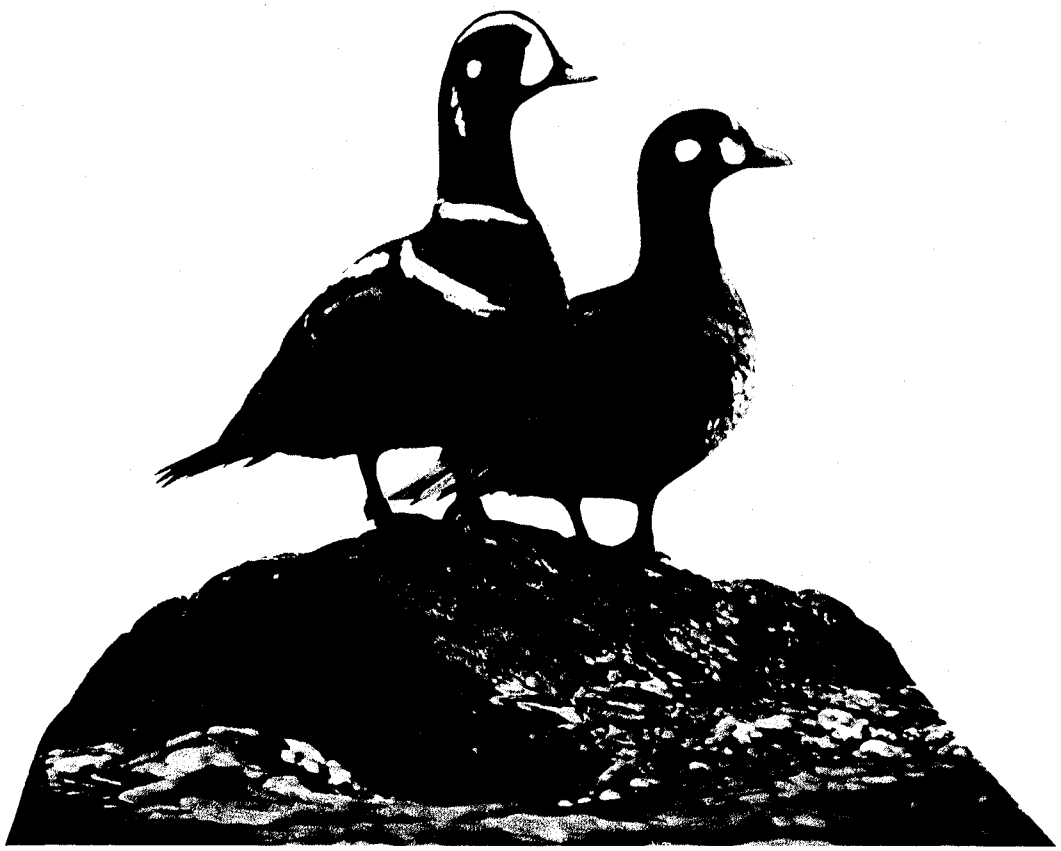
HARLEQUIN DUCK ECOLOGY IN IDAHO: 1987-1990



by

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EXECUTIVE SUMMARY

Harlequin ducks (Histrionicus histrionicus) are sea ducks that winter in coastal areas and nest along swiftly flowing mountain streams. The species exists in two disjunct populations: Atlantic and Pacific. Because of a substantial decline in numbers, the species is classified as endangered in eastern Canada and the hunting season has been closed on the Atlantic population throughout most of its' range in eastern North America. The Pacific population is considerably larger, but population size and trend are unknown. Little research has been conducted on the ecology of the species.

Harlequin ducks were studied in Idaho from 1987-1990 to document numbers, distribution, breeding biology and habitat use. This report summarizes the results of Idaho research and compares characteristics of harlequin duck breeding ecology in Idaho to that in other areas. Management, inventory and monitoring programs are recommended and research hypotheses are presented and discussed.

Harlequin ducks arrived on Idaho streams in March, April and May. Incubation occurred from mid-May through July and males left breeding areas shortly after incubation commenced. However, some pairs apparently reunited off breeding areas and maintained the same mate over several breeding seasons. Most broods hatched at the end of June or the beginning of July and remained on breeding streams through late August or September. Mean brood size was 3.4. About one/third of broods were abandonded by the

hen prior to fledging, similar to rates of abandonment observed in Grand Teton National Park, Wyoming.

The timing of breeding activities was similar to that observed in Glacier National Park, Montana but about three weeks ahead of Grand Teton National Park, probably due to altitudinal differences. Males spent one to three months in Idaho and females with broods spent up to six months in the state.

Although body weight and brood size were average compared to other breeding areas, pair density (0.15/km) and percent of pairs successfully breeding (29%) were low. However, both of the latter exhibit considerable annual variation and monitoring should be continued for at least several years to better document these findings.

Individuals appeared to have a high fidelity to a relatively small number of streams. Confirmed breeding occurred on 13 streams north of and including the Lochsa River and one stream on the west slope of the Teton Mountains in northwest Wyoming. Some adult harlequins observed in Idaho during the spring nested elsewhere. The population remaining in Idaho during the breeding season was probably under 100 individuals.

Harlequin ducks primarily used riffle, run and rapid stream habitats with a cobble to boulder substrate, on second to fifth order streams over 50 m from roads. In northern Idaho these streams were usually in mature to old-growth western red cedar (Thuja plicata)-western hemlock (Tsuga heterophylla) or spruce (Picea engelmanii)-fir (Abies lasiocarpa) overstory. Harlequins

on the west slope of the Teton Mountains in southeastern Idaho and northwestern Wyoming were observed on stream reaches with shrubby riparian vegetation and younger age-class Douglas-fir (Pseudotsuga menziesii) overstory. Although no nests were discovered, nesting areas appeared to be upstream from breeding pair activity centers in northern and north-central Idaho. Broods used upstream reaches with slower flows, more vegetative overhang and more woody debris in the stream. Comparison of habitat on streams with high and low pair densities suggested that brood-rearing habitat may be limited on some streams.

Use of clear, clean, swiftly flowing streams is universal to all five breeding areas where harlequins have been studied, probably partly due to the abundance of benthic macroinvertebrates in these stream reaches. A preliminary examination of the role of benthic macroinvertebrates in population regulation and productivity was conducted by collecting samples on several streams in Idaho and on streams with greater harlequin productivity in Glacier National Park and Grand Teton National Park.

All stream reaches where harlequins are known or suspected to breed are listed and should be surveyed for adults a minimum of once in May and for broods at least once in August. Management of streams used by harlequin ducks in Idaho should emphasize maintaining healthy macroinvertebrate populations and minimizing disturbance of riparian areas. Rocky Mountain studies have also suggested that human disturbance may reduce

productivity. Logging, road-building and human disturbance should be avoided along stream reaches used by harlequins. However, if such actions are planned, monitoring and habitat measurements should be included in the biological evaluation of that activity. Continued inventory of additional streams is also recommended. Future research could address factors potentially limiting the population including benthic invertebrate biomass, nesting and brood-rearing habitat availability, flood events, weather, and factors outside breeding areas.

