MONTANA STATE UNIVERSITY

Habitat utilization by harlequin ducks in Grand Teton National Park
by Richard L Wallen

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
© Copyright by Richard L Wallen (1987)

Abstract:
A study of the Pacific harlequin duck (Histrionicus histrionicus) was conducted during 1985 and 1986 to gather baseline data on its relative abundance and distribution in Grand Teton National Park. Population and habitat data were largely gathered on four streams. Ninety-one birds were banded during the two summers; 38 adults were marked with nylon nasal discs. Twelve adults (52%) and one young of the year banded in 1985 returned in 1986. Fifteen broods were located and a chronology of plummage development was determined. Most birds hatched between 20 July and 6 August, with brood sizes ranging from three to seven (mean 5.4). Age at first flight was approximately 42 days. Six hens were fitted with poncho mount radio transmitters but no nest sites were located. Sixty-two percent of all hens identified did not hatch a brood. Stream sections most suitable for harlequin breeding had gradients less than one degree and contained dense perennial shrubs lining the banks. Conflicts between harlequin breeding activities and human use of the park were identified and management recommendations were made to reduce human disturbances to harlequin ducks.

HABITAT UTILIZATION BY HARLEQUIN DUCKS IN GRAND TETON NATIONAL PARK

by

Richard L. Wallen

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

May 1987

MAIN LIB.
N378
W156
Cop. 2

APPROVAL

of a thesis submitted by

Richard Lee Wallen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

May 22, 1987 — Robert L. Eng
Date — Chairperson, Graduate Committee

Approved for the Major Department

May 22, 1987 — Peter F. Brussard
Date — Head, Major Department

Approved for the College of Graduate Studies

June 10, 1987 — Henry L Parsons
Date — Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Director of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Richard L. Wallen

Date 22 MAY 87

ACKNOWLEDGEMENTS

This study was funded through the combined support of ten sources. I thank the following for their contributions to this research.

Grand Teton Natural History Association
Grand Teton National Park Volunteers-In-Parks
National Rifle Associaton
International Aviculture Resources
WJH Bird Resources
MSU Agriculture Experiment Station
Tsisqua Crafts
UW-NPS Research Station
Veterans Administration

I am especially grateful to Robert Buttery for sparking my interest in harlequin ducks by sending me a 1980 issue of Wyoming Wildlife. Bob's assistance in trapping and observing birds in the early stages of the field work led to improved methods.

I thank my wife, Carolyn, for her quality assistance in the field and continued encouragement during the entire study.

My committee chairman, Robert Eng, provided valuable guidance during all stages of the project. His vast knowledge of waterfowl behaviors and keen insight into project planning made difficult decisions easier to make. Bob's presence on the study area during a trying time was an inspiring contribution to my morale and motivation. The grand canoe escapade will always be remembered.

I thank Dale and Wendy Schendel for their interest in this project. The use of the captive wood duck flock to study telemetry procedures was greatly appreciated.

Robert Wood provided valuable suggestions in study design and review of several sections of the thesis. His assistance in fund raising is graciously acknowledged.

I thank Wm. Gould and L. Irby for their critical review of earlier drafts of this thesis.

I wish to thank the many friends (31) who assisted in the trapping and banding of ducks. Carolyn Wallen, Bob Buttery, Cynthia Buttery, Dave Wallace, Doug Buttery, Alan Williams, Vicki Herron, Tom Vercolen and Janissa Balcomb each accompanied me on more than one expedition. Their assistance improved the trapping efficiency tremendously.

TABLE OF CONTENTS

TABLE OF CONTENTS-Continued

LIST OF TABLES

LIST OF TABLES-Continued

LIST OF FIGURES

ABSTRACT

A study of the Pacific harlequin duck (Histrionicus histrionicus) was conducted during 1985 and 1986 to gather baseline data on its relative abundance and distribution in Grand Teton National Park. Population and habitat data were largely gathered on four streams. Ninety-one birds were banded during the two summers; 38 adults were marked with nylon nasal discs. Twelve adults (52%) and one young of the year banded in 1985 returned in 1986. Fifteen broods were located and a chronology of plummage development was determined. Most birds hatched between 20 July and 6 August, with brood sizes ranging from three to seven (mean 5.4). Age at first flight was approximately 42 days. Six hens were fitted with poncho mount radio transmitters but no nest sites were located. Sixty-two percent of all hens identified did not hatch a brood. Stream sections most suitable for harlequin breeding had gradients less than one degree and contained dense perennial shrubs lining the banks. Conflicts between harlequin breeding activities and human use of the park were identified and management recommendations were made to reduce human disturbances to harlequin ducks.

INTRODUCTION

The harlequin duck (*Histrionicus histrionicus*) is classified in the tribe Mergini with *Histrionicus* being a monotypic genus. This species is considered to be intermediate morphologically between the eiders (*Somateria sp.* and *Polysticta stelleri*) and the oldsquaw (*Clangula hyemalis*) and the scoters (*Melanitta sp.*) (Delacour and Mayr 1945, Johnsgard 1960, 1978, Bellrose 1980). The harlequin was probably involved in the speciation of the Mergini tribe and it's adaptive radiation to fresh-water niches.

Harlequins on their breeding range have been likened to the South American torrent duck (*Merganetta armata*) and the New Zealand blue duck (*Hymenolaimus malacorhynchos*) (Bengtson 1966, Kuchel 1977). All three show affinities to turbulent streams in remote mountain areas, striking color patterns of the plumage and an insectivorous diet. However, the harlequin is not closely related to either species taxonomically (Todd 1979) and their ecological similarities are probably a result of convergence (Kuchel 1977).

The harlequin duck was named for the nuptial plumage of the drake. The latin word "histrio" means stage player (Kortwright 1943). The term "harlequin" came from a poor Italian character who wore a costume made from patches donated by his friends. These birds have a variety of other common names as well, the lord and lady, mountain duck, rock duck and sea mouse.

The species is easily identified. The drake with its' contrasting color patterns of rust, gray, blue, black and white, is considered by some to have the most bizarre plumage of all waterfowl. The hen, with it's cryptic coloration, is similar in plumage to the scoters and bufflehead hens, although the beak, the speculum, and the white patches on the head differentiate harlequins from others.

The species is currently grouped into two populations based on the ocean in which they winter (Pacific or Atlantic). Their winter range closely corresponds to the most nutrient rich coastal areas of the northern hemisphere. The Pacific population is by far the largest (Todd 1979, Bellrose 1980, Palmer 1976), possibly because the Labrador Duck (<u>Camptorhynchus</u> <u>labradorius</u>) once occupied the north Atlantic Ocean and may have competed with the harlequin for a portion of its range.

The breeding habitat of harlequins has been studied at few locations within its range (Bengtson 1972, Kuchel 1977, Dzinbal 1982). Pair bonds are generally formed on the winter range prior to their migration to remote mountain streams where nesting occurs. The nesting habitat is largely confined to backcountry streams where dense overhead cover is found. The drake will defend a small area around the hen, referred to as their individual distance (Kuchel 1977). This allows for an overlap of home ranges along streams which harbor numerous pairs.

Like many species of the waterfowl family, harlequins possess the ability to return to the same breeding areas in successive years (Bengtson 1972, Kuchel 1977). In order to find their remote breeding streams, harlequins may have evolved an atypical means of migration. Bengtson (1966) surmised that harlequins navigate up the rivers and streams to their breeding grounds swimming much of the way. This concept has been accepted by other authors due to a lack of direct research results (Kuchel 1977, Thompson 1985).

Bellrose (1980) noted that some subpopulations of waterfowl will make non-stop flights of 3,000 to 4,500 kilometers (km) during migration. The possibility that harlequins exhibit this behavior has not previously been postulated. This alternative to Bengtson's hypothesis appears likely in the wake of massive hydroelectric and irrigation development projects throughout the greater Columbia River basin. If the harlequins breeding in the Rocky Mountains exhibit this type of migratory behavior, they could winter anywhere throughout the known range of the Pacific population.

These small ducks have developed great proficiency at swimming and diving in swift water in search of food. While on inland streams they feed on aquatic insects and algae using several techniques: diving into plunge pools, walking around riffles probing under and on submerged stones and swimming along the slower currents near the banks collecting benthic, drifting and surface invertebrates (Michael and Michael 1922, Cottam 1939, Bengtson 1966, Kuchel 1977). The single specimen preserved for the Montana State University Museum was found to have an esophagus full of aquatic insect larvae (J. Sparks pers. comm.).

Waterfowl conservation has recently been a topic of much concern. Habitat loss in the 20th century has been targeted as the primary cause of declining waterfowl populations (Bellrose 1980). The harlequin, because of their remote habitat preferences, has probably suffered the least from human destruction of habitat. Nevertheless, reports from Montana and Colorado show that these mountain ducks have vacated portions of their former range (Parkes and Nelson 1976, Thompson 1985).

Harlequin duck sightings in the Jackson Hole area date back to the Hayden expedition of 1860 (McCreary 1937). The species has been reported as a permanent resident in northwestern Wyoming, including Park and Teton counties and Yellowstone National Park (McCreary op. cit.). The first record of harlequins within the present day boundaries of Grand Teton National Park (GTNP) was from two birds shot below the outlet to Jackson Lake in 1907 (Palmer 1913).

Wildlife observation files in the park show 13 sightings between 1913 and 1983.

An initial survey of several streams in the park during 1984 produced 24 sightings (Wallen unpub. field notes). This early effort identified a minimum of 27 individual birds along six streams and the Snake River. This evidence contradicted the impression among biologists, naturalists and tourist literature (Follet 1976) that harlequins were rare in GTNP.

This study was conducted during the summers of 1985 and 1986. The goal was to gather sufficient information about this little known segment of the population to formulate proper management considerations in GTNP. The specific project objectives are as follows:

-Identify and characterize breeding and nesting habitat within GTNP

-Quantify the breeding chronology

-Identify feeding opportunities (benthic insects)

-Identify Park population sizes (birds/summer)

-Identify any human/harlequin conflicts

-Identify possible migration patterns to and from the study area

DESCRIPTION OF THE STUDY AREA

Location

Grand Teton National Park is located in northwestern Wyoming in Teton County and includes much of the valley referred to as Jackson Hole. The valley floor ranges from 1980 to 2135 meters (m) above sea level from south to north with the Teton range rising to an elevation of 4200 m along the western boundary. The park is bordered by John D. Rockefeller, Jr. (JDR) Memorial Parkway on the north, Targhee National Forest on the west, the Absaroka and Gros Ventre Mountain ranges on the east and the urbanization of Jackson, Wyoming along the south. Originally established in 1929 the park now encompasses 1325 km^2.

Breeding Areas

The breeding habitat of the harlequin is found along backcountry tributaries of the Snake River. Most streams in the park drain from the high peaks of the Teton Range (Figure 1). The highcountry valleys from which they drain are classic U-shaped hanging canyons cut by the glaciers of the Pleistocene period (Fryxell 1984). About a dozen small alpine glaciers remain. Avalanches and rockslides have occurred producing stairstep creeks in many of the canyons.

