Harlequin Duck Inventory of the Upper Skagit River Watershed

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i. EXECUTIVE SUMMARY

In 2000, with funding from the Skagit Environmental Endowment Commission, we conducted an inventory of harlequin ducks in the upper Skagit River watershed. The study area was located in south-west British Columbia above the Ross Lake reservoir and included portions of the Skagit Valley and EC Manning Provincial Parks. This system was known to support harlequin ducks, however the extent of use of the watershed, the population and productivity were unknown. This information is necessary in order to propose methods of management and conservation compatible with current and future land use.

Our objectives were to estimate the population of breeding pairs and production, identify important areas for breeding, link the population to the marine zone, and develop recommendations for accommodating harlequin duck conservation and land use. To accomplish these objectives we used a combination of pair and brood surveys, mark-resight techniques, and collection and description of habitat data.

From the combination of these methods we were able to establish that harlequin ducks occupied specific reaches throughout the system including most reaches in the Skagit River and the mid-reach of the Sumalla River. We suspect that all activities associated with breeding (mating, nesting and brood rearing) are conducted on these reaches. Additionally from observations of previously marked ducks, we were able to establish a linkage between the marine environment of the Puget Sound and the upper Skagit River watershed. We estimated a minimum of 20pairs in the system which produced a minimum of 7 broods including 24 ducklings, 20 of which we anticipated to fledge. The productivity of 35% of hens producing broods compares well with estimates from other inventories in the Pacific Northwest.

Additionally with the use of logistic regression analysis of the habitat data collected we developed a model for predicting the presence of breeding harlequin ducks in the system. We found that a combination of stream wet-width, gradient and invertebrate abundance was 85.7% accurate in predicting the presence or absence of harlequin ducks on a reach. This information could be used to develop a GIS based model to assist the regional inventory of harlequin duck breeding streams.

We noted some potential conflicts with recreational use, considering anticipated increases in some activities in the future. We recommended monitoring and educational programs be developed to proactively address these conservation concerns. Additionally we recommended taking advantage of the wildlife viewing opportunities of harlequin ducks by providing a controlled area and involving the public in future wildlife management directed programs.

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1.0 INTRODUCTION

The harlequin duck (*Histrionicus histrionicus*) is an important species in the Pacific Northwest, occupying a riverine habitat niche distinct from other waterfowl. The harlequin duck nests along fast flowing mountainous streams, and returns to the marine environment, where populations winter throughout the Georgia Straight and Puget Sound. The small Eastern North America population is currently listed as *endangered* in eastern Canada (COSEWIC 1990), and *threatened* in the state of Maine. In the Pacific Northwest, the status of the population is unknown, however recent evidence suggests a decline (Robertson and Goudie 1999, Cassirer *et al.* 1993), causing concern for its conservation.

The United States Forest Service has classified the harlequin duck as a sensitive species in Regions I (Northern Rocky Mountains) and IV (Pacific Northwest) and the states of Idaho, Montana and Oregon have designated the harlequin duck as a species of special concern while Washington has identified the harlequin duck as a priority habitat species (Cassirer *et al.* 1993). In British Columbia, the harlequin duck is considered a species at risk with a S4/YCMG listing (Anon. 1995) meaning:

- S4 - conservation concerns by the provincial Conservation Data Centre;
- Y - yellow list
- C - conservation species as listed by CDC;
- M - managed for hunting[1];
- G - global responsibility, i.e., > 20% of the species spend all or part of the year in B.C.

In 1996, the harlequin duck was added to the Yellow "A" list of endangered and threatened species in Alberta (Anon. 1996), meaning:

"sensitive species that are not currently believed to be at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to human-related changes to the environment."

Some of the impacts that may be contributing to the decline include habitat alterations from forest and hydro-electrical developments, increased recreation activities such as river rafting, incidental harvest or changing conditions in the marine environment. While much work has been conducted with the species in the marine environment, little has been conducted on the nesting habitats in British Columbia. A few inventories have been completed Freeman and Goudie (1998) inventoried the Nahatlatch Drainage while Wright (1998), and Wright and Goudie (2000) investigated the Bridge River. The Skagit River was known to support harlequin ducks, however the extent of use of the Skagit watershed, the population and productivity were unknown. This information is necessary in order to propose methods of management and conservation of the population in the

[1] The Canadian Wildlife Service is gathering public input into changing harvest limits for sea ducks, including Harlequin Ducks.

Skagit River watershed to ensure sustainable resource use especially related to human recreation and development.

1.1 Objectives

In 2000, we conducted a pilot project in the upper Skagit River Watershed to identify the importance of this area for harlequin ducks. The specific objectives of the project were to:

- Estimate the population of breeding pairs in the upper Skagit River watershed.
- Identify important areas for pair staging, nesting and brood rearing and link the population to the marine zone (via ongoing coastal monitoring programs utilising ducks individually marked).
- Estimate production.
- Develop recommendations for accommodating harlequin duck conservation with land use in the upper Skagit Watershed, including forest, hydro-electrical and recreation uses.

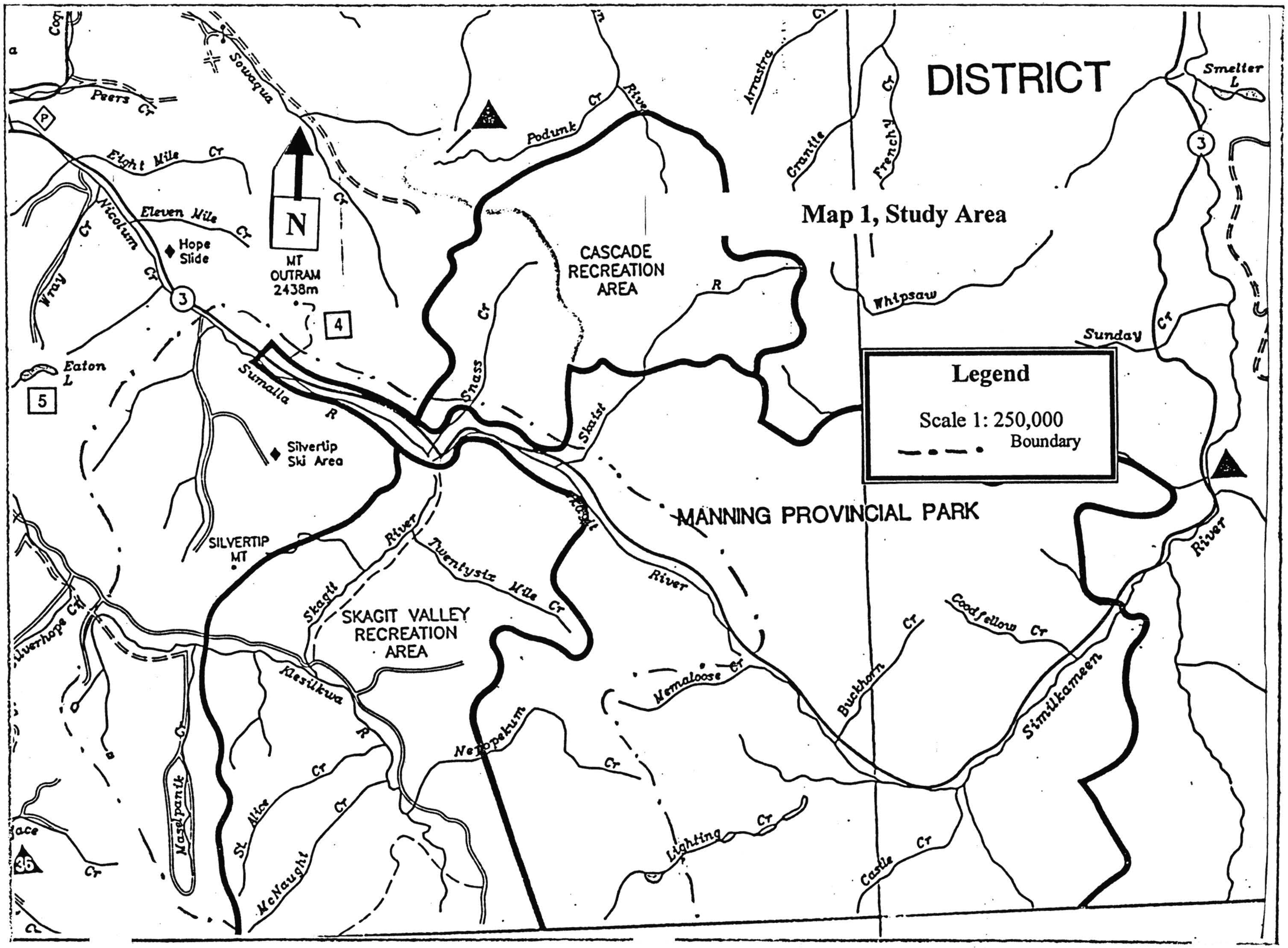
2.0 STUDY AREA

We focused the investigation within the upper Skagit Watershed (Map 1). This area was represented by the portion of the drainage within Canada, above the Ross Lake Reservoir. It included larger tributaries such as the Klesilkwa River, Sumalla River, Galene and Nepopekum Creeks. This area was predominantly crown land, and includes portions of EC Manning Provincial Park and the Skagit Valley Provincial Park. While the majority of the study area remains forested, the area is heavily used for a variety of recreational activities both inside and outside the parks. Forest development continues outside the Provincial Park boundaries and the water levels of the Ross Lake and the reach of the Skagit River immediately upstream from the reservoir are influenced by the Skagit hydro-electrical project.

The study area lies within the Cascade Mountain Range and is ecologically classified as the Coast and Mountains Pacific Ecoprovince, Cascade Ranges Ecoregion and the Eastern Pacific Ranges Ecosection (Luttmerding *et al.* 1990). The elevation ranges from 480 to 2,180m and is represented by the Coastal Western Hemlock, Mountain Hemlock, Engelmann Spruce-Subalpine Fir and Alpine Tundra biogeoclimatic zones (Meidinger and Pojar 1991). The generalised geology of the area is represented by a combination of intrusive igneous rock and folded and faulted volcanic and sedimentary rock (Valentine *et al.* 1981). Streams are generally, clear, cold and fast flowing with coarse substrate, typical of coastal influence and geology of the mountainous Pacific Northwest.

This area has had substantial land use in the past, including mining, forestry, urban development, transportation and recreational development. Earlier in the last century, the Silver Daisy silver mine operated near the confluence of the Sumalla and Skagit Rivers. Impacts on the Skagit River proximate to its operations are still apparent on the river itself. The lower reaches of the upper Skagit River watershed were heavily developed for timber values early in the last century. Much of the riparian forest had been logged but has since regenerated to a young conifer or thick deciduous forest. Forest development continues in areas outside the Manning and Skagit Valley Provincial Parks. The Sunshine Valley resort development was established at the mid-reach of the Sumalla River. This development included houses and cottages, many directly on the bank of the Sumalla River. The community of Sunshine Valley currently is occupied by about 50 to 100 people, as full time or seasonal residents. The Hope-Princeton Highway (Highway 3), a main transportation corridor, parallels the lower Sumalla and upper Skagit river for nearly 30 km of their length. This corridor is heavily used and crosses rivers or parallels their banks in a number of locations.

As the study area is close to the heavily populated Lower Mainland of British Columbia, the parks receive a high level of use, currently estimated at 65,000 user days in the Skagit Valley (MoELP 1997). Activities include fishing (catch and release from 1 July to 31 October), hunting (Skagit Valley Provincial Park), hiking, backpacking, horseback riding, camping, and day use. Use is generally low prior to June, but increases dramatically during the summer months. This is exemplified by the parks use data which shows use of campgrounds and day-use areas in 1999 as 508 and 173 parties respectively in May, versus 2,556 and 2,022 parties in July.



Map 1, Study Area

3.0 METHODS

To accomplish the objectives we used a combination of:

i. pair and brood surveys,
ii. capturing, marking and resighting of individuals,
iii. population estimation by mark-resight methods, and
iv. collection and description of habitat data.

Methods adhered to terms of reference in parks use research permits LM0010260, OK0010176, and OK0010178 issued by the parks branch of British Columbia Ministry of Environment, Lands and Parks, and the scientific permit to capture and band migratory birds, permit number 10201 BK, issued by Environment Canada.

Harlequin ducks were captured by mist net from mid-April until early May. We curtailed banding after 10 May when pair bonds were dissolving, and we had concerns with handling egg-laden hens. Each unbanded duck captured was banded with a black, individually encoded plastic leg band and a standard stainless steel leg band. Coding of leg bands was consistent with the markings used to identify other western North American populations, and has been approved by the International Harlequin Working Group. We used the encoded white "S" series in the alphanumeric code to identify Skagit ducks. Appendix I includes photographs of the mist net and bands used.

Coding of individual ducks had a number of benefits including:

i. resights of marked birds were the basis for the mark/resight population estimate,
ii. resights of marked individuals allowed us to assess the chronology of breeding
iii. resights of marked individuals linked these ducks to specific reaches of the watershed, and
iv. resights of marked individuals Harlequin Ducks nesting on the Skagit River to associated marine moulting and wintering area in the Puget Sound, Washington State or Strait of Georgia, British Columbia.

3.1 Pair Surveys

We conducted pair surveys between 17 April and 13 May 2000. Initially the study area was divided into 11 habitat units or reaches. One reach was further subdivided after observing summer flow conditions for a final sample of 12 reaches. The reaches reflected differences in the stream habitat as applicable to harlequin ducks. Due to the size of the study area, after an initial survey of all 12 reaches, we selected the reaches (n=8) which had harlequin ducks and those we believed had a likelihood of being used by harlequin ducks based on their stream characteristics or adjacency to reaches with ducks. Reaches selected were then surveyed on a weekly basis for a minimum of three replicates until pair bonds dissolved. We conducted surveys by walking or with a combination of walking and vehicle surveys along the stream bank on a route established early in the project. When possible surveys were conducted in an upstream direction.
Binoculars and 20-60X zoom spotting scopes were used to identify the band status of the ducks. Surveyors wore soft (e.g. wool or cotton) drab or camouflaged coloured clothing to enhance stealth while surveying. Surveyors recorded harlequin ducks in one direction

along the stream (observations on the return where recorded as incidental), and on occasion when survey routes were split between surveyors, surveyors started at the same location mid-reach and surveyed in opposite directions to prevent double counting of ducks. The distance of each survey and duck observations were plotted on 1: 20,000 TRIM maps (British Columbia MoELP) for future habitat measurements and to calculate duck density for the reach. Additionally, these data are available for future GIS input. Appendix II is an example of the survey data sheets.

3.2 Brood Surveys

We conducted brood surveys biweekly from 9 July to 11 August 2000. Surveys were undertaken along established routes in a similar fashion to pair surveys. We emphasised coverage along reaches where we had focused the pair surveys, however all reaches surveyed in the spring (with the exception of the gentle sloped, vegetation overgrown and meandering upper Klesilkwa Creek [K2] where we only conducted reconnaissance level surveys) were surveyed at least once for broods. When broods were observed, we categorised each to age class according to Gollop and Marshall (1954) as modified by Kuchel (1977). Hens were discriminated from ducklings in older broods by comparing the size and definition of the plumage of the cheek patch (hens had smaller, more sharply defined patches) and behaviour of the broods (hens usually led). As with pair surveys, locations of duck observations were plotted on 1:20,000 TRIM maps for calculations of densities and future GIS input.

