	1	3	5	3	4	3
Saddle	8	3	1	3	3	1	3	1	3	3	2
Saddle	9	2	1	3	2	7		3	3	15	2
Saddle	10	3	1	3	3	7		4	3	10	2

Appendix I (cont'd)

RIVER			BANK						CLOSEST SHRUB COVER TO STREAM			
	RIGHT				LEFT				RIGHT		LEFT	
RIVER	SLOPE	Stn	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT		DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Barren	2	1	2	1	2	2	1		70	1	50	1
Barren	2	2	5		3	2	1		50	1	3	1
Barren	3	3	5		3	5			20	1	20	1
Barren	3	4	2	1	2	1	1		20	1	3	1
Barren	3	5	5		3	5			5	1	4	1
Green	1	1	2	1	1	1	2		40	3	2	2
Green	2	2	1	1	2	2	1		7	2	6	2
Green	2	3	1	1	2	5			5	1	12	1
Green	2	4	1	2	2	1	2		4	2	4	2
Green	2	5	1	1	1	1	1		10	1	30	2
Green	2	6	2	1	1	2	1		15	1	5	1
Green	1	7	2	1	1	2	1		1	1	2	2

Appendix I (cont'd)

		BANK						CLOSEST SHRUB COVER TO STREAM			
		RIGHT			LEFT			RIGHT		LEFT	
RIVER	Stn	SLOPE	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT	DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Winnie	1	2	1	3	2	1	3	-1	3	-1	3
Winnie	2	3	5		3	2	1	3	1	6	1
Winnie	3	2	5		4	6		15	1	10	3
Winnie	4	2	1	1	1	2	1	20	2	200	1
Winnie	5				1	2	1	3	2	2	1
Winnie	6	2	1	1	3	2	1	2	1	5	1
Winnie	7	3	6		3	6		2	3	5	1
Winnie	8	3	1	1	2	1	1	30	1	1	1
Winnie	9							100	2	200	2
Winnie	10							4	1	2	1
Becca	1							1	2	3	2
Becca	2	3	5	1		1	1	7	3	4	1
Becca	3	2	1	3	2	1	1	2	3	3	1
Becca	4	3	5		3	6		12	1	25	1
Becca	5	2	1	2	3	7		10	2	20	1
Becca	6	3	5		2	1	1	2	3	12	1
Becca	7	3	5		3	7		5	2	3	1
Becca	8	3	1	2	1	5		5	2	12	1
Becca	9	2	6		3	7		15	2	15	1
Becca	10	1	5		1	2	1	20	1	40	1

APPENDIX II. Habitat measurements taken at random 200 m intervals within 5 strata on Harlequin Brook, Hebron Fiord, Labrador in 1996. See Fig. 14 for locations of sample stations and strata, Methods for a description of how measurements were taken, and Table 1 for an explanation of coding systems used.

SECTION	SAMPLE	STRATUM	DATE	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)
Flyway	1	1	23 Jun	1	0.3	100	4	2	2		6.0	
Flyway	1	1	23 Jun	2	1.1	45	3	3	2		4.0	1.37
Flyway	1	1	23 Jun	3	1.3	30	3	2	2		3.5	
Flyway	1	1	23 Jun	4	1.5	40	3	2	2		3.5	
Flyway	1	1	23 Jun	5	1.7	30	3	2	2		4.5	
Willows	1	2	23 Jun	6	2.0	70	3	3	2		3.5	
Willows	1	2	23 Jun	7	2.4	70	2	3	2		3.0	1.60
Willows	1	2	23 Jun	8	2.6	70	2	3	2		3.0	2.63
Gyrfalcon	1	3	24 Jun	9	3.4	30						
Gyrfalcon	1	3	24 Jun	10	3.8	15	3	3	5		3.0	
Gyrfalcon	1	3	24 Jun	11	4.0	15	3	3	5		3.0	
Gyrfalcon	1	3	24 Jun	12	4.2	15	2	3	3		3.0	
Gyrfalcon	1	3	24 Jun	13	4.6	35	2	3	3		3.0	
Inukshuk	1	4	24 Jun	14	5.2	60	2	3	2		3.0	1.36
Inukshuk	1	4	24 Jun	15	5.4	25	2	3	3		3.0	1.77
Gooseneck	1	5	24 Jun	16	5.6	30	3	1	2		3.0	0.23
Gooseneck	1	5	24 Jun	17	6.6	35	3	1	1		6.0	0.19
Gooseneck	1	5	24 Jun	18	7.8	30	3	1	1		6.0	0.42
Gooseneck	1	5	24 Jun	19	8.0	45	4	1	2		4.0	
Wolftrot	1	2	24 Jun	20	8.4	20	1	3	3		3.5	1.52
Wolftrot	1	2	24 Jun	21	8.8	90	2	3	2		3.5	2.54

Appendix II (cont'd)