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INTRODUCTION

This report is a synopsis of the first four years of harlequin duck (Histrionicus histrionicus) research in Idaho (Wallen and Groves 1988, 1989; Cassirer 1989; Cassirer and Groves 1989, 1990a b; Atkinson and Atkinson 1990). The primary objectives of this research were to determine the population status and distribution of the species in the state. We also documented breeding chronology, productivity, habitat use and movements. Results are presented in the context of current knowledge of harlequin duck biology, management implications are discussed and future research needs and hypotheses are identified and discussed in detail.

BACKGROUND

Description

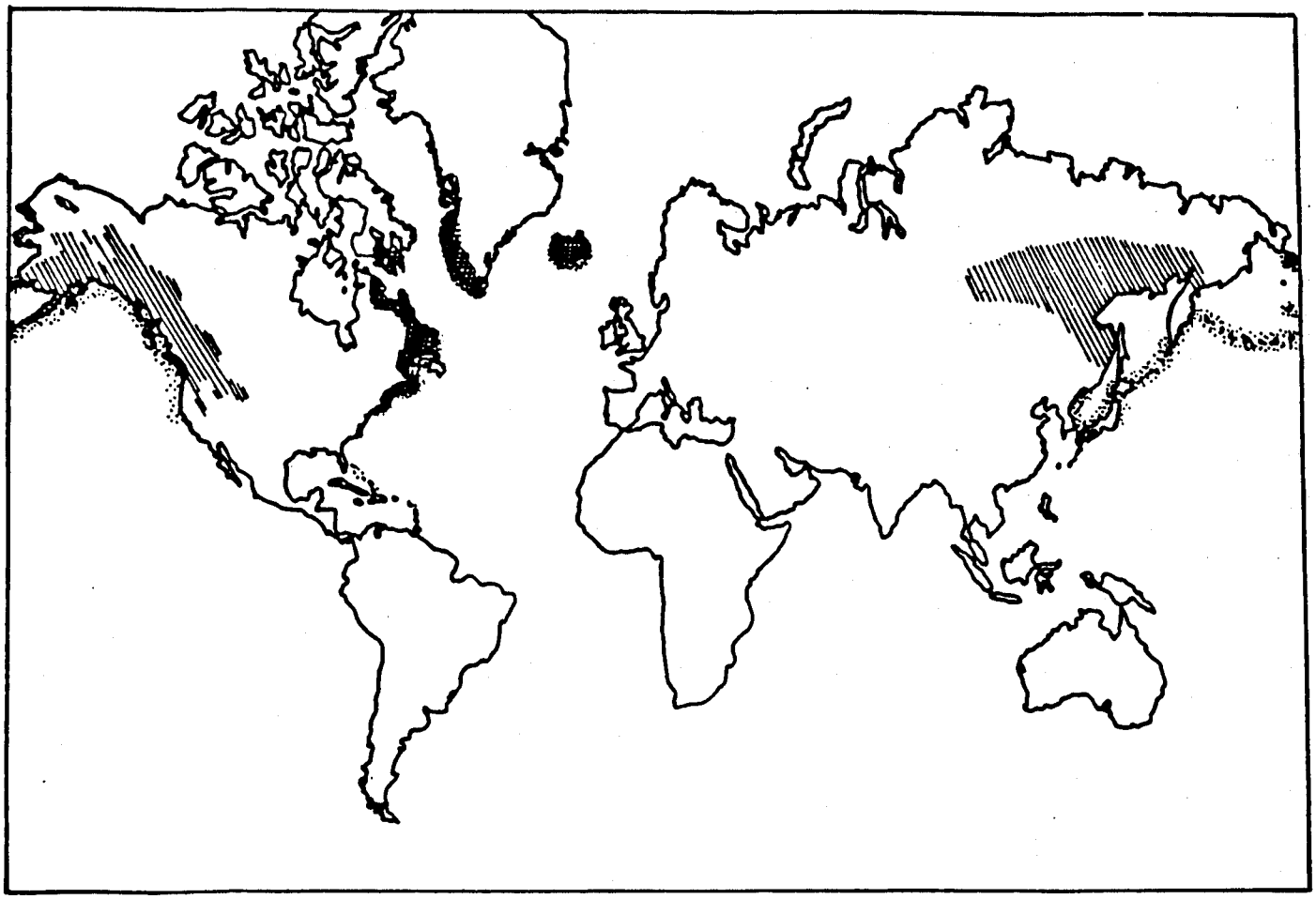
Harlequin ducks are small (500-800 g) sea ducks. Males are slate blue with chestnut flanks and crown and white markings on the head, neck and back. Females and juveniles are an inconspicuous brown with three white marks on the side of the head and a buff-colored belly. The striking markings of the male led Bellrose (1980) to describe the harlequin as "the most bizarrely colored waterfowl", however Bengston (1966) remarked that this spectacular plumage can actually be cryptic in the whitewater habitat where the ducks are often found. Once juveniles have attained flight skills (40-65 days), females and juveniles are physically indistinguishable in the field except that juveniles have yellowish-gray legs and feet, whereas those

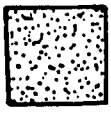
of adults are completely gray. Males molt into partial breeding plumage their first winter but do not acquire full nuptial plumage until the following winter. Females are smaller than males and both sexes usually appear completely dark in flight. Distinctive behavioral characteristics include noticeable buoyancy in the water and a characteristically low flight pattern close to the water surface.

Distribution

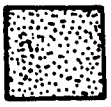
Harlequin ducks winter in coastal waters and migrate inland to nest along mountain streams. The species is Holarctic in distribution but occurs in two distinct populations, eastern (Atlantic) and western (Pacific) (Figure 1). At one time these were considered separate subspecies (H. h. histrionicus and H. h. pacificus respectively) but currently are classified as disjunct populations with no subspecific designation (American Ornithologists' Union 1983).

The breeding distribution of the eastern population ranges from Baffin Island south through eastern Quebec and includes Iceland, parts of Greenland, Labrador and Newfoundland with wintering areas extending south along the Atlantic coast of North America to Virginia and occasionally to Florida and the Gulf coast. The western breeding range is located in northeastern Siberia from the Lena River to the Kamchatka Peninsula, the Commander Islands, north to the Arctic Circle, the Pribilof and Aleutian Islands, and interior Alaska south through British Columbia, Washington, Idaho, Oregon and Montana to the Rocky



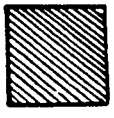


Atlantic winter range



Pacific winter range

Atlantic breeding range



Pacific breeding range

Figure 1. Global distribution of harlequin ducks.

Mountains of northwestern Wyoming and the Sierra Nevada Mountains in central California. Historical breeding records have occurred as far south as southwestern Colorado (Parkes and Nelson 1976). Wintering areas extend along the Pacific coast of eastern Eurasia from southern Kamchatka to central Japan and from the Pribilof and Aleutian islands to central and rarely southern California in the United States (Bellrose 1980, AOU 1983, Vickery 1988).