3.3 Habitat Descriptions

Habitat data were collected during the pair and the brood surveys. Initially during pair surveys, these data were collected and analysed in conjunction with a small sample unit around the duck locations, or random locations in reaches without ducks. The parameters measured are identified in Table 1. Where applicable, habitat data were collected in adherence with Anonymous (1989). Appendix III is a template of the data sheet used.

After becoming more familiar with the study area and undertaking preliminary analysis of the data collected during the pair surveys, we increased the resolution of analysis to a river-reach level. This resolution better reflected the homogeneity of the habitat. During the brood surveys we collected habitat data from both reaches with harlequin ducks and those without. We collected a minimum of five samples for each of 10 reaches (five with pair and brood activity, and five without duck activity).

Reach SK5 of the upper Skagit River was further subdivided, resulting in analyses of 11 reaches (no data were collected for K2) five with pair and brood activity and six without. Habitat data were collected throughout the brood survey period at random locations or sites associated with brood activity. Within reaches not used by ducks, an estimate of the time to complete the survey was made, and samples were collected at 5 intervals. That is, if the survey required 100 minutes to complete then samples was taken at 20, 40, 60, 80 and 100 minutes along the route. For reaches which had ducks present, a combination of data were taken including specific sites under broods and random samples.

Table 1. Habitat data collected during surveys for pairs and broods of harlequin ducks in the Skagit River watershed, April-August 2000.

Parameter	Method for pair survey	Method for brood survey
Elevation	From plotted observation on TRIM map	From plotted observation on TRIM map
Gradient	Clinometer	Clinometer
Riffle: Glide: Pool ratio	Estimated for reach	Estimated for reach
Stream habitat unit classification	riffle, pool, glide, cascade or other	riffle, pool, glide, cascade or other
Channel Form	Unconfined, Slightly confined, Confined or Entrenched	Unconfined, Slightly confined, Confined or Entrenched
Stream wetted width	Estimate width	Estimate and range finder
Stream bank width	Estimate width	Estimate and range finder
Mean depth	Estimate/measuring tape	Estimate/measuring tape
Maximum depth	Estimate/measuring tape	Estimate/measuring tape
Stream velocity	Timed floating object over a known distance	Timed floating object over a known distance
Flow	Calculated from a multiplication of velocity, mean depth, and wetted width	Calculated from a multiplication of velocity, mean depth, and wetted width
Substrate material	Estimate composition of boulder, cobble, gravel, fines	Estimate composition of boulder, cobble, gravel, fines
Riparian vegetation description	By seral stage for 5m distance intervals, right and left bank and general description	By seral stage for 5m distance intervals, right and left bank and general description
Nesting structure	Rated as High, Moderate, Low or None based on ability of riparian and in stream structure to conceal a nest	Rated as High, Moderate, Low or None based on ability of riparian and in stream structure to conceal a nest. Main structure noted i.e. vegetative cover or CWD
CWD (coarse woody debris)	Estimated number/50m length of stream	Estimated number/50m length of stream
Relative aquatic invertebrate abundance	Number of invertebrates under a sample of five cobbles	Number of invertebrates under a sample of five cobbles
Invertebrate taxonomy		From samples collected and identified with Thorp and Covich (1991)
Canopy Closure	Estimate % cover of stream	Estimate % cover of stream
Islands	Presence or absence and description	Presence or absence and description

3.4 Statistical Analysis

We used the Lincoln-Peterson index as modified by Chapman (1951) to derive population estimates based on the ratio of marked to unmarked birds in the samples. The population estimate is calculated following his revised mark-resighting fomula:

$$N \text{ (population estimate)} = \frac{(N_1 + 1)(N_2 + 1)}{(M_2 + 1)} - 1$$

where: N_1 = initial number of marked birds
N_2 = no of birds in subsequent sample ascertained as banded or not banded
M_2 = number of marked birds in the subsequent sample

$$\text{Variance } (S^2) = \frac{(N_1 + 1)(N_2 + 1)(N_1 - M_2)(N_2 - M_2)}{(M_2 + 1)^2 (M_2 + 2)}$$

We used stepwise multiple regression and logistic regressions to ascertain the relationship of river use (dependent variable) with habitat parameters (explanatory or independent variables) (Sokal and Rohlf 1995). Habitat data were not pooled for pair and brood surveys as a number of variables changed with the season including wet width, depth of the stream, and invertebrate abundance. All analysis was completed with the use of the program STATISTIX (Analytical Software Inc., Tallahassee, Florida 1998)

4.0 RESULTS

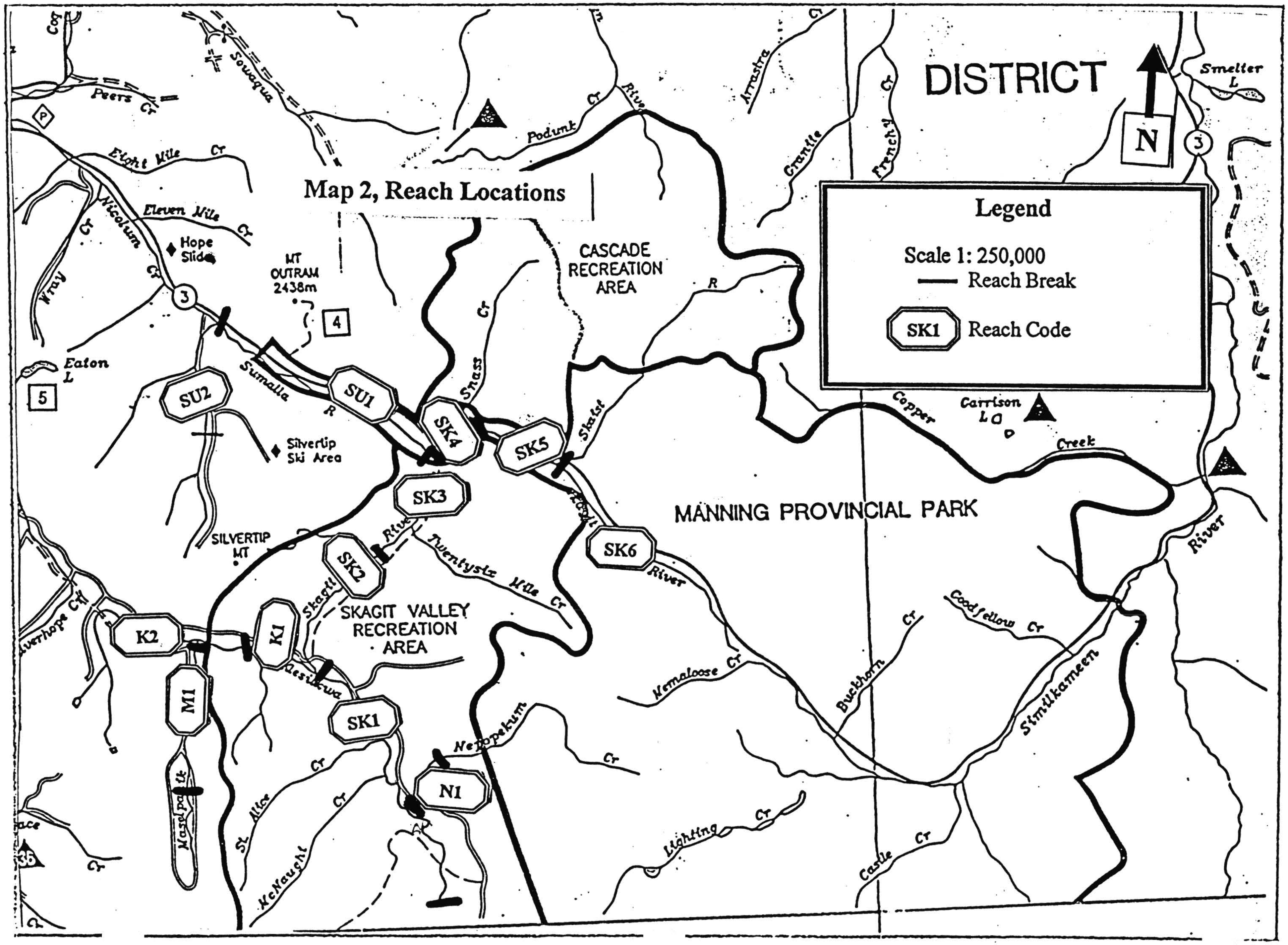
4.1 Pair Distribution and Population Estimate

We divided the watershed into 12 habitat units or reaches for identifying use and estimating population. Reaches were selected as having similar features, such as slope, flow, width etc. which may influence harlequin duck use. Confluence of streams or rivers, and/or marked changes in topology (channel characteristics) were used to identify reach breaks. The reaches are listed in Table 2 and illustrated by Map 2. Appendix IV provides pair locations at a larger scale.

Table 2, River reaches and observation of harlequin duck during pair surveys of the Skagit River watershed, April-May 2000.

Reach	Code	Length (km)	Surveys	No. of pairs/individuals observed[a]	Max observed density (pairs/km)[b]	Max observed density (HARD/km)[b]
Sumalla , lower	Su1	13.7	3	0/0	0	0
Sumalla, upper	Su2	7.4	6	3/9	0.41	1.22
Skagit, Lower	Sk1	15.9	4	2/5	0.22	0.56
Skagit, Klesilkwa to 26mile Creek	Sk2	7.9	3	4/10	0.51	1.27
Skagit 26mile creek to Sumalla	Sk3	6.3	5	6/16	0.95	2.54
Skagit, Rhododendron flats	Sk4	2.0	4	0/0	0	0
Skagit, upper to Skaist	Sk5	5.8	4	2/5	0.42	1.04
Skagit, upper[c]	Sk6	11.4	2	0/0	0	0
Nepopekum, lower	N1	3.4	2	0/0	0	0
Maselpanik, lower	M1	3.4	2	0/0	0	0
Klesilkwa, lower	K1	2.9	3	0/0	0	0
Klesilkwa, upper	K2	10.0	1	0/0	0	0
Average for reaches with HARD					0.50, sd=0.27	1.33, sd=0.73

[a] Maximum observed during 28 April to 4 May survey
[b] Not extrapolated, based on surveyed distance.
[c] Sk5 was further divided to Sk5 and Sk6 after pair surveys to reflect differences in stream discharge.

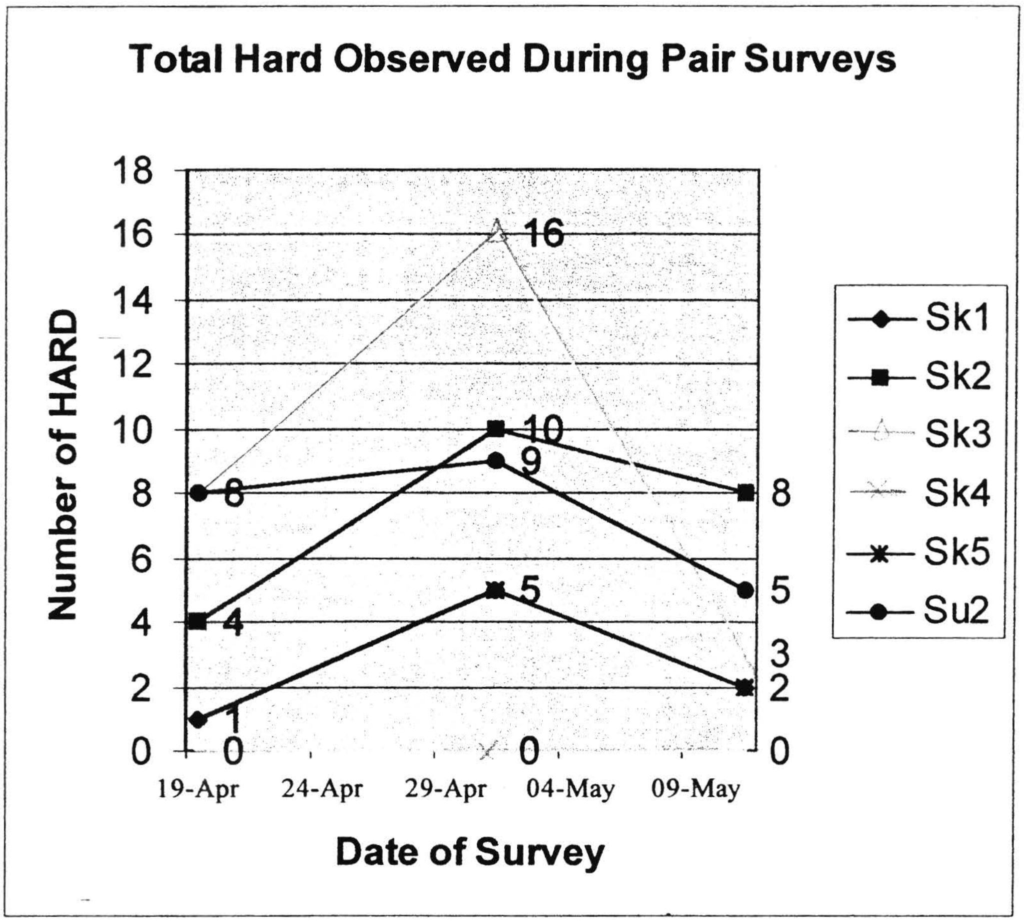


Map 2, Reach Locations

We conducted pair surveys along stream reaches identified between the17 April and 13 May 2000. The trends in the number of harlequin ducks observed were similar for each reach at similar times (Fig. 1). We returned to survey reach Su2, Sk3 and Sk5 on 30-31 May, and very few harlequin ducks were observed, consistent with the trend indicated by the earlier surveys. The observed pattern suggests a direct migration to the breeding reaches as opposed to a progressive migration upstream which would have been evidenced by an observed pulse of duck observations progressing from lower reaches to higher reaches with concurrent surveys.

The chronology of behaviour influenced our analyses of the data to achieve a population estimate. As there was little movement by ducks outside of identified reaches, sub-populations were associated with a particular reach. This philopatric behaviour challenges one of the assumptions required to successfully use mark-recapture techniques for population estimates; that the marked birds should be evenly distributed in the sample, and would require a marked population within each reach. We attempted to address this potential bias by surveying all reaches identified to have harlequin ducks, in other words, we attempted to achieve a sample of the entire population.

Figure 1, Harlequin duck observations for reach vs. survey period



4.2 Population Estimates

4.2.1 Mark-resight Estimate

We captured 12 harlequin ducks in the watershed (Table 3), and morphometrics were collected from marked ducks (Table 4). Additionally we observed two previously marked ducks in the study area, a male bearing yellow band 77, paired with an unbanded hen on reach Sk3 on 26 April 2000, and a hen bearing yellow band K8 paired with an unbanded male on reach Sk5 on 3 May 2000 (Table 5). The combination of the ducks we marked and those previously banded provides a total marked population of 14, distributed throughout the study area. This sample was the basis for our mark-resight population estimate.

