ECOLOGY OF HARLEQUIN DUCKS IN NORTHERN IDAHO

PROGRESS REPORT 1991

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ABSTRACT

Harlequin duck (Histrionicus histrionicus) breeding ecology was examined on six streams in northern Idaho, April-September, 1991. Population size was estimated at 15 pairs and 10 males, at an average density of one pair per 5 km of stream. Single surveys tended to underestimate the number of harlequin ducks using a stream, probably due to duck movements between streams and out of survey areas. Four pairs (27%) produced broods to at least one week of age, and 11 ducklings (73%) survived to fledging.

Harlequin ducks were observed in swiftly flowing water away from roads and trails. Average stream velocity at observations was 1.3 m/sec and 73% of observations were in flows >1 m/sec. Nine streams where harlequin ducks were not observed were similar in size and velocity to those at harlequin duck observations, but were higher in average elevation, differed in streambank and channel characteristics and were more frequently logged along the bank. Two nests were discovered, one in a tree cavity and one 3 m above the stream in a rocky cliff. Both were adjacent to swiftly flowing water and away from areas where pairs were observed during the prenesting period. These are the second and third nesting records for Idaho.

Adult females and paired males used an average of 7 km of stream, with observations concentrated in 5-km core reaches. Several harlequin duck females and broods used more than one stream during the breeding season. Fifty-three percent of 19

adults marked since 1987 returned at least once, however 89% of those that returned once continued to return to the same stream year after year. One hen radio-marked on Upper Priest River in mid-July was located in the San Juan Islands, Washington, less than two weeks later. This may be an important migrating or wintering area for harlequin ducks breeding in the Rocky Mountains.

INTRODUCTION

Harlequin ducks (Histrionicus histrionicus) breed on a small number of streams in northern, northcentral and southeastern Idaho (Cassirer et al. 1991). They are a state species of special concern, a U.S. Forest Service sensitive species (Moseley and Groves 1990) and a U.S. Fish and Wildlife Service candidate (C2) for listing as threatened or endangered (Federal Register 1991). Prior to 1987, no work had been conducted on harlequin ducks in Idaho and little is known about the ecology of this species. Initial work in Idaho concentrated on determining distribution, population status, and ecology throughout the state (Wallen and Groves 1988, 1989; Cassirer and Groves 1989, 1990a b, 1991; Atkinson and Atkinson 1990; Cassirer et al. 1991). The current study examines ecology and habitat use on selected breeding streams in northern Idaho.

OBJECTIVES

1. Determine population density, productivity, and return rates to breeding streams.
2. Define adult, nesting, and brood habitat use.
3. Investigate factors affecting density and productivity.
4. Determine appropriate monitoring techniques.

STUDY AREA

Streams in the Priest Lake, Upper Priest Lake and southeastern Lake Pend Oreille watersheds, all in northern Idaho,

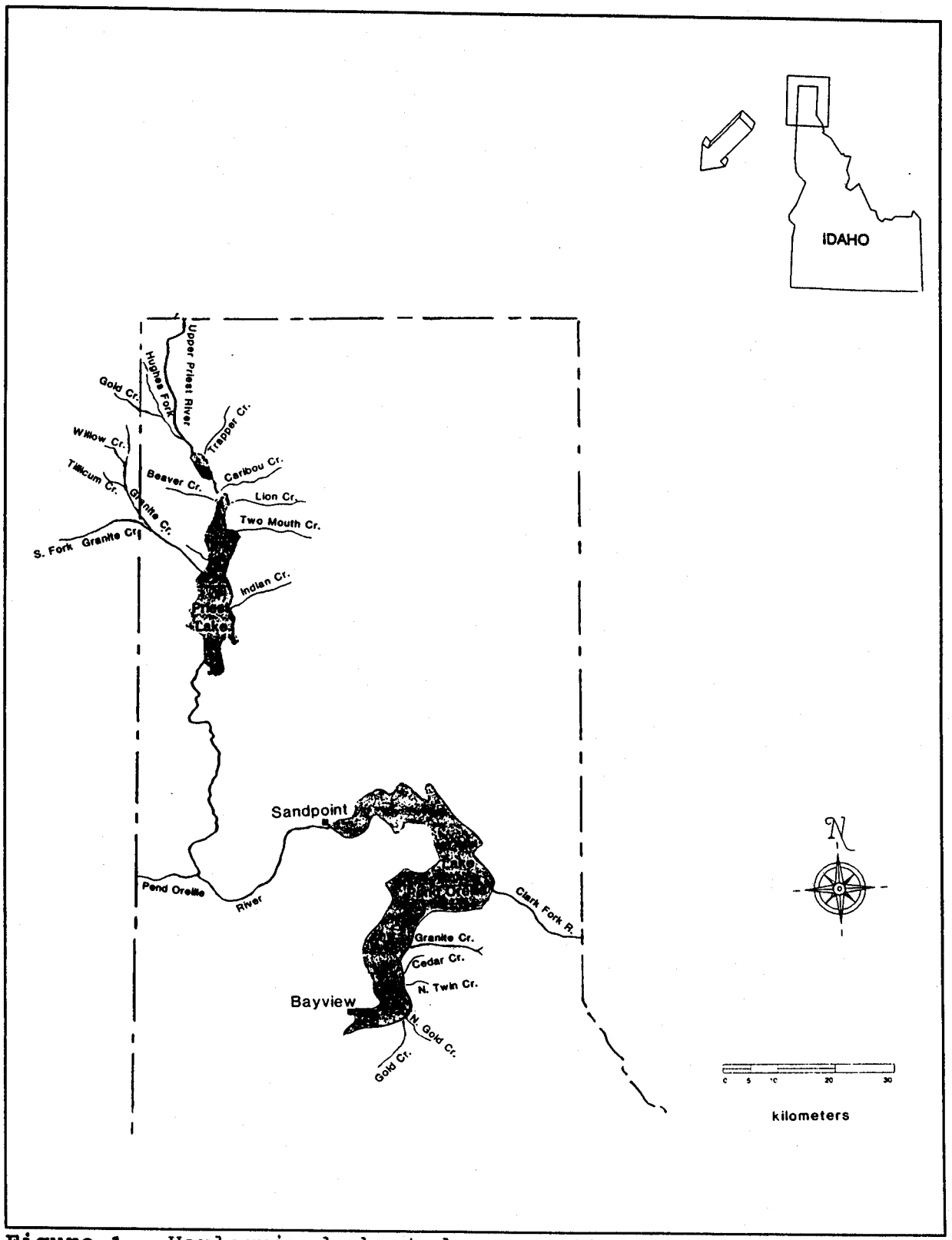


Figure 1. Harlequin duck study area, 1991.

were included in the study (Figure 1). Land management is under the jurisdiction of the Priest Lake and Sandpoint Ranger Districts on the Idaho Panhandle National Forests, and the Idaho Department of Lands. A small amount of land is under private ownership. About 30-40% of Idaho's known harlequin duck population breeds on streams in these areas (Cassirer and Groves 1990a).

METHODS

Surveys

On April 19 and 23, boat surveys were conducted on Lake Pend Oreille and Priest Lake, respectively, by boating along the shoreline and by walking about 0.5 km up tributaries. On Lake Pend Oreille, the southern shoreline was surveyed from Bayview to Granite Creek. Gold Creek and Granite Creek were searched on foot. The entire shoreline of Upper Priest Lake, the "Thorofare" between Priest Lake and Upper Priest Lake, and the northern shoreline of the lower lake from Granite Creek to Lion Creek were surveyed at Priest Lake. Trapper Creek, Lion Creek, Beaver Creek, Tango Creek and Granite Creek were surveyed on foot.

From April 25 to August 30, reaches on six streams used by harlequin ducks were surveyed on foot at approximately weekly intervals. Weekly surveys on the Hughes Fork were continued through September 25. Surveys were also conducted on streams not known to be used by harlequin ducks. Beaver, Blacktail, Cedar, Caribou, S. Fork Granite, Lion, North Gold, North Twin, Two Mouth, Willow and Tillicum Creeks were surveyed May 2-June 4

Table 1. Streams and dates surveyed, 1991.

Stream	No. surveys	Dates
Lake Pend Oreille		
Gold Creek	19	5/1-8/30
Granite Creek	20	5/1-8/30
North Gold	1	5/10
North Twin	2	5/8, 5/22
Cedar Creek	1	5/9
Priest Lake		
Granite Creek	19	4/30-8/28
Gold Creek	15	4/29-8/27
Hughes Fork	21	4/25-9/25
Upper Priest River	15	5/14-8/28
Beaver Creek	1	5/7
Blacktail Creek	1	5/7
Caribou Creek	1	5/23
Lion Creek	1	5/2
Two Mouth Creek	1	6/4
S. Fork Granite Cr.	1	5/28
Tillicum Creek	1	5/6
Willow Creek	1	5/21

(Table 1 and Appendix A).

Surveys on foot were conducted by walking in or along the stream and looking for ducks. One survey of lower Granite Creek at Priest Lake was conducted by raft on June 3. Ducklings were classified by plumage development according to Gollop and Marshall (1954). Plumage development was categorized into three

classes and seven subclasses, from class I, downy, no feathers visible, to class III, fully feathered.

Trapping, marking, and radiotelemetry

Harlequin ducks were trapped by setting up a 10-cm mesh mist net across the stream and flushing the ducks into the net (Bengston 1972). All ducks were legbanded with USFWS bands. Adults were also individually marked with colored nylon nasal markers and juveniles were color-banded with yellow aluminum legbands (Appendix B).

Eleven adults were marked during May-July; eight ducklings and two hens were trapped in August. One duckling and hen were held together in a nylon stuff sack during processing and died as a result of trapping stress. Ambient temperatures of 18-21°C may have contributed to the mortalities. Both were necropsied and were in good condition with no apparent cause of death other than trapping stress. Two intestinal worms (Amplocepgalidae) were found in the adult hen. A second duckling in this brood was found dead the following week apparently as a result of avian predation; the last duckling in the brood was never observed after release.

In addition to being nasal-marked, four harlequin duck hens were radioed in May and another four were radioed in June and July. Transmitters (Model PD-2, Holohil Systems Ltd., Ontario, Canada) weighed 3.9 g and were sutured between the wings directly behind the nape with two stitches of 3/0 nonabsorbable suture material. Initially the radios were also glued to the feathers

with marine epoxy (Titon Corp., Lynwood, WA), but this was later discontinued. The marine epoxy pulled out the feathers and did not help hold the radio on the bird. The 15-cm antenna extended freely down the length of the back in the feathers. Range on the transmitter was about 1 km using a two-element hand-held "H" antenna (Telonics, Inc., Mesa, AZ).

The four hens instrumented in May were followed by radio 14-45 days. Two transmitters failed (possibly because of water leakage into the radio package) within 14-25 days: one was removed after 21 days and the other was shed after 30 days. The radio that was removed was held on by a single suture at the time it was taken off. The other suture had pulled through the skin and the suture location had healed over completely. There was some redness and swelling around the suture still holding the radio. Duck behavior or movements did not indicate any irritation caused by the radio.

A third radio was removed after 27 days when the duck was observed pulling on the antennae and had adopted a very secretive behavior. Again, one suture had pulled through the skin and healed over, the area around the other holding on the radio was red and slightly swollen. The final radio put on in May fell off next to the nest after 45 days.

None of the four hens instrumented in June and July were radiolocated or observed on the study area after being radioed.

Habitat use

Data on stream and streambank characteristics (Appendix C)

were collected at all harlequin duck observations. During May and June, the same data were systematically collected at 1-km intervals on stream reaches used by harlequins. Also during May and early June these habitat data were collected at 1-km intervals on reaches of nine streams not known to be used by harlequin ducks (Beaver, Blacktail, Caribou, Cedar, Lion, Two Mouth, S. Fork Granite, Tillicum and Willow Creeks). Eight of these streams were in the Priest Lake watershed, one (Cedar Creek) was in the Pend Oreille watershed.