Status

The Atlantic population of harlequin ducks was recently estimated at 4,000. The subpopulation wintering in eastern North America has declined substantially since the early 19th century and is currently estimated at less than 1,000 individuals (Vickery 1988; Goudie 1988, 1989). Harlequin ducks were classified as an endangered species in eastern Canada in 1990, and Maine has closed the hunting season and is considering state designation as a threatened species.

The Pacific population has always been larger than the Atlantic, but there is no reliable estimate of harlequin duck numbers in this population. Harlequin ducks are not an important game species in most of western North America and are usually missed in wintering waterfowl counts because they occur in different (often relatively inaccessible) areas than other waterfowl and because they can be difficult to detect and identify from the air. One of the highest density populations probably winters on the Aleutian Islands National Wildlife Refuge in Alaska although numbers are probably lower than the estimated

counts of 600,000 to one million reported by Bellrose (1980) (V. Byrd, U.S.F.W.S. pers. comm.). An estimated 900 harlequins winter in the Straits of Juan de Fuca and around the San Juan Islands, Washington (Hirsch 1980).

In the Rocky Mountains, low population size, restricted distribution and relative lack of information on the species recently led to designation of the harlequin duck as a "sensitive species" in Regions 1 (Reel et al. 1989) and 4 of the U.S. Forest Service (Mosely and Groves 1990). Protection of sensitive species involves implementation of management practices to insure that they do not become threatened or endangered. Harlequins are technically a game species in Idaho but have usually migrated out of the state by the opening of waterfowl season. In 1989 the Idaho Department of Fish and Game classified the harlequin as a "species of special concern (priority species)". This designation is not accompanied by statutory protection. Harlequins are also classified as a state species of special concern in Montana and in 1990 both Montana and Idaho recommended that the U.S. Fish and Wildlife Service list harlequins as a Category 2 candidate species under the Endangered Species Act.

Harlequins are a game species in Alaska, Washington, Oregon, and California. Hunting pressure is considered low in most areas (V. Byrd, U.S.F.W.S., G. Schirato, W.D.O.W pers. comm.).

Research and Monitoring

Harlequin ducks have received relatively little scientific attention. There have been few comprehensive studies on breeding

areas and even fewer on wintering areas.

Outside Idaho, harlequin breeding ecology has been studied in Glacier National Park, Montana (Kuchel 1977), Prince William Sound, Alaska (Dzinbal 1982), Grand Teton National Park, Wyoming (Wallen 1987a, 1991), and Iceland (Bengston 1966, 1972; Bengston and Ulfstrand 1971; Gudmundsson 1971; Inglis et al. 1989).

Annual or occasional breeding surveys have been conducted on streams in Glacier National Park (Steve Gniadek, N.P.S. pers. comm.), western Montana (Miller 1988, 1989, 1990; Markum 1990), Yellowstone National Park, Wyoming (Terry McEneany, N.P.S. pers. comm.), Grand Teton National Park (Wallen 1987b, 1991), the Methow River, Washington (George Brady, W.D.O.W., unpubl. data), North Cascades National Park, Washington (Bob Koontz, N.P.S., pers. comm.), and northern Labrador (Goudie 1988). A survey is scheduled for streams on the Olympic Peninsula, Washington in 1991 (Greg Schirato, W.D.O.W., pers. comm.).

Most wintering information concerns food habits or has been collected in conjunction with research on the ecology of sea ducks as a whole. Information on wintering harlequins has been collected in Puget Sound, Washington, the Strait of Georgia, British Columbia (Myres 1959, Hirsch 1980, Fleischner 1983, Gaines and Fitzner 1987, Vermeer 1983) and southeast Newfoundland (Goudie 1984; Goudie and Ankney 1986, 1988). Wintering area surveys have been conducted at and around Acadia National Park, Maine (Vickery 1988, Mittlehauser and Hazen 1990), Newfoundland (I. Goudie, C.W.S., pers. comm.), northwest Washington (Hirsch

1980, Cassirer and Schirato 1990), Prince William Sound, Alaska (K. Laing, U.S.F.W.S., pers. comm.) and Aleutian Islands National Wildlife Refuge, Alaska (V. Byrd, U.S.F.W.S., pers. comm.).

Breeding Ecology

Harlequins usually do not mature sexually until their second year and most immature individuals remain in coastal areas during the breeding season. Pairs probably migrate to the breeding grounds together during April and May. Some unpaired males and rarely unpaired females also migrate inland. Spring breeding area populations average 55-64% males (Bengston 1972, Kuchel 1977, Inglis et al. 1989).

Habitat use

Harlequins are the only duck in North America to breed exclusively on whitewater streams. In the southern hemisphere this niche is occupied by the torrent duck (Merganetta armata) in South America, the blue duck (Hymenolaimus malacorhyncos) in New Zealand, the African black duck (Anas sparsa) and Salvadori's duck (Anas waigiyensis) in New Guinea, although these species do not share the anadromous lifestyle of the harlequin. Harlequin ducks generally nest along second order or greater streams with a cobble to boulder substrate, a relatively healthy stream macroinvertebrate population and some shallow and low gradient reaches. Geology on harlequin duck breeding areas ranges from glacial till and bedrock to lava flows. Vegetation varies from coniferous forest in the northern Rocky Mountains to moorland in Labrador and Iceland.

Nesting

Harlequin duck nests are well-hidden, and most investigators outside Iceland have been unable to locate nests. In Iceland, harlequins usually nest on the ground on islands or on the streambank in shrubby vegetation (Salix spp. and Angelica spp.) within 5 m of the stream (Bengston 1972). A few nests are in rocky areas, cavities, and in moorland and grasslands. Nests have been found under a root overhang in the creek bank, on a cliff ledge over the river and on a 2 m high rock on an island in British Columbia (Campbell et al. 1990), and in a logjam in Montana (Thompson 1985). Merriam (1883) reported harlequins nesting in hollow tree stumps on islands in Newfoundland. Kuchel (1977) and Dzinbal (1982) remarked that nests often appeared to be upstream from the pair's breeding season home range whereas Wallen (1987a) felt that nests were near areas where pairs were observed during the breeding season.

Egg-laying occurs from mid-May to mid-June, relatively late compared to other waterfowl, and may be timed so that the incubation period is synchronized with the period of peak stream runoff and hatching coincides with time of greatest benthic macroinvertebrate availability (Kuchel 1977, Wallen 1987a). Stream insect larvae are the primary food on breeding areas (Bengston and Ulfstrand 1971, Pool 1962) although harlequins will also feed on roe when available (Dzinbal 1982).

The incubation period is 27-29 days (Bengston 1972). Shortly after females begin incubation most males return to the

coast, eliminating any opportunities for renesting if the clutch is unsuccessful. Only one case has been reported of a male accompanying a female with a brood during the summer (Harrison 1967).

Bengston (1972) documented an average clutch size of 5.7 and hatching success (number of eggs hatched/number of eggs laid) of 84-91%. Nest predation by ravens (Corvus corax), mink (Mustela vison), arctic skua (Catharacta skua), and arctic fox (Alopex lagopus) accounted for most egg loss. Kuchel (1977) was unable to locate any nests, but suggested that some nests may be washed out during spring runoff.