Population estimation by mark-resighting is only possible after a sufficient sample of marked individuals has been achieved. Our marking efforts were incremental, and coincided with some of the maximum observed numbers of harlequin ducks. Therefore subsequent observations were biased low due to breeding phenology. These two factors affected our ability to generate an unbiased estimate of the population, and therefore, as described in section 4.2.2, we selected the sum of maximum numbers observed on individual reaches as a conservative population estimate for 2000. With the marked sample now released in the Skagit watershed, we anticipate being able to generate an accurate estimate of breeding numbers in future years because of the high rates of breeding philopatry demonstrated for this species (Robertson and Goudie 1999).

Table 3, Harlequin ducks captured in the upper Skagit River watershed, April-May 2000.

Band plastic Code	Band Metal	Sex	Age	Status	Capture date	Long	Lat	General Location
SB	1905-17851	M	ATY	single	22/04/00	121° 14.60'	49° 15.10'	Sumalla R. above Sunshine Village
SC	1905-17852	M	ATY	single	22/04/00	121° 14.60'	49° 15.10'	Sumalla R. above Sunshine Village
SE	1905-17853	M	ATY	single	22/04/00	121° 14.60'	49° 15.10'	Sumalla R. above Sunshine Village
SF	1905-17854	M	ATY	pr w SG	22/04/00	121° 14.60'	49° 15.10'	Sumalla R. above Sunshine Village
SG	1905-17855	F	ATY	pr w SF	22/04/00	121° 14.60'	49° 15.10'	Sumalla R. above Sunshine Village
SI	1905-17857	M	ATY	single	23/04/00	121° 14.0'	49° 16.34'	Sumalla R. above Sunshine Village
SH	1905-17856	F	ATY	pr w SJ	23/04/00	121° 14.0'	49° 16.34'	Sumalla R. above Sunshine Village
SJ	1905-17858	M	ATY	pr w SH	23/04/00	121° 14.0'	49° 16.34'	Sumalla R. above Sunshine Village
SK	1905-17859	F	ATY	pr w SL	27/04/00	121° 04.70'	49°12.50'	Sumalla/ Skagit Confluence
SL	1905-17860	M	ATY	pr w SK	27/04/00	121° 04.70'	49°12.50'	Sumalla/ Skagit Confluence
SN	1905-17861	M	ATY	single	07/05/00	121°01.30'	49° 12.90'	Upper Skagit R. near Hwy 3 bridges
SR	1905-17862	M	ATY	pr w ubF	09/05/00	121° 09.10'	49° 08.50'	Near confluence of Skagit R. and Silver-tipped Cr.

Table 4, Morphometrics of the harlequin ducks captured in the upper Skagit River watershed, April-May 2000.

Band plastic (white code on black)	Sex	Tarsus (mm)	Culmen Midline (mm)	Wing Chord (mm)	Weight (g)
SB	M	38.3	27.8	211	596
SC	M	38.7	27.4	205	605
SE	M	37.5	26.4	210	615
SF	M	38.4	27.1	201	600
SG	F	35.6	26.1	198	590
SI	M	37.4	28.2	202	640
SH	F	35	25.2	198	670
SJ	M	37.7	26.0	214	595
SK	F	37.5	25.1	190	655
SL	M	38.1	26.6	206	665
SN	M	37.9	28.8	212	640
SR	M	37.7	28.1	203	645

Table 5, Resights of previously banded harlequin ducks in the upper Skagit River watershed, April-May 2000.

Band plastic (black code on yellow)	Band Metal	Sex	Age	Status	Date	Long	Lat	General Location
K8	?	F	ATY	Paired with unbanded M	03/05/00	121° 01.30'	49° 12.90'	Upper Skagit River near Hwy 3 bridges
77	?	M	ATY	Paired with unbanded F	26/04/00	121°05.80'	49°10.75'	Upper Skagit River near 26 Mile Creek confluence
77	Worn[a]	M	ATY	Single	09/05/00	121° 09.10'	49° 08.50'	Near confluence of Skagit River and Silver-tipped Creek

[a] Yellow 77 was recaptured in a mist net, metal band was very worn and number was indecipherable.

4.2.2 Minimum Population Estimate

We used a coarse, but effective minimum population estimate from the maximum observed ducks during the surveys in combination with the unobserved marked ducks. We observed the maximum density during surveys conducted between the period 28 April to 4 May. The combined number of ducks observed during this survey replicate was 17 pair and 11 single males, of which the band status of 1 pair and 1 single male was undetermined. Additionally from the combination of our marked ducks and the yellow-banded ducks, an additional 4 pair and 3 single males were not observed during the surveys. When we combine the number of ducks with band status positively identified and the banded paired ducks that were not observed, the combination resulted in 20 pairs and 13 single males (53 ducks). When we extrapolated the density estimates for the entire system, to account for areas not surveyed within reaches, the population is estimated at 52 ducks, of which 19 are paired. The lower population estimate for the extrapolated density reflects the nearly complete coverage of the surveys and does not include the addition of banded ducks not observed. Table 6 summarises the survey results for reaches with harlequin ducks.

Table 6, Summary of survey results for reaches with harlequin ducks in the upper Skagit River watershed, April-May 2000

Date	Survey Type[a]	Survey Method[b]	Reach	Total Length	Surveyed Length.	No. Pairs	No. Males	No. Females	No. Black Bands	No. yellow Band	Total banded	Total not banded	Possibly banded	Comments
April 19	R	V	Sk1	15.9	6.4	0	1	0	0	0	0	0	0	
April 24	P	V	Sk1	15.9	9.6	2	0	0	0	0	0	0	0	
May 2	P	V	Sk1	15.9	9	2	1	0	0	0	0	2	0	
May 10	P	V	Sk1	15.9	10	1	0	0	0	0	0	0	0	
April 18	R	W	Sk2	7.9	7.9	0	4	0	0	0	0	4	0	
May 1	P	W	Sk2	7.9	7.9	4	2	0	0	0	0	1	0	
May 9	P	W	Sk2	7.9	7.9	3	2	0	0	0	0	0	1	
April 17	R	W	Sk3	6.3	3.1	4	0	0	0	0	0	0	1	
April 18	R	W	Sk3	6.3	3.2	3	0	0	0	0	0	0	0	
April 26	P	W	SK3	6.3	5	5	2	1	0	1	1	3	0	ye77 male
May 3	P	W	Sk3	6.3	6.3	6	4	0	0	0	0	0	3	
May 11	P	W	Sk3	6.3	6.3	0	3	0	0	0	0	2	0	
May 31	P	W	Sk3	6.3	6.3	0	0	2	0	0	0	1	0	
May 2	P	V	Sk5	5.8	5	2	1	0	0	0	0	1	0	
May 12	P	V	Sk5	5.8	5	1	0	0	0	0	0	0	0	
May 13	P	W	Sk5	5.8	2.7	1	0	0	0	0	0	0	0	
May 30	P	V	Sk5	5.8	2	0	0	0	0	0	0	0	0	
April 20	R	W	Su2	7.4	5.1	2	4	0	0	0	0	0	0	
April 22	R	W	Su2	7.4	4	0	4	0	0	0	0	0	0	
April 28	P	W	Su2	7.4	7.4	3	3	0	3	0	3	0	1	4@bkS?, bkSF, bkSG,
May 8	P	W	Su2	7.4	6.8	2	6	0	2	0	2	1	1	bkSF, bkSE
May 12	P	W	Su2	7.4	6.8	1	3	0	2	0	2	0	0	bkS?
May 13	P	W	Su2	7.4	6.8	1	2	0	1	0	1	0	0	bkSJ
May 30	P	W	Su2	7.4	5.2	1	3	0	1	0	1	0	0	bkSE, bkSB

[a] P is pair survey, R is reconnaissance
[b] V is vehicle based, W is walking

4.3 Brood Distribution and Productivity Estimate

The distribution of broods in the study area (Table 7) was similar to that of pairs in spring. The chronology of brood development (Fig. 2 and 3) was consistent with our interpretation of breeding phenology in spring. The average hatch date was 13 June 2000, using the median number of days of duckling development for each observed brood, and ranged from 27 May to 8 July 2000. Appendix V provide brood locations at a 1:20,000 scale.

4.3.1 Productivity

From the maximum broods observed during a single brood survey (6) in combination with a brood believed fledged or not observed, we estimated a minimum of 7 broods (25ducklings) produced to age class IIB or older. This included 1 brood of IIb (5 ducklings), 3 broods of age class III (10 ducklings), and 3 fledged broods (9 ducklings). Of the 24 ducklings, 20 of these were likely to survive to fledging considering age class survival rates calculated by Smith (2000).

Detectability of broods is likely less than that of pairs but more likely to be similar for older broods. On our final survey, we only detected banded black SK with a brood of 2 at age class III, and observed a brood only once in SK5, though from their location associated with pair activity, they had likely been present during all surveys. This suggested detectability may be as low as 1 in 3 (33%), and this could be influenced by observer experience, brood age, abundance of cover, riparian vegetation, stream width and time of day. Given these sources of error, when we consider our minimum pair estimate (20) and our minimum number of ducklings expected to fledge (20), productivity was approximately 1duckling/hen and 35% of hens successfully reared broods (7 broods for 20 hens).

Table 7, Survey reaches and harlequin duck densities observed during brood surveys of the Skagit River watershed June-August 2000.

Reach	Code	Length (km)	No. of Surveys	Max No. of broods [a]	Max density observed (broods/km) [a]	Max density observed (HARD/km)[b]
Sumalla , lower	Su1	13.7	3	0	0	0
Sumalla, upper	Su2	7.4	3	2	0.38	1.34
Skagit, Lower	Sk1	15.9	3	1	0.18	0.7
Skagit, Klesilkwa to 26mile Creek	Sk2	7.9	3	1	0.12	0.73
Skagit 26 mile creek to Sumalla	Sk3	6.3	3	1	0.14	1.11
Skagit, Rhododendron flats	Sk4	2.0	3	0	0	0
Skagit, upper to Skaist	Sk5	5.8	3	1	0.21	1.25
Skagit, upper	Sk6	11.4	3	0	0	0
Nepopekum, lower	N1	3.4	1	0	0	0
Maselpanik, lower	M1	3.4	1	0	0	0
Klesilkwa, lower	K1	2.9	3	0	0	0
Klesilkwa, upper	K2	10.0	0	0	N/A	N/A
Average for reaches with HARD					0.21, sd=0.10	1.03, sd=0.30

[a] Maximum densities for reaches were all observed on the surveys between 7 August and 11 August

[b] Density includes single hens and ducklings. With the exception of Sk3, maximum numbers observed were during survey 3 (7 –11 August 2000. Maximum observed on Sk3 was on the first survey (9-14 July 2000).

Figure 2, Duckling observations vs. survey period
The period of survey 1 was between 9-13 July, Survey 2 was 24-28 July, and Survey 3 was 7 – 11August.

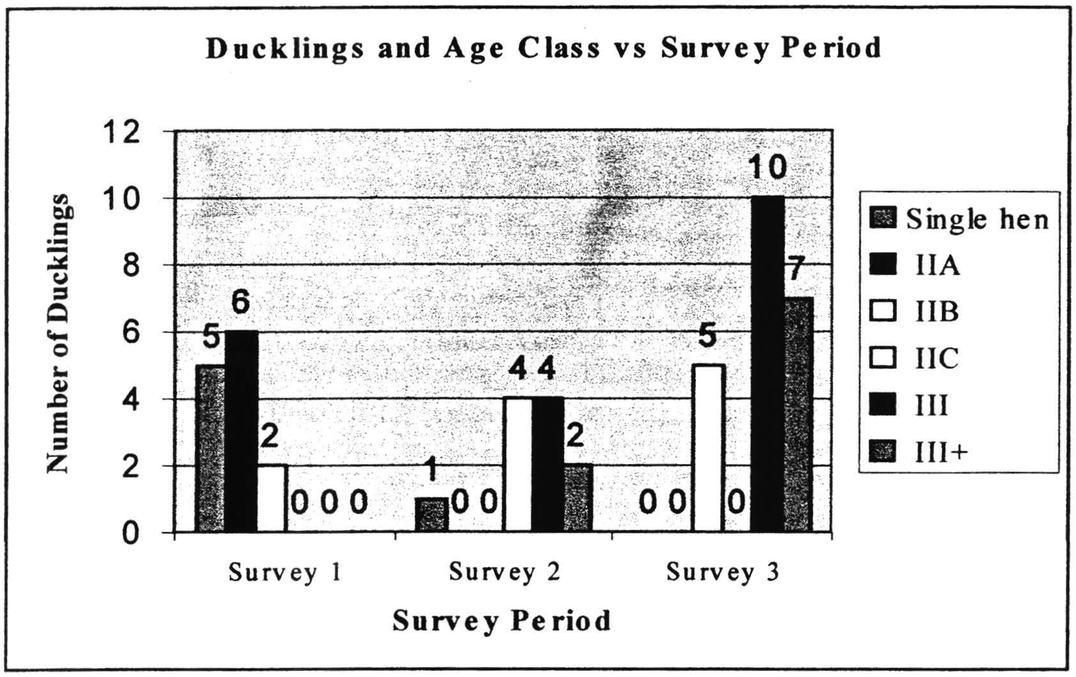
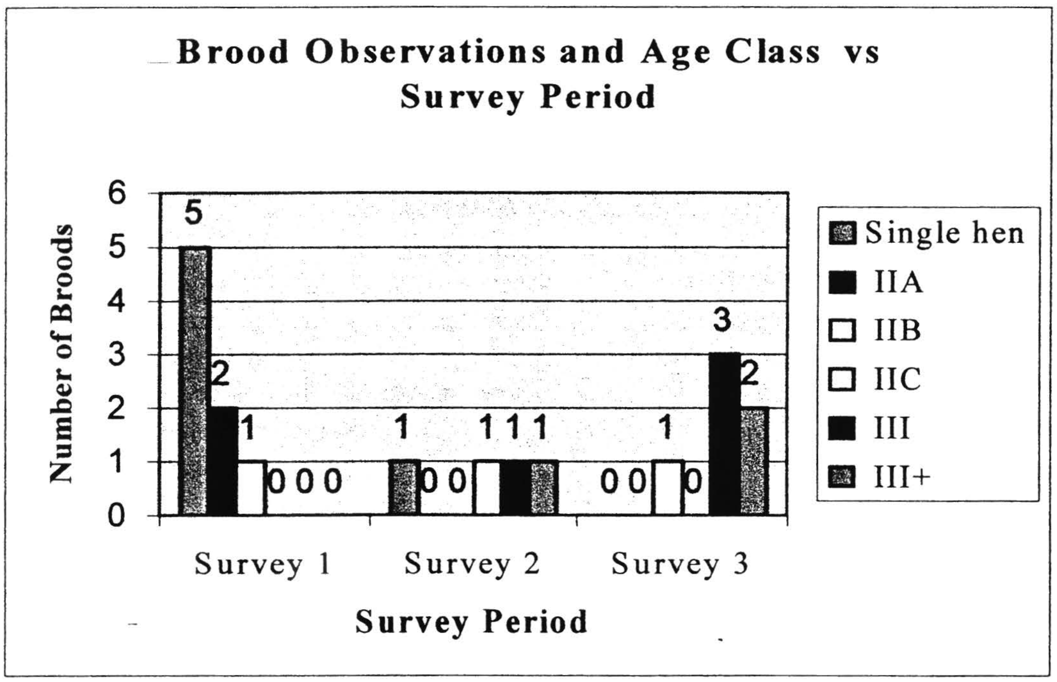


Figure 3, Brood observations vs. survey period
The period of survey 1 was between 9-13 July, Survey 2 was 24-28 July, and Survey 3 was 7 – 11August.