SECTION	SAMPLE	STRATUM	DATE	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)
Wolftrot	1	2	24 Jun	22	9.6	25		3	2	6.9	4.5	2.51
Blockfall	1	3	24 Jun	23	9.8	20	2	3	3		3.5	2.85
Blockfall	1	3	24 Jun	24	10.8	15	2	3	3		3.5	3.12
Boulder	1	4	24 Jun	25	11.0	20	2	3	3	7.2	4.5	0.85
Boulder	1	4	24 Jun	26	11.4	30	2	3	3	6.9	4.0	1.63
Flyway	2	1	18 Jul	1	0.3	120	3	2	2	7.3	10.5	0.69
Flyway	2	1	18 Jul	2	1.1	50	2	3	2	7.2	10.5	1.55
Flyway	2	1	18 Jul	3	1.3	20	2	2	2	7.2	10.5	0.78
Flyway	2	1	18 Jul	4	1.5	30	2	2	2	7.1	10.5	0.92
Flyway	2	1	18 Jul	5	1.7	25	2	2	2	7.1	10.5	0.56
Willows	2	2	18 Jul	6	2.0	100	1	3	2	7.1	10.5	0.98
Willows	2	2	18 Jul	7	2.4	80	1	3	3	7.2	10.5	1.16
Willows	2	2	18 Jul	8	2.6	80	1	3	4	7.1	10.5	
Gyrfalcon	2	3	18 Jul	9	3.4	35	1	3	3			
Gyrfalcon	2	3	18 Jul	10	3.8							
Gyrfalcon	2	3	18 Jul	11	4.0	15	1	3	3			
Gyrfalcon	2	3	18 Jul	12	4.2	9	2	3	4			
Gyrfalcon	2	3	18 Jul	13	4.6	20	2	3	3			
Inukshuk	2	4	18 Jul	14	5.2	70	1	2	2	7.1	9.5	0.59
Inukshuk	2	4	18 Jul	15	5.4	25	2	2	2	7.1	9.5	1.44
Gooseneck	2	5	18 Jul	16	5.6	35	2	1	2	7.1	9.5	
Gooseneck	2	5	18 Jul	17	6.6	200	2	1	1	7.1	10.5	
Gooseneck	2	5	18 Jul	18	7.8	30	2	1	1	7.2	11.0	
Gooseneck	2	5	18 Jul	19	8.0	35	2	1	2	7	10.5	
Wolftrot	2	2	18 Jul	20	8.4	40	1	3	2	7.2	11.5	0.93

Appendix II (cont'd)

SECTION	SAMPLE	STRATUM	DATE	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)
Wolftrot	2	2	18 Jul	21	8.8	100	1	2	2	7.1	12.5	0.70
Wolftrot	2	2	18 Jul	22	9.6	35	2	3	2	7.3	12.0	2.18
Blockfall	2	3	18 Jul	23	9.8	20	2	3	2			
Blockfall	2	3	18 Jul	24	10.8	15	2	2	2			
Boulder	2	4	18 Jul	25	11.0	15	2	2	2	7.3	12.5	0.60
Boulder	2	4	18 Jul	26	11.4	35	1	2	2	7.1	12.0	0.97
Flyway	3	1	6 Aug	1	0.3	200	3	1	2	7.3	13.0	
Flyway	3	1	6 Aug	2	1.1	50	2	2	2	7.3	13.0	1.82
Flyway	3	1	6 Aug	3	1.3	25	2	1	2	7.3	13.5	0.59
Flyway	3	1	6 Aug	4	1.5	20	2	2	2	7.4	13.5	0.68
Flyway	3	1	6 Aug	5	1.7	20	2	1	2	7.2	13.5	0.56
Willows	3	2	6 Aug	6	2.0	200	2	2	2	7.3	13.5	0.69
Willows	3	2	5 Aug	7	2.4	80	2	3	3	7.3	17.0	1.00
Willows	3	2	5 Aug	8	2.6	80	2	3	4	7.3	17.0	2.00
Gyrfalcon	3	3	5 Aug	9	3.4	40	1	3	4			1.42
Gyrfalcon	3	3	5 Aug	10	3.8							
Gyrfalcon	3	3	5 Aug	11	4.0	15	2	3	4			1.66
Gyrfalcon	3	3	5 Aug	12	4.2	15	2	3	4			1.25
Gyrfalcon	3	3	5 Aug	13	4.6	25	1	3	4			1.25
Inukshuk	3	4	5 Aug	14	5.2	60	1	2	3	7.3	17.5	
Inukshuk	3	4	5 Aug	15	5.4	50	1	2	3	7.3	17.5	0.86
Gooseneck	3	5	5 Aug	16	5.6	30	2	1	1	7.2	17.5	
Gooseneck	3	5	5 Aug	17	6.6	100	2	1	1	7.3	18.5	
Gooseneck	3	5	5 Aug	18	7.8	150	2	1	1	7.1	18.0	
Gooseneck	3	5	5 Aug	19	8.0	50	2	1	2	6.9	14.5	

Appendix II (cont'd)

SECTION	SAMPLE	STRATUM	DATE	STATION	DISTANCE (km)	WIDTH (m)	DEPTH	SURFACE	SUBSTRATE	PH	TEMP (°C)	FLOW (m/s)
Wolftrot	3	2	5 Aug	20	8.4	60	2	3	4	7.2	16.0	1.17
Wolftrot	3	2	5 Aug	21	8.8	80	1	2	3	7.2	16.0	0.68
Wolftrot	3	2	5 Aug	22	9.6	50	2	3	3	7.1		1.81
Blockfall	3	3	5 Aug	23	9.8	25	2	3	4			
Blockfall	3	3	5 Aug	24	10.8	12	2	2	4			
Boulder	3	4	5 Aug	25	11.0	25	1	2	4	7.1	16.0	0.95
Boulder	3	4	5 Aug	26	11.4	60	1	2	3	7.1	16.5	1.33

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Appendix II (cont'd)