Brood Rearing

Ducklings are born in June and July. Survival rates to fledging range from 18-83% (Bengston 1972, Kuchel 1977) and reflect significant annual variation. Most duckling mortality occurs in the first three weeks of life. Causes of mortality are high water flows, mammalian and avian predation (Bengston 1972, Kuchel 1977, Wallen 1987a), and possibly adverse weather and human disturbance (Bengston op. cit.). Young broods are fairly sedentary and remain in pools and backwaters presumably near nesting areas for the first few weeks of life (Kuchel 1977, Dzinbal 1982). Later in the summer they move downstream and use faster water before migrating to the coast in August or September. Average brood size at class III (36-42 days) is 2.6-4.5 (Kuchel 1977, Dzinbal 1982, Wallen 1987a, 1991). Wallen (1987a) found 40% of broods were abandoned by the hen prior to

fledging while Kuchel (1977) and Dzinbal (1982) did not observe any brood abandonment.

Winter Ecology

Harlequins winter close to reefs, rocky islands and cobble beaches usually in small groups but occasionally in rafts of several hundred or more (Fleischner 1983, Goudie and Ankney 1988). They appear to be more tolerant of rough surf than other waterfowl and usually do not occur in flocks with other ducks. Harlequins are considered more wary of humans during winter than during the breeding season (Alford 1920, Bengston 1966, Fleischner 1983).

Wintering harlequins feed mainly on snails, crabs, amphipods, isopods, mollusks and other invertebrates associated with rocky and gravel substrates and kelp and eelgrass beds (Vermeer 1983, Goudie and Ankney 1986, Gaines and Fitzner 1987). Harlequins may be limited in their ability to meet energy requirements in harsh winter conditions due to their small body size (Goudie and Ankney op. cit.). Males outnumber apparent females throughout the winter on the west coast (Fleischner 1983, Campbell 1990) while apparent females slightly outnumbered males in most counts off the coast of Maine (Mittlehauser 1989, 1990). The percent of paired individuals increases from October to January and from February through mid-May the majority of flocks are pair groups. By late May most pairs have left wintering areas (Fleischner op. cit.).

Migration

Little is known about migration between breeding and wintering areas. Harlequins probably follow stream corridors during migration, however the western population must fly overland to reach breeding areas on the eastern side of the continental divide. Migration from the coast to breeding areas is probably accomplished by a combination of swimming and flight and may be influenced by weather and snow conditions encountered enroute. Return migration may be relatively rapid (Bengston 1966, Wallen 1987a). Wallen (op. cit.) suggested that harlequins may fly more during the long migration to breeding areas in Grand Teton National Park than Bengston hypothesized for harlequins in Iceland. Wallen also suggested that males may fly directly back to the coast prior to molting or may migrate at night because few male harlequins are observed on intervening streams during this period. Some broods apparently leave breeding streams before fledging (Kuchel 1977, Dzinbal 1982).

METHODS

Data collection methods used in Idaho surveys and research are summarized below. Methods varied to some extent during the study and more detailed descriptions of methods used each year are contained in annual reports (Wallen and Groves 1988, 1989; Cassirer 1989; Cassirer and Groves 1989; Cassirer and Groves 1990; Atkinson and Atkinson 1990).

Surveys

From 1987-1990, eighty streams, primarily in northern and north-central Idaho and on the west slope of the Teton Range in southeastern Idaho and Wyoming, were surveyed between April and August. Sections of some streams in central Idaho where harlequin ducks were reported were also checked. Streams were chosen on the basis of reports of harlequin use, proximity to streams with known use and on availability of suitable habitat as described by Wallen (1987a).

Surveys were conducted primarily by walking in and along streams and also by rafting or inner tubing and driving on roads adjacent to streams. In 1990 stream reaches known to be used by harlequin ducks were repeatedly censused to estimate population size and reproductive success. Both field effort and harlequin observations increased during the study, but surveys remained labor intensive with an average of three person-days expended for each harlequin observation from 1988-1990 (Figure 2). More harlequin duck

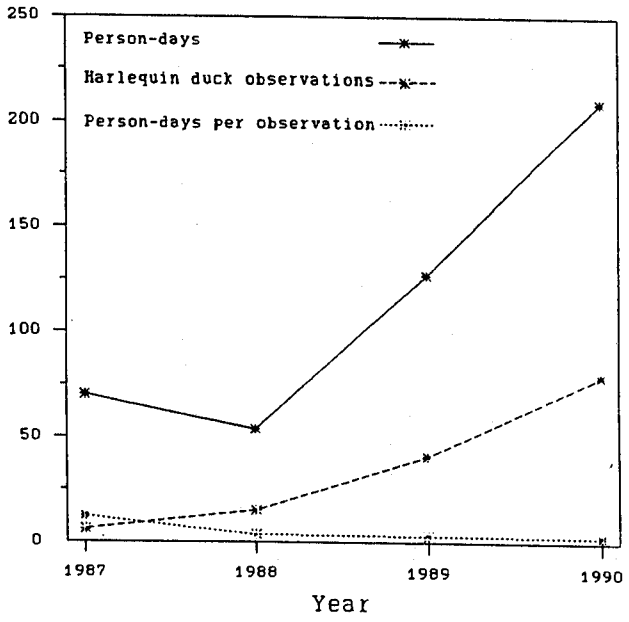


Figure 2. Field effort allocated to harlequin duck surveys in Idaho, 1987-1990. (From 1988-1990 each harlequin duck observation required 3 person-days in the field).

observations did not denote increased numbers of ducks, but was due primarily to more complete censuses and more confirmations of reports.

Ducklings were classified by plumage development according to Gollop and Marshall (1954) and aged using harlequin duck development as calculated by Wallen (1987a). Laying, incubation and hatching dates were estimated by backdating from estimated duckling ages.

A poster soliciting reports of harlequin duck observations was circulated to Department of Fish and Game and National Forest offices and to river guides. Trailheads and other stream access points were also posted. Reported sightings were usually followed up by a stream survey. Posters requesting reports of marked harlequins were also distributed to natural resource agencies and Audubon chapters and Christmas Bird Count compilers near wintering areas in western Washington, Oregon, British Columbia and Alaska (Appendix A).

Trapping and Marking

Harlequins were trapped by setting up a mist net across the stream and driving the ducks into the net (Bengston 1972, Kuchel 1977, Wallen 1987a, Cassirer and Groves 1989). All trapped ducks were marked with U.S. Fish and Wildlife Service legbands, and most were marked with colored nylon nasal discs attached to stainless steel rods inserted through the nares (Bartonek and Dane 1964, Lokemoen and Sharp 1985). Before release individuals were weighed, and culmen length, wing chord and total body length

were measured.