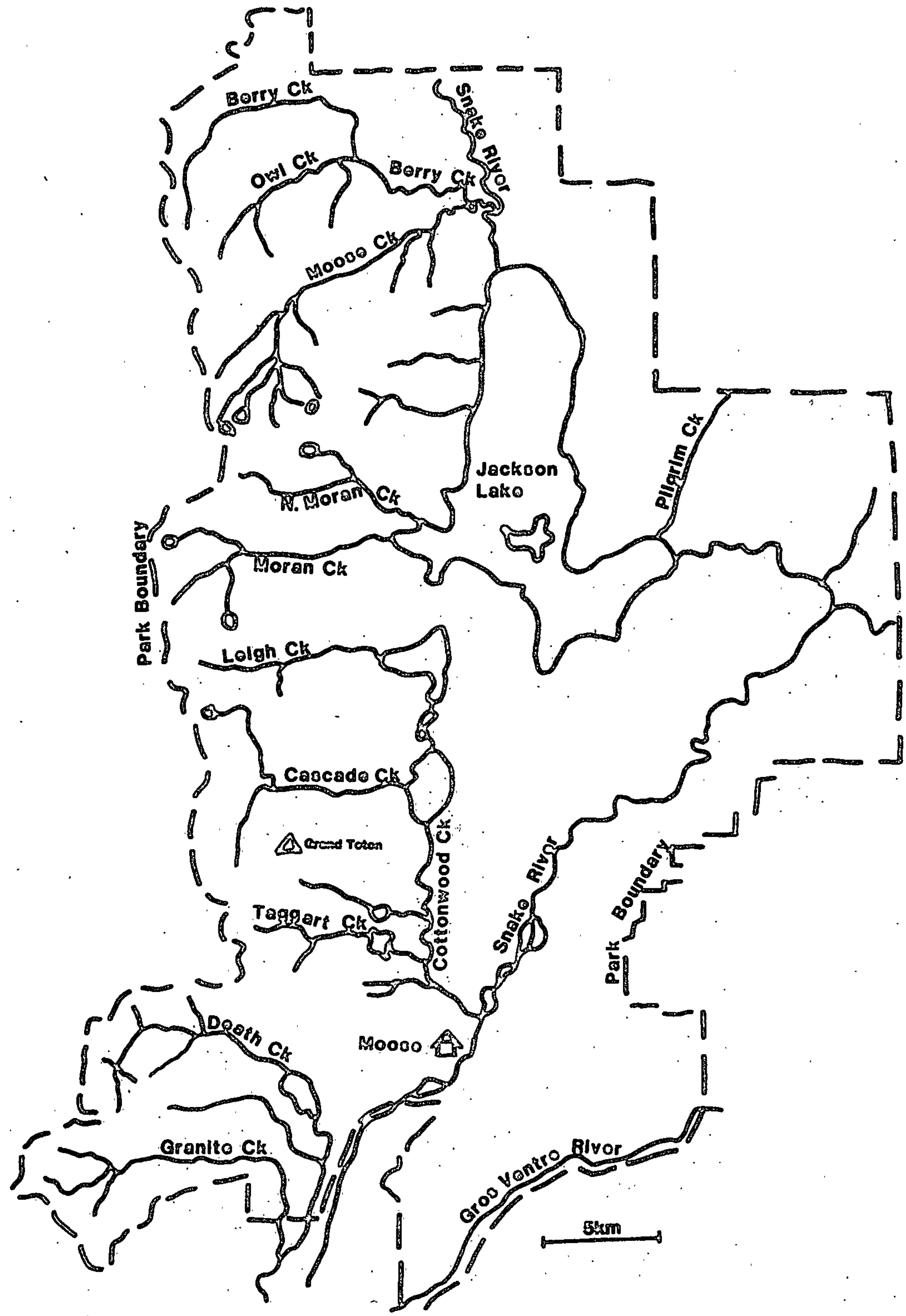

Figure 1. Major streams in Grand Teton National Park

Hynes (1970) points out that glacial streams are consistently turbid and low in temperature and oxygen. Stream sections which harbor harlequins are adequately removed from the glaciers to avoid these biological deficiencies. The primary streams of this study showed only a small increase in turbidity at high water and were clear sooner than the Snake River. Numerous openings in the forest canopy exist, allowing the water to warm sufficiently for filamentous algae to accumulate along several streams. These streams are fed primarily from snowmelt with about 30 percent (%) of the water coming from summer rains (Clark 1981). Willow (Salix spp.) and dogwood (Cornus sp.) are the dominant shrubs lining the banks while Engelmann spruce (Picea engelmannii) and subalpine fir (Abies lasiocarpa) dominate the overstory.

Purpose of the Park

Grand Teton National Park was established to protect the areas scenic values characterized by the Teton Range and Jackson Hole, and to preserve the native plant and animal life (Annon. 1985). This area is managed as a public park for the benefit and enjoyment of the people of the United States (Annon. 1986). Primary management objectives are:

-To manage all resources under the ecosystem concept, aimed to perpetuate natural systems and to establish ecologically sound thresholds of use.

-To manage all activities and uses to ensure compatibility with the preservation of park resources and the "high quality" visitor experience.

-To manage wildlife under conditions that are as natural and unrestrained as possible.

Eighty seven percent of the park land is managed as a natural zone with 45% of these lands being recommended for wilderness designation. This park is unique in that it contains eight grazing allottments, a water storage facility, an airport and a management oriented elk hunt.

Human Use

Human use of the park occurs year around, while the majority of the use occurs during the summer season (June through August). Recreational use encompasses all types of outdoor activities popular to the American public. Backpacking, horseback riding, fishing, boating and mountain climbing are activities that occur in and around the streams used by harlequins. Mean annual visitation for the two years of this study was 2.15 million people (range 2.13-2.18). This figure is down from a high of 4.1 million visitors in 1978, however visitation to the park appears to have stabilized during the past decade (GTNP unpub. files).

METHODS

Field Strategy

Based on information collected during a 1984 survey (Wallen unpub. field notes), searches for harlequins arriving on the study area were initiated along the Snake River beginning on 3 May 1985. On 24 May the search effort was shifted to backcountry tributaries of the Snake River. The remainder of the season was spent along these small streams in the Teton Range. Three to four days per week were spent in the field during May and June. After 17 June evenings and weekends were spent pursuing harlequins until 30 August. The 1986 field season lasted from 5 May until 20 September.

During 1985, the primary emphasis was on trapping and marking birds, evaluating telemetry techniques and identifying duck use and nesting areas. The 1986 season was used to concentrate on determining patterns of habitat use, a more intensive search for nests, feeding site examinations and collection of quantitative data pertaining to habitat use and availability.

In 1986, searches were made weekly along four primary streams: Granite Creek, Cascade Creek, Moose Creek and Berry Creek. When time allowed, surveys were periodically conducted along other streams to detect harlequin occurrence. Death canyon was surveyed seven times while many of the other canyons received less than five visits throughout the study.

Observations

Birds were observed by hiking along streambanks and using binoculars and a spotting scope to collect information on the behavior and the identity of ducks. Snake River canoe trips were taken during May of each year to search for birds arriving on the study area.

Trapping

Adult birds were captured using a mist net with 10 centimeter (cm) mesh stretched across the stream with the bottom of the net at or just above the water surface. The ducks were driven towards the net and flushed from the water surface at 5 m from the net. Broods were captured by setting large rocks on the bottom of the net to secure it to the streambed and placing a second mist net of 5 cm mesh downstream. The hen and chicks 3 weeks of age or older would be caught in the larger mesh while the younger chicks would normally get through and tangle in the smaller mesh.

An unsuccessful attempt was made to catch birds along the Snake River with a decoy trap constructed of welded wire wrapped around a frame of 128 millimeter (mm) angle iron (Anderson, Sayler and Afton 1980). Wooden decoys were used to lure the birds. These decoys were also used during netting operations to maneuver birds.

Marking

Adult birds were marked using nylon nasal discs of four shapes and eight colors (Lokemoen and Sharp 1985). Six adult hens were fitted with poncho mount transmitters weighing 13 grams (g) (Amstrup 1980, J. Montgomery and J. Toepfer pers. comm.). Birds captured in 1986 were measured using dial calipers and a Pesola scale (1000 g). The six measurements taken were: weight (g), total length (mm), culmen (mm), middle toe (mm), tarsus (mm) and wing (mm).

Habitat

Eight habitat parameters (Table 1) were recorded at each observation point. To assess habitat availability, these parameters were recorded at approximately 200 m intervals along the primary study streams. These data were statistically analyzed for utilization-availability at the 95% confidence level (Byers et al. 1984). Habitat and observation data from throughout the season have been combined.

Table 1. Habitat parameters used in evaluating each observation site and for availability of habitat along each stream (modified from Kuchel 1977)

Stream bank type		
	vertical-	> 45 degrees from horizontal
	horizontal-	< 45 degrees from horizontal
Stream bottom- Dominant type		
	bedrock	
	mud	
	sand	
	pebbles	16-64 mm diameter
	cobbles	65-256 mm diameter
	boulders	> 256 mm diameter
Streamside vegetation- Dominant type		
	annual plants	
	perennial shrubs	
	trees	
Streambank composition- Dominant type		
	vegetation	
	downed snags	
	rip-rap	
	bedrock	
	cobbles	
Channel type		
	meander	
	braided	
	bedrock canyon	
Availability of mid-stream loafing sites		
	0/ 10m	
	1-3/ 10m	
	> 3/ 10m	
Proximity of birds to human activities		
	adjacent -	maintained hiking trail within 10m of creek
	near -	maintained hiking trail within 50m of creek
	away, accessible-	unmaintained trail used by humans for access to the creek
	away, inaccessible-	stream is inaccessible to humans via any kind of trail
Amount of human use of the area (numbers of people viewing the stream area per unit of time)		
	heavy -	> 10 people per day
	moderate -	> 5 people per week
	little -	2-5 people per week
	none -	< 5 people per month

Other observations of harlequins which were reported to Park biologists were investigated. If a positive identity was determined, via markers, the observation was used to keep track of movements. The habitat around these observations was measured if the observer was able to pinpoint the location.

Morphometry of Streams

Topographic maps (7.5 minute series) were used to estimate three morphometric features along all streams in the Teton Range; stream distance, elevation difference and drainage basin area. Distance was measured with a cartometer and used with the elevation differences to calculate the mean slope. Drainage basin areas were measured with a polar planimeter. Streams longer than 4.5 km were divided into smaller units based on elevation differences.

Stream Discharge

To monitor stream flow, a water bottle tied to a string was used to estimate water velocity (Robins and Crawford 1954). Discharge was calculated using surface width (m), mean depth (m), mean water velocity (m/second) and a coefficient of roughness (eight) (Hynes 1970). In 1986, mensurations were performed on the four primary study streams and one stream where harlequins were not found.

These measurements were tabulated in cubic meters per second (cms). Discharge measurements from two nonregulated streams in the valley were supplied by the Bureau of Reclamation, Minidoka Project office.

Invertebrate Sampling

Benthic invertebrates were collected with a kick sampler at riffle feeding sites along the four primary study streams. Samples were taken on a monthly basis from May until September 1986. An Ekman dredge was used on three occasions in the pond in lower Cascade Canyon. One stream, on which harlequins were not found, was sampled on three occasions during the summer. Notes were taken on relative abundance during collections. Invertebrates were preserved in the field in Kahle's solution and keyed to family or genus in the lab (Pennak 1978, Merritt and Cummins 1984).

Fecal material was collected while handling birds and preserved in 90% alcohol. This material was sorted under a dissecting microscope to try and identify remains. One trapping mortality occurred, allowing for a single esophageal examination.

RESULTS

Observations

This study produced 224 observations of harlequin ducks, 94% of which were along four backcountry streams. The number of birds individually identified on the study area are presented in Table 2. Several birds were known to frequent more than one location, but were included in the area in which they were most often observed.

Small groups of pairs and bachelor drakes arrived on the study area throughout May and early June. The only sighting below Moose along the Snake River occurred while attending the decoy trap on the night of 17 May 1985. When birds began arriving on the breeding streams the snowpack still covered the willow vegetation and human recreational use was at a minimum. The earliest sighting for each year occurred on 17 May 1985 and 5 May 1986.

Twenty-four observations of identifiable broods were recorded in 1986. From these observations, the chronology of plummage growth for juvenile harlequin ducks was determined (Table 3). Brood classifications followed those outlined by Gollop and Marshall (1954). When juveniles began flying they had grown to 95% of the weight of adult hens (540-560 g.). Forty percent of all broods which were observed as class III birds were not accompanied by an adult. Backdating, by use of plummage development, shows that most birds on this study area hatched between 20 July and 6 August (Figure 2).