			ISLANDS					SHORELINE					
								RIGHT			LEFT		
SAMPLE	STATION	EXPOSED BOULDERS	NUMBER	WIDTH OF LARGEST (m)	LENGTH OF LARGEST (m)	COVER	VEGETATION HEIGHT	SLOPE	WIDTH (m)	COVER	SLOPE	WIDTH (m)	COVER
1	1	0	2	15	50						2	2	4
1	2	0	2	3	15			1	>25	4	3	0.5	1
1	3	0	0					1	>25	4	2	4	2
1	4	0	3	4	10			2	2	4	3	0.4	2
1	5	0	1	3	12			3	10	1	2	1	1
1	6	0	10	10	40						2	10	2
1	7	0	6	40	75						4	7	1
1	8	0	10								3	1	1
1	9	0	0					4	3	7	1	6	1
1	10	0	0					4	2	7	4	2	7
1	11	0	0					4	4	6	3	4	5
1	12	0	0					4	2	7	4	3	6
1	13	0	2			5		4	2	7	4	6	6
1	14	0	2					3	1	2	3	2	7
1	15	0	0					4	1	7	1	4	2
1	16	0	0					3	8	7	2	3	1
1	17	0	1	5	10	2	1	3	2	7	1	>25	2
1	18	0	1			4		3	1	7	1	>25	2
1	19	0	0					3	2	1	1	3	7

Appendix II (cont'd)

SAMPLE	STATION	EXPOSED BOULDERS	ISLANDS NUMBER	ISLANDS WIDTH OF LARGEST (m)	ISLANDS LENGTH OF LARGEST (m)	ISLANDS COVER	ISLANDS VEGETATION HEIGHT	SHORELINE RIGHT SLOPE	SHORELINE RIGHT WIDTH (m)	SHORELINE RIGHT COVER	SHORELINE LEFT SLOPE	SHORELINE LEFT WIDTH (m)	SHORELINE LEFT COVER
1	20	0	1	10	30	2	2	2	2	1	2	2	7
1	21	0	4	50	300	1	2	1	>25	2			
1	22	10	1	15	50	1	2	1	>25	1	3	2	7
1	23	0	0					4		6	4		7
1	24	0	0					2	20	6	4	0	7
1	25	0	0					1	>25	5	4	7	7
1	26	0	0					2	2	2	4	1	7
2	1	0	2			4		1	>25	4	1	1	4
2	2	0	1	20	60	4		1	>25	3	3	1	1
2	3	0	0					1	>25	4	3	2	2
2	4	0	1	10	15	4		1	15	4	2	1	2
2	5	0	1	10	20	4		3	0.5	2	2	2	4
2	6	0	8	10	30	1	3				1	2	4
2	7	0	4	15	50	1	3	3	3	4	3	3	4
2	8	100	4	10	30	1	3	3	4	4	3	1	2
2	9	100	0					4	6	6	3	1	4
2	10												
2	11	10	0					3	4	6	3	2	5
2	12	0	0					3	1	1	3	0.5	1

Appendix II (cont'd)

			ISLANDS					SHORELINE					
								RIGHT			LEFT		
SAMPLE	STATION	EXPOSED BOULDERS	NUMBER	WIDTH OF LARGEST (m)	LENGTH OF LARGEST (m)	COVER	VEGETATION HEIGHT	SLOPE	WIDTH (m)	COVER	SLOPE	WIDTH (m)	COVER
2	13	10	1	10	30	5		4	2	6	4	3	1
2	14	100	1	15	30	1	2	3	2	2	2	2	2
2	15	0	1	10	20	2	1	2	1	2	2	0.5	2
2	16	0	0					3	1	2	2	1	4
2	17	0	4	10	60	1	3				2	1	2
2	18	0	1	10	20	3		2	3	2	2	2	2
2	19	0	0					4	2	1	2	3	4
2	20	0	1	15	35	1	3	2	1	2	2	0.5	2
2	21	0	6	50	200	2	1	1	0.5	2	3	0.5	2
2	22	0	1	20	50	1	3	3	0.5	2	2	0.5	2
2	23	10	0					4	6	6	2	3	5
2	24	0	0					2	15	5	4	3	7
2	25	7	0					2	>25	5	3	3	4
2	26	50	0					2	2	4	2	0.5	2
3	1	0						2	>25	3	2	1	3
3	2	2	1	20	60	4		2	>25	3	3	1	2
3	3	0	0					2	>25	3	3	0.5	2
3	4	5	1	10	10	4		2	10	3	3	1	2
3	5	10	2	6	20	4		2	1	4	2	3	4

Appendix II (cont'd)

			ISLANDS					SHORELINE					
								RIGHT			LEFT		
SAMPLE	STATION	EXPOSED BOULDERS	NUMBER	WIDTH OF LARGEST (m)	LENGTH OF LARGEST (m)	COVER	VEGETATION HEIGHT	SLOPE	WIDTH (m)	COVER	SLOPE	WIDTH (m)	COVER
3	6	0	6	15	100	1	3	3	0.5	2	2	0.5	3
3	7	100	6	15	100	1	3	3	4	4	3	3	4
3	8	100	3	15	100	1	3	3	3	4	2	0.5	1
3	9	100	0					4	15	6	3	0.5	5
3	10												
3	11	10	0					3	>25	2	3	2	5
3	12	5	0					3	>25	2	3	1	5
3	13	100	1	10	30	1	3	3	>25	5	3	3	5
3	14	200	1	10	30	1	2	3	0.5	2	2	2	2
3	15	40	0					3	0.5	4	2	2	4
3	16	0	0					3	1	2	2	2	2
3	17	0	1	20	100	1	3	2	2	2	2	1	2
3	18	0	1	50	200	1	3	2	2	2	2	3	2
3	19	0	0					3	2	1	2	3	2
3	20	50	1	15	40	1	3	2	0.5	2	2	0.5	2
3	21	20	1	50	200	2	1	3	0.5	2	3	0.5	2
3	22	0	1	10	50	1	3	2	0.5	1	2	2	2
3	23	10	0					4	15	6	2	4	2
3	24	8	0					2	10	5	4	6	7