Habitat Use

Habitat data were collected at brood sightings on the Upper Priest River near the Canadian border in 1989 and all sightings in 1990 (Appendix B). Less extensive habitat data were collected at adult observations 1987-1989. During August 1990, available habitat was characterized by systematically collecting data along stream reaches used by harlequin ducks at 1-km intervals (Gold Cr.-Lake Pend Oreille, Gold Creek-Priest Lake, Hughes Fork, N. Fork Granite Creek, E. Fork Lightning Creek, Crooked Fork and the Coeur d'Alene River), 3-km intervals (Upper Priest River, Moyie River) or 5-km intervals (Lochsa, St. Joe, N. Fork Clearwater) intervals. Used and available habitats, brood and adult habitats and habitats on different streams were compared with a Chi-square test of homogeneity and a Bonferroni Z statistic (Marcum and Loftsgaarden 1980, Thomas and Taylor 1990) at $P = 0.05$.

Macroinvertebrate collections

Benthic macroinvertebrate samples were collected with a 0.1 m^2 Hess sampler on streams used by harlequins in Idaho and Grand Teton and Glacier National Parks in August 1990. Samples are being analyzed at the U.S. Forest Service, Intermountain Region Aquatic Ecosystem Analysis Laboratory at Brigham Young University, Utah.

HISTORICAL DISTRIBUTION IN IDAHO

The scant historical record of harlequin duck distribution

in Idaho prior to the 1960's consists of one breeding record and four sight records on three rivers. Harlequins were collected on the Coeur d'Alene and St. Joe Rivers (Merrill 1897, Rust 1915) and were observed on the Lochsa River and again on the St. Joe River (Hand 1932, 1941). Hand (1941) reported seeing a photograph of a female on a nest at the mouth of Malin Creek on the St. Joe River and also stated that harlequins probably occurred on the Little North Fork of the Clearwater River although he never observed them there.

"Uncommon" and "rare" are used to describe the prevalence of the species in these accounts, indicating that harlequin ducks may have never been abundant in Idaho. However, the lack of even one brood observation indicates the incompleteness of these historical records. Due to the remoteness of their range and the lack of commercial or other incentive to find harlequins, little can be deduced other than that harlequins occurred historically on several rivers in northern Idaho but were not conspicuously common.

Larrison et al. (1967) described the harlequin duck as an uncommon breeder on the headwaters of "larger" streams in Shoshone, Clearwater and Idaho counties, and also possibly on the Pack River, tributaries to Priest Lake, and streams in Valley, Lemhi and Custer counties. Burleigh (1972) also called the harlequin uncommon and cited the historical accounts mentioned above. Burleigh (op. cit.) further stated that harlequins were not known to occur south of the Lochsa River. The 1983 AOU

checklist states that harlequins breed from the Canadian border to central Idaho.

More recent reports have been compiled in the course of avian species inventories in Idaho (Reese and Melquist 1985, Stephens and Sturtz 1990). In addition we collected a number of accounts dating back to the 1970's while conducting our research (Wallen and Groves 1988, 1989; Cassirer and Groves 1989, 1990a b). A complete list of reports prior to 1987 (the first year of our surveys) is contained in Appendix C. During this period harlequins were reported on 28 streams and four lakes from the Canadian border to the Snake River. Most reports were from the Lochsa River north to Canada. Broods were reported on three streams; the Little North Fork of the Clearwater, Kelly Creek and Gold Creek at Lake Pend Oreille, all north of the Lochsa River.

CURRENT DISTRIBUTION AND STATUS

Since 1987 we have observed harlequin ducks on 18 streams in Idaho and northwest Wyoming, and broods on nine of those (Table 1). We received reports of adults on an additional 27 streams and 1 reservoir and broods on five additional streams (Table 2). Appendix D contains a more detailed discussion of current harlequin breeding distribution in Idaho. Breeding has been confirmed from the Lochsa River north to the Canadian border and on the west slope of the Teton range in northwest Wyoming (Figure 3). The majority of the most productive streams are tributaries on the west side of Priest Lake and Upper Priest Lake in the

Table 1. Streams where harlequins were observed 1987-1990.

Stream	Date	Type of observation[1]
	CLEARWATER RIVER DRAINAGE	
Selway River	1989	Female
Lochsa River	1987-90	Brood
Crooked Fork	1987-88, 1990	Male
Kelly Creek	1988	Pair
N. Fork Clearwater River	1987, 1990	Brood
	ST. JOE RIVER DRAINAGE	
St. Joe River	1988, 1990	Brood
Marble Creek	1988	Male
	COEUR D'ALENE RIVER DRAINAGE	
Coeur d'Alene River	1990	Female
	LAKE PEND OREILLE DRAINAGE	
Gold Creek (PDO)	1988-90	Brood
E. Fork Lightning	1989-90	Brood
	PRIEST LAKE DRAINAGE	
Granite Creek	1987-90	Brood
Hughes Fork	1988-90	Brood
Upper Priest River	1989-90	Brood
Gold Creek	1990	Pair
	KOOTENAI RIVER DRAINAGE	
Moyie River	1990	Pair

[1] Brood observation type indicates that at least one brood was observed on the stream in one or more years.

Table 1 cont'd. Streams where harlequins were observed 1987-1990.

Stream	Date	Type of observation[1]
	SNAKE RIVER DRAINAGE	
Big Elk Creek	1989-90	Pair
Darby Creek	1990	Brood

[1] Brood observation type indicates that at least one brood was observed on the stream in one or more years.

Table 2. Streams where harlequins were reported (but not observed in this study) 1987-1990.

Stream	Date	Type of observation
	CLEARWATER DRAINAGE	
S. Fork Clearwater	May-June 1989	Pair
Crooked River	1988,May 1989	Pair
Red River	April-May 1989	Pair
Bear Creek (Selway)	June-July 1989	Pair
White Sands Creek	June 1988	Female
	July 1990	Female
Hog Meadow Creek	April 1988	Pair
Little North Fork Clearwater River	July 1988	Brood
Orogrande Creek	May 1988	Pair
	ST. JOE DRAINAGE	
Marble Creek	August 1988	Brood
Mica Creek	July 1987	Pair
N. Fork St. Joe River	June 1990	Male
Slate Creek	May 1989	Pair
	COEUR D'ALENE DRAINAGE	
Teepee Creek	July 1987	Pair
Jordan Creek	July 1987	Brood
	LAKE PEND OREILLE DRAINAGE	
Clark Fork River	May 1989	Female
N. Fork Gold Creek	July 1990	Females

Table 2 cont'd. Streams where harlequins were reported (but not observed in this study) 1987-1990.