Stream velocities were measured at 1-km intervals during each stream survey and at harlequin duck observations by throwing a fishing bobber into the center of the stream current and recording the length of time it took to travel 5 m.

Analysis of use was based on 137 observations made during systematic stream surveys. From 15-28 observations were made on each of the six study streams used by harlequin ducks. Fourteen observations made incidental to surveys were not used in habitat analysis because they were biased towards areas visible from roads. Habitat comparisons were made with chi-square tests (Neu et al. 1974) and t-tests. To eliminate differences due to varying stream flows during the season, stream habitat, velocities and number of loafing sites at observations vs. streams not known to be used by harlequin ducks were compared only for data collected during similar time periods (May 2-June 4).

Food habits and availability

Benthic macroinvertebrates in streams used by harlequin ducks and in streams not known to be used by harlequin ducks were sampled with a 0.1 m^2 Hess sampler (Mundy's Machine Shop, Moscow, ID). All sampling was done in riffles. Riffles sampled on streams used by harlequin ducks were those where harlequins were frequently observed. Three samples were collected per site, and two sites were sampled per stream. One collection was made on nine streams in early June. A second collection was made during the brood-rearing period in late June on two streams used for nesting. Feces were also collected opportunistically when harlequin ducks were observed.

Results of invertebrate analysis are not yet available.

RESULTS

Population size and distribution

No harlequin ducks were observed on Priest or Pend Oreille Lakes in April. However, a male was observed near the mouth of Granite Creek at Lake Pend Oreille on April 19. This stream was not previously known to be used by harlequin ducks and was incorporated into the study area.

An estimated 15 pairs and 10 unpaired drakes (sex ratio = 62% males) were observed on the six study streams (Table 2). Average density on stream reaches used by harlequins was one pair per 5.3 km of stream. Densities were higher, although not significantly ($P = 0.15$) on streams at Lake Pend Oreille (one pair per 2 km) than on Priest Lake streams (one pair per 7 km).

Table 2. Harlequin duck population size, density and productivity on six streams in northern Idaho, 1991

Stream	Pairs	Single drakes	Total adults	Density (km/pair)	Productivity (%)[1]
Gold Creek, L. Pend Oreille	4	0	8	1.9	0
Granite Creek, L. Pend Oreille	2	3	7	2.2	50
Granite Creek, Priest Lake[2]	1	2	4	10	0
Gold Creek, Priest Lake	2	2	6	4.3	100
Hughes Fork	4	1	9	3.3	0
Upper Priest River	2	2	6	10	0
Total	15	10	40		
Average				5.3	20

[1] percent of pairs producing ducklings to fledging

[2] U.S.F.S. employee reported seeing two pairs on May 8, but one was maximum observed in surveys.

Productivity

Twenty-seven percent of pairs (4) observed produced broods to a minimum of class IA (3-5 days). Sixty-three percent were nonbreeders or nested unsuccessfully. Only one of seven females without broods trapped in June and July had a brood patch indicating unsuccessful nesting or brood loss.

The secretiveness of broods, and the fact that broods moved among streams during the summer, complicated data collection on

survival. Four broods were observed at class IA, three of which probably survived at least partially to fledging (Table 2). The other brood was last observed at age 16 days. The (marked) hen was observed alone nine days after last seen with a brood. One of three broods that survived was abandoned by the hen prior to fledging.

All successful nesting appeared to occur on Gold Creek, Priest Lake and Granite Creek, Lake Pend Oreille. Two nests were found, a successful nest on Granite Creek, Lake Pend Oreille, and an unsuccessful nest on North Gold Creek, Lake Pend Oreille (Appendix D). These are the only documented Idaho nest records other than one nest near the St. Joe River recorded in Hand (1941). Two eggs from the unsuccessful nest were collected on July 7 and are being analyzed for environmental contaminants. A total of 11 ducklings were fledged on the six study streams, or 73% of those observed at class IA.

Survey accuracy

Estimates of the maximum pairs using a stream were made by summing all marked pairs observed on the stream during the field season with the maximum number of unmarked pairs observed during a single survey. Twenty-three (58%) of the estimated 40 harlequin ducks on the study area were marked. An average of 49% (s.d. 15.85) of the maximum pairs estimated to actually be using the streams were observed per survey from April 25-June 5 (Figure 2).

Less than 40% of the maximum pairs were observed per survey

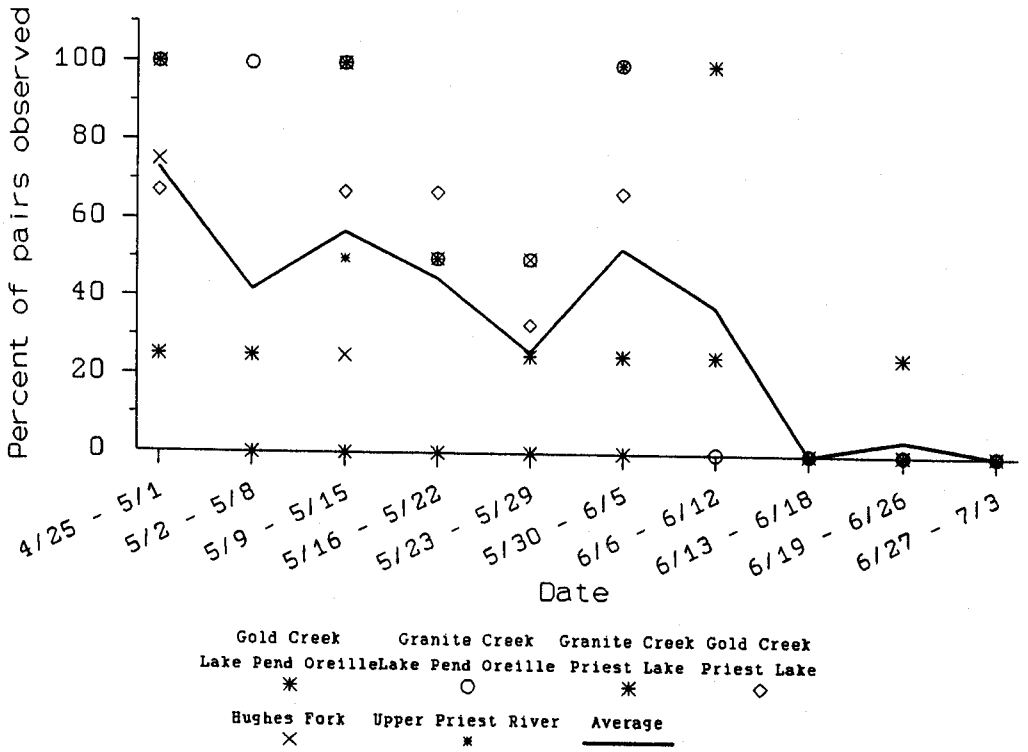


Figure 2. Percent of harlequin duck pairs actually using a stream observed per survey, 5/25-7/3/91.

June 6-June 26, the date of the last male observation. Surveys between April 25-May 1 appeared to reveal all of the pairs using Granite Creek Lake Pend Oreille, and Gold and Granite Creeks at Priest Lake and had the overall best accuracy (73%). The maximum number of pairs on Upper Priest River were observed June 5, however, for logistical reasons the first complete survey of this river was not made until May 14. On both Gold Creeks and the Hughes Fork, all pairs known to use the streams were never observed during one survey.

Chronology

Harlequin ducks were observed from April 19 (the date of the first survey), to September 9 (Figure 3). The last male was

observed on June 26 on Granite Creek at Lake Pend Oreille. The mean date for the last male observation on the six study streams was June 10 (SE 4.14). The last female without a brood was observed on August 1 on Gold Creek at Lake Pend Oreille. The average date for the last sighting of nonbreeding or unsuccessful females was July 21 (SE 2.92). Ducklings were observed from June 21 on Granite Creek at Lake Pend Oreille to September 9 on the Hughes Fork. Estimated average hatching date was June 25. The mean date of the last duckling observation was August 7 (SE 16.83).

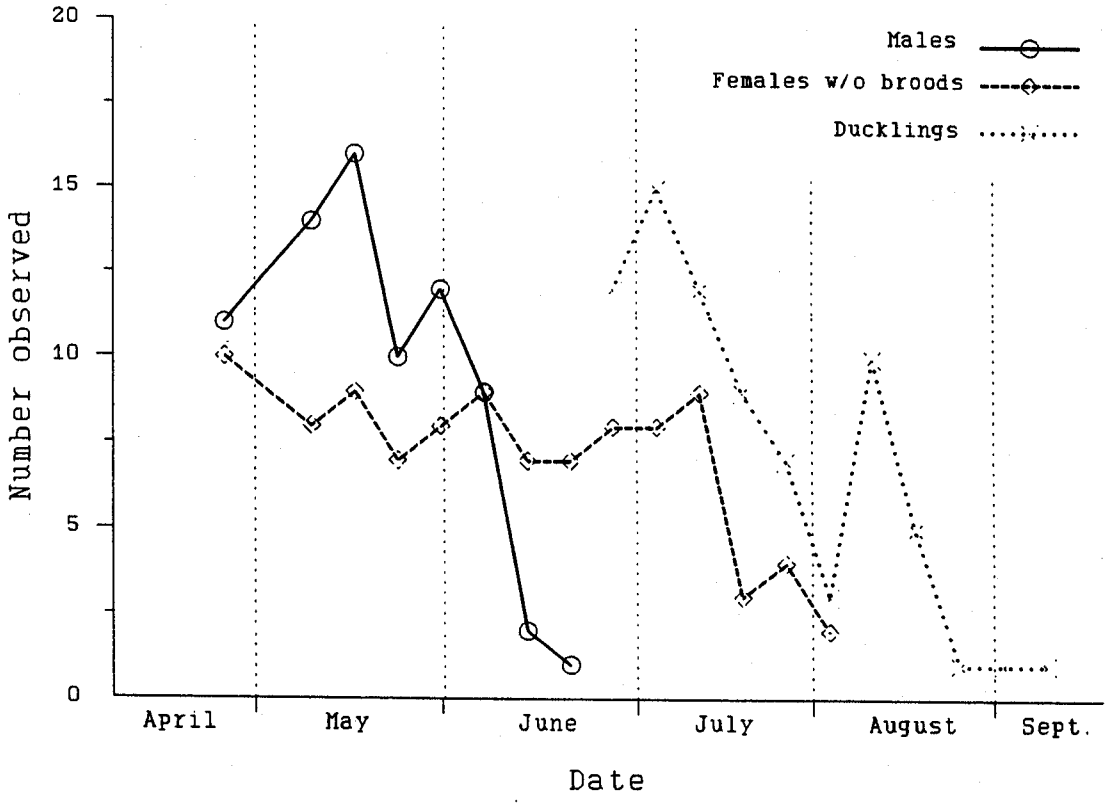


Figure 3. Chronology of male, female and duckling observations on six stream in northern Idaho, 1991.

Males were observed on streams without successful nesting an

average of two weeks longer than on streams where hens did successfully nest, although this difference was not significant. There was no difference in timing of use by females on streams with and without successful nesting. There were also no significant differences in timing of duck use between streams on Lake Pend Oreille and Priest Lake streams.

Duckling development

Ducklings in three broods all fledged by age 51 days (August 13) (Table 3). It took an average of 17 days for ducklings to reach class II.

Table 3. Duckling development in four broods, 1991.