Appendix II (cont'd)

			ISLANDS					SHORELINE					
								RIGHT			LEFT		
SAMPLE	STATION	EXPOSED BOULDERS	NUMBER	WIDTH OF LARGEST (m)	LENGTH OF LARGEST (m)	COVER	VEGETATION HEIGHT	SLOPE	WIDTH (m)	COVER	SLOPE	WIDTH (m)	COVER
3	25	10	0					2	20	5	3	3	2
3	26	100	1	3	20	2	1	2	2	2	2	3	1

Appendix II (cont'd)

SECTION	SAMPLE	STATION	BANK RIGHT SLOPE	BANK RIGHT COVER	BANK RIGHT VEG. HEIGHT	BANK LEFT SLOPE	BANK LEFT COVER	BANK LEFT VEG. HEIGHT	CLOSEST SHRUB COVER TO STREAM RIGHT DISTANCE (m)	CLOSEST SHRUB COVER TO STREAM RIGHT SHRUB HEIGHT	CLOSEST SHRUB COVER TO STREAM LEFT DISTANCE (m)	CLOSEST SHRUB COVER TO STREAM LEFT SHRUB HEIGHT
Flyway	1	1				1	2	1				
Flyway	1	2				2	1	3			0.5	3
Flyway	1	3				1	1	2			4	1
Flyway	1	4	1	4		1	2	1				
Flyway	1	5	1	1	1	1	1	2	3	1	0	1
Willows	1	6				1	2	1			1	1
Willows	1	7				1	1	3			-2	3
Willows	1	8				2	1	3			-1.5	3
Gyrfalcon	1	9	2	7		3	1	3	50	1	-1	3
Gyrfalcon	1	10	3	7		3	6		100		4	3
Gyrfalcon	1	11	4	7		4	1	3	4	2	4	3
Gyrfalcon	1	12	3	7		3	1	2	70	2	2	2
Gyrfalcon	1	13	3	7		3	1	3	100		-1	3
Inukshuk	1	14	2	1	1	2	2	1	8	1	25	1
Inukshuk	1	15	2	7		3	1	1	15	2	4	1
Gooseneck	1	16	2	1	2	2	1	2	7.5	2	2	2
Gooseneck	1	17	1	7					-1	3	200	2
Gooseneck	1	18	3	1	1				4	1	150	1
Gooseneck	1	19	1	1	3	1	7		-1	3	3	3
Wolftrot	1	20	1	1	3	1	7		1	3	3	1

Appendix II (cont'd)

			BANK						CLOSEST SHRUB COVER TO STREAM			
			RIGHT			LEFT			RIGHT		LEFT	
SECTION	SAMPLE	STATION	SLOPE	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT	DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Wolftrot	1	21							1	2		
Wolftrot	1	22				1	1	3	-1	3	2	3
Blockfall	1	23	1	4		1	7					
Blockfall	1	24	3	4		2	7					
Boulder	1	25				1	7		30	1		
Boulder	1	26	1	1	1	1	7		4	1		
Flyway	2	1				2	4		100	1	60	1
Flyway	2	2				2	1	3	200	1	1	2
Flyway	2	3				1	1	3			2	2
Flyway	2	4	3	4		2	2	1			1	1
Flyway	2	5	3	1	2	2	1	2	0.5	2	8	2
Willows	2	6				3	4		1	3	10	1
Willows	2	7	1	1	2	1	1	1	3	2	0.5	3
Willows	2	8	1	2	1	2	1	3	4	1	-1	3
Gyrfalcon	2	9	2	1	2	3	1	3	6	2	1	3
Gyrfalcon	2	10										
Gyrfalcon	2	11	3	7		3	5		4	1	2	3
Gyrfalcon	2	12	3	1	3	3	1	3	1	3	0.5	3
Gyrfalcon	2	13	3	2	1	3	1	2	2	1	-1	3
Inukshuk	2	14	1	2	1	2	2	1	0	1	0.5	1
Inukshuk	2	15	2	2	1	2	1	2	5	2	10	2

Appendix II (cont'd)

			BANK						CLOSEST SHRUB COVER TO STREAM			
			RIGHT			LEFT			RIGHT		LEFT	
SECTION	SAMPLE	STATION	SLOPE	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT	DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Gooseneck	2	16	2	1	1	2	1	2	4	2	1.5	2
Gooseneck	2	17				2	2	1			10	2
Gooseneck	2	18	2	1	2	2	1	2	3	2	3	2
Gooseneck	2	19	2	1	3	2	1	3	-1	3	3	3
Wolftrot	2	20	2	1	2	2	1	2	1	2	1	2
Wolftrot	2	21	1	2	1	2	1	2	0	1	0	1
Wolftrot	2	22	2	1	2	1	1	3	0.5	2	-1	3
Blockfall	2	23	3	2	1	3	7		6	1	60	
Blockfall	2	24	3	5		2	7		100	1	60	1
Boulder	2	25	2	2	1	2	1	2	50	2	3	2
Boulder	2	26	1	1	2	2	2	1	5	2	5	1
Flyway	3	1				2	2	1	100	2	50	1
Flyway	3	2				3	1	3	200	1	1.5	3
Flyway	3	3				1	2	1	200	1	3	2
Flyway	3	4	2	1	1	2	1	1	10	1	1	1
Flyway	3	5	3	1	2	1	1	2	1	2	2	2
Willows	3	6	1	1	3	3	3		0.5	3	3	1
Willows	3	7	1	1	1	1	1	2	2	2	1	3
Willows	3	8	2	1	1	2	1	3	2	1	-1	3
Gyrfalcon	3	9	2	1	2	3	1	3	15	2	0.5	3