Stream	Date	Type of observation
	PRIEST LAKE DRAINAGE	
Bear Paw Creek	April 1990	Pair
Huff Lake	May 1987	Pair
Two Mouth Creek	May 1989	Pair
	KOOTENAI RIVER DRAINAGE	
Long Canyon Creek	July 1990	Brood
Smith Creek	July 1987	Brood
	SALMON RIVER DRAINAGE	
Bargamin Creek	April 1990	Male
E. Fork, S. Fork Salmon	June 1989	Male
N. Fork Salmon River	April 1990	Male
Salmon River	May 1989	Pair
	November 1989	Female or imm.
	SNAKE RIVER DRAINAGE	
Camas Creek	June 1989	Pair
Chesterfield Reservoir	April 1989	Pair
McCoy Creek	May 1989	Pair
Teton Creek	May/June 1990	Pair

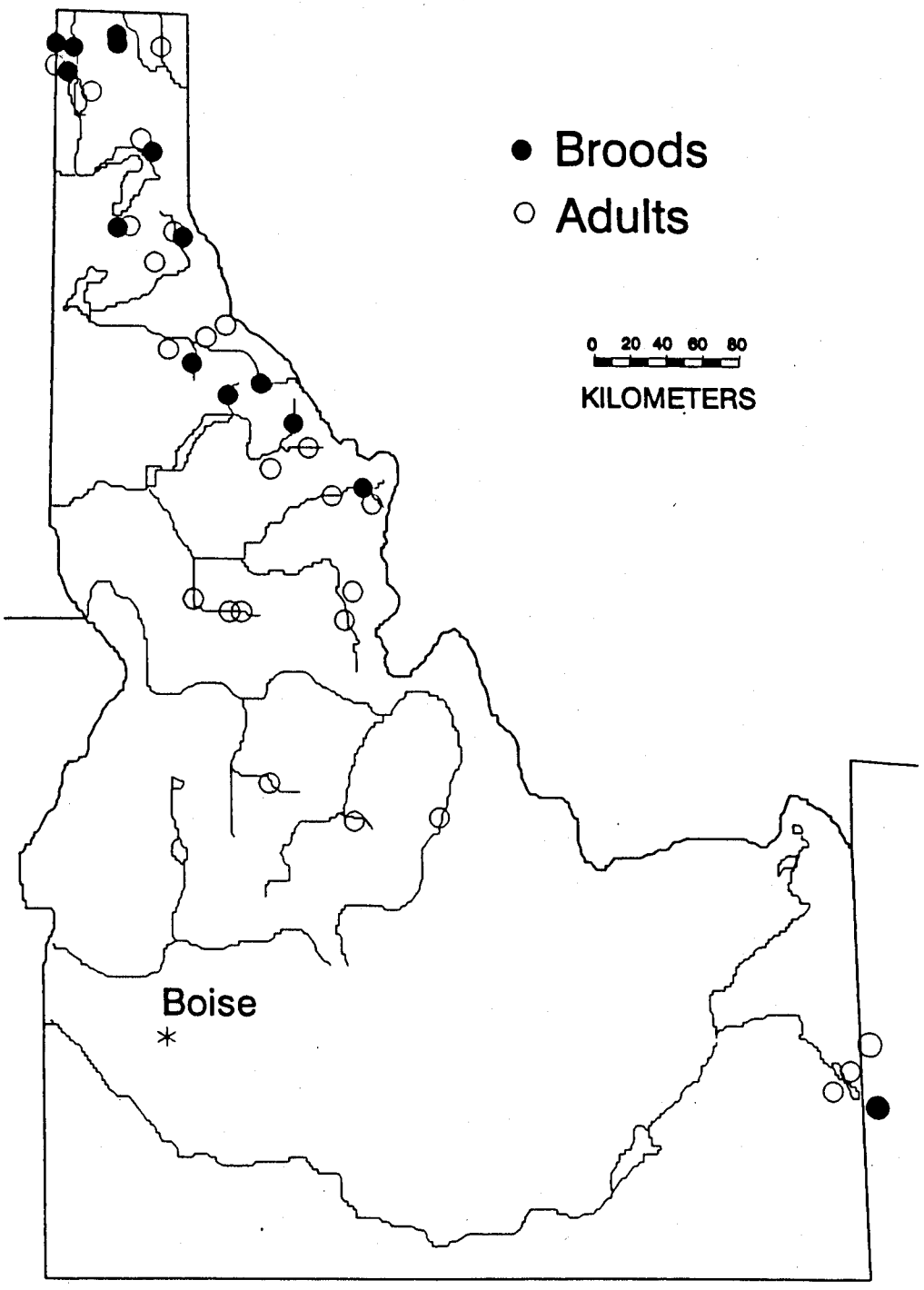


Figure 3. Distribution of harlequin ducks in Idaho, 1987-1990.

northwest corner of the state.

In 1990 we observed 32 pairs and 11 broods and, based on this information, and the extensiveness of our surveys, we estimate the adult population resident during the breeding season to be less than 100 individuals. In at least some years less than 30 individuals (15 pairs) may breed successfully. Data are currently insufficient to determine population trend. We were unable to find harlequins on some streams where they were reported prior to 1987 and this is disturbing. However, because of natural variability in productivity and lack of long term data, further monitoring is necessary before drawing any conclusions regarding population decline or increase.

BREEDING CHRONOLOGY

The timing of harlequin breeding activity is probably influenced by snow melt (Wallen 1987), stream runoff and perhaps other weather conditions. There is considerable individual variability as well. For instance, in 1990, hatching dates of three broods on the same stream were estimated to span a two-week period. Kuchel (1977) reported an average range of three weeks in hatching dates on MacDonald Creek in Glacier National Park.

Harlequins probably start arriving in Idaho in March or early April (Figure 4) but may not reach breeding areas until May. The earliest reports are from the Lochsa River in March. Our earliest observation is April 24, the earliest field survey, also on the Lochsa River. Kuchel (1977) noted that early

arrivals congregated in downstream reaches below nesting areas.