Table 2 Number and location of harlequin ducks identified in Grand Teton National Park in 1985 and 1986.

Streams	Adult males	Adult females	Juveniles	Broods	Total
Granite Ck.					
1985	2	2	6	1	10
1986	1	1	7	1	9
Cascade Ck.					
1985	5	6	0	0	11
1986	5	4	5	1	14
Moose Ck.					
1985	5	6	17	3	28
1986	5	7	21	4	33
Berry Ck.					
1985	4	7	15	3	26
1986	10	7	10	2	27
String Lk.					
1985	0	0	0	0	0
1986	2	0	0	0	2
Snake R.					
1985	1	0	0	0	1
1986	2	2	0	0	4
Total					
1985	17	21	38	7	76
1986	25	21	43	8	89

Table 3. Chronology of plummage development in juvenile harlequin ducks including number of observations of each brood in their associated plummage class.

Creek	Hatch date	Number of observations by age classes Ia	Ib	Ic	IIa	IIb	IIc	III	flight
Granite	14 Jul	1		1					
Cascade	27 Jul			2				1	1
Lower Berry	20 Jul			2	3	1	1	1	1
Upper Berry	27 Jul						1		
Lower Moose	25 Jul			2					
Upper Moose	25 Jul						1		1
Upper Moose	29 Jul				2				1
Upper Moose	1 Aug							1	
Days after hatching		1-5	6-9	10-14	15-21	22-27	28-35	36-42	~ 42
<u>Juvenile weight</u> = Adult hen weight		.25		.50	.75			.95	

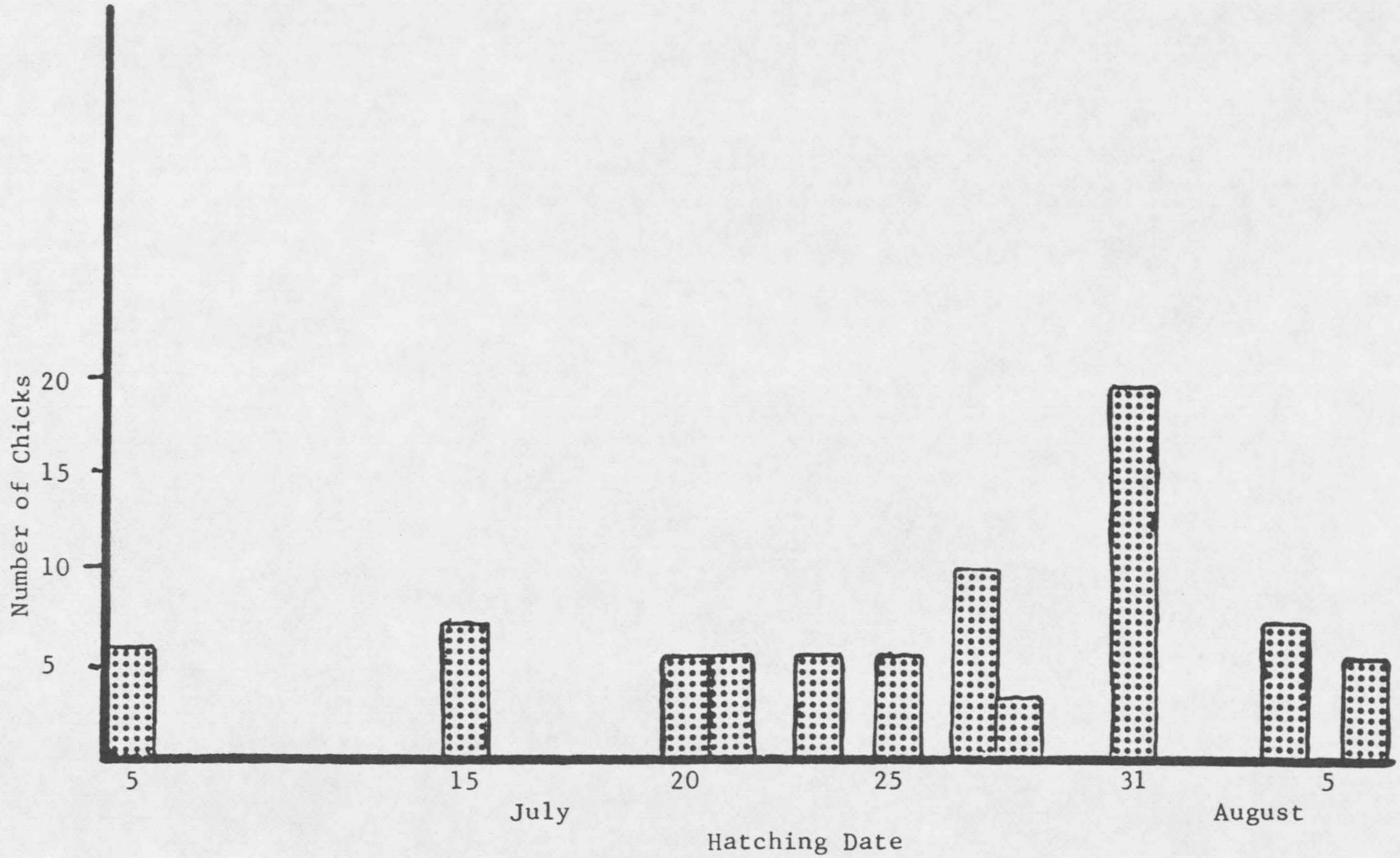

Figure 2. Dates of harlequin duck hatching based on 1985 and 1986 brood observations.

Trapping and Banding

Ninety-one birds which include 16 adult males, 22 adult females and 53 young of the year were banded (Appendix A, Tables 13 and 14). Thirty-four recaptures occurred.

All birds were captured with mist nets. The decoy trap was discontinued following the 1985 season after proving unsuccessful. However, the decoys were used to manuever birds during netting operations. The decoys would entice unpaired males while pairs kept their distance.

Fifty-two percent of the adults banded in 1985 were observed on the study area in 1986. Of these birds, only one hen was observed in a different location in 1986. This hen was suspected to have failed at nesting in 1985 along Cascade Creek and was observed along Berry Creek (27 km to the north) in mid-May 1986. After that one relocation in 1986 the bird was not observed again.

No band returns were received from the Bird Banding Laboratory. Harvest data from the Banding Laboratory revealed only two birds of the year, one bird each from Montana and Washington, were bagged in the 25 years prior to this study (E. Martin pers. comm.).

Measurement data taken from adult birds (Table 4) suggest that harlequins summering in GTNP are slightly smaller than those from Glacier National Park (Kuchel 1977) with respect to weight and total length. Both studies had small sample sizes (less than 15) for each mensuration.

Table 4. Measurements of adult harlequin ducks in Grand Teton National Park in 1986.

	Male			Female		
Parameter	N	Mean	Range	N	Mean	Range
Weight (g)	10	602.50	490-650	15	539.27	470-610
Total Length (mm)	10	411.30	385-429	12	391.92	375-405
Culmen (mm)	10	27.55	26.3-28.95	12	24.43	22.0-25.65
Middle Toe (mm)	10	57.90	54.5-61.82	12	54.99	52.6-59.25
Tarsus (mm)	10	41.17	35.5-45.9	12	40.36	38.4-43.75
Wing (mm)	10	198.90	185-207	12	189.58	181-195

It appears that breeding birds can be differentiated from non-breeders by weight. On this study paired males weighed between 640 and 650 g while bachelor drakes weighed less than 600 g. Two females weighed more than 550 g while other hens weighed between 470 and 540 g. Only one of the smaller hens was found attending a brood.

Marking of Birds

Nasal markers, which were placed on 38 adult birds, enabled easy identification at distances of 70-100 m. Five birds which were marked in 1985 were recaptured in 1986 and thoroughly examined. The markers themselves showed no sign of fading but the sharp corners had worn. The birds showed no ill effects from wearing the discs, no ruptured nares or excessive feather wear from preening.

Most people who reported sightings of harlequins were unable to distinguish the shapes and rarely even noticed the markers. The red and orange markers were often incorrectly identified along with the blue-gray-green combinations. The gray markers were only detectable at distances less than 60 m.

Radioed Birds

The radio collar transmitting unit used on this study was tested on a flock of captive wood ducks (*Aix sponsa*) prior to use in the field. Six birds were collared with two exhibiting severe intolerance by picking at the transmitter package and removing feathers which held it in place.

During 1985 four hens were radio-tagged, three of which appeared to adjust to the poncho within a few hours while the fourth did not. Twelve days after attachment the later hen was observed without the radio but with the herculite bib remaining. In 1986 this hen returned to the same creek, without the bib, and raised a brood. The other three radioed hens did not nest. In all 1985 relocations, they were loafing in midstream. Two of these birds departed the study area prior to the drakes. The remaining hen stayed until mid-July. None of the radioed hens showed signs of having brood patches.

In 1986, high water limited trapping success and only two hens were captured during the egg laying period. One hen was radioed on 25 May, prior to most copulatory behavior. She was observed feeding and loafing with her mate on many occasions. They were observed at a favored loafing site during one night relocation. The second bird radioed was suspected to be producing eggs, as she was the heaviest hen weighed throughout the summer. This hen showed discontent with the radio package by picking at it and plucking away the feathers which held it in place. On 30 July she was observed alone at the site of initial trapping. The radio had been uncovered by removal of feathers but was still functioning. She was not relocated again. This hen was suspected to have had a nest but no signal was detected during incubation. One brood in the area of the suspected nest was orphaned shortly after hatching which may have been a result of stress caused by radio attachment.

No nest sites were found during this study, but in 1986 four hens were found to use specific stream sections which contained a great deal of overhead bank cover and slow backwaters. Searches in the thick willow and dogwood were undertaken but no nest sites were identified. A bank cavity was excavated in August which earlier was suspected to have been a nest site. By August, all four hens were observed with broods near where the nests were suspected to have been.

Hens were very secretive about returning to their nest site. They would usually lure any onlookers downstream, then fly back upstream so they were undetected when they slipped into the brush.

Habitat

Observational data indicate that harlequins use areas with certain habitat characteristics in rather high proportions. Habitat parameters identified in greater than 50 % of all observations include perennial shrub vegetation along the streamsides, meandering channel types, greater than three loafing sites per 10 m and areas with no human use (Appendix B, Table 15).

Brood rearing activities occurred within the same locations as courtship. Thus, habitat and observation data from throughout the season have been combined.

The habitat and observation data from Moose and Berry creeks (north) and Granite and Cascade creeks (south) were combined to evaluate the unique qualities at each end of the park (Appendix B, Tables 16 and 17). Bank composition and bottom type were not analyzed because they did not meet all the assumptions of the procedure. A Chi-square test resulted in a rejection of the null hypothesis for the remaining habitat parameters at the .05 level of significance when all habitat data were combined (Table 15).

This habitat evaluation procedure produced information contrary to many suspicions. These data indicate a preference for areas with moderate to heavy human use and an avoidance of secluded stream locations (Table 5). However, many of the stream sections away from human use had a relatively high gradient and lacked the habitat features for which the ducks showed a preference.

Avoidance of stream areas where both banks were vertical indicated an aversion for bedrock canyons (Table 6). However, a vertical barrier to visual detection was evident in their preference for perennial shrub vegetation along the streamside. Braided stream reaches and ponds were preferred and offered the greatest quantity of mid-stream loafing sites.