Appendix II (cont'd)

			BANK						CLOSEST SHRUB COVER TO STREAM			
			RIGHT			LEFT			RIGHT		LEFT	
SECTION	SAMPLE	STATION	SLOPE	COVER	VEG. HEIGHT	SLOPE	COVER	VEG. HEIGHT	DISTANCE (m)	SHRUB HEIGHT	DISTANCE (m)	SHRUB HEIGHT
Gyrfalcon	3	10										
Gyrfalcon	3	11				3	5		2	2	2	3
Gyrfalcon	3	12				3	1	3	2	3	1	3
Gyrfalcon	3	13				3	1	3	10	2	2	3
Inukshuk	3	14	2	1	2	2	2	1	1	2	5	1
Inukshuk	3	15	2	1	2	2	1	2	4	2	4	2
Gooseneck	3	16	2	1	1	2	1	2	4	2	2	2
Gooseneck	3	17	2	1	3	1	2	1	2	3	5	2
Gooseneck	3	18	2	1	2	2	2	2	3	2	3	2
Gooseneck	3	19	1	1	3	2	1	3	0	3	3	3
Wolftrot	3	20	2	1	1	1	2	1	1	2	15	2
Wolftrot	3	21	1	2	2	1	2	1	3	2	100	2
Wolftrot	3	22	1	1	3	2	1	2	-1	3	1	2
Blockfall	3	23	2	2	1	3	2	1	15	1	60	2
Blockfall	3	24	4	6		2	7		50	1	40	1
Boulder	3	25	2	1	2	2	1	2	20	2	3	2
Boulder	3	26	1	1	1	2	2	1	4	1	5	1

APPENDIX III. Observations of Harlequin Ducks on the lower 10 km of streams (except Harlequin Brook) emptying into Hebron Fiord, Labrador in 1996. Stream and observation locations are shown in Figs. 3-13.

Name	Date	Number and sex	Time	Distance from estuary (km)	Behaviour and habitat
Ikarut	2 Jul	0			
Saddle	2 Jul	0			
Primogenitor					
- below lake	4 Jul	1m1f	1050	8	Standing on gravel shoreline just below lake outflow.
- above lake	4 Jul	4f	1530-1550	2	Swimming and diving along gravelbar just below shrub-covered island.
			1638	0	Flying upstream from lake.
			1640	2	Flying upstream.
	5 Jul	4f	1110	2.5	On gravel shoreline of shrub-covered island, then swimming downstream.
		3f	1156	3	On gravel edge under shrub-covered bank, then swimming downstream.

Appendix III (Cont'd.)

Caribou	7 Jul	2f	1507	1	Flying downstream and out into fiord.
		1f	2055	1	Flying downstream and out into fiord.
		1f	2112	1	Flying downstream and out into fiord.
	8 Jul	1f	2135	1	Swimming by gravel bar, then flew out into fiord.
Kame Terrace	7 Jul	5m10f	1430	-	Roosting on rocky shoreline across the fiord from estuary.
	9 Jul	3m1f2	1310	-	Roosting on rocky shoreline across the fiord from estuary.
		2f	1624	0	Flying upstream.
		3m5f	1625	-	Diving just offshore of estuary, then flying out to middle of fiord.
		3m9f	1830	-	Landed just offshore of estuary, then flew across fiord.
		2f	2100	0	Flew in from fiord upstream to 100 m, then swam further upstream.
	10 Jul	4f	1900	0.4	Roosting on gravel bar.
Golden Eagle	12 Jul	2f	1215	7	Roosting on rock along shrub-covered bank.

Appendix III (Cont'd.)

Winnie	25 Jul	1f	1300-1330	0	Swimming and diving in estuary.
		2f	1330-1400	0	Second female swam downstream to join above female in estuary.
		2f	1800-2125	0	Swimming, diving and roosting in estuary.
			2125-2200	0	Slowly moving upstream; diving, roosting, preening and swimming.
Becca	27 Jul	1f	1530	1	Roosting on rock then swimming upstream into fast water in canyon.
		3f	1550	1	Roosting on rock shoreline in canyon.
		6f	2018-2125	0	Diving in estuary, then 3 flew upstream.
Barren	28 Jul	0			
Green	29 Jul	1f	1220	1	Roosting on rock in canyon.
		1f6Y	1300	2	Swimming in quiet water in 2 m wide channel with shrub-covered banks.
			1706	1.5	Roosting on rock in canyon.
		1f5Y	1445	2.5	Swimming along edge of 3 m wide channel under shrub-covered bank.
		1f	1751	1	Roosting on rock in canyon.

APPENDIX IV. Incidental sightings of other species at Hebron Fiord, 8 June - 14 August 1996. Sightings were near the Harlequin Brook base cabin (Fig. 2) unless otherwise specified. See Fig. 3 for locations of rivers in Hebron Fiord and Fig. 14 for specific sections of Harlequin Brook mentioned.

Flies and other things

Intertidal invertebrates - Lots of amphipods and small bivalves at Kame Terrace estuary on 9 July, and lots of amphipods at Golden Eagle estuary on 11 July.

Biting insects - Large numbers of adult black flies for first time at Inukshuk on 2 August. Black flies and mosquitoes bad at Inukshuk and J-Kûk on 3 August, and lots of mosquitoes at Gooseneck Steadies on 4 August.

Mammals

Black Bear - One to three present on all rivers explored in the inner fiord and as far east as Winnie and Green Brooks. Often feeding on caribou carcasses. Sighted occasionally from 8 June to 5 August on Harlequin Brook. Adult with cub on west side of Gyrfalcon Gorge on 17 July.