4.4 Habitat Descriptions

We observed pairs and broods of harlequin duck within nearly half of the river reaches that we surveyed. The habitat associated with reaches occupied by harlequin ducks was relatively homogeneous in channel form, but riparian habitat varied from residential development to old-growth conifer forest. We provide a summarised description of the habitat of surveyed reaches at summer flow conditions during the brood rearing period (Table 8). Aquatic benthic invertebrate communities where similar for all reaches. These communities were dominated by caddisflies (*Trichoptera*), stoneflies (*Plecoptera*), and Mayflies (*Ephemeroptera*).

We observed brood use of a man-made pond in the community of Sunshine Valley. Although brood rearing in ponds has been documented (Goudie and Jones 1999), we censored this observation from our analysis as it was the only occurrence of this type of habitat in the study area, thus the small sample limited our ability to assess for selection. Additionally the pond was considered a habitat unit, a sub-component of a reach that was the sampling unit used for analyses of the habitat data collected during the brood rearing period.

We performed stepwise multiple linear regression analyses of the habitat data initially collected during the pair survey period. We conducted this analysis to detect important habitat features and direct data collection during the brood survey period. This analysis indicated that a combination of average depth and wet width were predictors of harlequin duck presence on the stream (r^2=0.52, P=0.074, df=23). For this analysis we used the number of ducks observed as the dependant variable, and the independent variables were those data collected in the immediate area (approximately 50m of stream) in conjunction with the observations. These results were reflective of the homogeneity of the stream habitat within occupied reaches, as well as the greater linear use of habitat (i.e. banded ducks were resighted at distances up to 2.5 km between previous sightings).

We hypothesised that a combination of variables influenced the use of habitat by harlequin ducks, and considering the greater linear use of habitat, we broadened our resolution and used the reaches as our sample unit. We directed habitat data collection during the brood surveys accordingly. We incorporated logistic regression analysis of the data collected during brood surveys to allow for the consideration of a combination of nominal, rank and continuous variables, and our objective was predicting use versus non-use of reaches by harlequin ducks. We anticipate that the results from this analysis could be used as a basis for a model to predict presence and distribution of breeding harlequin ducks in other watersheds. Beginning with the initial set of variables displayed in Table 8, we found that the combination of Wet Width, Invertebrates per Cobble, and Gradient (slope) was 85.7% accurate in correctly predicting the presence or absence of harlequin ducks on a reach. This model was accurate at predicting presence of harlequin ducks 82.1% and the absence 89.3% of the time. Table 9 display the statistics for the logistic regression model.

We retained Gradient in the model, despite its relatively low contribution to the models' fit of the data, for a number of reasons, including: (a) the importance of this variable for defining the physical limits of harlequin breeding reaches, i.e. we did not observe ducks on reaches with slopes < 1% or greater than 7% (b) for its importance in influencing stream form (e.g. step-pool associated with steep beds vs. meandering glide associated with gentle gradient) and thus physical attributes of a reach, and (c) and its value for use in future GIS modelling. We are confident that the homogeneity of our study area influenced the value of this variable as an indicator for predicting harlequin use, and with sampling a greater range of channel forms, slope would be increasingly important in predicting harlequin use.

Riparian vegetation has also been identified as an important aspect of harlequin duck habitat (Robertson and Goudie 1999). We did not find this variable valuable in predicting use in our study area perhaps because there had been no development associated with the areas we surveyed for decades, and as such all riparian areas were well vegetated. Few examples of early seral stage vegetation, of sufficient size to be considered at the resolution of our analysis, were present in our investigations considering the time since development.

Applying the results of the logistic regression analysis and the calculated values of the important predictor variables (Table 8), we anticipate that, regionally, the majority of stream reaches with a wet width at summer flow greater than 10m, gradient between 1% and 7%, and invertebrate densities greater than 2 invertebrates/cobble could support breeding harlequin ducks. This is somewhat simplistic as we anticipate, but have not identified from our samples, an upper threshold in wetted width of rivers and streams for use by harlequin ducks.

Table 8, Habitat descriptions during brood rearing activity.
(Italicised reaches had harlequin ducks present during both pair and brood rearing periods)

Reach	N	Average Elevation (M)	HARD Observed	Ave. Pool%	Ave. Riffle%	Ave. Glide%	Habitat Unit Sampled Most	Ave. Length (M) HU	Ave. Gradient (slope %)	Ave. Bank Width (M)
K1	5	539	No	12.6	61.0	26.4	Riffle/glide	50+	2.1	20.0
M1	5	602	No	5.0	79.0	14.0	Cascade	45	7.8	15.8
N1	5	519	No	3.9	72.8	23.3	Riffle	42	3.0	19.6
Sk1	*5*	*501*	*Yes*	*15.0*	*45.6*	*39.4*	*Riffle/glide*	*75*	*1.3*	*54.2*
Sk2	*6*	*564*	*Yes*	*9.6*	*75.8*	*14.6*	*Riffle*	*60*	*1.8*	*41.8*
Sk3	*7*	*608*	*Yes*	*7.0*	*85.7*	*7.3*	*Riffle*	*79*	*1.9*	*28.9*
Sk4	5	636	No	14.0	57.0	27.0	Riffle	60	1.8	23.0
Sk5	*5*	*768*	*Yes*	*11.0*	*72.0*	*17.0*	*Riffle*	*40*	*2.8*	*18.9*
Sk6	3	937	No	8.3	83.3	8.3	Riffle	50	2.7	11.0
Su1	5	643	No	5.0	45.0	50.0	Riffle	36	0.7	11.9
Su2	*6*	*758*	*Yes*	*5.8*	*85.8*	*8.3*	*Riffle*	*95*	*2.8*	*18.4*

Reach	Ave. Wet Width (M)	Ave. Velocity (M/Sec)	Ave. Maximum Depth (cm)	Ave. depth (cm)	Channel type	Ave. Boulder (%)	Ave. Cobble (%)	Ave. Gravel (%)	Ave. Fine (%)
K1	17.7	1.6	93	40	slightly confined	29.6	61.4	6.0	3.2
M1	8.6	2 est	78	38	slightly confined	54.0	24.8	14.2	4.2
N1	9.0	1.6	43	24	slightly confined	22.4	58.4	15.6	4.4
Sk1	*43.6*	*1.5*	*155*	*66*	*Unconfined*	*10.0*	*32.0*	*44.6*	*14.2*
Sk2	*28.2*	*1.3*	*105*	*43*	*Unconfined*	*5.5*	*47.5*	*31.7*	*15.3*
Sk3	*27.3*	*1.5*	*81*	*49*	*slightly confined*	*19.3*	*53.6*	*22.6*	*6.0*
Sk4	12.2	1.2	44	25	Unconfined	28.0	55.4	13.5	4.1
Sk5	*11.6*	*1.4*	*61*	*26*	*slightly confined*	*11.4*	*52.4*	*28.4*	*8.8*
Sk6	10.1	1.0	28	22	slightly confined	31.7	48.3	36.3	3.7
Su1	11.0	0.8	108	55	Unconfined	14.0	20.0	47.0	19.0
Su2	*14.6*	*1.7*	*64*	*40*	*slightly confined*	*36.3*	*39.5*	*16.7*	*4.5*

Reach	Riparian Vegetation Right (most common)	Riparian Vegetation Left (most common)	Ave. Canopy Closure %	Islands present	Ave. CWD/ 50m	Ave. nesting structure	Ave. number of inverts/ cobble	Range invertebrate length (mm)
K1	Mature conifer	Mature conifer	10.0	No	6.8	Low	0.64	1.0-25.0
M1	Young conifer	Mature conifer/ Deciduous	34.0	Yes	19.4	Good	1.12	1.0-40.0
N1	Mature conifer	Mature conifer	10.5	Yes	26.2	Moderate	4.04	1.0-30.0
Sk1	*Young Conifer/ Deciduous*	*Mix*	*0.4*	*Yes*	*19.4*	*Good*	*3.75*	*1.0-45.0*
Sk2	*Mix*	*Mature conifer*	*2.5*	*Yes*	*18.3*	*Good*	*5.10*	*1.0-25.0*
Sk3	*Mature conifer*	*Mature conifer*	*8.0*	*Yes*	*11.7*	*Moderate*	*4.70*	*1.0-40.0*
Sk4	Mature conifer	Mix	3.8	Yes	19.0	Moderate	4.90	1.0-35.0
Sk5	*Mix*	*Mature conifer*	*4.3*	*No*	*12.8*	*Moderate*	*5.60*	*1.0-35.0*
Sk6	Other	Mature conifer	10.3	No	4.7	Moderate	4.10	1.0-35.0
Su1	Shrub	Mix	9.2	No	1.8	Moderate	1.96	1.0-30.0
Su2	*Mix*	*Mix*	*12.7*	*Yes*	*2.0*	*Moderate*	*3.80*	*1.0-30.0*

Table 9, Logistic regression results for the model

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	COEF/SE	P
CONSTANT	-7.45633	2.18337	-3.42	0.0006
INVERTS	0.63294	0.22117	2.86	0.0042
GRADIENT	0.25431	0.18117	1.40	0.1604
WETWIDTH	0.28552	0.08430	3.39	0.0007

DEVIANCE	39.95
P-VALUE[a]	0.8890
DEGREES OF FREEDOM	52

HOSMER-LEMESHOW GOODNESS OF FIT TESTS FOR HARDPRES

HOSMER-LEMESHOW STATISTIC (C)	4.39
P-VALUE[a]	0.8204
DEGREES OF FREEDOM	8

CLASSIFICATION TABLE FOR HARDPRES

	PREDICTIONS		
ACTUAL	0	1	TOTAL
0	25	3	28
1	5	23	28
TOTAL	30	26	56

Proportion of category 0 correctly classified	0.893
Proportion of category 1 correctly classified	0.821
Overall proportion correctly classified	0.857

[a] Note that the high P-value indicates a good fit

4.5 Linkage with Marine Habitat

From observations of previously banded ducks we were able to link harlequin ducks breeding in the upper Skagit River to Puget Sound of Washington State. Yellow band 77 and K8 were both banded in a moult drive in 1995 at Fort Flagler near Port Townsend, Washington (Greg Schirato, Washington F and W, pers. Comm.).

Additionally, in the upper Silverhope Creek (in a watershed adjacent to the study area but part of the Fraser River Basin) white band N32 was observed on 18 April at N 49° 15'10", W 121° 23' 31". This duck was banded at Lilly Point, south of Point Roberts in the Georgia Strait.

5.0 DISCUSSION AND RECOMMENDATIONS

The upper Skagit River watershed is an important area for the breeding and production of harlequin ducks. Concentrations of harlequin ducks within the watershed are associated with specific reaches in the system and we suspect that all activities associated with breeding (mating, nesting and brood rearing) were confined to these reaches.

Our population estimate suggested this system is important for its contribution to the population moulting and wintering in Puget Sound, Washington. This area is part of the greater protected inland marine ecosystem which also encompasses the Strait of Georgia. Our minimum estimate of 20 pairs compares to the estimated 45pairs present in the Elwha River, the system with the greatest population estimated in Washington State (Greg Schirato, Washington F and W, pers. Comm). The average density of pairs observed for reaches in the Skagit River (0.50 pairs/km, n=5, sd=0.27) is slightly higher than the average observed for streams with harlequins in British Columbia (average density 0.36pair/km in Wright and Goudie 1998) and Montana (0.33pair/km, Genter *et al.* 1998). The highest density we observed for a specific reach was 0.91pair/km.

Our brood surveys focused on periods when broods had developed past age class I. The greatest mortality of broods occurs during age class I (Smith 2000). Surveys after this period better reflect the productivity from the system. We observed a minimum of 7 broods (24 ducklings) from a minimum estimate of 20 pairs. This represents approximately 35% production of broods, and approximately 20 of these ducklings would have fledged (accounting for anticipated survival from age class IIB, IIC and III to fledging of observed broods). The productivity we observed compares well with productivity estimates from other areas. The average of 1 duckling/hen observed compares favourably with Genter *et al* (1998) average estimate of 1.38 ducklings/hen in Montana, and the 35% of hens successfully rearing broods (to fledging) calculated from our investigation is comparable to the average 37.9% (range 7-55%) observed by Genter *et al* (1998), although lower than the 50% calculated from data in Smith (2000). The proportion of hens successfully rearing broods varies greatly between years (Genter *et al.* 1998) and survival estimates among geographic areas can be site specific (Mauser *et al.* 1994 in Smith 2000).

The habitat variables we identified as being important to predicting harlequin duck presence are not surprising. The physical features of wet width and gradient are important in dictating the other physical properties of the channel. The abundance of invertebrates and their taxonomic diversity suggests food availability, and water quality sufficient for their sustenance. The combination of these three habitat features is important, for reaches which did not have harlequin ducks, examination of the habitat data reveals that one or more of the features was outside of the range associated with reaches supporting harlequin ducks, and may have been limiting. Specifically, SU1 had too gentle a gradient (0.7%), while M1 was too steep and narrow (slope7.8%, wet width 8.6m). N1 and SK6 were both narrow (9.4m and 10.1m respectively). K1 did not have adequate invertebrates (0.64/cobble), and the darker, tea-coloured water suggests water chemistry may have influenced the aquatic invertebrate community in this reach. SK4 was the only exception, while wet width, invertebrate densities, and gradient were all within the range of reaches supporting harlequin ducks, the channel was eroded and braided (possibly a legacy from past land use), resulting in more shallow water which may have limited this reaches value.

The results suggest that there is likely a specific combination of biophysical features required to support breeding harlequin ducks, and that these feature must all be available within a certain range to provide breeding habitat.

The combination of the variables we found important could be used to develop a model for identifying the potential presence of harlequin ducks within regional watersheds. Two of the variables, Gradient and Wet Width, could be used with GIS data currently available to MoELP to develop a GIS based model for predicting reaches which may have breeding harlequin duck. This information could prove valuable at a landscape level for assisting land use planning and in absence of inventory data, identifying areas were harlequin duck management should be given greater consideration. This model could incorporate the TRIM data and Fish Stream Inventory data, conceivably identifying reaches of average slope between 1% and 7% of stream class S1, S2, and S5 as defined by the Forest Practices Code of British Columbia (1995) as potentially having breeding harlequin ducks.

Disturbance can influence harlequin duck productivity (Cassirer and Groves 1992, Clarkson 1992, and Hunt 1998). Prior to May 30, there was little human disturbance in the system, and courtship and mating behaviour were likely not influenced by this factor. The greatest human disturbances we encountered were during the brood rearing period in the summer.