			Age in days at class							
Stream	est. hatch date	initial brood size	IA	IB	IC	IIA	IIB	IIC	III	fledged[1]
Gold Cr., Priest Lake	6/23	5	4	8	-	15	-	24	-	51
"	6/29	3	2	-	9	-	-	-	24	41
"	6/29	2	2	-	9	16	-	-	-	-
Granite Cr., L. Pend Oreille	6/17	5	3	7	13	21	-	30	36	42

[1] first day when flight was observed.

Fledged ducklings were as large or larger than the hen and nearly indistinguishable from an adult female in the field. In the hand, ducklings had lighter legs and feet than the hen (yellowish vs. gray), a darker bill with no light callous on the end and a darker face, particularly the light patch next to the

bill. Overall, ducklings were slightly browner. The white dot near the ear was just as bright in ducklings as the hen.

Habitat Use

Harlequins were usually observed in rapids, runs, riffles and pocketwaters (75%) (Figure 4). Stream temperatures ranged from 1°C to 13°C and averaged 7°C (SE 0.49). Water velocities at harlequin observations ranged from 0.06 m/sec to 3.3 m/sec and averaged 1.3 m/sec (SE 0.05). Loafing (n = 46) occurred in faster water (1.4 m/sec) than swimming and feeding (n = 53, 1.2 m/sec, P = 0.019). Most observations (73%) were in areas with average velocities in the main stream channel of over 1 m/sec, and only one observation was in an area with an average velocity less than 0.3 m/sec. Substrate was predominantly (76%) cobble, gravel or boulder, and bank composition was primarily (79%) trees, shrubs or a tree-shrub mosaic. Seventy percent of observations were in areas that were inaccessible by road or trail, or accessible only by trail (Figure 4). Observations on the six streams were primarily (83%) in western red cedar (Thuja plicata)-western hemlock (Tsuga heterophlla) forest and only 14% of observations were in areas where logging had occurred adjacent to the creek.

Brood habitat was similar to that used by adults (Appendix E, Table 1). Ducklings were observed significantly more frequently than adults in riffles and less frequently in runs. Broods were less likely to be observed in areas without woody debris, although the average number of downed trees and logs at

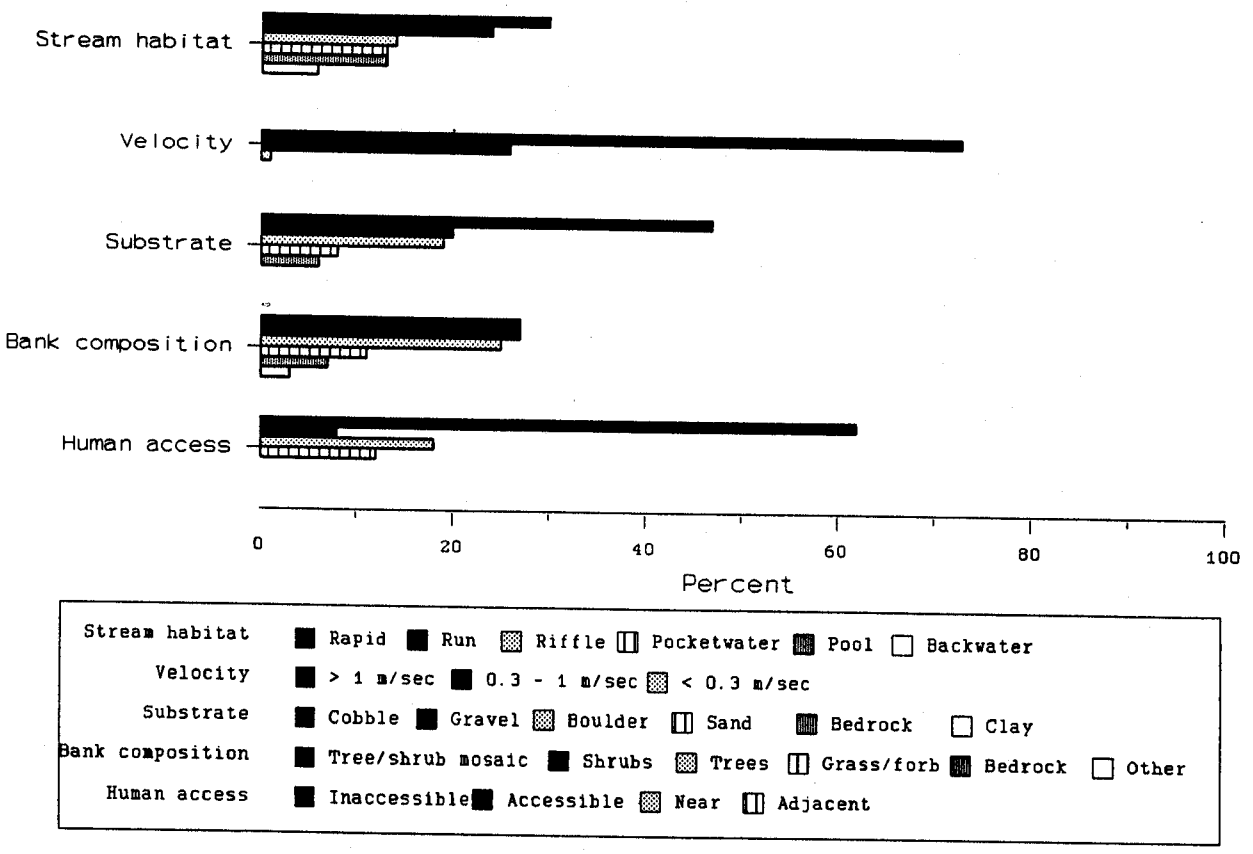
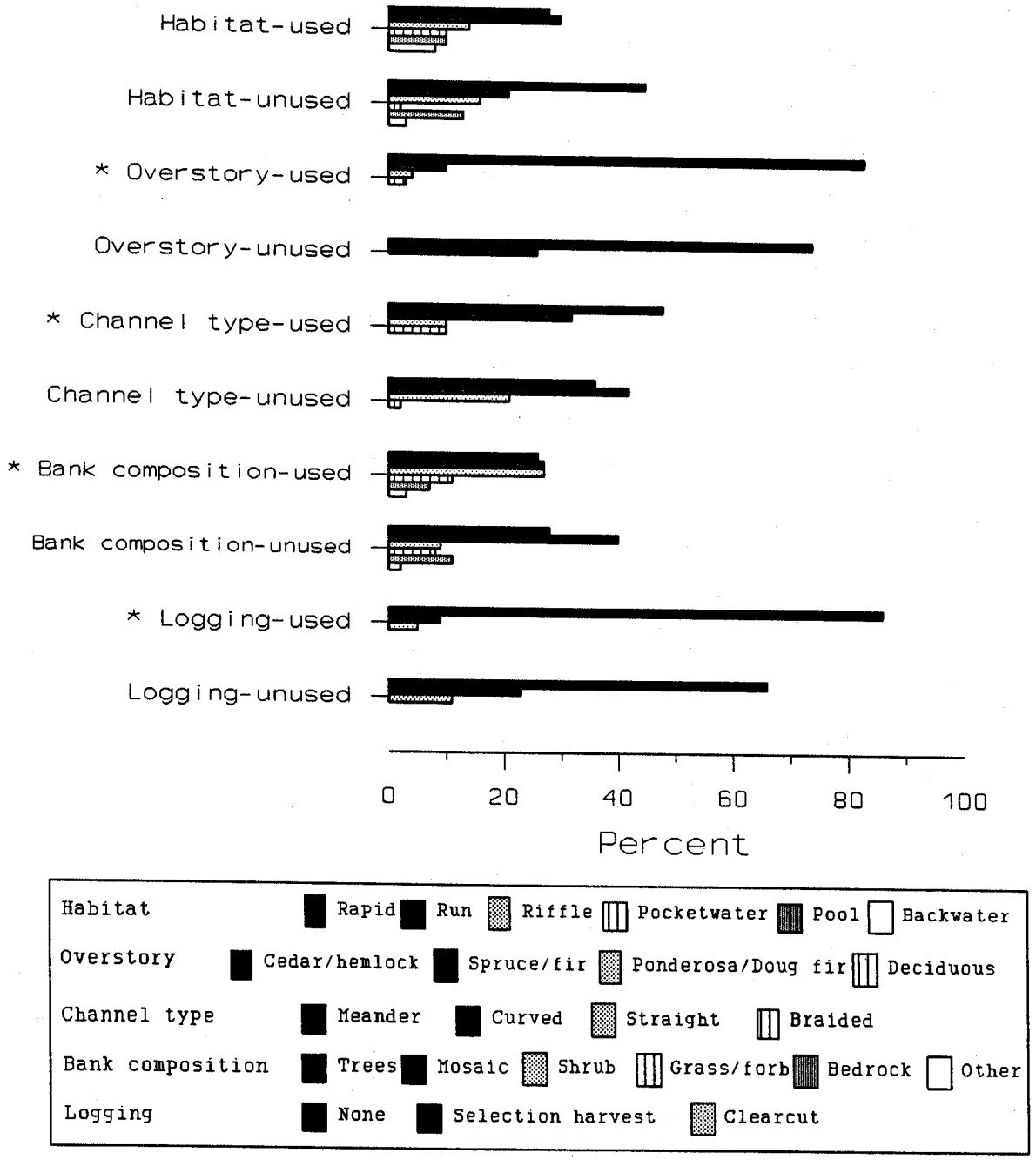


Figure 4. Habitat use by harlequin ducks on six streams in northern Idaho, 1991.

brood observations did not differ from that in areas used by adults. Broods used significantly narrower stream reaches, generally upstream of adult observations. Stream flow was slower and more loafing sites were found at brood observations, a function of low summer stream flows occurring during the brood-rearing period.

Streams where no harlequins were observed were similar in size and had similar water velocities and distribution of pool-riffle-run-pocketwater habitats to areas where harlequins were observed (Appendix E, Table 2). Streams with no use were generally higher in elevation, more commonly in spruce (Picea



* used and unused characteristics significantly different ($p < 0.05$)

Figure 5. Comparison of habitat characteristics at harlequin duck observations and on streams not used by harlequin ducks.

englemanii)/fir (Abies lasiocarpa) as opposed to cedar-hemlock

overstory, in straight channels with a greater component of bedrock and tree-shrub mosaic bank composition and a lesser shrub component. They were also more likely to have been logged (Figure 5 and Appendix E, Table 2). There were no significant differences in substrate, overstory age, accessibility, or presence of bank undercut, vegetative overhang, loafing sites or woody debris (Appendix E, Table 2).

Movements

Eight individuals located four or more times were observed over average linear reaches of 7 km with locations concentrated within 5 km (Table 4). Five hens (two located less than four times) and three broods, were observed using two streams, either adjacent streams or tributaries. Two hens nested on streams where they were never observed prior to nest discovery or hatching.

Return rates and migration

Ten of nineteen adults (53%) marked on the study streams since 1988 were observed in 1991. However, nearly all (8 of 9 marked 1988-1989) those that returned once after being marked returned again in successive years (Table 5). One male marked on Gold Creek, Lake Pend Oreille in 1990 was only observed on Granite Creek, Lake Pend Oreille in 1991. All other individuals returned to the stream where they were marked.

One hen originally marked in May 1988, was retrapped and radioed July 17, 1991. She was next located on July 30 off Battleship Island in the San Juan Islands, Washington, in the

Table 4. Areas used by eight harlequin ducks on six streams in northern Idaho, 1991.

Stream(s)	Sex	No. Locations	Time Period	Reach Length Used (km)[1]	Core Reach Length (km)[2]	No. Streams Used
Hughes/Gold	F	6	4/25-7/17	12.2	5	2
Hughes/Upper Priest	F	9	5/12-7/17	13.4	5	2
Hughes	M	5	5/12-6/6	2	2	1
Granite PDO	F	12	5/16-7/16	3.6	3.6	1
Granite PDO	F	12	5/30-8/7	4.6	4.6	1
Gold PDO	F	10	5/31-7/12	6	6	1
Gold/N. Gold PDO	F	15	5/9-7/25	7.6	7.6	2
Gold PDO	M	4	5/9-5/27	6.1	6.4	1
Average		9		6.9	5.0	

[1] Distance via stream between two furthest locations.