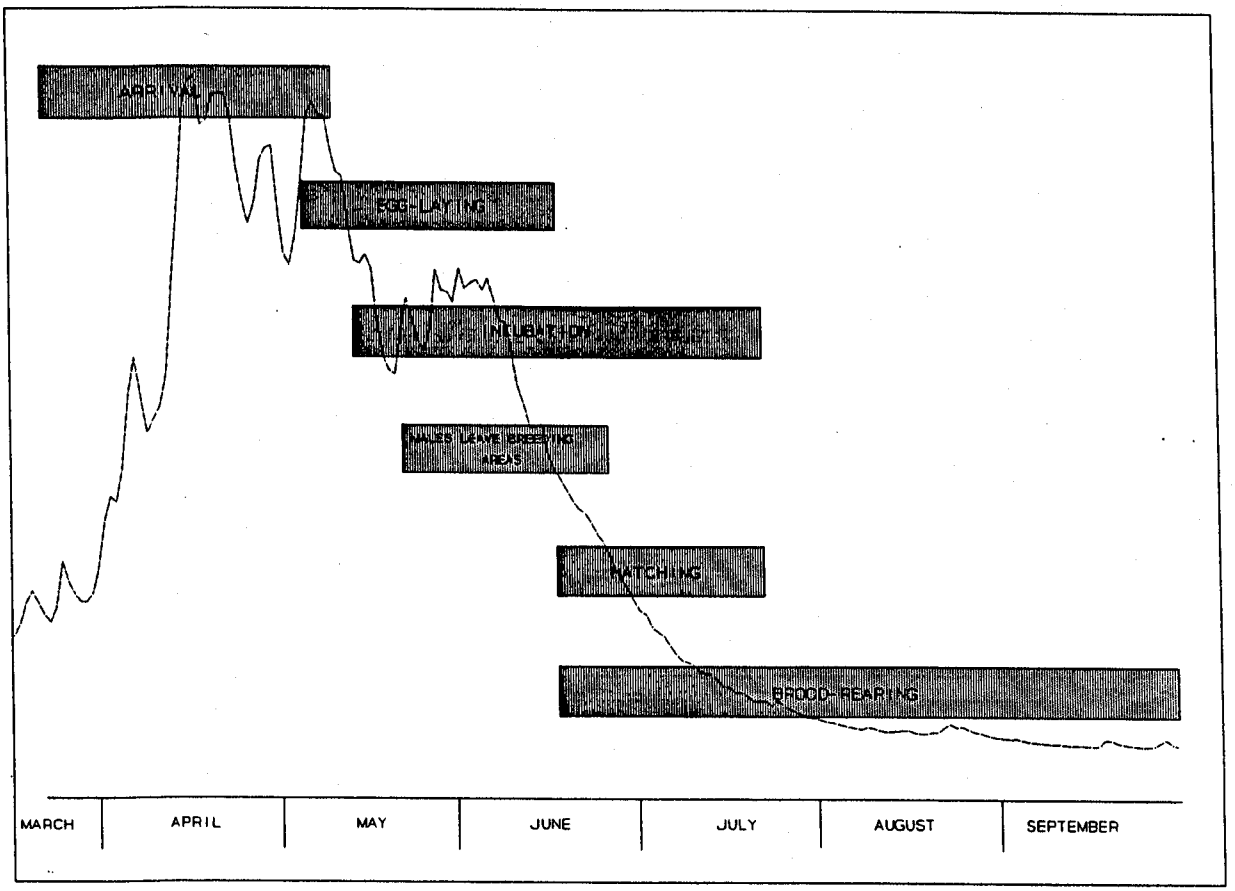


Figure 4. Chronology of harlequin duck activities in Idaho 1987-1990 in relation to stream flow on four breeding streams. Line depicts average flows on the Lochsa, St. Joe, North Fork Clearwater and Upper Priest Rivers 1987-1990.

Egg-laying is not initiated until May or June based on backdating from brood observations. In the intervening period harlequins may be selecting nest sites and waiting for optimal laying conditions. Courtship and copulation occur throughout this period and probably even before pairs arrive in breeding areas (Pearse 1945, Kuchel 1977, Dzinbal 1982, Fleischner 1983).

Incubation, again based on backdating from brood observations, occurs between mid-May and the third week in July.

Males start to leave breeding areas near the end of May and few harlequins are observed on streams in mid- to late June. Most observations in June and early July are single females and may be unsuccessful breeders, nonbreeders, breeders taking incubation breaks or hens with broods that are hidden (Bengston 1972, Wallen 1987a). Hatching begins in mid-June and some broods have fledged by the end of August while others can't fly until the end of September.

Males spend 1-3 months on Idaho streams, nonbreeding and unsuccessful females 2-4 months and successfully breeding females 5-6 months.

Although chronology among breeding areas overlaps, the median dates for the breeding activities of the majority of the population appear most similar in Idaho and Glacier National Park, although harlequins arrive in Idaho earlier. Breeding activities in Grand Teton National Park are three to four weeks behind Idaho and Iceland and Sawmill Bay, Alaska generally fall in between (Figure 5). Differences in breeding chronology may be due to altitudinal and latitudinal variation in the timing of snowmelt.

Broods in Idaho may spend several more weeks on breeding streams than broods in Grand Teton National Park or other areas where hatching dates are later. Most broods appear to stay on breeding streams until the end of August to the third week in September (Bengston 1966, 1972; Kuchel 1977; Dzinbal 1982; Wallen 1987a). Ducklings also appear to develop more slowly in Idaho

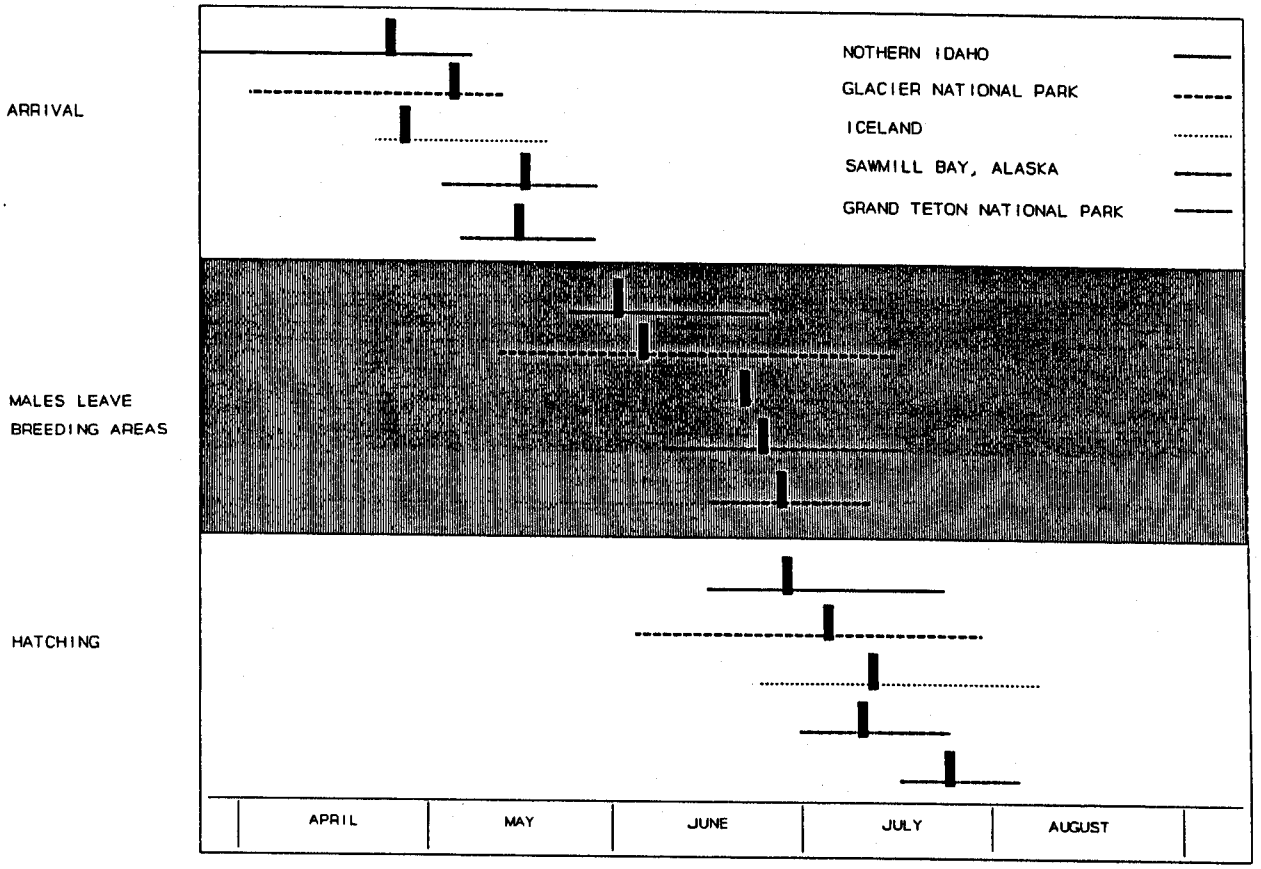


Figure 5. Range and median dates for harlequin duck activities on five breeding areas. Horizontal lines denote range, vertical lines indicate the median date of peak activity.

than in other areas. In 1989, we estimated it took 62 days for ducklings in two Idaho broods to fledge as opposed to estimates of 55 days in Glacier National Park, 42 days in Iceland and 42 days in Grand Teton National Park. Hochbaum (1944) noted a variation of about two weeks in the prefledging period of canvasbacks (Aytha valisineria) in Manitoba, Canada.