Disturbance appeared to effect brood rearing in some instances, however the type of disturbance appeared to play a greater role. This can be exemplified by observations of broods in the Sumalla River, reach 2 (SU2). Within this reach, broods were observed in the community of Sunshine Village, in areas where there were high concentrations of human activity. Broods were even observed using a man-made pond opposite the community's recreation complex. One gentleman observed that a hen had reared a brood for the last five years in the pond, suggesting hens using this habitat had relatively good success. As this is a private community with a more conservation-orientated mind set, we speculate that disturbance is different than in areas open to the general public (i.e. The Skagit Valley Provincial Park) where park users represent a greater diversity of recreational use and environmental awareness. Additionally, the park areas are exploited by fishermen (and in many instances their dogs) who regularly wade the rivers, and this likely cause greater disturbance to the broods, particularly later in the summer when water levels are lower and less cover is provided adjacent to the waters edge. Anecdotal evidence of this disturbance is provided by our observations of broods in areas limited to fishermen from legislation (i.e. the Ecological Reserve) or access (i.e. deeper water in the SK1 reach with thick riparian vegetation and little access to the river). This is consistent with observations made by Kuchel (1977) and Wallen (1987) who found hens lead broods to undisturbed stretches of river. We can not speculate on how this influences brood survival.

Rafting and boating are threats to harlequin conservation in other systems (Hunt 1998). We did not observe rafters or kayakers in waters during our survey, however, it can be anticipated that demand for this form of recreation will increase in the future. Therefore proactive planning measures are advised.

5.1 A Management Plan for Integrating Harlequin Ducks and Land Use

The results of the inventory this year have provided sufficient insight regarding harlequin duck use of the study area to begin to formulate a plan which will allow for the integration of harlequin duck conservation and recreational use. Conservation of this species can be considered for parks and other land tenure. Within parks, integrating management of the species with recreational use will be the primary function, while management of the species with other tenures will require the consideration of a greater range of land use.

5.1.1 Managing Harlequin Ducks in Parks

The majority of the riverine habitat within our study area found to support harlequin ducks is under Provincial Park land tenure. Integrating recreational use with conservation of the species is thus the primary consideration of management. Generally, the Management Plan for the Skagit Valley Provincial Park (MoELP 1997) provides opportunities to integrate harlequin duck conservation with the conservation and recreation goals identified. The conservation goals for the park include maintaining a representation of the of the local ecology and preservation of representative features, while the recreation goals include providing a variety of river and valley related camping and outdoor experiences to meet the needs of regional recreation. These specific recreation experiences include river fishing, nature study and easy access river camping.

As the population increases in the Lower Mainland of Greater Vancouver, greater use of the parks is expected. Berg (1994) identified recreation activities forecasted to increase by 2003 and beyond. Within the study area those activities which are expected to increase that we consider important to integrate with harlequin conservation include: bird watching, freshwater fishing, and canoeing/kayaking. These activities are forecasted to increase by 14%, 13% and 5.5 % participation respectively by 2003 (Berg 1994). He suggests that 22.7 % of the population will participate in bird watching, 34.1% in freshwater fishing, and 24.9% in canoeing/kayaking by 2003.

These activities can cause disturbance to breeding harlequin ducks, which can result in reduced feeding and increasing energetically costly behaviours (e.g. flying) as well as breakdown of pair bonds during the spring, or by disturbing incubation, fragmenting broods (increasing duckling mortality), or their feeding and loafing patterns. Such impacts on behaviour are hypothesised to negatively affect subsequent body condition and thereby survival.

We observed the greatest disturbance during July and August (and likely into September) when fisherman were wading the stream. This type of activity is particularly disturbing to broods at this time due to the lower water levels (and thus limited riparian cover).

Additionally, the presence of domestic dogs accompanying fishermen was encountered in reach Sk1 and Sk2 near the Silvertipped Campground (an area identified as an Intensive Recreation Zone in the Skagit Management Plan [MoELP 1997]).

Initial strategies for limiting this disturbance to harlequin ducks should be educational and voluntary. This could include providing signs identifying the harlequin duck and potential concerns for disturbance, increasing visibility of the ecological reserve boundary and enforcing the no fishing policy within.

Additionally, monitoring the number of fisherman, the number of dogs and their behaviour as well as compliance with recommendations is required. Dependent upon compliance and use of the area by fishermen, future management strategies may include restraining or not permitting dogs in these areas, or creating additional harlequin duck refuges in reaches Sk1, Sk2, and Sk3. An alternate approach may include delaying the fisheries opening. Based on estimate of average hatching date, (June 13) broods are still at age class I, and quite vulnerable during the early part of July. Opening the river to fishing two weeks later (July 15) and extending the opening by two weeks to provide the same opportunities to fisherman (provided other ecological considerations are compatible) would allow the majority of broods to develop to age class II. Older broods would be less vulnerable to disturbance. This may be a consideration if recreational fishing increases.

While we observed little disturbance during the pairing activity (April-May), forecasted increases in activities such as bird watching and canoeing/kayaking may provide management challenges in the future. During these months, the use of the trail seems to have little effect on duck behaviour at the current recreational use levels. Keeping with the objectives of the Skagit Valley Management Plan, potential exists to promote wildlife viewing and education opportunities, particularly in April and May. Caution would be required and early emphasis on having observers staying on the trail or using viewpoints should be promoted. "Harlequin Duck" viewpoints where ducks are active are already available at campsites along the trail between Sumalla Grove and Silvertipped campsite and where the trail comes close to the river. These could be promoted by the inclusion of interpretative signs, and providing benches/blinds, where observers would be encouraged to quietly sit and watch for harlequin ducks.

Future management of development is consistent with the Parks management objectives, including: Avoid increasing trail through the riparian, and future trail relocation should stay away from paralleling the edge of the creek (50m is sufficient to provide cover and limit disturbance in most cases), but instead, switch back to the stream for brief sections.

Additional opportunities for involving the public in recreational and wildlife viewing activities, which will contribute to the management of the species, include developing a protocol for volunteer monitoring of the population. Long-term monitoring is essential to identify the status of the population and as there are a number of factors that can effect annual productivity and nesting success (i.e. weather conditions, variation in stream flow, marine conditions, etc.) long–term monitoring is required to confidently establish trends. Developing a protocol which can be successfully implemented by volunteers could allow for collecting these data annually, permitting managers an opportunity to assess trends. Additionally this activity would have both recreational and educational values for those participating in the program. If this type of program is successful, it may be expanded beyond the study area or to other species.

5.1.2 Managing Harlequin Ducks in Other Land Tenures

Managing harlequin ducks outside parks requires the consideration of a number of other potential conflicts. These include land use such as forest development, and hydroelectric operations, in addition to commercial recreational operations. Within our study area, the only reach producing harlequin ducks outside Provincial Park jurisdiction is the Sumalla reach Su2. This reach has experienced substantial forest development in the past as well as the creation of a residential development along the riverbanks. While the continued production of harlequin ducks in this area reflects the resilience of this species, we have no indication of how the development influenced the population in the past.

Managers should consider future land use proposals and their potential impact on harlequin ducks. While forest development will likely not occur along the stream until the second growth attains a merchantable size (20-40years from now), there may be interest in hydroelectic operations. Commercial recreation such as rafting in the river will likely not be proposed, and the current recreation types and level appears compatible with harlequin conservation. The occurrence of the private community at the lower part of this reach likely ensures that all future development proposals will receive thorough scrutiny.

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Appendix I, Photographs of the Capture and Banding of Harlequin Ducks

Photo 1, Setting mist net for duck capture

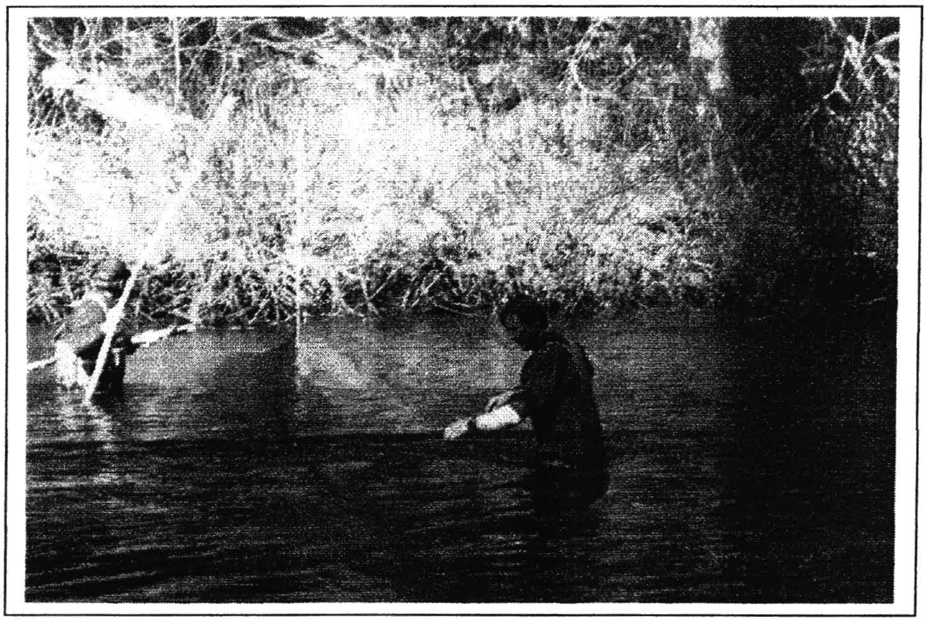


Photo 2, Banding and collecting morphometrics on a captured Harlequin Duck

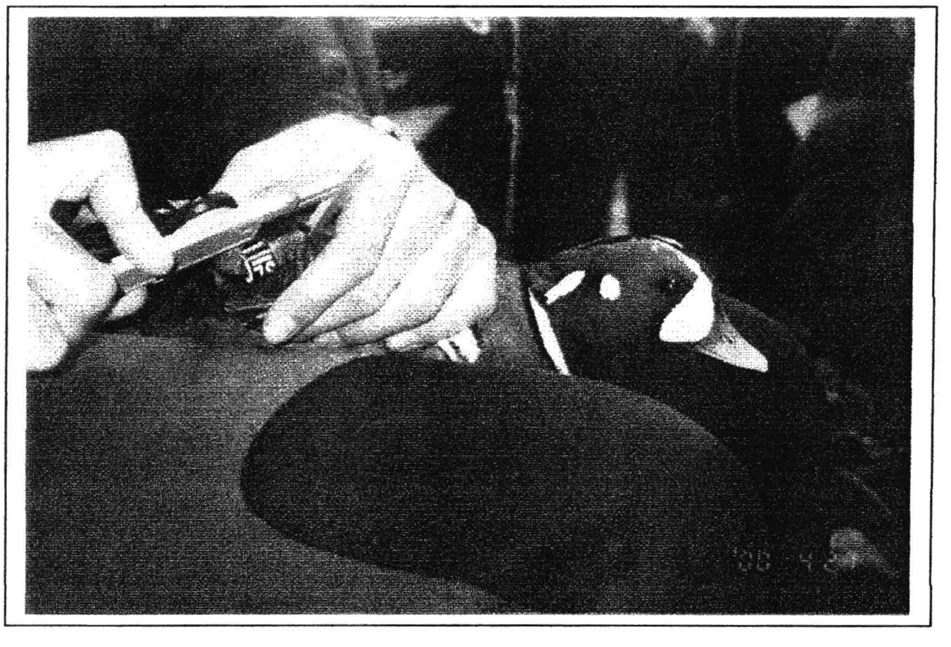
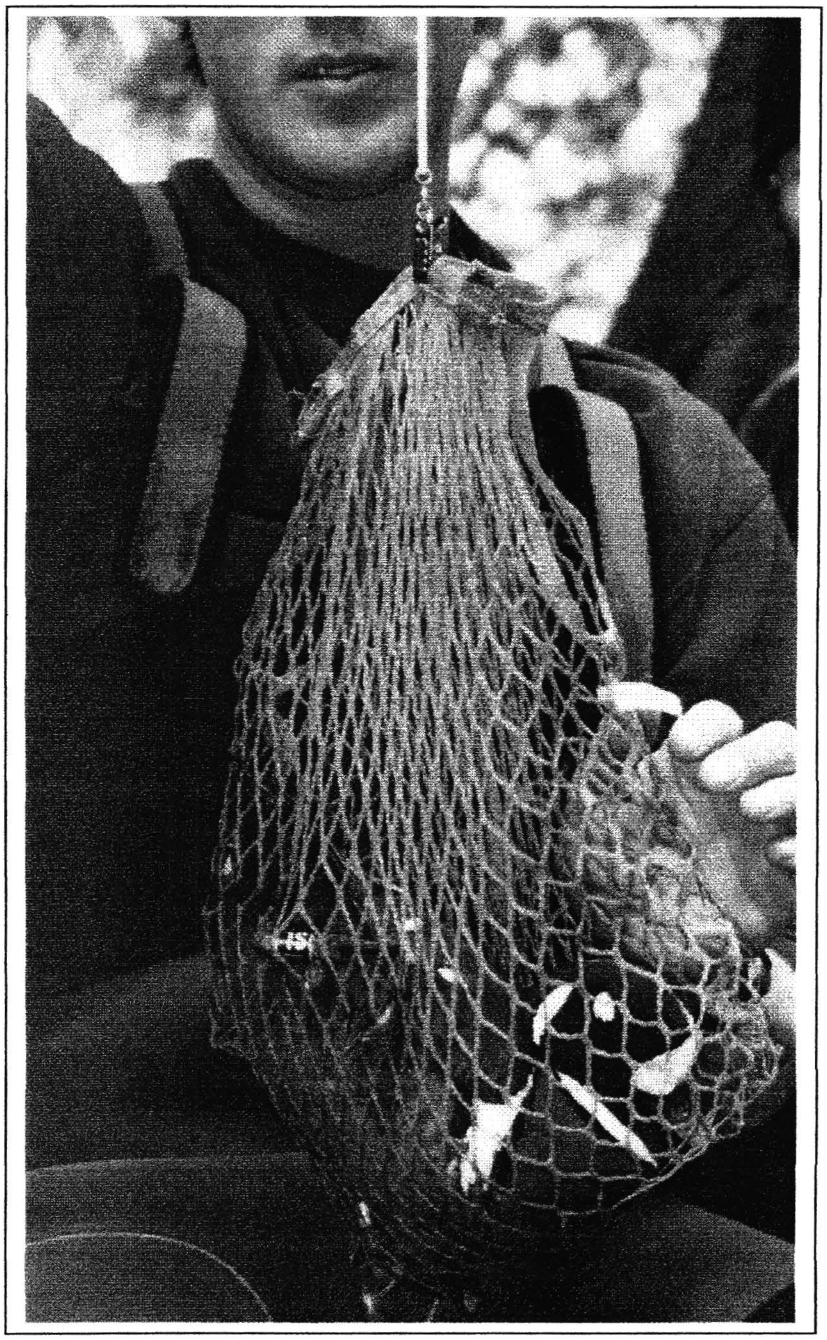


Photo 3, Weighing a captured harlequin duck



Appendix II, Survey Data Sheets

Skagit Harlequin Duck Survey Data Sheet **PG ___/___**

Date______________ **Location**______________ **Observers**________________
TRIM map sheet number________ Location Description _______________________
____

Survey Type: Pair Brood Recce Incidental Other *Walk/Vehicle*

Start Location____________________________________ Time_________
Finish Location___________________________________ Time_________

Reference all locations on TRIM Maps

HARD Observations *Location Code*: numerical location referenced to map *Banded* y: yes, n: no, u: Unidentified. # Band number