[2] Distance calculated between furthest locations within a stream and totalled for all streams used.

Pacific Ocean. On July 31 she was observed alone and able to fly on this small reefy National Wildlife Refuge. A boat survey of the shoreline of nearby San Juan Island revealed 20 harlequins, all south of Friday Harbor. All appeared to be females or juveniles and at least 14 were molting and flightless.

Telemetry flights on 7/29-30 covered the south shore of the Straits of Juan de Fuca, the outer coast south to Destruction Island, Protection Island, San Juan Islands, Bellingham Bay and the southern Gulf Islands. Additional ground surveys were conducted along the east coast of Vancouver Island 8/2-8/3. About 150 harlequins were observed near Point Lazo, mostly

Table 5. Return rates of adult nasal-marked harlequin ducks, 1988-1991.

	First year	Successive years[1]
Females (n=12)	7 (58%)	6 (86%)
Males (n=7)	3 (43%)	2 (100%)[2]
Combined (n=19)	10 (53%)	8 (89%)

[1] Percentages based on harlequins that had returned previous years.

[2] Data available for more than one year on only two returning males (one returning male marked in 1990).

molting males and females. None were marked and no other radio signals were heard.

In mid-September another telemetry flight was conducted over the San Juan Islands and no radio signals heard. Battleship Island was revisted on September 30; one unmarked male was observed off the island. Eleven unmarked harlequins were observed on a survey of the shoreline of nearby Henry's Island.

DISCUSSION

Population size, productivity and movements

Harlequin density and productivity continued to be low as in previous years. Lack of brood patches on most females without broods suggested mainly a lack of nesting although unsuccessful nesting and brood loss were also documented. Repeated surveys revealed that the number of harlequin ducks observed during a single survey may underestimate the number actually using the stream. This appeared to be due to the movement of harlequins between streams, particularly where several streams used by

harlequins are close together. Harlequins also occasionally moved up above survey reaches. Although ducks could also have been overlooked, data from radioed birds suggested this did not occur during our surveys. Observability was highest during the last week of April and dropped off after the first week in June.

Another factor complicating survey accuracy was the fact that some harlequin ducks appeared on northern Idaho streams for only short periods of time. The pattern of returns of marked harlequins to the study streams suggested that up to half may be transient. Some were never reobserved during the season after being marked, and many were never observed in following years. The other half of the marked population exhibited a strong site fidelity, remaining on the stream after being marked and returning to the same streams for up to three consecutive years.

Home range

Kuchel (1977, Appendix VII) documented linear home ranges averaging 7.7 km (SD 2.36) on MacDonald Creek in Glacier National Park, similar to the 7 km observed in this study. Pair use was more concentrated on MacDonald Creek, with 1-2 km core reaches as opposed to the 5 km core reaches observed in northern Idaho.

Habitat use

Habitat use by adults and broods was similar to that observed in previous years. Streams not used by harlequins were similar to areas used, although differences in elevation, channel type, bank composition and logging activity may account for lack of use on some streams. Although extensive clearcuts occur near

some streams used by harlequin ducks, such as Gold Creek, Priest Lake, substantial buffer strips of old growth or mature trees were left along the stream and roads have been closed or have washed out.

The two nests discovered in 1991 occurred in habitat considerably different from that suggested by previous studies (Bengston 1972), including use of tree and cliff cavities and proximity to swiftly flowing water. These nests were also not near areas where adults were observed during the prenesting period and, within one week of hatching, the brood from the successful nest had traveled several kilometers from the nest site. Thus, neither prenesting or brood-rearing areas corresponded to nesting locations.

Migration

The San Juan Islands area of Washington is used as a wintering or migrating area by harlequin ducks breeding in the Rocky Mountains, based on location of a hen this year and a 1989 report of a male marked in Grand Teton National Park (R. Wallen, pers. comm.). Because both were only observed in the area for a short period of time during the summer, it is not yet clear whether this is a wintering area for harlequins breeding in the Rocky Mountains or part of a migration corridor.

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APPENDIX A

Survey schedule and areas, 1991

Appendix A, Table 1. 1991 survey schedule on streams used by harlequin ducks.

Gold Cr., Lake Pend Oreille		Granite Cr., Lake Pend Oreille		Granite Cr., Priest Lake		Gold Cr., Priest Lake		Hughes Fork		Upper Priest River	
Date	Area[1]	Date	Area	Date	Area	Date	Area	Date	Area	Date	Area
5/1	GOPD1	5/1	GRPD1	4/30	GRPL1	4/29	GOPL1	4/25	HU1	5/14	UPR1
5/9	GOPD1	5/8	GRPD2	5/6	GRPL2	5/12	GOPL2	5/12	HU1	5/22	UPR1
5/16	GOPD2	5/16	GRPD1	5/13	GRPL3	5/21	GOPL1	5/23	HU1	5/29	UPR1
5/24	GOPD2	5/22	GRPD1	5/15	GRPL2	5/29	GOPL1	5/29	HU1	6/5	UPR1
5/27	GOPD2	5/24	GRPD1	5/20	GRPL4	6/5	GOPL1	6/6	HU1	6/18	UPR1
5/31	GOPD3	5/30	GRPD1	5/28	GRPL2	6/18	GOPL1	6/10	HU1	6/25	UPR1
6/2	GOPD2	6/4	GRPD1	5/30	GRPL2	6/27	GOPL1	6/17	HU1	7/1	UPR1
6/6	GOPD2	6/12	GRPD1	6/3	GRPL5	7/1	GOPL1	6/24	HU1	7/9	UPR1
6/14	GOPD1	6/21	GRPD1	6/10	GRPL2	7/8	GOPL1	7/2	HU1	7/16	UPR1
6/26	GOPD1	6/27	GRPD1	6/19	GRPL2	7/15	GOPL1	7/10	HU1	7/23	UPR1
7/3	GOPD1	7/3	GRPD1	6/26	GRPL2	7/22	GOPL1	7/17	HU1	7/29	UPR1
7/12	GOPD1	7/11	GRPD1	7/3	GRPL2	7/30	GOPL1	7/22	HU1	8/6-8/9	UPR1 UPR2
7/16	GOPD1	7/16	GRPD3	7/10	GRPL2	8/14	GOPL1	7/30	HU1	8/12	UPR1
7/25	GOPD1	7/19	GRPD1	7/18	GRPL2	8/20	GOPL1	8/9	HU2	8/19	UPR1
8/1	GOPD1	7/25	GRPD1	7/24	GRPL2	8/27	GOPL1	8/13	HU1	8/28	UPR1
8/7	GOPD1	8/1	GRPD1	7/31	GRPL2			8/21	HU1		
8/15	GOPD1	8/7	GRPD3	8/14	GRPL2			8/27	HU1		
8/21	GOPD1	8/15	GRPD1	8/21	GRPL2			9/3	HU1		
8/30	GOPD1	8/21	GRPD1	8/28	GRPL2			9/9	HU1		
		8/30	GRPD1					9/17	HU1		
								9/25	HU1		
Total	19	20		19		15		21		15	
Average interval	7	6.5		6.7		8.7		7.7		7.5	
S.D.	2.35	1.87		2.63		3.12		2.79		2.38	
Minimum	3	2		2		4		4		3	
Maximum	12	9		14		13		17		13	

[1] Areas surveyed described in Appendix A, Table 2.

Appendix A, Table 2. 1991 Survey Routes

Stream Route	From	To	km
Gold Creek, Lake Pend Oreille			
GOPD1	T54N,R1W,S10,SW road 2707 crossing	T54N,R1W,S3,NW mouth	3.2
GOPD2	T53N,R1W,S20,NW power line road	T54N,R1W,S3,NW mouth	7.0
GOPD3	T53N,R1W,S25,SW road 332 crossing	T54N,R1W,S3,NW mouth	10.1
Granite Creek, Lake Pend Oreille			
GRPD1	T55N,R1E,S29,SE road 278 crossing	T55N,R1W,S26,SE mouth	6
GOPD2	T55N,R1E,S34,NE trail 71 crossing	T55N,R1W,S26,SE mouth	9
Granite Creek, Priest Lake			
GRPL1	T38N,R45E,S26,NE (WA) below Granite Falls	T61N,R5W,S12,SW Kerr Lake	21.9
GRPL2	T38N,R45E,S26,NE (WA) below Granite Falls	T62N,R5W,S28,SE (ID) road 302 crossing	15
GRPL3	T38N,R45E,S22,NE (WA) above Granite Falls	T61N,R5W,S34,SW (ID) Blacktail Creek	18
GRPL4	T38N,R45E,S16,SE (WA) road 1122 crossing	T62N,R5W,S12,SW road 302 crossing	19.5
GRPL5	T38N,R45E,S26,NE (WA) below Granite Falls	T61N,R4W,S16,SW mouth	27.4
Gold Creek, Priest Lake			
GOPL1	T38N,R45E,S2,SW (WA) Helmer Creek	T63N,R5W,S10,SW (ID) confluence with Hughes	9
GOPL2	T38N,R45E,S12,NW (WA) Hemlock Creek	T63N,R5W,S10,SW (ID) confluence with Hughes	7.6
Hughes Fork			
HU1	T64N,R5W,S32,NE trail 311 crossing	T63N,R5W,S10,SW 1 km above confluence with Upper Priest R.	21.4
HU2	T64N,R5W,S32,NE trail 311 crossing	T63N,R5W,S13,SE Upp. Priest confluence	22.4

Appendix A, Table 2 cont'd. 1991 survey routes.

Stream Route	From	To	km
Upper Priest River			
UPR1	T65N,R5W,S14,SE Continental Creek	T63N,R5W,S2,SW road 1013 crossing	24.0
UPR2	T63N,R5W,S13,SE Hughes confluence	T63N,R5W,S19,NW mouth	2.1
Cedar Creek	T54N,R1W,S10,SE powerline	T54N,R1W,S22,NE mouth	2.7
North Gold	T53N,R1W,S1,SE Branch North Gold	T53N,R1W,S3,NE mouth	3.8
Beaver Creek	T62N,R5W,S1,SW	T62N,R4W,S9,NE mouth	5.9
Blacktail Creek	T62N,R5W,S22,NW	T62N,R5W,S34,SW confluence with Granite Creek	4.7
Caribou Creek	T63N,R3W,S28,NE Abandon Creek	T62N,R4W,S4,NE 1 km above mouth	5.5
Lion Creek	T62N,R4W,S4,NW end of road	T62N,R4W,S10,NE mouth	8.2
North Twin	T54N,R1W,S23,SE Beaver pond	T54N,R1W,S26,NE road 278 crossing	0.5
Two Mouth Creek	T62N,R3W,S28,NE end of road	T62N,R4W,S34,NE mouth	10.2
South Fork Granite Creek	T36N,R45E,S20,SE (WA) end of road	T62N,R5W,S30,NW (ID)	9.9
Tillicum Creek	T37N,R45E,S35,SW (WA)	T37N,R45E,S11,NW (WA) confluence with N. Fork Granite Creek	2.7
Willow Creek	T38N,R45E,S28,SW (WA) Road 1122 crossing	T38N,R45E,S23,NW (WA) N. Fork Granite	3.1

APPENDIX B

Trapping record 1991

Appendix B, Table 1. Harlequin duck trapping record, 1991.