Table 5. Analysis of utilization-availability data showing harlequin duck use relative to human use of Grand Teton National Park. (+=preference, -=avoidance, o=neither)

Habitat parameter	South creeks	North creeks	All creeks combined
Proximity to human activities			
adjacent	o	+	-
near	o	o	o
away,accessible	+	o	+
away,inaccessible	-	-	-
Human use of the area			
none	-	o	o
little	o	o	o
moderate	+	+	+
heavy	o	+	o

Table 6. Analysis of utilization-availability data showing harlequin duck use relative to physical habitat features. (+=preference, -=avoidance, o=neither)

Habitat parameter	South creeks	North creeks	All creeks combined
Bank type			
vertical-horizontal	o	+	+
vertical-vertical	-	-	-
horizontal-horizontal	+	o	o
Streamside vegetation			
shrub	o	+	+
annual	-	-	-
trees	o	-	o
none	+	o	o
Channel type			
meander		-	-
braided		+	+
bedrock canyon		-	-
pond		n/a	+
Loafing site availability			
0/10 m	-	-	-
1-3/10 m	o	o	o
> 3/10 m	o	+	+

Morphometry of Streams in the Teton Range

Streams where breeding harlequins were observed offered the lowest gradients of any of the streams draining from the Teton Range (Appendix B, Table 18). Table 7 shows the morphometric comparison of streams where the habitat data were gathered. These data indicate that breeding and brood rearing activities occured along streams with a mean gradient of less than 3^{o}.

Table 7. Morphometry of the primary study streams relative to the harlequin duck productivity in Grand Teton National Park. The numbers in parentheses indicate the portion of the streams used during the breeding season.

Stream	Length (km)	Gradient (degrees)	Elevation of suspected nest sites (m)	Number of broods (total)
Granite	6.55 (2.24)	3.5 (2.9)	2257	2
Cascade	6.24 (3.32)	2.7 (1.3)	2269	1
Moose	8.68 (2.92)	1.9 (.3 &1.3)	2066,2293	7
Berry	7.92 (3.71)	1.0 (.3 &.3)	2066,2196	5

Stream Discharge

Discharge from two nonregulated streams in Jackson Hole showed that the peak of discharge for 1986 was slightly more than twice that of 1985 (Figures 3 and 4). Historic records of discharge along Pacific Creek shows wide variation in peak flow volumes (48-152 cms) and dates (21 May to 30 June) (United States Geological Survey records 1965-1985).

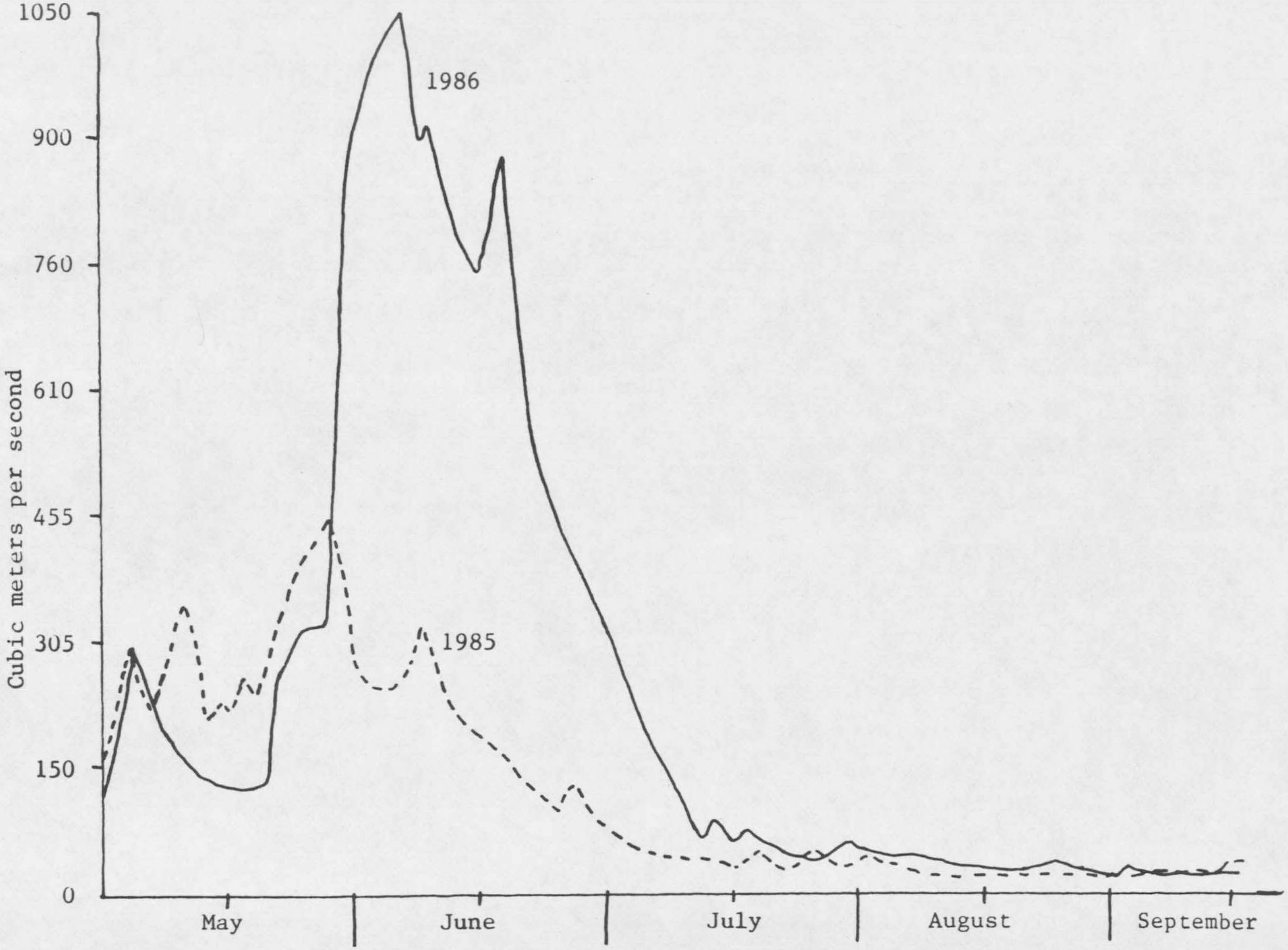

Figure 3. Stream discharge measured on Pacific Creek at the Snake River.

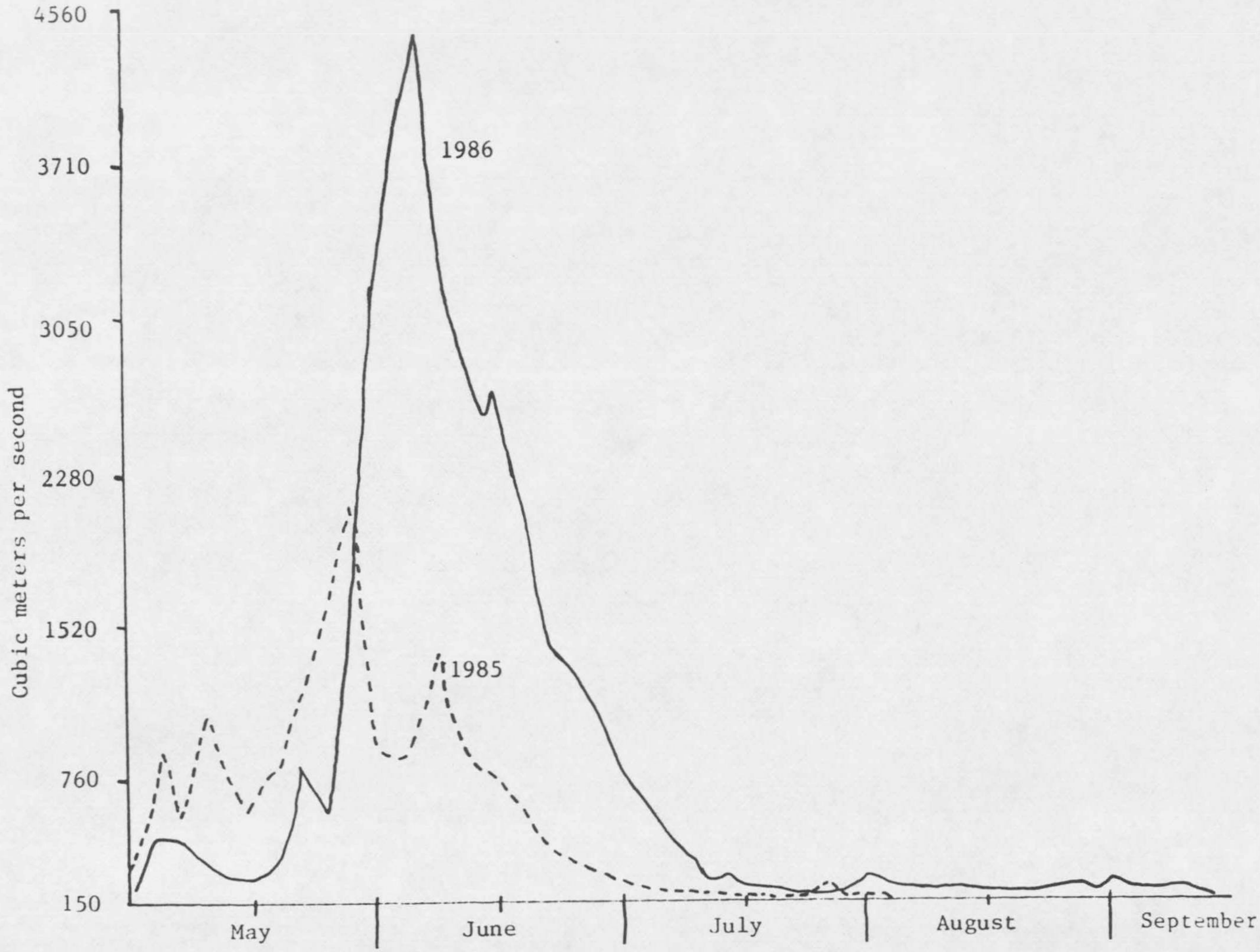

Figure 4. Stream discharge measured on the Snake River near Flagg Ranch.

Discharge calculations taken in 1986 indicated that the primary study streams were comparable in volume. Figure 5 shows that Moose Creek, which harbored the most breeding activity, also had the highest discharge. Moran Creek and Death Creek had discharge measurements similar to the primary study streams (Figure 5), but no breeding harlequins were detected.

Birds first arrived on the study area when discharges were 0.3-1.4 cms along the primary study streams. At the north end of the study area birds were observed spending a great deal of time on the Snake River until water flow in Berry Creek had risen to greater than 5.0 cms. As the turbidity in the river increased, the ducks spent a greater percentage of time along Moose and Berry Creeks. The pair observed along Granite Creek did not move into the upper basin, where the nest site was suspected, until that creek began increasing in flow. They were observed on the valley floor prior to this movement. Birds in Cascade Canyon moved onto their breeding stream prior to the initiation of spring runoff. This drainage offered a large pond for security with a much larger water volume at that location than anywhere along the other streams. The turbidity of the primary study streams was minimally affected by the high flow of the runoff.