Wolf - One seen on the Ikarut River on 2 July and on Caribou River on 8 July. Tracks seen on 8 and 9 June in Ikarut valley and on 9 July at Kame Terrace estuary.

Red Fox - One at Gooseneck Steadies on 21 and 22 June.

Caribou - Present along Harlequin Brook throughout season in groups of 2-70. Mass movement of 1200 to Ikarut estuary flats on 14 July. Also 600 on flats on 17 July; 880 (mostly females with calves) on flats plus 500 above Saddle Brook on 23 July. On 19 July, 85 females with calves were moving north past Gooseneck Steadies, plus 4 large males were foraging on tall willows on Gooseneck islands. One large stag was standing belly deep in the water avoiding the flies at Gooseneck Steadies on 4 August.

Sightings on other rivers included: 150 on Primo River on 4 July; 150 with small calves on Primogenitor River on 5 July; 500 on Caribou Flats on 7 July; 32 at Kame Terrace estuary on 9 July; 90 with small calves on Kame Terrace River on 10 July; and 445 at Golden Eagle Flats on 11 July.

Ringed Seal - Frequent on the ice in June: 25 scattered over ice in fiord on 8 June; 40+ on ice on 10 June; 100 on ice off Hebron on 27 June. Small numbers (1-3) seen regularly in fiord in July.

Appendix iv (Cont'd.)

Birds

Common Loon - One pair frequently sighted, heard calling, and suspected nesting on lakes north of Gooseneck Steadies. One to four also seen at estuary and flying inland. Also sighted on Primo Lake (2 diving on 4 July), at Primo River estuary (2 on 7 July), off Caribou estuary (1 on 9 July), off Kame Terrace estuary (2 on 9 July), in Winnie Bay (2 on 25 July), in Becca Bay (1 on 27 July), and on Barren Lake (1 on 28 July).

Red-throated Loon - One flying and calling on 8 and 9 June, and 2 adults and 1 immature flying at Primo River estuary on 4 July.

Canada Goose - Flock of 35 on estuarine flats on 8 June, flocks of 6-16 common there throughout June, and 2 birds sighted there on 16 and 17 July. Five present at Inukshuk on 16 June, 5-7 present at Gooseneck Steadies on 16, 19, 20, and 21 June, and 8 at Gooseneck on 19 July. Adult on nest with 1 egg on islet above Gooseneck Steadies, plus second adult nearby, and 37 at Canada Lake on 21 June. Fourteen (2 probably sitting on nests) at North Creek Lakes on 22 June.

Other records include: 7 south of Eider Island on 26 June; 5 at Hebron on 27 June; 2 suspected nesting at Primo Lake, 2 adults with 6 small ducklings just above Caribou estuary and empty nest with hatched eggshells on Caribou Flats on 7 July; 34 at Winnie Bay and 10 on Winnie Lakes on 25 July; and one empty nest on Green River on 29 July.

Snow Goose (blue phase) - One at Gooseneck Steadies with 5 Canada Geese on 19 June.

Pintail - One pair at estuary on 8 June, and 1 pair at Primogenitor estuary on 4 July.

Green-winged Teal - One male on 9 and 10 June.

Greater Scaup - Nesting in Willows and Gooseneck Steadies. Female on a nest containing 9 eggs found under dense shrubs on island in Willows on 21 July. Female still on nest on 2 August, but nest was empty with no sign of eggshells on 4 August. Female with 7 small downy ducklings at Gooseneck on 5 August. Pair seen near J-Kûk on 9 and 18 June and 3 July, and pair diving at Gooseneck on 19-23 June. Single female diving at Gooseneck on 19 July and 4 August.

Also 3 males at Kame Terrace estuary on 9 July, and 1 female diving at Winnie Bay on 25 July.

Black Duck - Small numbers at most estuaries and inland on ponds and slow moving river sections. Maximum of 27 at Ikarut estuary on 10 June; also 20 on 26 June, 24 on 30 July, and 45 on 3 August. One pair at Gooseneck Steadies and 4 on Canada Lake on 21 June. One female with 7 ducklings at estuary on 17 July.

Appendix iv (Cont'd.)

Also 30 at Primo River estuary on 4 July, 1 on ponds near Primogenitor River on 5 July, 22 flying on Primo Lake, 5 on Primo River, 30 at Caribou Rattle, and 15 near Caribou River on 7 July, 5 at Kame Terrace estuary on 9 July, 1 female with 7 ducklings and 1 female with 1 duckling on small ponds on east side of Golden Eagle River on 12 July, 41 at Winnie Bay, 3 on Winnie Lakes, 2 at Hebron on 25 July, 16 at Becca Brook estuary on 27 July, and 18 at Barren Bay on 28 July.

Common Eider - Regular at Eider Island and in the outer fiord: 35 males and females at Eider Island on 8 and 9 June, 16 male and 5 female at Eider Island on 26 June, 30 flying in Hebron Fiord and 100 around outer fiord on 27 June, 14 males and 19 females at Eider Island on 4 July, 2 at Golden Eagle estuary on 11 July, and 1 male and 17 females east of Winnie Bay on 25 July.

Oldsquaw - Seen primarily off river estuaries: 20 at Ikarut estuary on 10 June; 1 pair flying off Hebron on 27 June; 2 females at Primogenitor estuary on 5 July; 1 male flying on Primo River on 7 July; 11 male and 1 female diving off Kame Terrace estuary on 9 July; and 21 flying off Golden Eagle River on 12 July.