Date	Creek	Age Sex	Band Number	Marker left	Marker right	Radio frequency	Body length (cm)	Culmen length (mm)	Weight (gm)	Wing length (cm)
5/9	Gold PDO	AHYF	805-90236	Red +	White +	151.873	415	24.0	610	205
5/9	Gold PDO	AHYM	805-90237	Blue +	White +	_	430	25.6	590	205
5/16	Granite PDO	AHYF	805-90238	Green +	Red +	151.788	410	26.0	590	202
5/16	Granite PDO	AHYM	805-90239	Yellow +	Red +	-	445	27.2	590	220
5/21	Granite PDO	AHYM	805-90241	Purple oval	White oval	-	440	24.8	590	440
5/27	Granite PDO	AHYM	805-90240	White oval	Tan oval	-	450	26.8	610	210
5/31	Gold PDO	AHYF	805-90242	White oval	White oval	151.198	415	26.4	585	214
6/10	Granite PL	AHYF	805-90243	White +	Gray +	151.160	415	24.8	520	207
7/3	Gold PDO	AHYF	805-90244	Green oval	Orange oval	-	436	26.0	530	210
7/8	Gold PL	AHYF	805-90245	Blue +	Black +	151.834	410	24.4	500	205
7/17	Upper Priest	AHYF	805-90246	Pink oval	Green oval	151.197	428	25.4	525	203
8/7	Granite PDO	L	805-90248	-	-	-	411	25.7	570	197
8/7	Granite PDO	L	805-90249	-	-	-	411	25.4	520	194
8/7	Granite PDO	L	-	-	-	-	435	27.2	605	200
8/7	Granite PDO	AHYF	-	-	-	-	422	26.7	595	201
8/12	Hughes Fork	L	805-90247	-	-	-	385	23.8	515	194
8/12	Hughes Fork	L	805-90250	-	-	-	410	24.0	480	190
8/12	Hughes Fork	L	805-90251	-	-	-	440	26.2	545	195
8/12	Hughes Fork	L	805-90252	-	-	-	394	24.6	520	195
8/12	Hughes Fork	AHYF	805-90253	-	-	-	450	25.2	590	211

Appendix B, Table 2. Harlequin duck retraps, 1991.

Date	Creek	Age Sex	Band Number	Marker left	Marker right	Radio frequency	Body length (cm)	Culmen length (mm)	Weight (gm)	Wing length (cm)
5/31	Gold PDO	AHYF	805-90217	Blue +	Green +	151.178	-	-	540	-
5/9	Gold PDO	AHYM	805-90240	White oval	Tan oval	-	-	-	610	-
6/13	Granite PDO	AHYF	805-90238	Green +	Red +	151.788	-	-	460	-
6/21	Gold PDO	AHYF	805-90242	White oval	White oval	151.198	-	-	500	-
7/10	Hughes Fork	AHYF	805-90218	White plus	White plus	151.788	-	-	560	-
7/17	Upper Priest	AHYF	805-90204	Yellow +	Orange +	151.126	-	-	590	-

APPENDIX C

Habitat use data sheet, 1991.

HARLEQUIN DUCK DATA SHEET 1991

DATE_____ TIME_____ STREAM_____ OBSERVER_____

OBSERVATION TYPE- NO._____SEX_____AGE CLASS_____

ACTIVITY **LO** LOAFING **SW** SWIMMING **SF** SWIMMING/FEEDING **FL** FLYING

OT OTHER Explain_____

CIRCLE ONE	CIRCLE ONE PER DUCK	CIRCLE ONE	CIRCLE UP TO TWO
HABITAT	**LOCATION**	**SUBSTRATE**	**BANK COMPOSITION**
PO POOL	**BA** BANK	**CL** CLAY	**TR** TREES
BA BACKWATER	**LO** LOAF	**SA** SAND	**SH** SHRUB
RI RIFFLE	**EY** EDDY	**GR** GRAVEL	**GF** GRASS/FORB
RU RUN	**ED** EDGE	**CO** COBBLE	**MO** TREE/SHRUB MOSAIC
GL GLIDE	**BT** BANK 1/3	**BO** BOULDER	**SA** SAND
PW POCKETWATER	**CE** CENTER	**BE** BEDROCK	**SI** SILT
RA RAPID			**GR** GRAVEL
			DE DEBRIS
			BE BEDROCK

CIRCLE AS APPROPRIATE

OVERSTORY AGE	**TIMBER MGMT**	**CHANNEL TYPE**	**HUMAN ACCESS**
SE SEEDLING	**NO** NONE	**ME** MEANDER	**AD** ADJACENT
SA SAPLING	**CL** CLEARCUT	**BR** BRAIDED	**NE** NEAR
PO POLE	**ST** SEED TREE	**ST** STRAIGHT	**AC** ACCESSIBLE
IM IMMATURE	**SW** SHELTERWOOD	**CU** CURVED	**IN** INACCESSIBLE
MA MATURE	**CT** COMM. THIN		
OG OLD-GROWTH	**SH** SELECTION HARVEST		

DEBRIS / 10 M
ENTER # OF EACH TYPE

BR BRIDGE_____
CB COLLAPSED BRIDGE____
RA RAMP_____
DR DRIFT_____

LOAFING SITES / 10M____

STREAM WIDTH (M)_____

OVERSTORY SPP._____

DENSIOMETER READING_____ _____ _____ _____

BANK UNDERCUT Y N

VEG. OVERHANG Y N

WATER VELOCITY _____ _____ _____

UTMN_____ UTME_____

T_____ R_____ S_____ 1/4_____

COMMENTS_____

STREAM HABITAT
POOL- deep slow water areas in the stream.
BACKWATER- slow water area out of the main stream channel.
RIFFLE- shallow water areas where the water surface is influenced by the stream bottom.
RUN- deeper than a riffle, no whitewater but velocity greater than 0.3 m/sec, too fast to be a glide or pool.
GLIDE- run areas with velocities < 0.3 m/sec.
POCKETWATER- a run or riffle with boulders (> 30 cm in diameter) which create numerous small pools.
RAPID- deep fast water, water influenced by stream bottom and/or streambank (whitewater).

LOCATION
BANK- on streambank.
LOAF- loafing on rock or log.
EDDY- in an eddy created by a rock or log.
EDGE- at the very edge of the stream next to the bank-in the bank eddy.
BANK 1/3- not directly adjacent to the bank but in the third of the stream closest to the bank, not in an eddy.
CENTER- in the water in the center third of the stream, not in an eddy.

SUBSTRATE
GRAVEL- 0.2-7 cm (0.1"-3") diameter
COBBLE- 8-30 cm (3"-12")
BOULDER- >30 cm

OVERSTORY AGE
SEEDLING- 1-10 years old, < 4.5' tall.
SAPLING- 10-40 years old, > 4.5'tall, DBH <5"
POLE- 40-70 years old, DBH 5"-9".
IMMATURE- 70-100 years old, DBH 9"-14".
MATURE- 100-160 years old, DBH 14"-20".
OLD GROWTH- over 160 years old or DBH > 20".

CHANNEL TYPE
MEANDER- channel follows sinuous curves, deep pools separated by shallow riffles, appears to shift slightly during peak flows.
BRAIDED- channel located in flat bottomed valley, midstream bars occur and divide the stream into several intersecting and shifting channels.
STRAIGHT- stream channel linear, structurally controlled by a "V" shaped valley. No movement of channel during peak flows.
CURVED- stream channel curves or zig-zags more abruptly than a meander. Channel structurally controlled by a "V" shaped valley, no movement during peak flows.

HUMAN ACCESS
ADJACENT-established area of human activity maintained within 10 m.
NEAR- established area of human activity maintained within 10-50 m.
ACCESSIBLE- >50 m from human activity, accessible by boat or trail.
INACCESSIBLE- >50 m from human activity, not accessible by boat or trail.

WOODY DEBRIS
BRIDGE- log across stream.
COLLAPSED BRIDGE- log across stream, submerged in the middle of the stream.
RAMP- one end of log in the stream, the other on the bank.
DRIFT- log floating in stream.

LOAFING SITE- rocks or log in the stream completely surrounded by water, suitable for resting site.

VEGETATIVE OVERHANG-vegetation extending over the stream within 12" of the water surface.

APPENDIX D

Description of harlequin duck nests located in 1991

CAVITY NESTING BY HARLEQUIN DUCKS IN THE PACIFIC NORTHWEST

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cliff nest is 00% on North Gold Creek
tree nest is 01% on Granite Creek

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Abstract. Three Harlequin Duck (Histrionicus histrionicus) nests were found along streams in northern Idaho and northwestern Washington. Two were in tree cavities, the third in a rock cavity on a cliff face. One of the tree cavity nests was at ground level immediately adjacent to the stream, the other was 1.8 m above the ground and 14.1 m from water. The cliff nest was 3 m directly above the stream. One of the tree nests was successful, the 00% cliff nest was unsuccessful (eggs did not hatch), and the fate of the other tree nest was unknown. This constitutes the first documentation of harlequin duck nesting in tree cavities and establishes the species as both a ground and cavity nester.

Key words: Histrionicus histrionicus, Harlequin Duck, nest,

eggs, Washington, Idaho.

Although Harlequin Ducks (Histrionicus histrionicus) are relatively common winter residents along the Pacific Coast of North America, little is known about their breeding biology, particularly nesting characteristics. The species occurs in two distinct populations: Atlantic and Pacific (AOU 1983). Most published nest records are from Iceland in the Atlantic population where 90% of 98 nests were found on the ground in dense vegetation and 10% in rocky hollows or lava cavities adjacent to swiftly flowing streams (Bengston 1972). The lack of adequate data from areas outside Iceland, and the sometimes conflicting nature of old records has led to disagreement as to whether Harlequin Ducks are sometimes cavity nesters (Merriam 1883, Bent 1925, Johnsgard 1960, Bengston 1966, Larrison 1967), or whether they are ground nesters, occasionally nesting in areas sheltered by rocks or woody debris (Myres 1959, Gudmundsson 1971, Burleigh 1972, Palmer 1976). Several accounts have dismissed old reports of cavity nesting, particularly in trees, as erroneous (Gudmundsson 1971, Palmer 1976).

We are aware of only eight published nest site descriptions from the Pacific population of Harlequin Ducks. Nests have been described from the states of Washington and Alaska (Bent 1925), Oregon (Jewett 1931), and Montana (Thompson 1985), and the province of British Columbia (Campbell et al. 1990). Three were on rocks, two on the ground, one in a cliff face (Bent 1925,

Campbell et al. 1990) and two in piles of woody debris adjacent to the stream (Jewett 1931, Thompson 1985). No documentation was found for nesting in tree cavities.

We describe three Harlequin Duck nests discovered in May and June 1991, in northern Idaho and northwestern Washington. Two were located in tree cavities, and a third in a rock cavity in a cliff face.

STUDY AREA

Nests were located near two tributaries to Lake Pend Oreille (47°55'N, 116°30') in northern Idaho and near the Elwha River on the Olympic peninsula (47°52'N, 123°57') in northwestern Washington.

The climate around 383 km^2 Lake Pend Oreille (elev. 629 m) is cool northern continental with a Pacific maritime influence. Annual precipitation averages 61 cm, 22% of which occurs as rain or snow during the Harlequin Duck nesting season in April, May and June. The tributaries where nests were located are 3rd and 4th order forested streams originating in the Coeur d'Alene Mountains. Dominant tree species along the streams are western redcedar (Thuja plicata) and western hemlock (Tsuga heterophylla), most over 70 years old. The understory is depauperate except in some areas immediately adjacent to the streams, where it is dominated by willow (Salix spp.), dogwood (Cornus stolonifera), alder (Alnus incana) and Devil's club (Oplopanax horridum). Human activity near the streams is low, particularly during the spring nesting season. The study area is

primarily on the Idaho Panhandle National Forests, adjacent to several private inholdings, and is accessible by boat or logging road. There are no hiking trails along the streams and both streams are closed to fishing until 1 July.