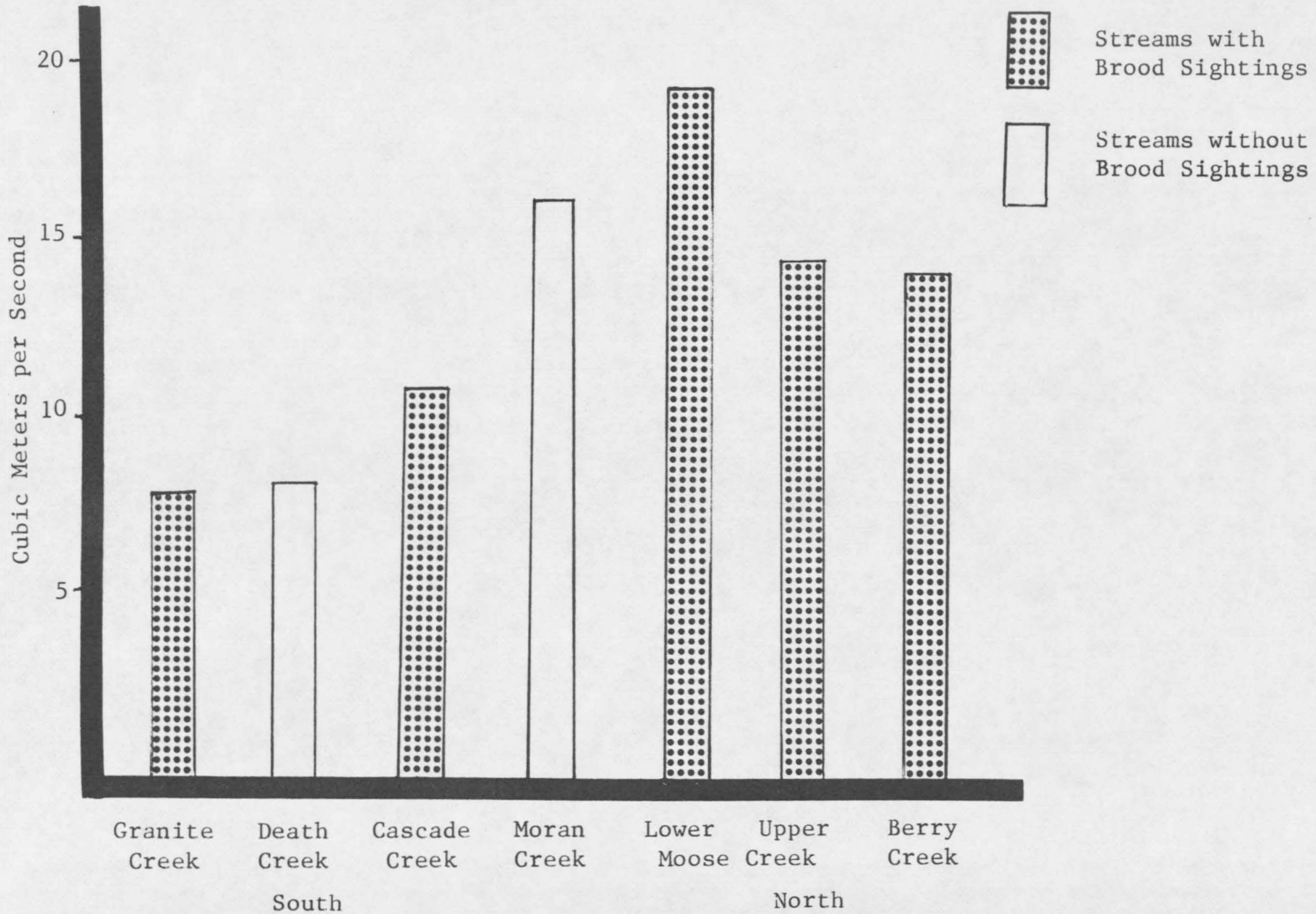

Figure 5. Discharge comparison of six streams in the Teton Range at high water.

Feeding Site Observations

Most feeding activities were observed at riffles. However, on Cascade creek, the pond in the lower canyon seemed to be the preferred feeding site. Feeding in the slower currents near the streambanks was observed the least. During high water, birds were observed to feed in overflow channels. On one occasion a hen was observed to surface with a small fish in her mouth. Cottus bairdi was identified in two benthic feeding site collections.

Harlequins feed with great intensity. Duration of feeding spells ranged from 5 to 45 minutes. The highest level of intensity occurred shortly after dawn.

During the courtship period drakes appeared to spend more time feeding than hens. The duration of time spent underwater was greater for males (Table 8). On several occasions males would dive three to five times for each time the hen dove.

Table 8. Mean diving times of harlequin ducks in Grand Teton National Park in 1986.

Gender	Mean time under water (sec)	Range (sec)	Sample size	Mean time on surface between dives (sec)
male	16.04	4-32	54	
female	12.25	3-32	81	5.83

Dredge samples taken in the pond in Cascade Canyon produced no invertebrates. Birds feeding at this location may have been feeding on drifting insects. Swimming mayflies (Baetis sp. and Ameletus sp.) were abundant among the vegetation in the flooded backwaters of the pond throughout the summer.

Invertebrates collected at 24 feeding sites on the primary study streams in 1986 are listed in Table 9. No major differences in the taxa were found between streams. Kogotus was only found at the lower elevations of Moose and Berry creeks. Taxa of invertebrates collected along Death Creek were found to be similar to the feeding site exams (Table 9).

Insect availability varied throughout the breeding season. Glossosomid and hydropsychid caddis larvae seemed to be the most readily available food source for harlequins arriving in early May. Food sources diminished with the onset of high water and drakes seemed to depart the area when the aquatic invertebrate abundance was lowest. During late June and early July chironomid (Diptera) larvae were found in the algae in large quantities and seemed to be the preferred food source. Algae was found in the fecal material while handling birds during this period. When broods began appearing in late July, the insect abundance was noticably greater in quantity and size than in late June when drakes abandoned the area.

Table 9. Invertebrates collected at feeding sites and in Death Canyon (* indicates invertebrates collected in Death Canyon).

Order	Family	Genus	Species	
Plecoptera				
		Acroneuria	sp	
		Megarcys	sp	*
		Isoperla	sp	*
		Kogotus	sp	
		Zapada	sp	
Ephemeroptera				
		Drenella	*spinifera*	
		Drenella	*coloradensis*	*
		Drenella	*doddsi*	*
		Rhithrogena	sp	*
		Epeorus	*longimanus*	
		Epeorus	sp	
		Ameletus	sp	*
		Parameletus	sp	
		Baetis	sp	*
		Pseudocloeon	sp	*
		Heptagenia	sp	
		Cinygmula	sp	*
Trichoptera				
		Parapsyche	sp	*
		Rhyacophila	sp	*
		Neothrema	sp	
		Glossosoma	sp	
		Goereilla	sp	*
		Hesperophylax	sp	
		Psychoglypha	sp	
Diptera				
	Sciomyzidae			
	Simuliidae			
	Culicidae			*
	Chironomidae			*
	Bibiocephelidae			*
Coleoptera				
	Amphizoidae			
	Elmidae			
Perciformes				
		Cottus	*bairdi*	

Feeding Habits

The one esophagus examined was empty. However, the gizzard contained a few recognizable remains. One mayfly of the Heptegeniidae family and numerous mayfly type gills and wingpads were identified.

The analyses of fecal material contained large quantities of sand. The larger sand grains (2 to 3 mm) appeared to match the cases of Glossosoma found in the feeding site exams. Portions of invertebrate exoskeletons were second in abundance while algae constituted a small part of the feces.

Identifiable remains of invertebrates represented three orders: Plecoptera, Ephemeroptera and Trichoptera. Several plecopteran legs were identified with two tarsal claws. The head of a large stonefly, possibly Megarcys or Isoperla, was seen along with a maxillary palp matching that of Megarcys. Numerous mayfly type gills were identified in each feces collection. One dropping was almost exclusively made up of parts of Drunella, with the tubercles on the fore femora. The lower mandible of a scraper type mayfly was also noted. Evidence of trichops in the feces included Unoidae and Limnephilidae cases. Also the heads and branched gills of a Hydropsychidae, possibly Parapsyche, were identified in one dropping.

DISCUSSION

Harlequin ducks begin nesting later than most other waterfowl species (Bengtson 1972, Kuchel 1977). On this study area environmental factors such as timing of snowmelt and lack of leaves on the perennial shrubs discourage early nesting. The earliest nesting was found on Granite Creek and the lower meadows of Moose and Berry creeks. These areas were free of snow sooner than the upper elevations in Cascade, Moose and Berry creeks. Nesting activities in GTNP were approximately 30 days later than in Glacier National Park (Kuchel 1977). However, the timing of nesting in GTNP was very similar to that in Iceland (Bengtson 1972). The difference in latitude is evidently compensated for by the difference in elevation.

This study area did not have the kind of habitat described by previous studies. Nesting in GTNP evidently occured in dense shrubs adjacent to streams where the gradient was lowest ($<1^{o}$). Nesting occurred in and around beaver ponds and abandoned meanders in Glacier National Park (Kuchel 1977). Bengtson (1972) found that 67% of all nests were located on islands and that 71% were located in dense shrubs in Iceland. Nesting in dense shrubs was a finding common to previous studies, although no nest sites have been found during two studies in the Rocky Mountains.

For finding nests, the Iceland study offered two advantages over studies in the Rocky Mountains. Dense shrubs (cover) were sparsely located along tundra streams, and breeding densities were considerably higher (Table 10).

Table 10. Comparative breeding density of harlequin ducks.

Location	Density of breeding (pairs/km)	Reference
Iceland	1.3 (range .2-7.1)	Bengtson 1972
Glacier National Park	.67-.91	Kuchel 1977
Grand Teton N. P.	.89 (range .67-1.25)	This study

During 1984 two broods were noted (Wallen, unpub. field notes). During that summer, a torrential rainstorm occurred in late July when hatching is normally at its peak. Cascade Creek rose approximately 0.6 m within 2 hours (hrs) and slowly returned to its pre-storm volume by the following morning. No young of the year were found after that storm. This type of environmental occurrence can cause catastrophic mortality at a vulnerable time in the breeding cycle.

This study produced a higher nonbreeding frequency (62%) than previous studies. Bengtson (1972) felt that harlequins had a relatively high nonbreeding frequency (15-30%) compared to other waterfowl. Dzinbal (1982) estimated a nonbreeding frequency of 47-50% along short coastal streams in Alaska. Human use of the adjacent areas was greater in GTNP than in the Iceland and Alaska studies and may have been a factor. On Moose creek, the most secluded stream on this study area, the frequency of nonbreeding hens was 46%. This compares to 90% along Cascade Creek which was the most accessible creek for human activities on the study area. Moose and Cascade Creeks offer nearly equal quantities of low gradient stream sections with dense shrub vegetation lining the streambanks. These data suggest that human activities may have greater influence on the success of harlequin breeding than the availability of habitat.

The chronology of breeding season activities has been reported in previous field studies (Bengtson 1966, Kuchel 1977, Dzinbal 1982). However, differences in the timing of these activities occurred in GTNP. First arrivals were pairs, which began appearing on the breeding grounds during the first week of May (Figure 6). Sometimes a second drake would accompany a pair, attempting to court the hen. Bachelor drakes arrived just after the first pairs while unmated hens arrived approximately 1 month later. Kuchel (1977) noted that single drakes arrived on the breeding grounds two weeks ahead of pairs. Dates of first hatching were two weeks later in GTNP than at either the Glacier National Park or the Iceland studies. However, all three studies document drake departures during the last week of June and the first week of July.