Pair 1 (location code)______ M banded y/n/u _#________ F Banded y/n/u #________
Details____
Pair 2 (location code)______ M banded y/n/u _#________ F Banded y/n/u #________
Details____
Pair 3 (location code)______ M banded y/n/u _#________ F Banded y/n/u #________
Details____
Pair 4 (location code)______ M banded y/n/u _#________ F Banded y/n/u #________
Details____

Single Male 1(location code)______ banded y/n/u _#________
Details____
Single Male 2(location code)______ banded y/n/u _#________
Details____
Single Male 3(location code)______ banded y/n/u _#________
Details____
Single Male 4(location code)______ banded y/n/u _#________
Details____

Single Female 1(location code)______ banded y/n/u _#________
Details____
Single Female 2(location code)______ banded y/n/u _#________
Details____
Single Female 3(location code)______ banded y/n/u _#________
Details____
Single Female 4(location code)______ banded y/n/u _#________
Details____

Comments____
____

Appendix III, Habitat Data Sheets
Skagit Harlequin Duck Inventory Habitat Data

Location reference________________ **Date**_____________ **Observer**__________
Map sheet________ **Elevation**___________ **Estimated Pool:Riffle:Glide ratio** ___:____:____

Number of Ducks observed at site and details ____________________________________

Habitat Unit *riffle pool cascade glide other* **Length of Habitat Unit**__________________m

Slope_______ **Bank width**________ **Wetted width**______ **Stream Velocity**__________m/s

Max Depth______cm **Mean Depth**_________cm **Channel Type**_________________________

Substrate Boulder %_____ Cobble%______ Gravel%_______ Fine%__________________

Riparian Habitat

Right
0-5m [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
5-10m [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
10-20m[herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
20m+ [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]

General description ____
____

Left
0-5m [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
5-10m [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
10-20m[herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]
20m+ [herb] [shrub] [deciduous forest] [regen forest] [pole forest] [young forest] [mature forest] [old forest]

General description ____
____

Canopy Closure______________ **Islands**__________ **CWD**___________
Nesting structure_______________

Invertebrate relative abundance *High Medium Low none* **# /Cobble**____________

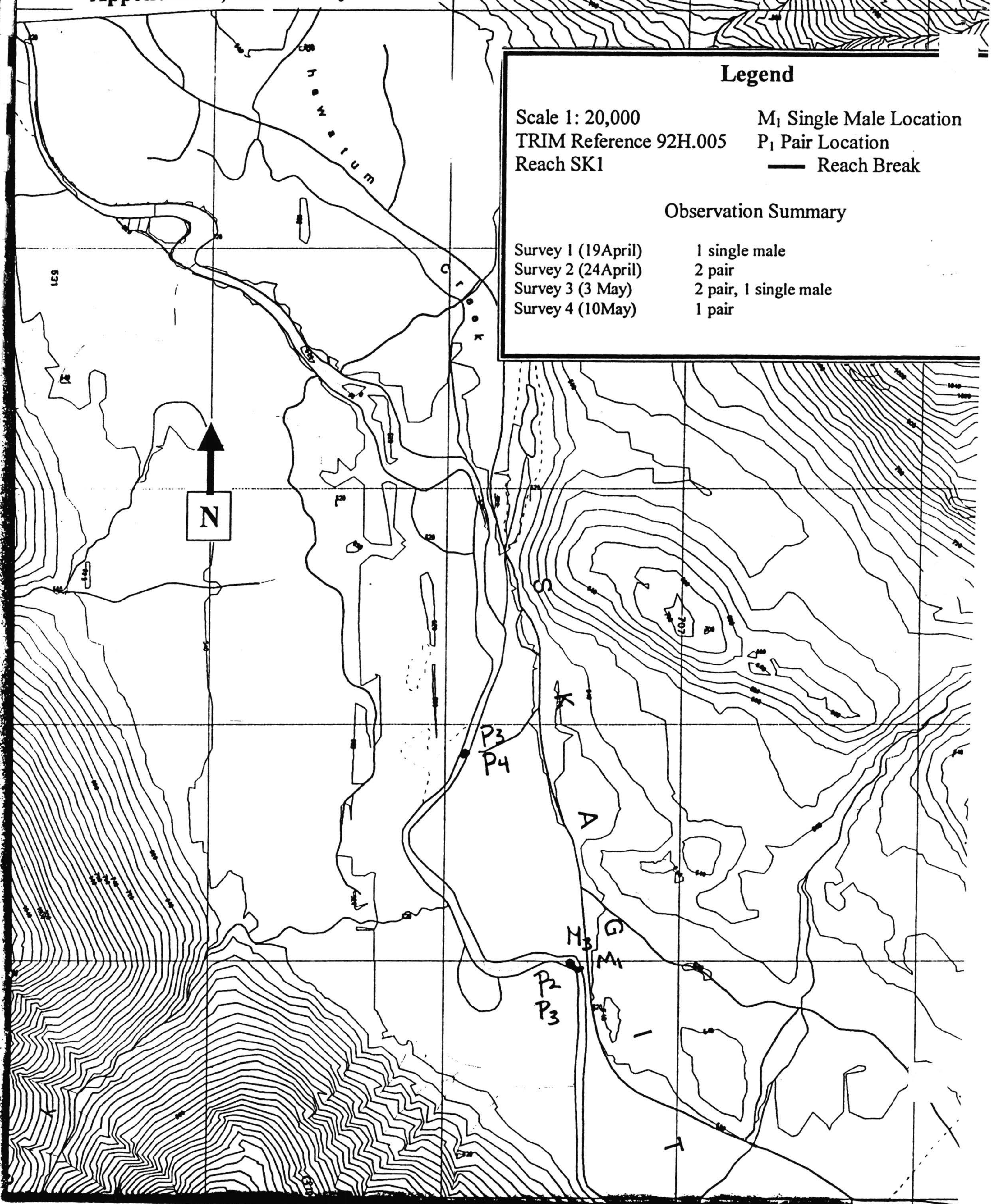
Comments____
____
____

Appendix IV, Maps of Harlequin Duck Locations during Pair Surveys

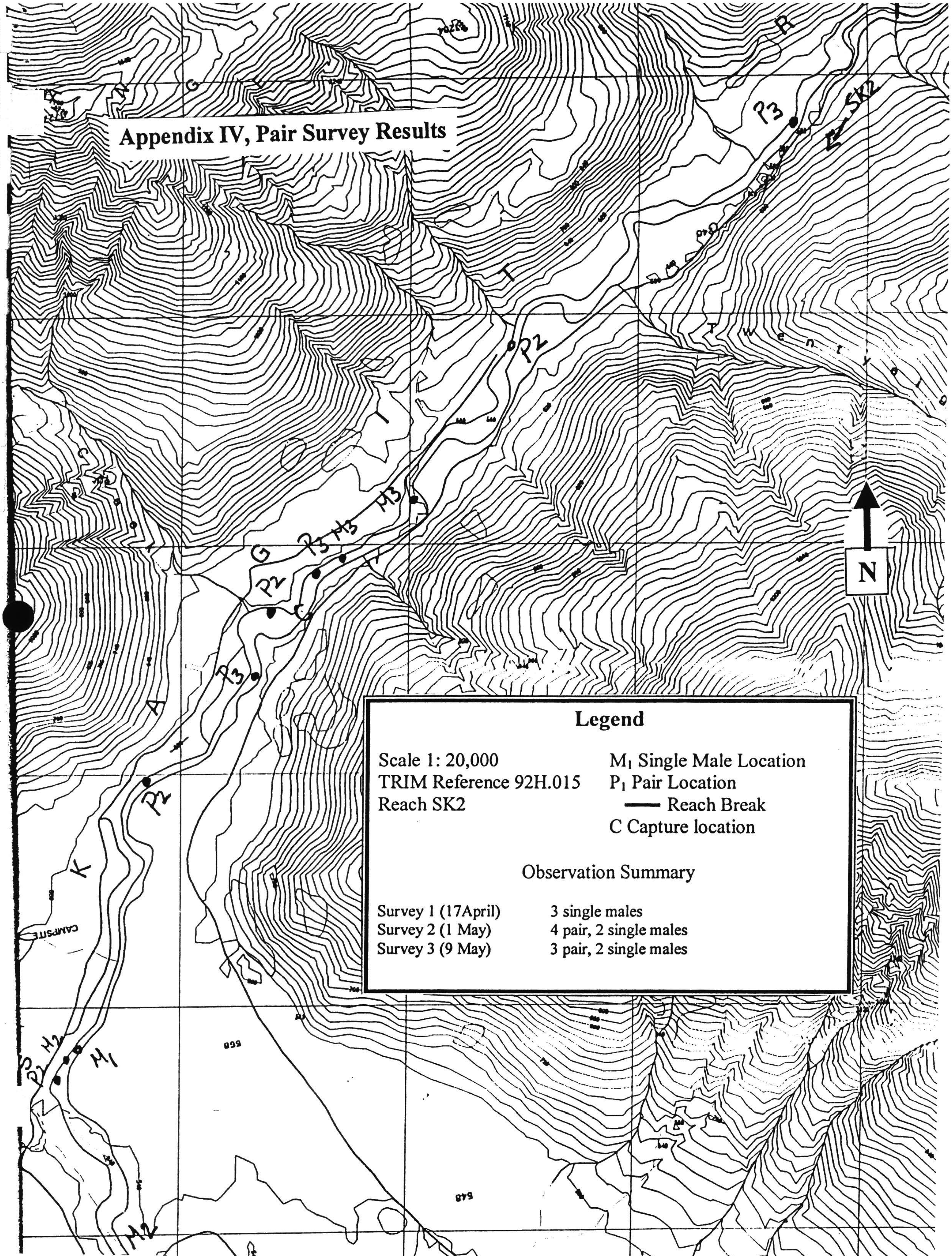
Maps are 1: 20,000 scale copies from TRIM maps available from BC MoELP.

Locations are described with a prefix for identifying P (pair), M (single male) C (capture location) with a subscript referencing the survey number, 1 for survey 1, 2 for survey 2 etc. An example, P_1 would indicate a pair was observed at that location during the first survey of that reach. For clarity, multiple observations at the same location (e.g. 2 single males together) receive only one label. Only reaches with harlequin ducks are included.