The Elwha River area has a moist coastal temperate climate. Annual precipitation averages 143 cm, most of which occurs as rainfall. The Elwha is a steep fluvial carved, V-shaped, 4th-order river canyon originating in the glaciers of the Olympic Mountains. High rainfall and snow melt cause peak flows during the Harlequin nesting season of 34 m^3/s - 74 m^3/s. Dominant tree species in the river bottom include Douglas-fir (Pseudotsuga menzeisii), Western hemlock, grand fir (Abies grandis), and red alder (Alnus rubra). Frequent fire episodes in the Elwha Valley create subclimax forest stages. The understory consists primarily of mosses and ferns (Fonda and Bliss 1969). The area is within Olympic National Park and accessible only by trail which is heavily used during the summer.

METHODS

One Idaho nest and the Washington nest were located in the course of stream surveys conducted during studies of Harlequin Duck ecology and distribution. These surveys consisted of walking in or along the stream reaches used by Harlequin Ducks and recording all observations of the species. Surveys were conducted approximately weekly in Idaho between April 25 - August 30. The Elwha River and other streams in Washington were surveyed once between May 1 - June 15.

The second Idaho nest was discovered using radiotelemetry. The hen was trapped prior to the nesting season in a 10 cm mesh mist net set up across the stream. A 3.9 g transmitter (Holohil Systems Ltd., Model PD-2) was temporarily (45 days) sutured between the wings, directly behind the nape. Transmitter range using a two-element "H" antenna (Telonics, Inc.) was approximately 1 km.

Nest site characteristics were measured when the nests were first discovered. Egg measurements were taken when the hen was absent from the nest during incubation breaks. Characteristics of the nest and nest cavity were measured after hatching or nest abandonment in Idaho and during an incubation break in Washington.

Stream velocity was estimated by measuring the length of time a fishing bobber thrown into the stream adjacent to the nest took to travel 5 m. Stream gradient was measured off topographic maps in a 100 m stream reach around the nest site (Idaho) and with a clinometer (Washington).

RESULTS

The Washington nest (Figure 1) was discovered after a pair of Harlequins were observed copulating on a slackwater pond 20 m inland of the main river. A male was later flushed in a wooded area 200 m downstream. He flew to the base of a snag, a female Harlequin flushed from a cavity in the tree, and the pair flew downstream.

In Idaho, adults were extremely secretive and were never

observed near nest sites. The tree nest (Figure 2) was located upstream from all but one adult observation. This nest was discovered when R. N. Anderson happened to look into the cavity during a stream survey. After he stood by the tree for several minutes, the hen flushed from the nest without covering the eggs. The Idaho cliff nest (Figure 3) was located on a small, 3rd order creek adjacent to the larger 4th order stream where the hen was marked and usually observed during weekly surveys. This (radioed) hen also moved off the nesting stream to the adjacent stream during incubation breaks. Because the nest was not on a regularly surveyed stream, it was not discovered until the hen had been incubating for about two weeks.

Idaho nest site description

Both nests in Idaho were located in relatively steep stream reaches immediately adjacent to the stream (Table 1). The cliff nest was located in a canyon between the bottom of a waterfall and a debris jam about 2 km from the lake. The tree nest was located next to a rapids, about 4 km above the lake in a hollow, living cottonwood (Populus trichocarpa).

There was almost no human activity near either site although a logging road was located 150 m from both nests but 55-60 m above the stream, and a power transmission line crossed the stream just downstream from the cliff nest. The road and the transmission line were not visible from the cliff nest site. The road was visible from the tree nest site, although the vertical depth of the tree cavity completely hid the hen while incubating.

Washington nest site description

The Washington nest was located adjacent to a trail on a 43° slope. The cavity was in a 3.7 m tall big leaf maple (Acer macrophylum) snag. The snag was 14.1 m from a backwater oxbow of the river and 24.7 m from the main river, in a grand fir and Douglas fir stand with an alder and vine maple (Acer circinatum) understory. The adjacent Elwha trail (1.3 m away) is a popular hiking trail, however, use is relatively low during the May nest initiation period. The nest was also within 25 m of a backcountry horse corral.

Description of nests and eggs

Nests were just large enough to hold the eggs (clutch sizes 5,7,3). They were composed primarily of gray-brown down and some white-tipped chest feathers. There was a minor component of moss and twigs in the cliff nest and some woody material mixed in with the feathers in the tree cavities. Although several authors have reported Harlequin nests as being lined with white down (Harrison 1979, Bellrose 1980), Harlequin Duck down is not white and this appears to an error.

Eggs were off-white in color. Egg size differed significantly between the two Idaho clutches (Table 2) but all were within the size range reported from the Atlantic population (Bent 1925). The eggs from the smaller clutch were significantly larger than those from the larger clutch, but all three were infertile. The reason for the small clutch size and failure of this nest is unknown. Radio transmitters can affect the behavior of diving

ducks (Korschgen et al. 1984), although radioed Harlequin Ducks have nested successfully (R. Wallen, S. Patten, pers. comm.).

Nesting Activity

On 12 June 1991, approximately 1 week prior to hatching, the Idaho Harlequin Duck tree nest was observed nearly continuously from 0530 to 1900. When first observed at 0530, the hen appeared to be sleeping. She did not leave the nest until 1755. The other Idaho hen also apparently took incubation breaks in the evening as she was observed on the stream adjacent to the nesting stream at 1930 approximately 2 weeks into incubation. All nests were covered with down when the hen left to feed.

When the Elwha nest was discovered on 15 May, the hen was brooding eggs in a chamber that was nearly devoid of downy material. The lack of downy nesting material and presence of the male near the nest site suggest that the nesting phase had just been initiated. Subsequent visits to the nest in June revealed covered eggs in a heavy bed of down. It was difficult to establish a precise pattern of incubation and feeding activity on the Elwha nest due to the limited number of observations. On three different days during the early nesting phase the hen was flushed from the nest at 2102, 0950, and 0840. On the final visit to the nest on 4 June the hen was brooding at 0820 and was absent from 1000 - 1230.

DISCUSSION

These nests establish Harlequin Ducks as both cavity and ground nesters. Harlequin Ducks will use tree and cliff cavities when

available, although cavities are not essential to Harlequin Duck nesting in the Pacific Northwest. Prior to this study, three ground nests were found in the Washington study area and elsewhere in the Olympic Mountains (Washington Department of Wildlife, unpublished data). These nests were constructed of fine twigs and located within 3.1 m of the stream.

Advantages of cavity nesting may be shelter from the elements, such as cold, wet weather and floods, and protection against predators (Collias and Collias 1984). Cavity nests can also be less elaborate than ground nests. The cavity nests described here were constructed almost entirely from down and feathers as opposed to a down-lined nest constructed from grasses and twigs as is typical for ground nests (Bent 1925, Bellrose 1980). It is also possible that nest type merely reflects site availability.

Harlequin Ducks are also thought to avoid areas of human activity during nesting (Kuchel 1977, Wallen 1987). Although this appeared to be the case in Idaho, the hen along the Elwha apparently habituated to hiking activity in the vicinity of the nest site. On two occasions hikers were observed passing within 1.3 m without flushing the female from the nest. We attribute this tolerance to the height of the nest entrance (1.8 m) and the depth of the nest cavity allowing her to remain completly hidden.

Finding Harlequin Duck nests is extremely difficult without the use of radiotelemetry because of the low nest density in most areas and the secretiveness of the species around the nest. Perhaps the most likely time to find nests is in the evening

during nest-building, egg-laying, or early incubation as occurred in Washington, when males are still on the breeding streams. Activity of Harlequin Ducks around the nest site appears to be most prevalent at dusk.

ACKNOWLEDGEMENTS

We appreciate the assistance of M. J. Ulliman, M. R. Robertson and S. Hise with field surveys. J. J. Rotella provided advice on radiotelemetry techniques and C. Pilling, B. C. Scheuch and Dr. D. Yearout were very helpful in initial telemetry trials. We thank the U.S. Forest Service Intermountain Research Station, Idaho Panhandle National Forests, Washington Department of Wildlife, Idaho Department of Fish and Game, and National Park Service for funding and logistic support.

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Table 1. Characteristics of Harlequin Duck nest sites in northern Idaho and western Washington, 1991.

	Nest		
	1	2	3
Date found Location	15 May, 1991 Washington	6 June, 1991 Idaho	14 June, 1991 Idaho
Distance to stream (m)	24.7	0.3	0
Stream width (m)	17	6.6	4.9
Stream gradient (%)	6	4	11
Stream velocity (m/s)	1.3	1.7	1.3
Nest height above ground (m)	1.8	0	3
Cavity opening dimensions (cm)			
Height/Length	15	40	25
Width	36	45	64
Interior dimensions			
Horizontal depth/diameter	38	60	30
Vertical depth	61	50	0
Tree diameter (m)	0.59	0.47	n/a
Distance from road or trail (m)	1.27 (trail)	150 (road)	150 (road)
Successful	unknown	Yes	No

Table 2. Characteristics of eggs in two Harlequin Duck nests in Idaho, 1991.

Clutch size	Average length (mm)	Average width (mm)	Egg mass (g)
7	54.3[2]	40.7	50.3[2]
3	59.8	41.4	57.4

1 egg mass calculated as $m=0.00056 \times (\text{length} \times \text{width}^2)$ (Rohwer and Eisenhauer 1989).

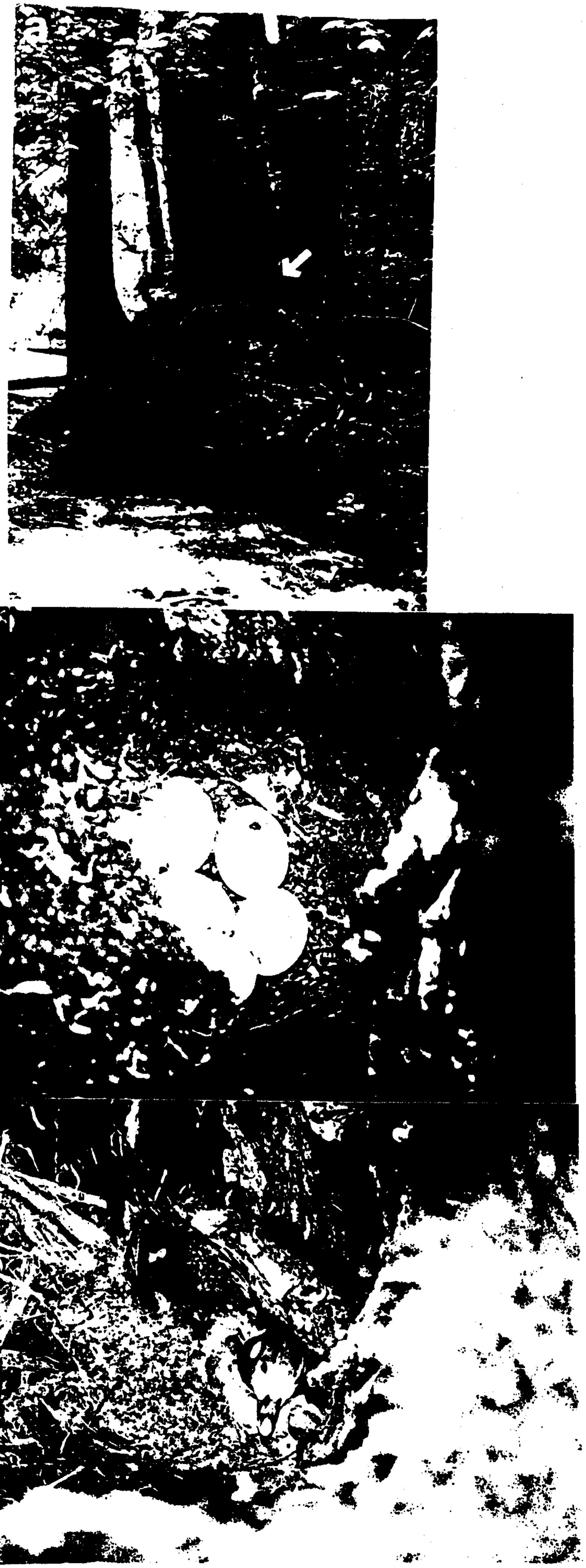
2 values differed significantly between nests (Mann-Whitney $\underline{U}$ = 18, df 3,2; $p = 0.05$).