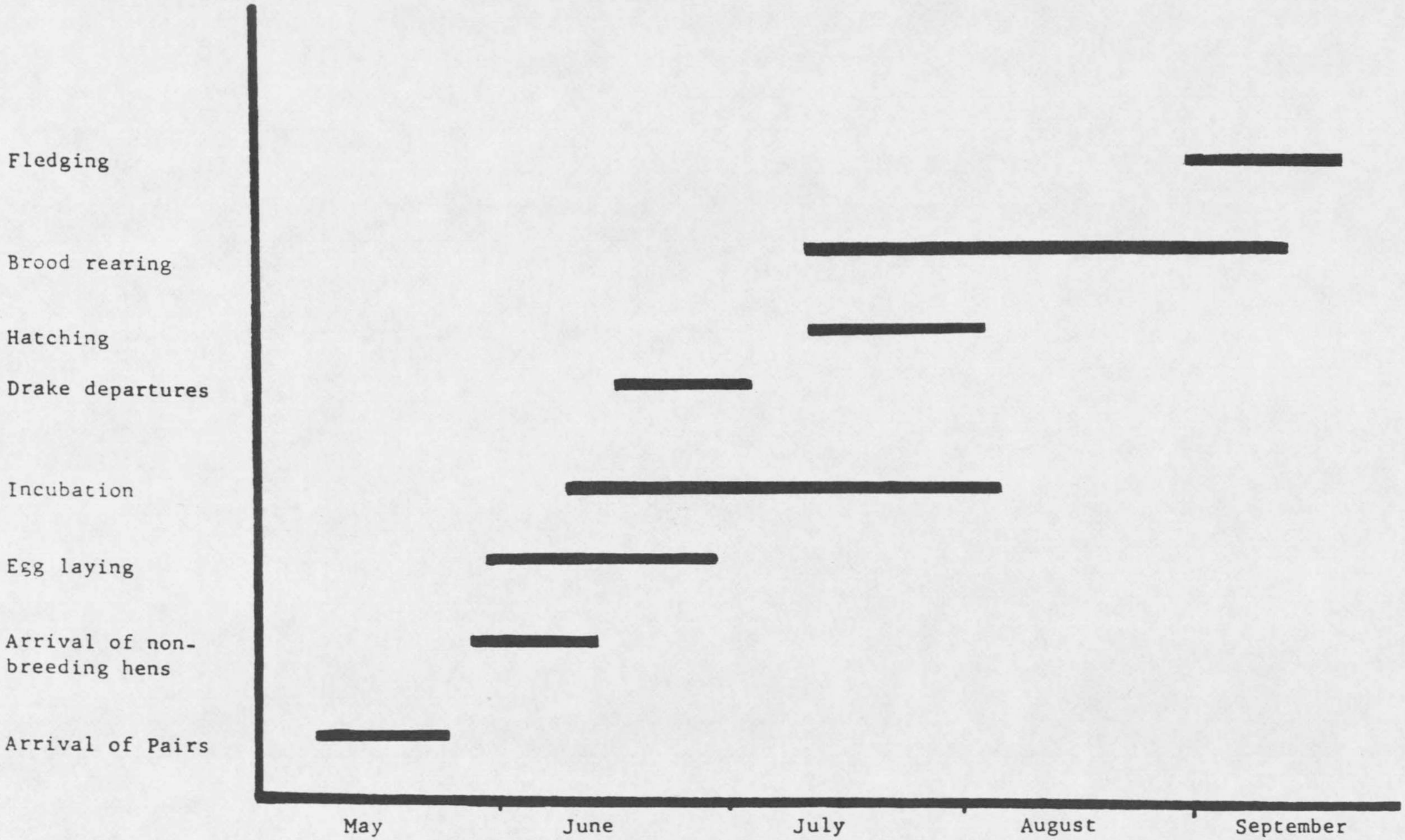

Figure 6. Chronology of harlequin duck breeding season activities in Grand Teton National Park.

The length of time birds remained on their summer range depended on their breeding status. Drakes remained for approximately 45 days with bachelors departing as much as a week ahead of males which broke pair bonds. Some pairs departed the study area at the same time as the bachelor drakes. Unpaired hens stayed for three to five weeks. Most of these hens departed shortly after the drakes, and rarely did they stay until broods appeared. Breeding hens remained on the summer range for about four months. Three of eight hens left ahead of their broods in 1986.

Birds spent a few days at particular "staging areas" in late June and early July then disappeared suddenly. This pattern suggested that harlequins migrate from their breeding grounds at night and spend their daylight hours loafing and feeding.

The literature indicates that non-nesting harlequins return to the coast to congregate in large flocks and molt (Bengtson 1966, Palmer 1976, Bellrose 1980, Dzinbal 1982). In early July 1984, a flightless hen was found on upper Moose Creek (Wallen unpub. field notes). This was the only harlequin noted to molt wing feathers on this study area. She was observed to use stream sections secluded from the trail by dense willow vegetation and remained in an area where the current was relatively fast. No evidence was gathered of males molting their wing and body feathers on the study area. D. Lockman (pers. comm.) indicated that reports exist of molting drakes in Wyoming.

Molting of the tail feathers did occur prior to migration in a few cases. Two hens and one drake were handled which had molted a portion of their tail feathers prior to departure.

Broods began hatching in mid July and were located on this study area until mid September. The birds which hatched at the highest elevations in Cascade and Moose creeks were the last to depart. These broods seemed to have been pushing the time limits on the summer range as snow was accumulating before they left. Broods were most visible in early September.

A complete food habits study on the harlequin duck was not feasible in GTNP. Killing birds to aquire a sufficient number of stomachs was not permitted in the Park. However, use of droppings to identify some of the food items taken could be done within a National Park. This technique has been used on other bird species (Dalke et. al 1942, Korschgen 1966). Since the exact food being consumed is not observed, fecal analyses are biased toward the harder non-digestible material.

Harlequins probably feed on the most available prey. Bengtson (1972) identified simulid larvae as comprising over 98% of the food in harlequin stomach analyses. Stoneflies and mayflies were nonexistent in Iceland and caddisflies were scarce (Bengtson op.cit.). He suggested that harlequin breeding success was limited by simulid larvae availability. Cottam (1939) revealed that the stomach contents of two birds taken from Wyoming in August contained 90% stoneflies.

August feeding site exams on this study showed four genera of stoneflies available; Acroneuria, Megarcys, Isoperla, and Zapoda. Some of these genera attained lengths greater than 40 mm. Plecopteran, Ephemeropteran and Trichopteran specimens were all represented in more than 95% of the feeding site examanations.

Low densities and surreptitious behavior make harlequin ducks difficult to locate in the Rocky Mountains. From the banding and marking results and the amount of suitable habitat, 50 adult harlequins could occupy GTNP during years with favorable weather. Also, 50-55 juveniles may be hatched along the four primary study streams and Leigh Creek.

Leigh Creek and the lower meadow of North Moran Creek seem to offer suitable breeding habitat. These two creeks were surveyed during this study, but due to their poor accessibility, minimal effort was expended in searching for breeding activities. Harlequins were identified on Leigh Creek in 1984 (Wallen unpub. field notes). Two drakes were found along the outlet to String Lake in 1986 where drakes from Cascade Creek had gathered. These two additional males probably spent May and June on Leigh Creek.

Moran Creek was surveyed twice but no harlequin activities were observed. Suitable low gradient stream sections do exist and future explorations are warranted. This stream is fed by a number of glaciers and wading was very difficult because of cold temperatures. A stream temperature comparison of this creek with Cascade Creek and Moose Creek may suggest lower potential for invertebrate productivity. Algal growth is an indicator of stream temperatures (Hynes 1970). Algae growth was found along Moran Creek in limited areas at higher elevations where forest canopy was reduced. An invertebrate collection in a low gradient section of this creek revealed that species abundance and diversity was poor relative to the primary study streams.

Death Creek was surveyed thoroughly and no harlequins were found. Discharge measurements (Figure 5) indicate the size is similar to other streams on the study. However, the point of measurement was just below the confluence of three forks, thus overestimating the discharge of the upper meadows. This stream has a steeper gradient (Appendix B, Table 18) and seems to be much colder than streams where breeding activity was observed. Although two sightings from this stream were recorded in the park observation files, breeding probably does not occur here. These two sightings are for mid to late July of 1954 and 1959 with the latter indicating a male. Phelps Lake may have been a molting area at one time, perhaps abandoned because of increased human activities.

Several streams on the study area seem unsuitable for breeding activities because of high stream gradient (greater than 3^{o}) and low water volume (less than 8 cms at high water). These streams include Open Canyon, Garnet Creek, Paintbrush Creek, Waterfalls Canyon, Colter Canyon and North Moran Creek above the lower meadow. Taggart Creek above the lake also fits this category. However, suitable gradients do exist at the inlet and outlet to Taggart Lake.

Descriptions of the migration seem quite unusual. Bengtson (1966) felt that harlequins migrate to their breeding grounds by swimming much of the way and making only short flights. Palmer (1976) and Kuchel (1977) agreed with this theory with some reservations for birds breeding east of the continental divide, while Thompson (1985) emphasized this behavior in his popular article about the life cycle of this species.

Few migratory staging grounds have been documented. Since July is a popular month for rafting and fishing along larger rivers, it seems that more drakes would be noted during their migration back to the coast. However, night migration may reduce the chances of encountering human activities on the larger rivers.

The possibility does exist that harlequins breeding in the Rocky Mountains fly directly to their destination.

This could explain why observations of harlequins are not made in July by river users. This possibility warrants further study through intensive banding efforts at both ends of the migration and coordinated communications between wildlife biologists. Identification of distinct sub-populations and wintering areas are necessary to evaluate such an occurrence.

Records of Harlequins found in Idaho along the Snake River are scarce. During the winter of 1977-78 a bird was discovered near Marsing and in the spring of 1982 a pair was noted near Shelly (C. Trost pers. comm). These sightings support the possibility that harlequins do migrate following the Snake River.

Sightings have been made along the Snake River in Jackson Hole by residents using the river for floating and fishing (R. Wood pers. comm.). Olaus Murie filed a July 1948 observation of four harlequins along the Snake River near his home at Moose.

When birds arrived on this study area they were observed flying more often and higher above the water surface than at any other time of the season. When birds would flush from the streams in early May they would often fly greater distances than any other time of the season. These observations suggest that this species does a great deal more flying during their migrations than was previously thought.

Harlequins have been noted in northwest Wyoming along two large rivers in March. Palmer (1923) reported two birds along the Snake River at Moran. The observation file at Yellowstone National Park holds one record of 15 drakes and 16 hens along the Yellowstone River near LeHardy Rapids on 31 Mar 61. These latter birds definitely had to make substantial flights to reach this area on the east side of the continental divide.

Recent reports indicated that drakes do a great deal of wandering outside their coastal winter range. The Logan River in Utah harbored a lone drake from 21 Dec 1985 until 21 Feb 1986 (Kingery 1986). The 1985 Christmas Bird Count in Glacier National Park also reported a solo drake (American Birds 1986). Sightings of a single drake in Yellowstone National Park for Jan 1986 (J. Cohen pers. comm.) and Feb 1986 (T. McEneaney pers. comm.) indicate at least one bird was using LeHardy Rapids during that time of winter. These reports all encompass a similar time span and offer the possibility that birds fly into the breeding grounds during warm spells. This phenomenon has been suggested for canada geese (Branta canadensis) at Canyon Ferry Reservoir, Mt. (R.L. Eng pers. comm.).

In Jackson Hole, conflicts between harlequins and humans are minimized by season of use. However, slight overlaps do occur in July and August. When harlequins began arriving on their breeding grounds, high snow depths discouraged most human use of the area. Human use was limited because of avalanche hazards and poor skiing conditions throughout the courtship and nest initiation period. By the time the backcountry canyons received heavy use from outdoor recreationists the drakes had broken their pair bonds and begun their migration back to the coast. During years when the snowmelt occurs early, the initiation of egg laying may coincide with increased recreational use, especially in Cascade Canyon.

As human use of the backcountry canyons increased in July, incubating hens were spending most of their time on the nest. It was very difficult to locate hens until broods began appearing in late July. Occasionally, nonbreeding hens were visible during July and seemed to tolerate hiking and backpacking activities much better than hens with broods.

Fishing seemed to be the most disruptive of all human activities in harlequin habitat. Harlequins showed a definite avoidance reaction to humans in the streambed or standing on the banks. Birds would often dive and swim underwater past humans. When they surfaced they would keep their bodies submerged while looking over their shoulder to see if they were being watched. When less threatened they would simply float away on the surface. Swimming upstream near the bank occurred less frequently while flying seemed to be their last resort. Harlequins are very strong flyers and can leap off rocks or logs directly into flight. During avoidance flights they often emitted rather stern vocalizations.

Hens with broods seem to show less tolerance to fishing activities than nonbreeding birds. On two occasions a nonbreeding hen was observed to slip by fishing parties unnoticed. Two hens with broods abandoned a section of lower Berry Creek in August when fishing pressure increased. In both cases they relocated their broods to lower Moose Creek where fishing activities were not observed. As broods approached flight attainment, the human use of the backcountry began to lessen.

MANAGEMENT RECOMMENDATIONS

Kuchel (1977) pointed out that without management considerations for harlequins, more streams capable of supporting breeding activities may never exist. Harlequins should be considered an indicator of wilderness and pristine ecosystems. Many of the insects on which these birds feed are considered as biological indicators of a healthy stream (Pennak 1978).