Barrow's Goldeneye - One pair at mouth of Ikarut on 8 June, 54 moulting males, 1 in female plumage east of Kame Terrace estuary on 9 July, and ~16 mostly moulting males (6 males in nuptial plumage) with ~73 Common Goldeneye off Kame Terrace estuary on 10 July.

Common Goldeneye - Mixed flock of ~73 mostly moulting males (6 males in nuptial plumage) with ~16 Barrow's Goldeneye on Kame Terrace estuary on 10 July.

Red-breasted Merganser - Most common waterfowl species on all rivers explored. One or two pairs regularly flying up and down Harlequin Brook and feeding at J-Kûk, Inukshuk, and Gooseneck Steadies. Maxima of 8 on 21 June, 7 males and 3 females on 15 July, 5 males and 12 females on 16 July, and 8 males and 2 females on 17 July. One pair were feeding in the morning and only the male was present in the afternoon, suggesting commencement of incubation at Gooseneck Steadies on 20 June. Female on nest with 8 eggs found under dense shrubs on small, 2x5 m island on Green River on 29 July. Females with downy broods sighted on Harlequin Brook: female with 7 ducklings (Ia) near cabin on 2 August, female with 4 ducklings (Ia) and female with 7 ducklings near estuary on 3 August, female with 4 ducklings at J-Kûk on 6 August, near cabin on 7 August, and just above estuary on 9 August, and female with 3 ducklings (Ib) near estuary on 10 August.

At other rivers: 1 pair on small islet in Saddle Brook on 2 July; 1 female flying at Primogenitor estuary on 4 July and 2 males flying on Primogenitor River on 5 July; 1 pair flying on Primo Lake, 7 males and 5 females on Primo River, 26 (mostly males) at Caribou Rattle, and 1 male and 2 females at Caribou estuary on 7 July; 8 males and 2 females on Caribou River estuary

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and 152 (mostly males) near Kame Terrace estuary on 9 July; 1 female on Kame Terrace River; 20 males and 7 females at Kame Terrace estuary on 10 July; 45 (mostly males) at Golden Eagle estuary on 11 July; 1 male and 2 females on Golden Eagle River on 12 July; 3 males and 2 females at Winnie Bay on 25 July; 1 female on Winnie Brook on 26 July; 9 at Becca Brook estuary on 27 July; 5 at Barren Bay on 28 July; and 2 males and 3 females at Green Bay estuary 29 July.

Red-necked Phalarope - One pair on tiny ponds near cabin on 9, 10, 13, and 15 June and 1 male there on 3 July. One pair on pond east of Golden Eagle River on 12 July, and 1 on pond on south side of Saddle Brook on 23 July.

Common Snipe - One on 13 July.

Spotted Sandpiper - Nest with 4 eggs found at J-Kûk under willow shrub 5 m from brook on 3 July; nest still contained 4 eggs on 21 July. One bird seen periodically in area from 9 June to 11 August. One also on Primo River on 4 July.

Least Sandpiper - Scattered pairs suspected nesting in tundra vegetation adjacent to Harlequin Brook; 3 pairs above cabin on 9 June. Also sighted on Caribou flats (1 pair on 7 July), at Winnie Brook (1 on 26 July), Barren Brook (3 on 28 July), and Green Brook (4 on 29 July). Gathering at Ikarut estuary in mixed flock of 35 with White-rumped Sandpipers on 31 July.

White-rumped Sandpiper - One at Hebron on 25 July, and in mixed flock of 35 with Least Sandpipers on 31 July.

Semipalmated Plover - One to 4 present and suspected nesting at estuary and at Canada Lake through June, July and August. One pair (suspect defending ducklings) on Caribou Flats on 7 July, 1 pair with 2 downy ducklings, 1 pair with 1 downy duckling, and 3 other pairs near suspected nest or ducklings along foreshore near Kame Terrace estuary on 9 July, 4+ at Winnie Bay and 3 at Hebron on 25 July, 1 performing injured wing display at Barren Brook on 28 July, and 3 at Green Bay on 29 July.

Semipalmated Sandpiper - One on 11 June.

Unidentified Peeps - Eight flying on 10 June.

Herring Gull - Isolated pairs nesting at North Creek Lakes north of Harlequin Brook (1 adult sitting on nest on small grassy islet on 22 June), and on Caribou Flats (1 pair near empty nest on 7 July). Maxima sighted along Harlequin Brook were: 7 on 9 June and 2 adults and 10 immatures on 30 June. One adult foraged and roosted near the estuary from 31 July to 13 August.

Other sightings include: 8 at Eider Island on 26 June, 10 adults and 41 immatures at Kame Terrace estuary on 9 July, 2 adults on Winnie Lakes on 25 July, 1 at Becca Brook estuary on 27 July, 1 adult at Barren Bay on 28 July, and 2 adults at Green Bay on 29 July.

Appendix iv (Cont'd.)

Great Black-backed Gull - Isolated pairs nesting on Caribou Flats (1 pair at nest with 2 eggs, 1 starting to pip, plus 1 cold egg outside of nest on 7 July), and at Kame Terrace estuary (1 broken egg found on beach; 5 adults and 1 immature in area on 9 July). Also 1 pair at Hebron on Dog Islands on 27 June, and 16 on Eider Island on 26 June. One or two adults frequently and 1 immature occasionally seen at Ikarut estuary from 10 June to 13 August. Other sightings include: 7 adults at Primo River estuary on 4 July; 2 adults at Primo River estuary on 7 July; 1 adult on Caribou River estuary 9 July; 2 adults at Winnie Bay on 25 July; 4 adults and 3 immatures at Becca Brook estuary on 27 July; 1 adult at Barren Bay on 28 July; and 1 adult at Green Bay on 29 July.