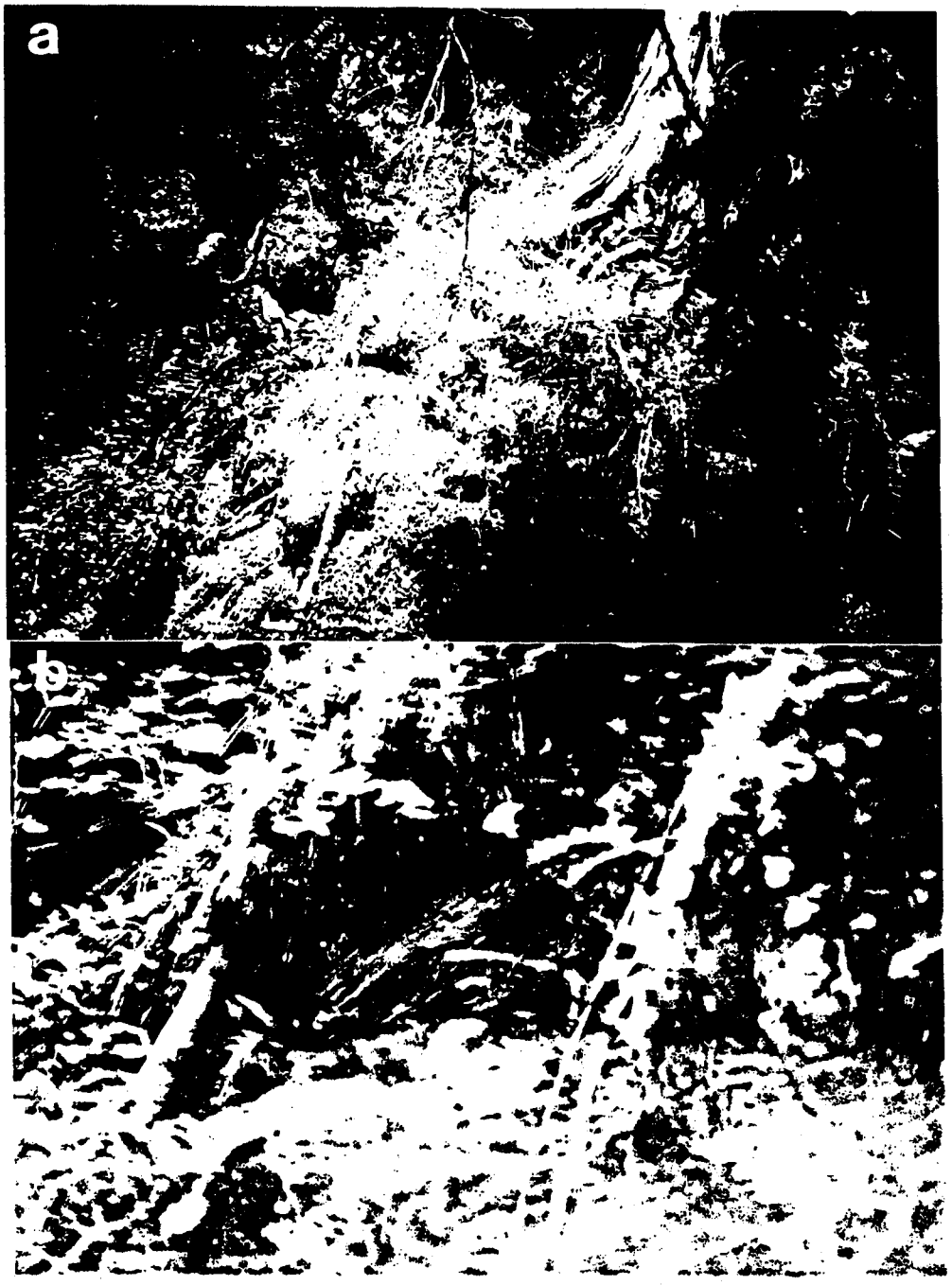
Figure 1. The Washington tree nest. a. Nest tree. b. Close-up of tree with arrow showing cavity entrance. c. Closeup of nest.

Figure 2. The Idaho tree nest. a. Nest tree with arrow showing nest location. b. Close-up of nest. c. Hen on nest.

Figure 3. The Idaho cliff nest. a. Cliff face with arrow showing nest location. b. Hen on nest.


a
b
c


b
c


a
b

APPENDIX E

Habitat use comparisons, 1991

Appendix F, Table 1. Comparison of adult and brood habitat use, 1991.

Stream habitat $X^2 = 12.97$, $P = 0.024$

	Riffle	Run	Rapid	Pocketwater	Pool	Backwater
Adults n=111 Percent	11.7	28.8	32.5	11.7	9.9	5.4
Broods n=25 Percent	24.0	4.0	20.0	20.0	24.0	8.0
Confidence interval $a = 0.05$	2.6-20.8	16.0-41.6	19.2-45.6	2.6-20.8	1.5-18.3	0-11.8
Difference[1]	+	-	o	o	+	o

Substrate $X^2 = 10.44$, $P = 0.064$

	Cobble	Boulder	Gravel	Sand	Clay	Bedrock
Adults n=111 Percent	48.7	15.3	19.8	8.1	0.9	7.2
Broods n=24 Percent	41.7	37.5	19.8	0	4.2	0
Confidence interval $a = 0.05$	34.6-62.8	5.2-25.4	8.6-31.0	0.4-15.7	0-9.9	0-14.5
Difference[1]	o	+	o	-	o	o

[1] o = no difference, + = brood observed more often in habitat, - = broods observed less often in habitat

Comparison of brood and adult habitat use, 1991, cont'd.

Channel type $X^2 = 1.403$ $P = 0.705$

	Straight	Curved	Meander	Braided
Adults n=111 Percent	10.8	31.5	48.7	9.0
Broods n=24 Percent	4.2	37.5	45.8	12.5

Bank Composition $X^2 = 8.61$, P = 0.197

	Trees	Tree/shrub mosaic	Shrub	Grass/forb	Gravel
Adults n=222 Percent	25.2	29.3	26.6	10.4	1.3
Broods n=50 Percent	28.0	16.0	32.0	10.0	6.0

Bank composition cont'd.

	Bedrock	Debris
Adults n=222 Percent	6.7	0.5
Broods n=50 Percent	6.0	2.0

Comparison of brood and adult habitat use, 1991, cont'd.

Overstory age $X^2 = 5.435$, $P = 0.245$

	Old growth	Mature	Immature	Pole	Sapling
Adults n=111 Percent	18.9	59.5	16.2	1.8	3.6
Broods n=25 Percent	8.0	80.0	4.0	4.0	4.0

Logging history $X^2 = 3.617$, $P = 0.164$

	None	Selection harvest	Clearcut
Adults n=111 Percent	86.5	9.9	3.6
Broods n=25 Percent	84.0	4.0	12.0

Human access $X^2 = 4.825$, $P = 0.185$

	Inaccessible	Accessible	Near	Adjacent
Adults n=111 Percent	63.1	8.1	15.3	13.5
Broods n=25 Percent	56.0	8.0	32.0	4.0

Comparison of brood and adult habitat use, 1991, cont'd.

Vegetative overhang $X^2 = 0.001$, $P = 0.973$

	No	Yes
Adults n=111 Percent	24.3	75.7
Broods n=13 Percent	24.0	76.0

Bank Undercut $X^2 = 0.016$, $P = 0.898$

	No	Yes
Adults n=111 Percent	33.3	66.7
Broods n=25 Percent	32.0	68.0

Woody debris within 10 m $X^2 = 0.844$, $P = 0.656$

	None	One	>One
Adults n=111 Percent	31.5	27.0	41.5
Broods n=25 Percent	40.0	20.0	40.0
Confidence interval $a = 0.05$	18.0- 43.6	24.9- 51.9	18.0- 43.6
Difference[1]	-	+	o

[1] o = no difference, + = brood observed more often in habitat, - = broods observed less often in habitat

Comparison of brood and adult habitat use, 1991, cont'd.

Loafing sites within 10 m $X^2 = 2.217$, $P = 0.330$

	None	One	>One
Adults n=111 Percent	17.1	22.5	60.4
Broods n=25 Percent	12.0	12.0	76.0

Forest type $X^2 = 12.40$, $P = 0.006$

	Cedar/ hemlock	Spruce/ fir	Ponderosa pine/ Douglas fir	Deciduous
Adults n=111 Percent	83.8	11.7	1.8	2.7
Broods n=25 Percent	80.0	0.0	16.0	4.0
Confidence interval $a = 0.05$	74.2-93.4	3.4-20.1	0-5.3	0-6.9
Difference[1]	o	-	+	o

Stream width $X^2 = 1.099$, $P = 0.577$

	1-9 m	10-19 m	> 19 m
Adults n=111 Percent	69.4	27.0	3.6
Broods n=25 Percent	76.0	24.0	0

[1] o = no difference, + = brood observed more often in habitat, - = broods observed less often in habitat

Comparison of brood and adult habitat use, 1991, cont'd.

	Adults (n=111)		Broods (n=25)		P
	$\bar{x}$	s.d.	$\bar{x}$	s.d	
Stream width (m)	8.3	4.02	6.8	2.35	0.02
Water velocity (m/sec)[1]	1.36	0.54	1.11	0.40	0.05
Loafing sites/10m	3.1	3.43	6.0	7.47	0.06
Elevation (m)	2699	463.25	2794	594.09	0.39
Debris/10m	1.9	2.22	1.8	2.48	0.81

[1] Adults n=92, broods n=22

Appendix F, Table 2. Comparison of habitat at harlequin duck observations and on streams not used by harlequin ducks, 1991.

Stream habitat, *May 2-June 4*, $X^2 = 6.90$, $P = 0.228$

	Riffle	Run	Rapid	Pocketwater	Pool	Backwater or Glide
Use n=50 Percent	14.0	30.0	28.0	10.0	10.0	8.0
No use n=53 Percent	15.9	20.8	45.3	1.9	13.2	3.8

Substrate $X^2 = 6.088$, $P = 0.298$

	Cobble	Boulder	Gravel	Sand	Clay	Bedrock
Use n=136 Percent	47.1	19.1	19.9	6.6	1.5	5.9
No use n=53 Percent	32.1	24.5	22.6	7.6	0	13.2

Channel type $X^2 = 9.074$ $P = 0.028$

	Straight	Curved	Meander	Braided
Use n=136 Percent	9.6	32.3	48.5	9.6
No use n=53 Percent	20.8	41.5	35.9	1.9
Confidence interval $a = 0.05$	3.3-15.8	22.4-42.3	37.9-59.2	3.3-15.8
Difference[1]	-	o	+	+

[1] o = no difference, + = observed more often in habitat, - = observed less often in habitat

Comparison of used and unused habitat, 1991, cont'd.