Careful planning of trail routes through harlequin breeding habitat will minimize the encounters between harlequin and human use of the area. Granite and Webb Canyons offer ideal examples of trail location. The trail stays away from the streambank where the stream gradient is less than one degree. Dense willow shrubs shield the stream from the view of the trail. Minimal disturbance to harlequin breeding activities will occur with this type of situation.

With the quantity of people using Grand Teton National Park for recreation purposes, human use management should be the primary concern. Heavy use of the trails and streams near where harlequin nesting occurs should be avoided in early June and in late July. The trail in Cascade Canyon is currently located close to the stream in areas where harlequins spend much of their time. This canyon should be used to fill the agency mandate of displaying the resources.

Since Moose and Berry creeks offer the most productive habitat for breeding activities, these two streams should be afforded highest priority in managing for harlequin ducks. The following recommendations would benefit harlequin ducks breeding in GTNP.

1. Do not clear timber from the trails in the following canyons until after the specified dates.
   Granite------------ 15 June
   Cascade------------ 1 July
   Webb--------------- 1 July
   Berry-------------- 1 July

2. Encourage early summer use in canyons away from nesting activities. Paintbrush Canyon, Garnet Canyon, Death Canyon and Open Canyon all offer backcountry travel away from harlequin nesting habitat. Trails found under 2135 m offer little chance of conflicting with harlequin use patterns.

3. Keep the trail away from the stream in low gradient sections where limited willow vegetation is available to shield the trail.

4. One .5 km section of trail adjacent to lower Berry Creek downstream from the patrol cabin should be eliminated from the trail system and allowed to revegetate. Much of this section is already damaged and will require major clearing. Another trail exists in the near vicinity and should be considered for primary access.

5. No permanent bridges should be constructed in the northern canyons. This will discourage some people from attempting to travel in this area.

6. A monitoring system should be incorporated to census population levels and breeding success.

Interpretive programs which increase the awareness of the local pristine ecosystem should be recognized as a valuable management tool. Educating the users to respect the wilderness setting and to avoid disrupting it will be easier than trying to develop a management recovery effort.

Monitoring Program

Harlequin ducks are quite secretive during breeding. The relatively few sightings noted in the park files can be attributed to a lack of proper timing when attempting to find harlequins in the park. This proposed monitoring program is intended to aid the management staff in censusing this species when they are most visible.

Four locations within the park and the JDR Parkway should be monitored. Since Moose Creek and Berry Creek are the areas with greatest productivity, they should be given the greatest amount of censusing effort as well as the most protection from human conflicts. Cascade Creek has the potential for more broods than were observed during this study. This creek should be evaluated as an area to display these beautiful mountain ducks to the visiting public. The river area immediately below Flagg Canyon in the JDR Parkway is another area which deserves monitoring for impacts caused by human use.

Harlequin pairs are most easily found by skiing or hiking along the snow covered banks between mid-May and early June. As the snow melts from the banks the dense shrubs cause travel and visibility problems. Most breeding pairs are on their respective summering streams by 15 May.

An additional survey should be undertaken between mid-August and early September to count broods in the same areas covered in May. The number of chicks per brood, the age of the brood and the location of the brood would provide valuable information. Hens with broods are extremely cautious of humans, thus more time needs to be allotted for brood surveys than was necessary for pair surveys.

Environmental information pertinent to these surveys include river discharge and flood event occurrences. The timing and magnitude of the peak of spring runoff can be gathered at the discharge station at the south gate of Yellowstone National Park. Information regarding the timing of periods of heavy rainfall during the snow melt season may be a useful indicator of brood success.

Pairs and broods can be used as indicators of a healthy harlequin population within the park. The numbers of pairs in the May census and the number of broods found in August should correspond to Table 11. After 10 years of censusing these estimates should be re-evaluated.

Table 11. Estimates indicative of a healthy harlequin population in GTNP.

Location	Number of pairs	Number of broods
Cascade Creek	2-3 pairs	1-2 broods
Lower Berry and Moose Creeks	3-6 pairs	2-4 broods
Upper Moose Creek	3-6 pairs	3-5 broods
Flagg Canyon	1-2 pairs	1-2 broods

LITERATURE CITED

LITERATURE CITED

Amstrup, S.C. 1980. A radio collar for game birds. J. Wildl. Manage. 44(1):214-217.

Anonymous. 1985. Statement for management. Grand Teton National Park, Moose, Wyoming.

Anonymous. 1986. Natural resources management plan and environmental assessment. Grand Teton National Park, Moose, Wyoming. 459pp.

Anderson, M.G., R.D. Sayler and A.D. Afton. 1980. A decoy trap for diving ducks. J. Wildl. Manage. 44:217-219.

Bellrose, F.C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pa. 540pp.

Bengtson, S.A. 1966. Field studies on the harlequin duck in Iceland. Wildfowl Trust Ann. Rpt. 17:79-94.

_____________ 1972. Breeding ecology of the harlequin duck, Histrionicus histrionicus, in Iceland. Ornis. Scand. 3(1):1-19.

_____________ and S. Ulfstrand. 1971. Food resources and breeding frequency of the harlequin duck in Iceland. Oikos 22:235-239.

Bent, A.C. 1962. Life histories of North American wildfowl, part 2. Dover Publications, New York. 376pp.

Byers, C.R., R.K. Steinhorst and P.R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48:1050-1053.

Cottam, C. 1939. Food habits of North American diving ducks. U.S. Dep. Agric. Tech. Bull. 643. 140pp.

Delacour, J. and E. Mayr. 1945. The Family Anatidae. Wilson Bull. 57(1):3-55.

Dzinbal, K. A. 1982. Ecology of harlequin ducks in Prince William Sound, Alaska during summer. M.S. Thesis, Oregon State University, Corvalis, Oregon. 89pp.

Follet, R. 1976. Birds of Yellowstone and Grand Teton National Parks. Yellowstone Library and Museum Assoc., Yellowstone National Park, Wyoming. 73pp.

Fryxell, F. 1984. The Tetons:Interpretations of a mountain landscape. Grand Teton Natural History Association, Moose, Wyoming. 77pp.

Gollop, J.B. and W.F. Marshall. 1954. A guide to aging duck broods in the field. Mississippi Flyway Council Technical Section Report 9pp.

Harju, H. 1977. Harlequin ducks in Wyoming. Wyoming Wildlife. Jan 80, pp16-17.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Canada. 555pp.

Johnsgard, P. A. 1960. Classification and evolutionary relationships of the sea ducks. Condor 62(6):426-433.

_______________ 1978. Ducks, geese and swans of the World. Univ. of Nebraska Press. Lincoln, Nebraska. 404pp.

Kingery, H.E. 1986. Regional sightings. American Birds. 40(2):2.

Kortwright, F.H. 1943. The Ducks, geese and swans of North America. The Stackploe Co., Harrisburg, Pa., and Wildlife Management Institute, Washington D.C. 476pp.

Kuchel, C.R. 1977. Some aspects of the behavior and ecology of harlequin ducks breeding in Glacier National Park. M.S. Thesis, University of Montana, Missoula, Mt. 163pp.

Lokemoen, J.T. and D.E. Sharp. 1985. Assessment of nasal marker materials and designs used on dabbling ducks. Wildl. Soc. Bull. 13(1):53-56.

Merritt, R.W. and K.W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Co., Dubuque, Ia. 722pp.

Michael, C.W. and E. Michael. 1922. An Adventure with a pair of harlequin ducks in the Yosemite Valley. Auk 39:14-23.

Montgomery, J. 1985. A collar radio-transmitter attachment for wood ducks and other avian species. Pages 19-27 in R.W. Weeks and F.M. Long eds., Proceedings of fifth international conference on wildlife biotelementry., Univ. of Wyoming, Laramie.

Palmer, T.S. 1913. Harlequin ducks in Wyoming. Auk 30:267-268.

Palmer, R.S. 1976. Handbook of North American birds. Vol3 Waterfowl (Part 2). Yale Univ. Press, New Haven. 560pp.

Parkes, K.C., and C.H. Nelson 1976. A definite Colorado breeding record for the Harlequin Duck. Auk 93:846-847.

Pennak, R.W. 1978. Freshwater invertebrates of the United States. John Wiley and Sons, Inc., New York, N.Y. 803pp.

Pool, W. 1962. Feeding habits of the harlequin duck. Wildfowl Trust, 13:126-129.

Robins, C.R. and R.W. Crawford 1954. A short accurate method for estimating the volume of stream flow. J. Wildl. Manage. 18:366-369.

Thompson, L.S. 1985. A harlequin romance. Montana Outdoors 16(2):21-25.

Todd, F.S. 1979. Waterfowl. Sea World Press, San Diego, Ca. 399pp.

APPENDICES

APPENDIX A

BANDING DATA

Index to the symbols in Appendix A

Age symbols — L=Birds born on the study area this year
AHY=Adult birds, year of hatch unknown

Table 12. Locations of stream sections on which birds were captured.

Creek	Latitude deg.	Latitude min.	Longitude deg.	Longitude min.	Township,Range,Section
Granite	43	37	110	51	T42N,R117W,Sec11
Cascade	43	46	110	47	T44N,R116W,Sec20,21&22
U.Berry	43	61	110	46	T47N,R116W,Sec27
L.Berry	43	59	110	42	T47N,R115W,Sec31
L.Moose	43	59	110	43	T47N,R115W,Sec31
U.Moose	43	57	110	47	T46N,R116W,Sec9,10&11

Disc marking system symbols are
S=squares, C=circles, T=triangles, O=oval

The (L) and (R) in the markers column show which side of the bill the indicated marker is on, left or right

1985 radioed hens- 201(151.149),204(Lost),206(151.033) and 213(recovered)

1986 radioed hens- 218 (151.298) and 253 (150.725)

655-07204 was recaptured on 20May86 in Cascade Canyon and fitted with nasal markers: C-Gray(L), Blue(R)

655-07236 was recaptured on 16Sep86 on upper Moose Creek and fitted with nasal markers: C-Orange(L), Blue(R)

Table 13. Summary of banding activities in 1985.

Number	Date	Sex	Age	Location	Disc Marking System
655-07201	24May85	F	AHY	L.Berry	S-Orange(L),Green(R)
655-07202	26May85	M	AHY	Cascade	S-Blue(L),Orange(R)
655-07203	26May85	F	AHY	Cascade	S-Green(L),White(R)
655-07204	2Jun85	F	AHY	Cascade	
655-07205	2Jun85	M	AHY	Cascade	C-Red(L),Red(R)
655-07206	6Jun85	F	AHY	Cascade	
655-07207	6Jun85	M	AHY	Cascade	C-Gray,White
655-07208	7Jun85	M	AHY	L.Berry	S-Black(L),White(R)
655-07209	7Jun85	M	AHY	L.Berry	S-Gray(L),Gray(R)
655-07210	7Jun85	M	AHY	L.Berry	S-Yellow(L),Blue(R)
655-07211	8Jun85	M	AHY	L.Moose	S-Yellow(L),Orange(R)
655-07212	8Jun85	M	AHY	L.Moose	T-Yellow(L),Blue(R)
655-07213	8Jun85	F	AHY	L.Moose	T-White(L),Green(R)
655-07214	22Jun85	M	AHY	Cascade	S-Red(L),Green(R)
655-07215	22Jun85	F	AHY	Cascade	C-White(L),Orange(R)
655-07216	22Jun85	F	AHY	Cascade	T-Orange(L),Yellow(R)
655-07217	30Jun85	F	AHY	L.Berry	T-Orange(L),Blue(R)
655-07218	30Jun85	F	AHY	L.Berry	S-Blue(L),White(R)
655-07219	4Jul85	F	AHY	U.Moose	C-Orange(L),Orange(R)
655-07220	28Jul85	F	AHY	L.Berry	T-Green(L),Green(R)
655-07221	11Aug85	F	AHY	L.Berry	C-Black(L),White(R)
655-07222	11Aug85	M	L	L.Berry	
655-07223	11Aug85	F	L	L.Berry	
655-07224	11Aug85	F	AHY	L.Berry	C-Blue(L),Blue(R)
655-07225	11Aug85	F	L	L.Berry	
655-07226	11Aug85	F	L	L.Berry	
655-07227	11Aug85	M	L	L.Berry	
655-07228	11Aug85	F	L	L.Berry	
655-07229	17Aug85	F	L	L.Berry	
655-07230	17Aug85	F	L	L.Berry	
655-07231	17Aug85	F	L	L.Berry	
655-07232	18Aug85	F	AHY	U.Moose	C-White(L),Blue(R)
655-07233	18Aug85	M	L	U.Moose	
655-07234	18Aug85	F	L	U.Moose	
655-07235	18Aug85	F	L	U.Moose	
655-07236	24Aug85	F	L	U.Moose	
655-07237	24Aug85	M	L	U.Moose	
655-07238	24Aug85	M	L	U.Moose	
655-07239	24Aug85	F	L	U.Moose	
655-07240	24Aug85	M	L	U.Moose	
655-07241	24Aug85	M	L	U.Moose	
655-07242	24Aug85	M	L	U.Moose	
655-07243	24Aug85	M	L	U.Moose	

Table 14. Summary of banding activities in 1986.