Glaucous Gull - One at Kame Terrace estuary on 9 July, 1 on Winnie Brook estuary on 26 July, and 2 at Becca Brook estuary on 27 July, all second year birds.

Black Guillemot - Abundant off and north of Hebron and small numbers seen in the outer fiord: 120 scattered through ice off Hebron, 30 around Kingitoarsuk Island on 27 June; 22 off Hebron on 25 July; 5 off Becca Bay on 28 July; 4 off Barren Bay on 29 July; and 2 seen 1 km off Ikarut estuary on 30 July.

Golden Eagle - Eyrie at Golden Eagle estuary (adult carrying prey to nest on 12 July, suspect 2 young in nest, 2 adults present). Two adults soaring south of Eider Island on 26 June and over Caribou River on 8 July.

Peregrine Falcon - One male and 1 female frequently flying around Harlequin Brook from estuary to Gooseneck Steadies. One diving at Common Raven above cliffs east of Gooseneck Steadies (possible eyrie?) on 22 June. One stooping on Red-breasted Merganser at J-Kûk on 17 July. One female at Primogenitor estuary on 4 July, 1 male at Caribou estuary on 7 July, 1 female on Caribou River 8 July, male and female chasing at Kame Terrace estuary on 9 July (suspect eyrie on cliffs across fiord), and 1 chasing Golden Eagle at Golden Eagle estuary on 12 July.

Gyrfalcon - Nesting in Gyrfalcon Gorge: adult at nest on 25 June with at least 3 ducklings, light phase, 1 about 2/3 adult size, others downy, possible 4th duckling is dark phase; adult with fledged young at Gyrfalcon Gorge, and white-phase adult chasing Ptarmigan at J-Kûk and perched on hill beside brook with second dark-phase bird (presumably a fledgling) on 18 July; white-phase adult circling and stooping on 2 female Harlequin Ducks at J-Kûk on 2 August; and 1 light and 1 brown phase on tidal flats on 10 August.

Rough-legged Hawk - One flying over Harlequin Brook on 9, 13 and 18 June, and 1 soaring on Caribou River on 8 July.

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Willow Ptarmigan - Common and nesting along most rivers explored: nest with 2 eggs on Ikarut River on 9 June; pair with newly hatched young on Primogenitor River on 5 July; pair with 3 small ducklings on Caribou River on 8 July; female with 5 fledglings at J-Kûk on 16 July; female with 3 fledglings at cabin on 18 July; female with 4 downy young and empty nest with 5 eggshells under shrub on island in Willows on 21 July; adult with 6 half grown young at Green River on 29 July; female with 3 fledglings below cabin on 4 August; female with 2 ducklings at J-Kûk on 6 August; and female with 1 duckling at cabin on 12 August.

Rock Ptarmigan - Two males on ridge above Caribou river on 8 July.

Common Raven - One to 3 frequently flying around Harlequin Brook: 1 chased by Peregrine Falcon at Gooseneck Steadies on 22 June, and 1 feeding on caribou carcass at Inukshuk on 4 August. Also 1 flying at Primogenitor estuary on 4 July.

Northern Shrike - Two on 13 August.

American Robin - One pair nesting on cabin: nest contained 3 eggs on 13 June. One or 2 birds present at Gooseneck Steadies through the summer. Also seen on Saddle Brook on 2 July (2), on Golden Eagle River on 12 July (1), and on Winnie Brook on 25 July (1).

Gray-cheeked Thrush - Two singing at Primogenitor estuary on 4 July, and 1 at cabin on 14 July.

Water Pipit - Common in most areas explored: nest with 4 eggs found in grass bowl inside of hummock at Gooseneck Steadies on 17 June; fledglings at Gooseneck on 18 July; and adults feeding young at Inukshuk on 22 July.

Horned Lark - Encountered periodically throughout June and July. One carrying insects at Barren Brook on 28 July.

Wilson's Warbler - One male first seen and heard singing on 30 June. Also seen at Primogenitor estuary (3 males singing on 4 July), at Kame Terrace estuary (1 on 9 July), and at Golden Eagle estuary (1 on 11 July).

Blackpoll Warbler - First seen on 4 July at Primogenitor estuary (2 males singing). One male on Harlequin Brook on 14 and 21 July.

Tree Sparrow - Common along major rivers: fledglings at Gooseneck Steadies on 18 July; nest with 2 eggs at Willows on 21 July (nest lined with Ptarmigan feathers).

White-crowned Sparrow - Abundant and nesting in all areas explored: 2 nests with 5 eggs each on Saddle Brook on 2 July; nest with 5 young just hatched on Primogenitor River on 5 July; nest with 4 young just feathering at Inukshuk on 22 July.

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White-throated Sparrow - Two singing at Primogenitor estuary on 4 July.

Savannah Sparrow - One or two regularly sighted in June and July; fledglings at Gooseneck Steadies on 18 July.

Fox Sparrow - Two on 11 June, and 1 singing at Primogenitor estuary on 4 July.

Common Redpoll - Frequently heard calling and groups of 1-3 seen flying through June and July along Harlequin Brook, e.g., 1 male at cabin on 9 June, 3 at Inukshuk on 16 July, 2 at Gooseneck on 20 July. Also recorded on Saddle Brook (4 on 2 July), at Primogenitor estuary (3 males 1 female on 4 July), and on Winnie Brook (1 female on 25 July).

Lapland Longspur - Seen occasionally and presumed nesting: 1 pair on Ikarut River on 9 June; 1 pair carrying feather at Inukshuk on 16 June; 3 at Canada Lake on 21 June; and 1 male on Saddle Brook on 23 July.

Snow Bunting - One male on ridge above Caribou River on 8 July.