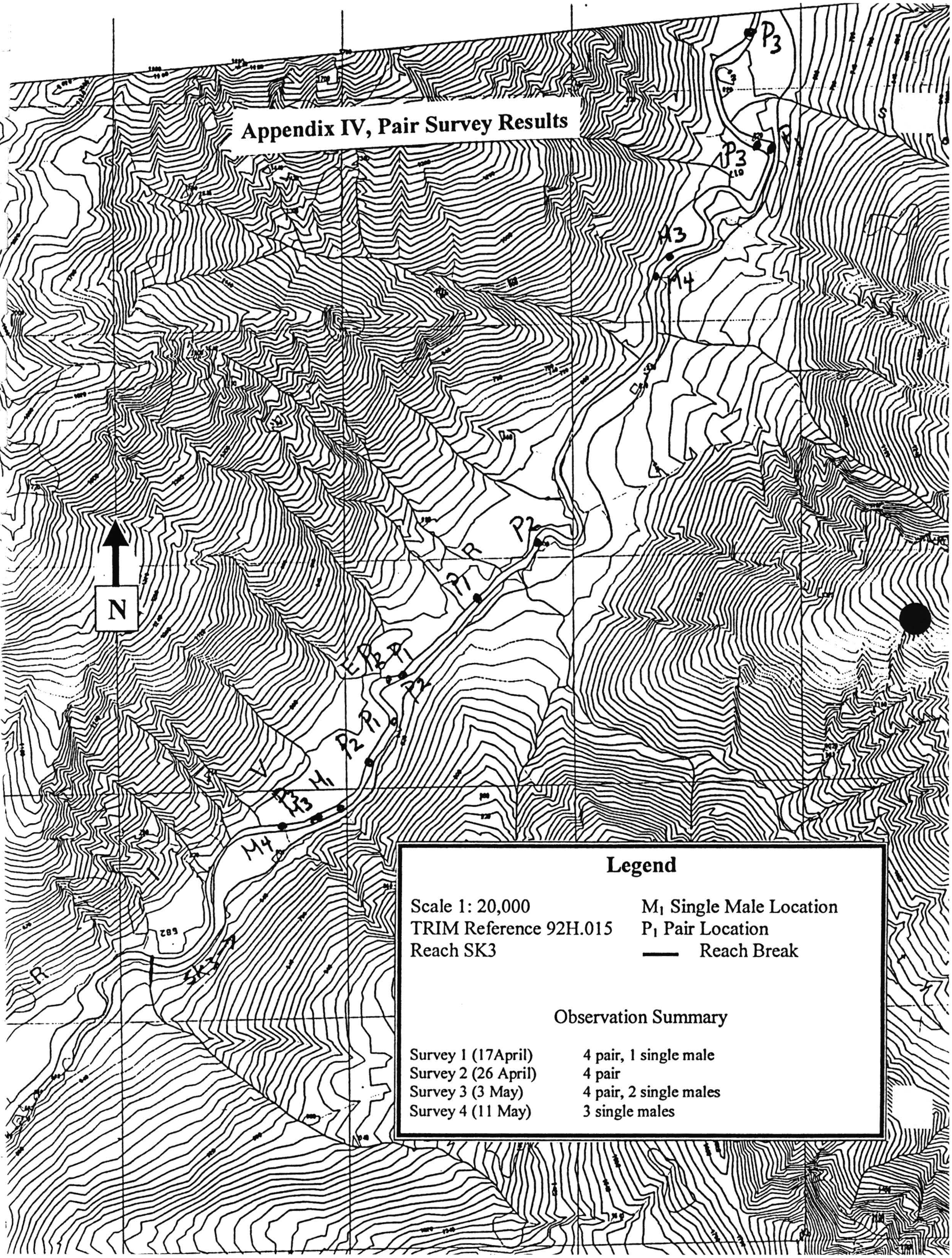
Appendix IV, Pair Survey Results



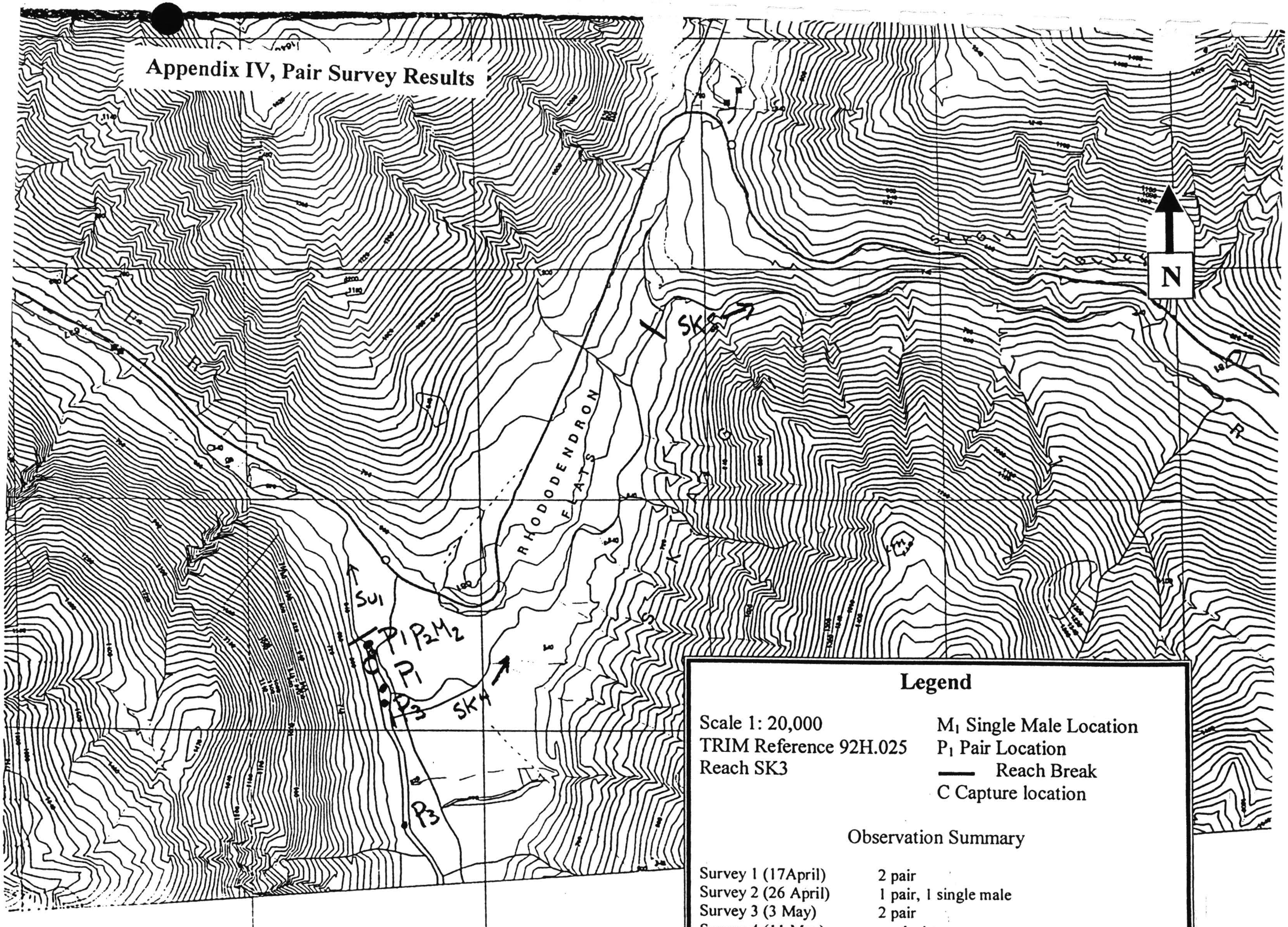
Appendix IV, Pair Survey Results



Appendix IV, Pair Survey Results



Appendix IV, Pair Survey Results



Legend

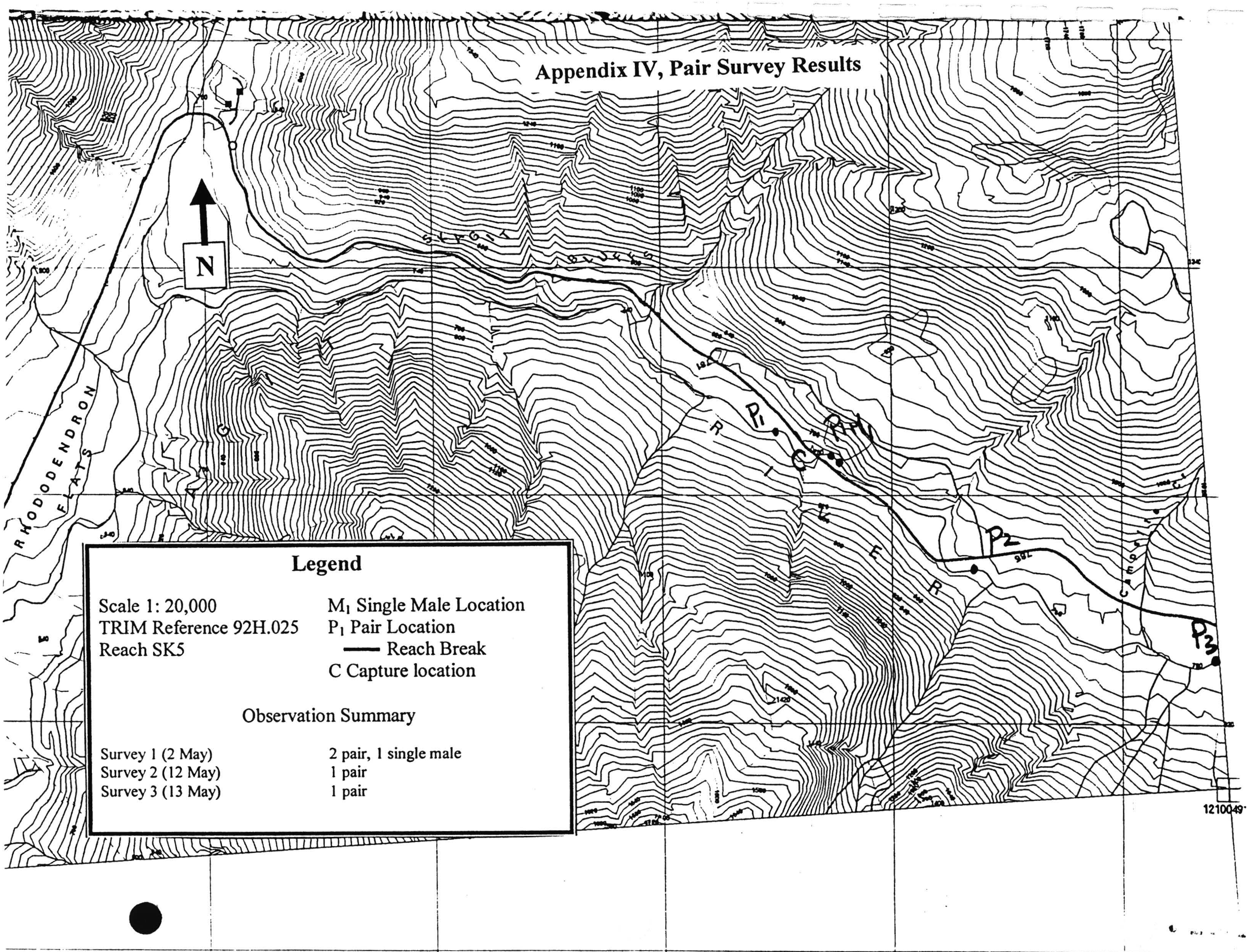
Scale 1: 20,000
TRIM Reference 92H.025
Reach SK3

M_1 Single Male Location
P_1 Pair Location
—— Reach Break
C Capture location

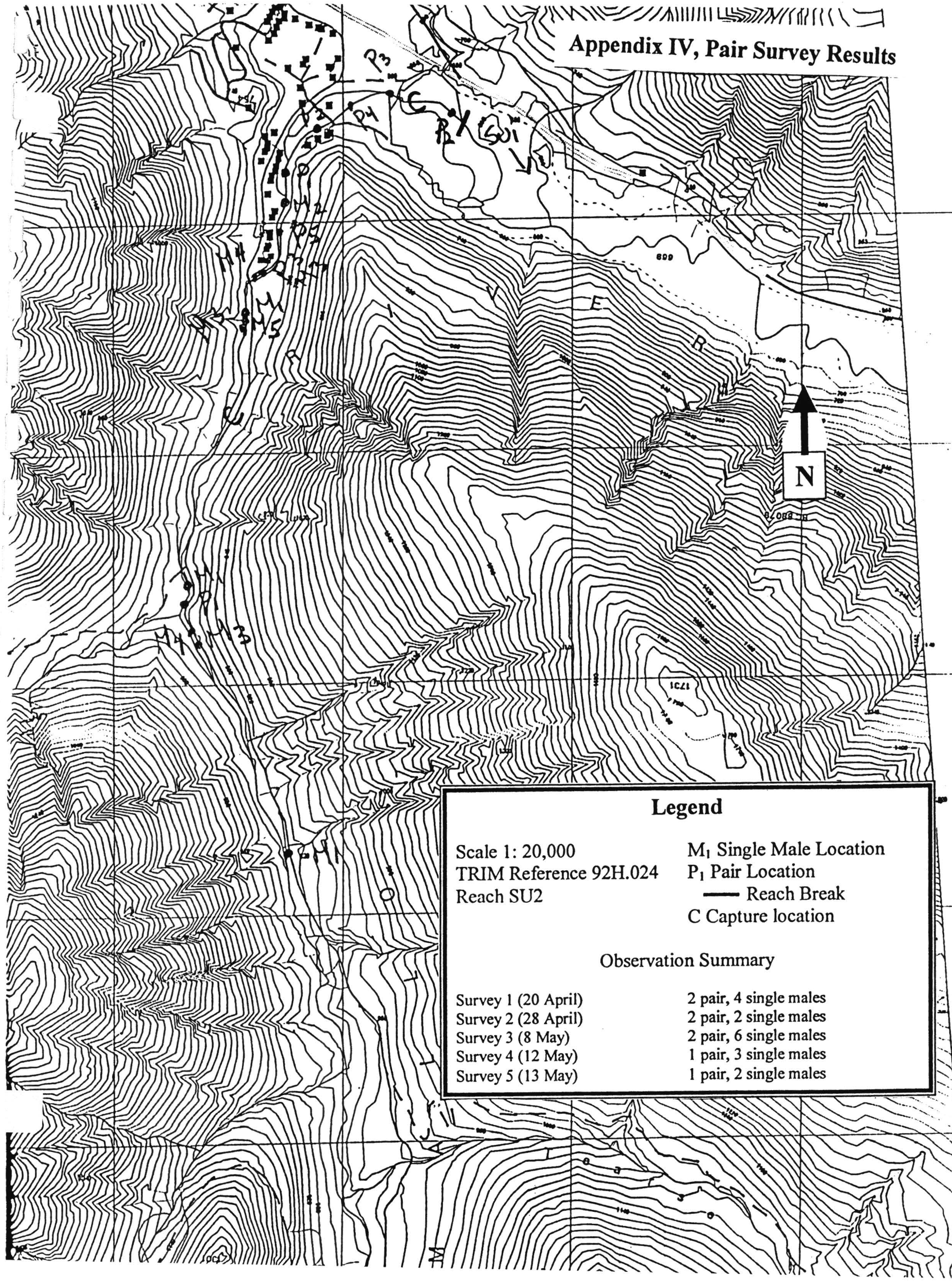
Observation Summary

Survey 1 (17April)	2 pair
Survey 2 (26 April)	1 pair, 1 single male
Survey 3 (3 May)	2 pair
Survey 4 (11 May)	no ducks