Number	Date	Age	Sex	Location	Markers
655-07244	20May86	AHY	M	Cascade	C-Green(L), Blue(R)
655-07245	25May86	AHY	M	L.Berry	S-Gray(L), Blue(R)
655-07246	25May86	AHY	M	L.Berry	S-White(L), Red(R)
655-07247	25May86	AHY	M	L.Berry	C-Green(L), Yellow(R)
655-07248	28May86	AHY	M	Granite	C-White(L), White(R)
655-07249	12Jun86	AHY	F	L.Berry	T-Black(L), White(R)
655-07250	12Jun86	AHY	F	L.Berry	C-Yellow(L), White(R)
655-07251	12Jun86	AHY	M	L.Berry	O-Green(L), Green(R)
655-07252	13Jun86	AHY	M	U.Moose	S-Orange(L), White(R)
655-07253	13Jun86	AHY	F	U.Moose	T-White(L), White(R)
655-07254	29Jun86	AHY	F	U.Moose	S-Green(L),Yellow(R)
655-07255	11Jul86	AHY	F	Cascade	C-Yellow(L), Yellow(R)
655-07256	31Jul86	L	?	L.Berry	
655-07257	31Jul86	L	?	L.Berry	
655-07258	31Jul86	L	?	L.Berry	
655-07259	31Jul86	L	?	L.Berry	
655-07260	31Jul86	L	?	L.Berry	
655-07261	1Aug86	AHY	F	Granite	C-Green(L),White(R)
655-07262	1Aug86	L	?	Granite	
655-07263	1Aug86	L	?	Granite	
655-07264	1Aug86	L	?	Granite	
655-07265	1Aug86	L	?	Granite	
655-07266	1Aug86	L	?	Granite	
655-07267	1Aug86	L	?	Granite	
655-07268	1Aug86	L	?	Granite	
655-07269	6Aug86	AHY	F	U.Moose	C-Yellow(L), Blue(R)
655-07270	9Aug86	AHY	F	L.Moose	S-Yellow(L), Yellow(R)
655-07271	10Aug86	L	?	Cascade	
655-07272	17Aug86	L	M	U.Moose	
655-07273	17Aug86	L	M	U.Moose	
655-07274	17Aug86	L	F	U.Moose	
655-07275	17Aug86	L	F	U.Moose	
655-07276	17Aug86	L	M	U.Moose	
655-07277	27Aug86	L	M	Cascade	
655-07278	2Sep86	L	M	U.Berry	
655-07279	2Sep86	L	M	U.Berry	
655-07280	2Sep86	L	M	U.Berry	
655-07281	3Sep86	L	?	U.Moose	
655-07282	3Sep86	L	M	U.Moose	
655-07283	3Sep86	L	M	U.Moose	
655-07284	3Sep86	L	F	U.Moose	
655-07285	3Sep86	L	M	U.Moose	
655-07286	16Sep86	L	F	U.Moose	
655-07287	16Sep86	L	F	U.Moose	
655-07288	16Sep86	L	F	U.Moose	
655-07289	16Sep86	L	F	U.Moose	
655-07290	16Sep86	L	F	U.Moose	
655-07291	16Sep86	L	M	U.Moose	

APPENDIX B

COMPILATION OF HABITAT AND MORPHOMETRY DATA

Table 15. Calculations for availability-utilization procedure for all creeks combined.

Habitat parameter	% Avail.	% Util.	Chi-square Value	Confidence interval (.05 significance)
Bank type			6.7	
V-H	.29	.39		.309 < Pi < .471 +
V-V	.38	.27		.196 < Pi < .343 -
H-H	.33	.34		.307 < Pi < .373
Bottom type				
sand	.06	.17		
16-64	.42	.67		
64-256	.26	.14		
Boulder	.18	.02		
Bedrock	.08	---		
Streamside vegetation			12.62	
shrub	.56	.67		.579 < Pi < .761 +
annual	.11	.02		.000 < Pi < .044 -
trees	.22	.16		.097 < Pi < .223
none	.11	.15		.088 < Pi < .212
Channel type			111.3	
meander	.70	.53		.444 < Pi < .616 -
braided	.18	.37		.287 < Pi < .453 +
bedrock	.11	.01		.000 < Pi < .027 -
pond	.01	.09		.041 < Pi < .139 +
Bank composition				
veg	.60	.77		
bed-rock	.10	.01		
rip-rap	.11	.00		
snag	.12	.02		
cobble	.03	.10		
mud	.04	.10		
Loafing site availability			31.91	
0/10 m	.47	.20		.134 < Pi < .266 -
1-3/10 m	.19	.23		.161 < Pi < .299
>3/10 m	.34	.57		.488 < Pi < .652 +
Proximity to human activities			29.14	
adjacent	.14	.21		.140 < Pi < .280
near	.25	.29		.212 < Pi < .368
away,acc.	.13	.26		.184 < Pi < .336 +
away,ina.	.48	.24		.166 < Pi < .314 -
Human use of the area			8.79	
none	.65	.56		.474 < Pi < .646 -
little	.16	.17		.105 < Pi < .235
moderate	.05	.11		.056 < Pi < .164 +
heavy	.14	.16		.097 < Pi < .223

Table 16. Calculations of availability-utilization procedure for Granite Creek and Cascade Creek combined.

Habitat parameter	% Avail.	% Util.	Chi-square Value	Confidence interval (.05 significance)
Bank type			19.16	
V-H	.32	.24		.122 < Pi < .358
V-V	.28	.14		.044 < Pi < .236 -
H-H	.40	.61		.475 < Pi < .745 +
Bottom type				
sand	.12	.45		
16-64	.33	.29		
64-256	.25	.23		
Boulder	.23	.03		
Bedrock	.07	---		
Streamside vegetation			50.86	
shrub	.67	.57		.427 < Pi < .713
annual	.07	.01		.000 < Pi < .039 -
trees	.23	.25		.125 < Pi < .375
none	.03	.16		.054 < Pi < .266 +
Channel type				
meander	.72	.64		
braided	.19	.12		
bedrock	.02	---		
pond	.07	.24		
Bank composition				
veg	.60	.90		
bed-rock	.03	---		
rip-rap	.19	.04		
snag	.16	.06		
cobble	.02	---		
Loafing site availability			17.97	
0/10 m	.40	.21		.098 < Pi < .322 -
1-3/10 m	.16	.27		.147 < Pi < .392
>3/10 m	.44	.52		.382 < Pi < .658
Proximity to human activities			69.08	
adjacent	.18	.45		.306 < Pi < .594 +
near	.33	.39		.249 < Pi < .531
away,acc.	.12	.08		.002 < Pi < .158
away,ina.	.37	.08		.002 < Pi < .158 -
Human use of the area			63.98	
none	.51	.15		.047 < Pi < .253 -
little	.09	.13		.033 < Pi < .227
moderate	.10	.28		.150 < Pi < .410 +
heavy	.30	.44		.297 < Pi < .583

Table 17. Calculations of availability-utilization procedure for Moose Creek and Berry Creek combined.

Habitat parameter	% Avail.	% Util.	Chi-square value	Confidence interval (.05 significance)
Bank type			18.92	
V-H	.28	.47		.367 < Pi < .573 +
V-V	.47	.34		.242 < Pi < .438 -
H-H	.25	.19		.109 < Pi < .271
Bottom type				
sand	---	.02		
16-64	.51	.87		
64-256	.28	.09		
Boulder	.13	.02		
Bedrock	.08	---		
Streamside vegetation			28.7	
shrub	.46	.71		.612 < Pi < .808 +
annual	.15	.03		.000 < Pi < .067 -
trees	.21	.11		.043 < Pi < .177 -
none	.18	.15		.073 < Pi < .227
Channel type			93.1	
meander	.69	.48		.377 < Pi < .583 -
braided	.16	.51		.407 < Pi < .603 +
bedrock	.15	.01		.002 < Pi < .018 -
Bank composition				
veg	.59	.72		
bed-rock	.16	.01		
rip-rap	.03	---		
snag	.08	---		
cobble	.05	.13		
mud	.08	.14		
Loafing site availability			73.55	
0/10 m	.53	.19		.109 < Pi < .271 -
1-3/10 m	.23	.22		.135 < Pi < .305
>3/10 m	.24	.60		.499 < Pi < .701 +
Proximity to human activities			45.87	
adjacent	.08	.07		.015 < Pi < .125
near	.16	.24		.148 < Pi < .332
away,acc.	.15	.36		.257 < Pi < .463 +
away,ina.	.61	.33		.229 < Pi < .431 -
Human use of the area			90.9	
none	.77	.78		
little	.23	.19		
moderate	---	.02		
heavy	---	.07		

Table 18. Morphometric measurements of drainage basins in the Teton Range.

Stream	Elevation (m above sea level)	Area (km2)	Length (km)	Slope (degrees)
Granite Creek	2110-2367	35.45	3.9	3.5
no.fork	2410-2745		4.0	4.8
so.fork	2410-2867		3.9	6.5
Open Canyon	2123-2684	12.53	4.0	8.0
Death Canyon	2023-2666	33.29	6.1	5.8
Taggart Creek	2105-2660	14.47	4.1	7.8
Garnet Canyon	2142-2928	6.78	3.4	13.0
Cascade Creek	2069-2361	42.43	6.2	3.0
no.fork	2361-2756		4.1	5.7
so.fork	2361-2879		4.8	6.3
Paintbrush Creek	2097-2879	11.13	5.2	8.6
Leigh Creek	2097-2806	23.23	9.6	4.3
Moran Creek	2065-2391	43.95	6.6	2.9
no.fork	2391-2928		4.3	7.3
so.fork	2391-2806		4.4	5.4
N. Moran Creek	2065-2306	24.53	3.9	3.6
no.fork	2306-2928		2.9	12.3
so.fork	2306-2830		5.3	5.8
Waterfall Canyon	2065-2928	11.76	4.9	10.0
Moose Creek	2062-2086	63.30	2.7	.5
canyon	2086-2269		3.2	3.3
bench	2269-2333		3.1	1.3
upper	2333-2916		7.0	4.9
Berry Creek	2058-2074	92.62	2.6	.3
canyon	2074-2178		4.0	2.0
bench	2178-2190		1.9	.3
upper	2190-2952		11.3	4.0
Owl Creek	2196-2257	31.44	4.4	.9
upper	2257-2798		4.9	6.1

MONTANA STATE UNIVERSITY LIBRARIES
3 1762 10020867 5