Bank Composition $X^2 = 20.546$, $P = 0.002$

	Trees	Tree/shrub mosaic	Shrub	Grass/forb	Gravel
Use n=274 Percent	25.5	27.0	27.4	10.6	2.2
No use n=106 Percent	28.3	39.6	8.5	7.6	2.8
Confidence interval $a = 0.05$	18.1-33.0	19.8-34.2	19.7-35.0	5.6-15.6	0-4.6
Difference[1]	o	-	+	o	o

Bank composition cont'd.

	Bedrock	Debris
Use n=274 Percent	6.6	0.7
No use n=53 Percent	11.3	1.9
Confidence interval $a = 0.05$	2.5-10.6	0-2.1
Difference[1]	-	o

Overstory age $X^2 = 7.172$, $P = 0.067$

	Old growth	Mature	Immature	Sapling/Pole
Use n=137 Percent	16.8	63.5	13.9	5.8
No use n=53 Percent	9.4	60.4	28.3	1.9

[1] o = no difference, + = observed more often in habitat, - = observed less often in habitat

Comparison of used and unused habitat, 1991, cont'd.

Logging history $X^2 = 9.902$, $P = 0.007$

	None	Selection harvest	Clearcut
Use n=137			
Percent	86.1	8.8	5.1
No use n=53			
Percent	66.0	22.7	11.3
Confidence interval $a = 0.05$	79.0-93.2	3.0-14.6	0.6-9.6
Difference[1]	+	-	-

Human access $X^2 = 5.699$, $P = 0.127$

	Inaccessible	Accessible	Near	Adjacent
Use n=137				
Percent	62.0	8.0	18.3	11.7
No use n=53				
Percent	64.2	0	26.4	9.4

Vegetative overhang $X^2 = 0.162$, $P = 0.687$

	No	Yes
Use n=137		
Percent	24.1	75.9
No use n=52		
Percent	26.9	73.1

[1] o = no difference, + = observed more often in habitat, - = observed less often in habitat

Comparison of used and unused habitat, 1991, cont'd.

Bank Undercut $X^2 = 1.474$, $P = 0.225$

	No	Yes
Use n=137		
Percent	32.9	67.1
No use n=52		
Percent	42.3	57.7

Woody debris within 10 m $X^2 = 0.046$, $P = 0.977$

	None	One	>One
Use n=137			
Percent	32.8	25.6	41.6
No use n=53			
Percent	31.4	25.5	43.1

[1] o = no difference, + = observed more often in habitat, - = observed less often in habitat

Comparison of used and unused habitat, 1991, cont'd.

Loafing sites within 10 m, May 2-June 4 $X^2 = 0.438$, $P = 0.803$

	None	One	>One
Use n=50			
Percent	20.0	28.0	52.0
No use n=51			
Percent	25.5	25.5	49.0

Forest type $X^2 = 12.013$, $P = 0.007$

	Cedar/ hemlock	Spruce/ fir	Ponderosa pine/ Douglas fir	Deciduous
Use n=137				
Percent	83.2	26.4	4.4	2.9
No use n=53				
Percent	73.6	9.5	0	0
Confidence interval $a = 0.05$	75.2-91.2	3.2-15.7	0-8.8	0-6.5
Difference[1]	+	-	o	o

Stream width $X^2 = 0.311$, $P = 0.856$

	1-9 m	10-19 m	> 19 m
Use n=137			
Percent	70.1	27.0	2.9
No use n=53			
Percent	73.6	24.5	1.9

[1] o = no difference, + = observed more often in habitat, - = observed less often in habitat

Comparison of used and unused habitat, 1991, cont'd.

	Use (n=137)		No use (n=53)		P
	$\bar{x}$	s.d.	$\bar{x}$	s.d	
Stream width (m)	8.06	3.84	7.02	4.66	0.12
Water velocity (m/sec)[1]	1.57	0.59	1.67	0.61	0.45
Loafing sites/10m^2	2.84	3.65	1.86	1.66	0.09
Elevation (m)	2702	489.46	3081	484.86	0.001
Debris/10m	1.9	2.24	1.5	1.77	0.25

[1] Water velocities May 2-June 4, use n=44, no use n=37

[2] Loafing sites available May 2-June 4, use n=50, no use n=51

Appendix F, Table 1. Reports of harlequin ducks, 1991.

Stream	Date	Location	Observation	Observer	TRS
Middle Fork Salmon	7/13	Love Bar below Big Cr.	one	Mel Hughes	T21N,R14E,S27
Lochsa	4/12	Badger Cr.	1 male	K. Carlson	T37N,R13E,S33 009
Lochsa	4/17	1/4 mi. below mp 168	1 male	John Etgen	T37N,R14E,S12 009
Lochsa	4/24	mp 127	1 male	M. Gorski	T35N,R10E,S18 downstream 009
Lochsa	4/29	near Powell	pair	Kim Ragotzkie	T37N,R14E,S33 009
Lochsa	4/30	near Powell	2 males/1 female	Kim Ragotzkie	T37N,R14E,S33 009
Lochsa	5/14	1 mi. below Papoose Cr.	1 male	Dave Mays	T37N,R13E,S36 009
Lochsa	5/28	Boulder Cr.	1 female	D. Kilgore	T35N,R9E,S34 downstream 009
Lochsa	5/30	3/4 mi. below Mocus	pair	C. & M. Campbell	T36N,R11E,S13 downstream 009
Crooked Fork	8/26	below Devoto	10 fem./juv.	R. James	T37N,R14E,S22 009
012 Little N. Fork Clearwater	5/25	between Little N.F. Camp. and Canyon Cr.	2 pair	Jim Ciardelli	T43N,R6E
017 Coeur d'Alene River	8/15	Imp Cr.	6 fem./juv.	Joel Hunt	T53N,R2E,S3

APPENDIX F

Harlequin duck reports, 1991

Appendix F, Table 1. Reports of harlequin ducks, 1991.

Stream	Date	Location	Observation	Observer	TRS
Coeur d'Alene River	8/19	200 m above Cathedral Cr.	1 fem./juv.	Joel Hunt	T53N,R2E,S20
N. Fork Coeur d'Alene River	4/21	Laverne Cr.	pair	reported-P. Backman	T50N,R1E,S6
Spokane River	12/4-12/11	Latah Cr.	1 fem./juv.	J. Wisman	
St. Joe River	5/25	above Simmons Cr.	1 male	Peter Grubb	T44N,R8E,S25
St. Joe River	7/6	Red Ives	1 fem./1 juv.	Mary Steachy	T43N,R9E,S20
St. Joe River	7/20	Fly Flat	1 female	Mary Steachy	T44N,R8E,S36
Simmons Creek	May	1.5 mi. above mouth	pair	Pat Mullen	T44N,R9E,S19
Moyie River	5/4	3 mi. below Meadow Cr.	pair	Peter Grubb	T63N,R2E,S25
Moyie River	5/18	below Meadow Cr.	pair	Peter Grubb	T63N,R2E,S13
Moyie River	6/2	2 mi. below Meadow Cr.	1 male	Peter Grubb	T63N,R2E,S24
Moyie River	6/1	1/2 mile above dam	pair	Nancy Mertz	T62N,R2E,S11
Deep Creek	May		pair	P. Sieracki	T61N,R1W

Appendix F, Table 1. Reports of harlequin ducks, 1991.

Stream	Date	Location	Observation	Observer	TRS
Priest River	4/20	N. of Dickensheet C.G.	pair	Dick Rivers	T59N,R4W,S19
N. Fork Granite	5/8	Tillicum Br.	4 male/2 females	Steve Young	T37N,R45E,S11
N. Fork Granite	5/9	Tillicum Cr.	pair	L. Hawdon	T37N,R45E,S11
N. Fork Granite	5/9	just above Tillicum	1 male/2 females	Art Carothers	T37N,R45E,S2

Reports received of U.S.F.S. Harlequin Duck Surveys, 1991

Powell Ranger District, Clearwater National Forest

John Lamb and John Citta conducted one survey each of the Lochsa River, White Sands and Crooked Fork in late May. The Lochsa count was conducted over two days. The maximum count on one day was eleven harlequin ducks (ten males). Harlequins were seen on the Lochsa between T37N,R14E,S33 and T36N,R11E,S21. They observed no harlequin ducks on Crooked Fork or White Sands Creek (but see Appendix F, Table 1).

The Powell Ranger District also conducted two surveys of the Lochsa (Appendix F, Table 2 and page 73).

Appendix F, Table 2. Survey routes on the Powell District, 1991.

Stream	From	To	Date	No. harlequins
Lochsa	T37N,R14E,S34	T35N,R9E,S27	5/20-21	9 males, 1 pair
Lochsa	T37N,R14E,S34	T36N,R11E,S30	6/1	3 males, 1 pair
Lochsa	T37N,R14E,S34	T36N,R11E,S30	7/12	8 females, 9 juv. (2 broods)
White Sands	T37N,R14E,S34	T36N,R15E,S14	May	none
Crooked Fork	T37N,R14E,S34	T38N,R15E,S32	May	none

North Fork Ranger District, Clearwater National Forest

John Lamb and John Citta surveyed the North Fork of the Clearwater, Kelly Creek and Orogrande Creek in late May and early June. No harlequin ducks were observed.

Appendix F, Table 3. Survey routes, North Fork Ranger District, 1991.

Stream	From	To
North Fork Clearwater	T40N,R11E,S5 and	T40N,R10E,S32 T39N,R10E,S18
Kelly Creek	T39N,R13E,S19	T39N,R10E,S18
Orogrande Creek	T37N,R7E,S7	T38N,R8E,S8

St. Maries Ranger District, Idaho Panhandle National Forests

T. Dash and Bob Holt surveyed Marble Creek by kayak from T44N,R3E,S33 to T45N,R3E,S13 on 5/11. Three male harlequin ducks were observed. Two were observed together at T45N,R3E,S25 and a single male was observed at T44N,R3E,S29.

United States Department of Agriculture | Forest Service | Powell Ranger District | Lolo, MT 59847

Date: September 3, 1991

Craig Groves
Natural Heritage Section
Idaho Department of Fish and Game
600 South Walnut, Box 25
Boise, Idaho 83707

Dear Craig,

The Powell Ranger District conducted two surveys of the Lochsa River for harlequin ducks this summer. The surveys were done from a raft guided by Kris and/or Bob Anderson. We surveyed from the twin bridges at the beginning of the Lochsa River to milepost 138. Here is a brief summary of our observations:

June 1, 1991:

1 pair, flying, near Squaw Creek (T.36N, R.13E, Sect.5).
1 male, flying, near Squaw Creek (T.36N, R.13E, Sect.5).
1 male, standing on north bank of Lochsa above Jerry Johnson Bridge (T.36N, R.13E, Sect.7).
1 male, standing on south bank of Lochsa above Jerry Johnson Bridge (T.36N, R.13E, Sect.7).

July 12, 1991:

1 female, flying, near Powell Creek (T.37N, R.14E, Sect.32).
1 female, standing on south bank of Lochsa above Jerry Johnson Bridge (T.36N, R.13E, Sect.7).
1 female with 5 young, swimming along south side of Lochsa above Jerry Johnson Bridge (T.36N, R.13E, Sect.7).
2 females, swimming, above Colgate Licks (T.36N, R.12E, Sect.15).
4 young, swimming, below Colgate Licks (T.36N, R.12E, Sect.15).
2 females, loafing on rock, below Mocus Bridge (T.36N, R.11E, Sect.13).

On July 12 we also saw 5 broods of common mergansers. On both June 1 and July 12 we observed an active osprey nest near the mouth of PostOffice Creek.

I believe there was one additional survey in May done by some contract harlequin surveyers based out of Orofino. I have not seen any results of that survey.

Sincerely,

Kim E Ragotzkie

Kim Ragotzkie, Wildlife Biologist

Submitted by: Craig Groves

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Tom Reinecker

Tom Reinecker, Chief
Bureau of Wildlife

Wayne Melquist 2/06/92

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