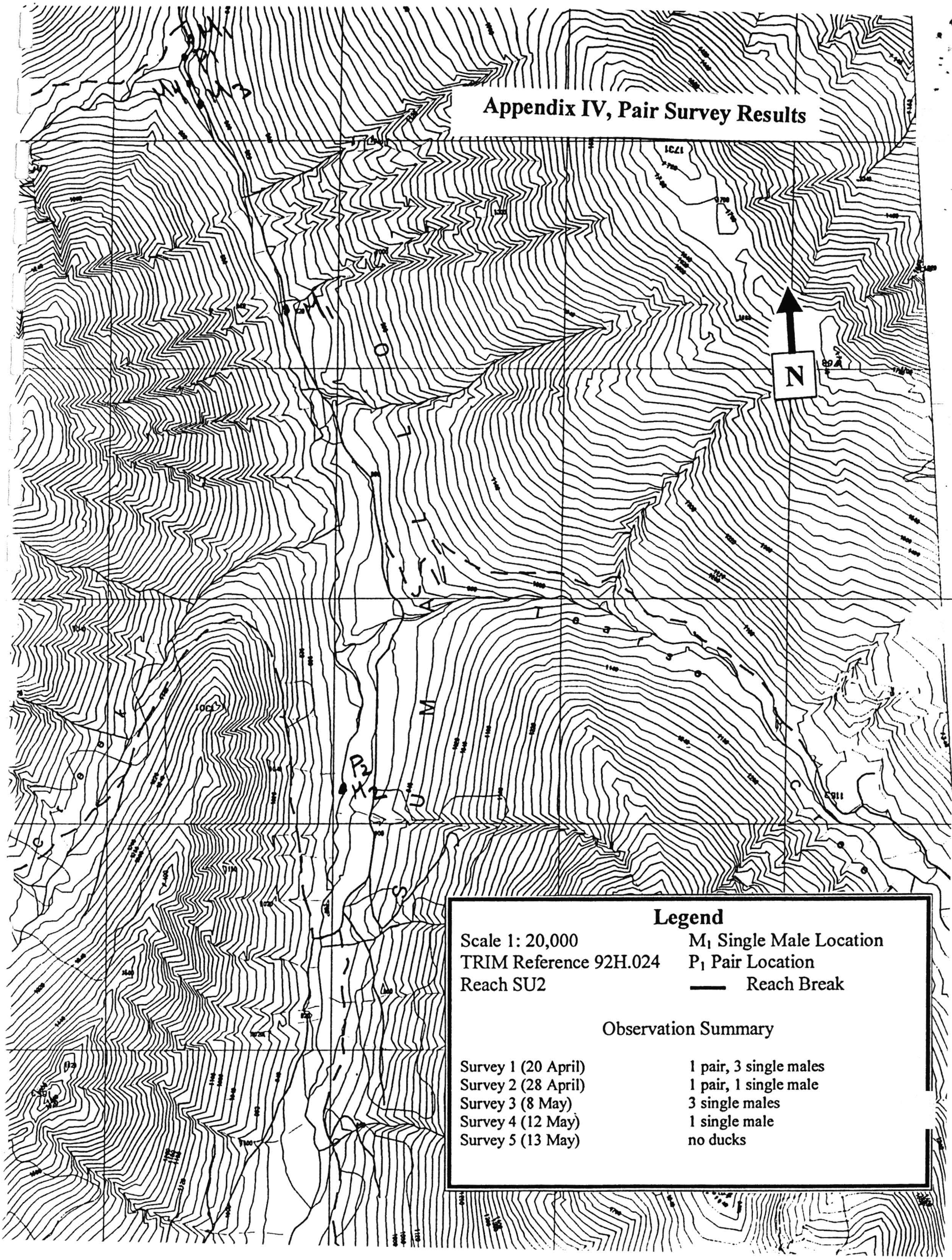
Appendix IV, Pair Survey Results



Appendix IV, Pair Survey Results



Appendix IV, Pair Survey Results

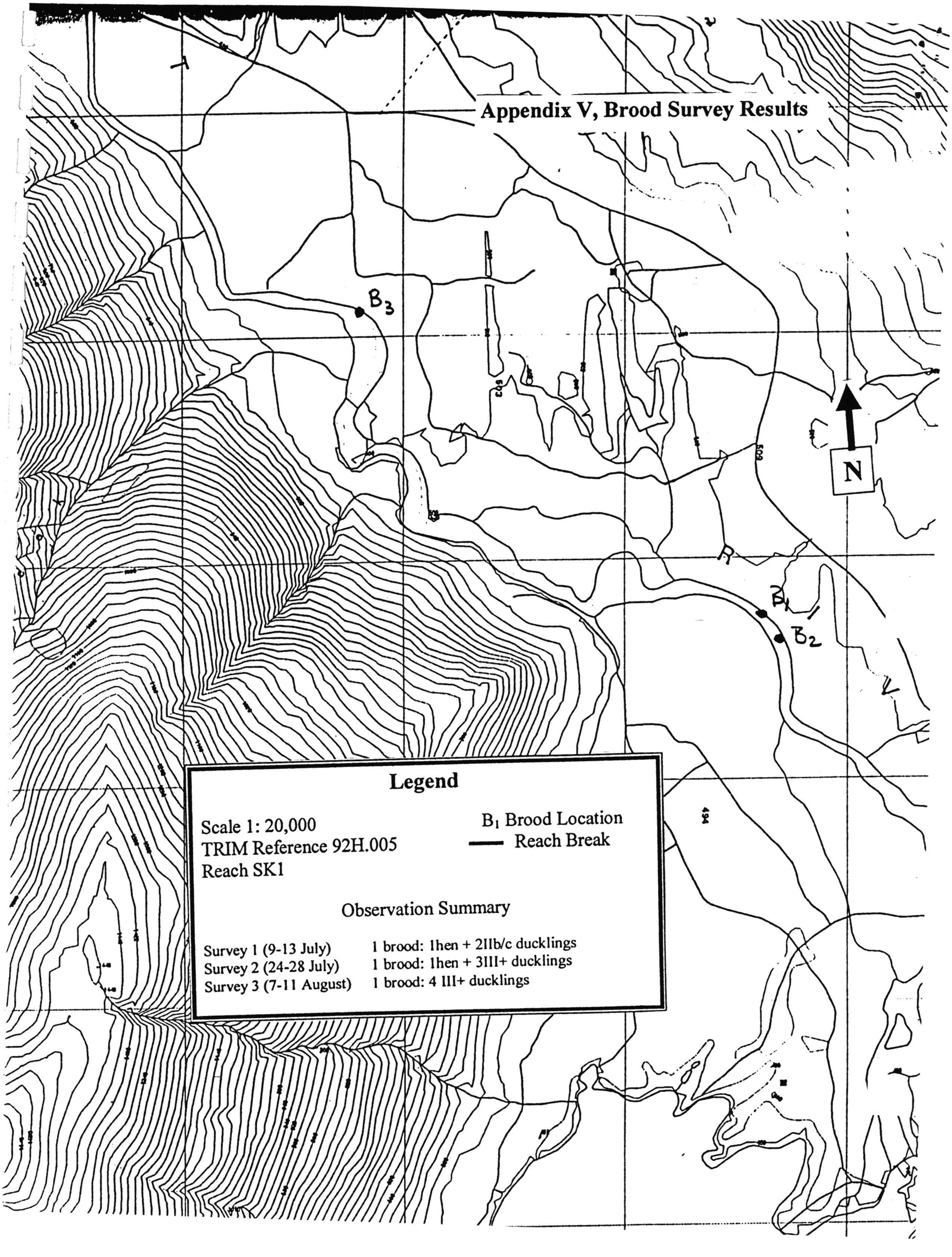


Appendix V, Maps of Harlequin Duck Locations during Brood Surveys

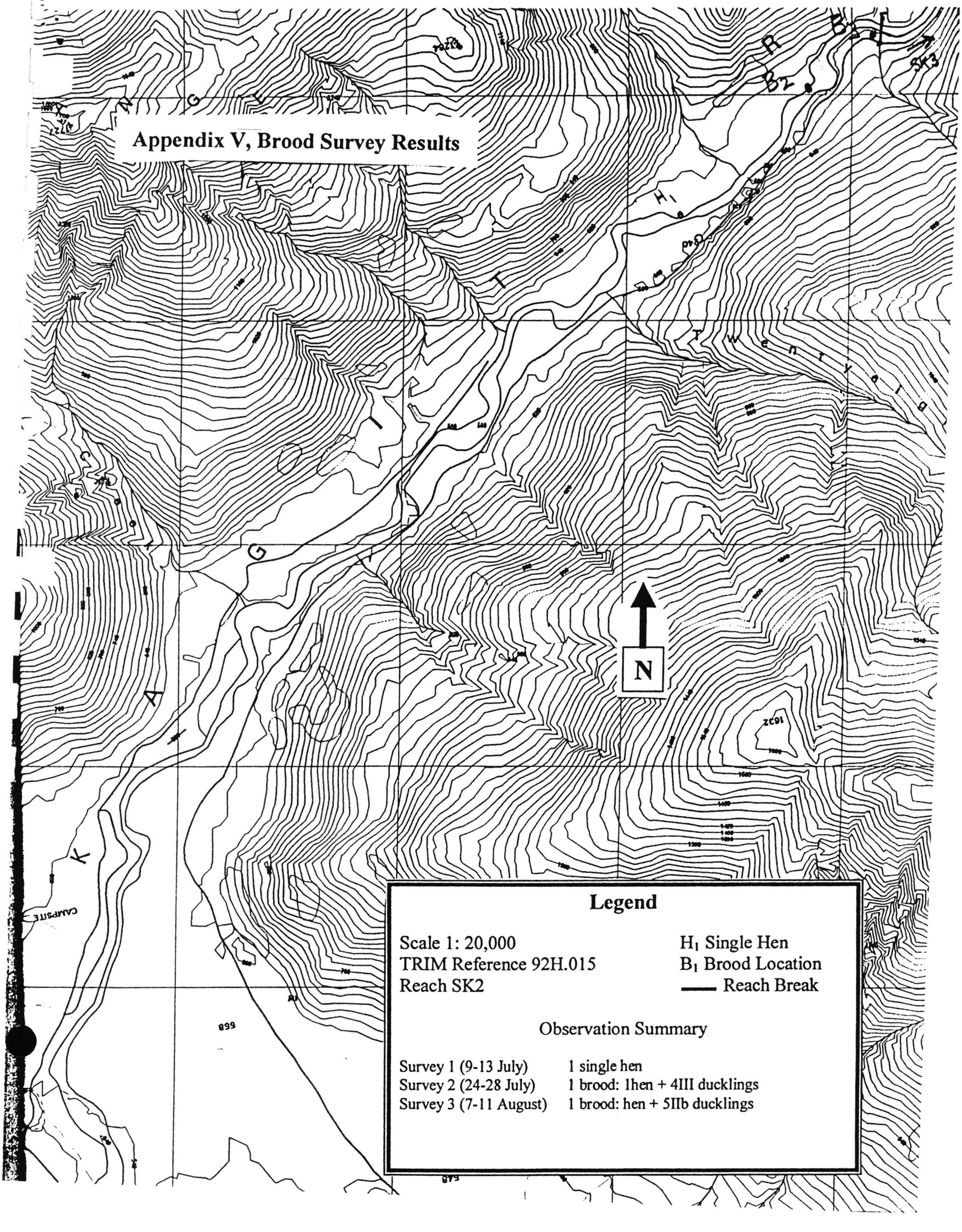
Maps are 1: 20,000 scale copies from TRIM maps available from BC MoELP.

Locations are described with a prefix for identifying B (brood), H (single hen) with a subscript referencing the survey number, 1 for survey 1, 2 for survey 2 etc. An example, B_1 would indicate a brood was observed at that location during the first survey of that reach. For clarity, multiple observations at the same location (e.g. 2 single hens together) receive only one label. Only reaches with harlequin ducks are included.

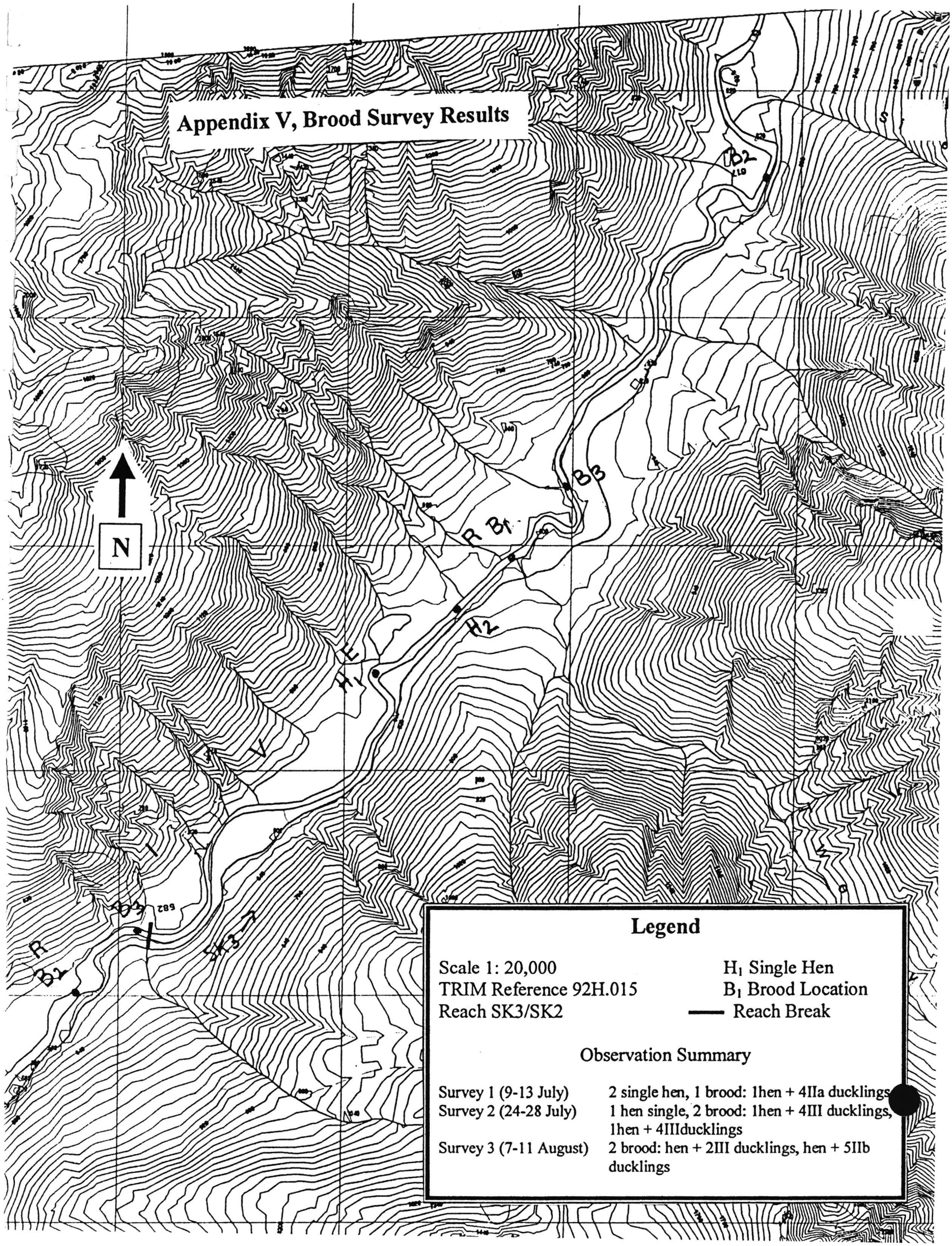
Appendix V, Brood Survey Results



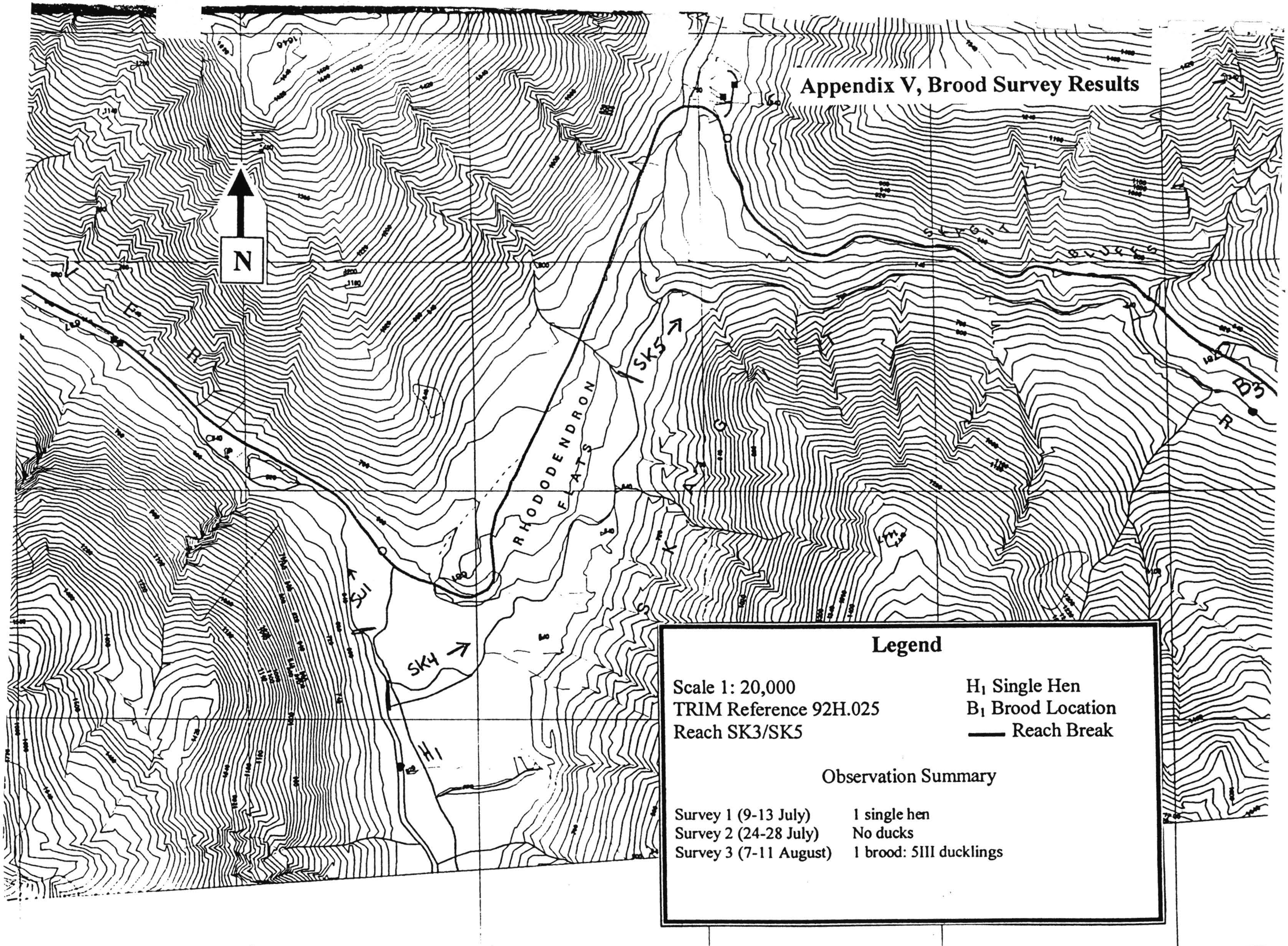
Appendix V, Brood Survey Results



Appendix V, Brood Survey Results



Appendix V, Brood Survey Results



Appendix V, Brood Survey Results