POPULATION ECOLOGY

Pair density

Density of pairs along stream reaches used by harlequin

ducks may be an indication of habitat quality. Pair spacing may be due to resource availability such as food or nesting habitat. Harlequins are not territorial, although males will defend an area around their mate (Bengston 1972, Kuchel 1977). We estimated pair densities on two streams in 1989 and eight in 1990 by dividing the maximum number of pairs observed in spring surveys into the length of stream where harlequins were observed. Average, pair density observed in Idaho was much lower than in in other study areas although this was not significant (Figure 6).

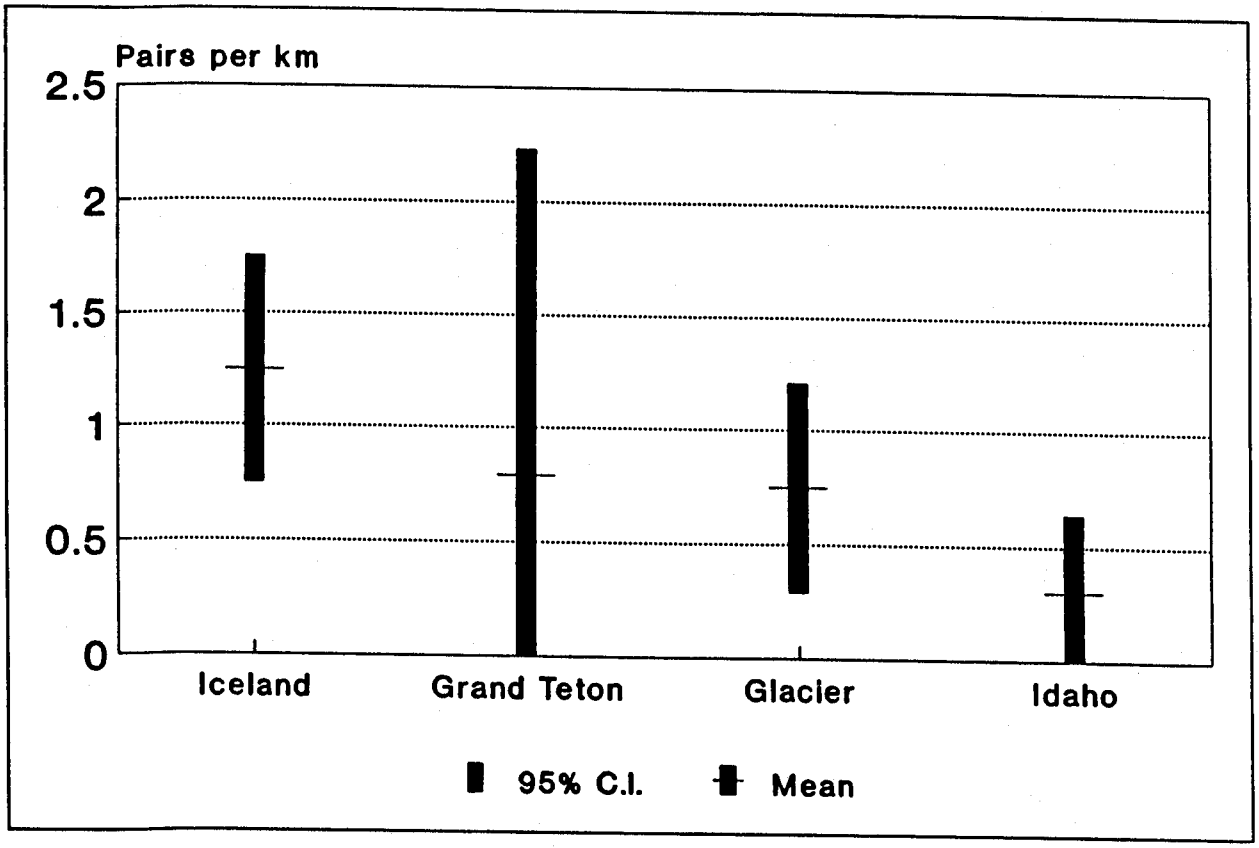


Figure 6. Densities of harlequin ducks on five breeding areas.

Pair density was very low on fourth and fifth order streams such as the Lochsa and the St. Joe, while shorter, smaller streams had

relatively higher pair densities (Table 3). This may indicate that the longer streams overall provided less satisfactory habitat, or that these streams only contained patches of suitable habitat.

Table 3. Harlequin duck pair densities on eight Idaho streams, 1989 and 1990.

Stream	km	Minimum no. pairs		Pairs/km		Mean density (pairs/km)
		1989	1990	1989	1990	
Lochsa River	80		5		0.06	0.06
St. Joe River	56		4		0.07	0.07
North Fork Granite Cr.	12	3	2	0.25	0.16	0.21
East Fork Lightning Cr.	5		1		0.20	0.20
Upper Priest River	19		4		0.21	0.21
Gold Creek (Priest Lake)	7		2		0.29	0.29
Hughes Fork	13	2	5	0.15	0.33	0.27
Gold Creek (L. Pend Oreille)	1.5		2		1.33	1.33
Average		2.5	3.1	0.20	0.15	0.15
Median		2.5	3.0		0.20	0.21

Alternatively, since harlequin ducks exhibit breeding philopatry (Kuchel 1977, Dzinbal 1982, Wallen 1987a, this study), density could reflect previous years production or habitat quality rather than existing conditions (Van Horne 1983).

Breeding Rates

In 1990, only 29% of paired females observed in the spring raised broods. Although within the range of rates observed in other areas this is below average (Table 4). Productivity depends in part on the number of females that nest and on nesting success. Other investigators have observed that not all harlequin pairs attempt to nest. Bengston and Ulfstrand (1971) classified 15-30% of sexually mature hens on the breeding grounds in northern Iceland as nonbreeders that did not lay eggs. Annual variation in the frequency of nonbreeders in the population was correlated to fluctuations in benthic macroinvertebrate biomass.

Table 4. Brood production of harlequin duck pairs in five breeding areas.

Area			% Pairs producing broods	
	no. years data	no. streams surveyed	average	annual range
Iceland	5	3	56[1]	11 - 85
Glacier National Park	2	1	43	21 - 64
Grand Teton National Park	5	4	47	29 - 62
Sawmill Bay, Alaska	2	2	27[2]	14 - 40
Idaho	1	8	29	

[1] reported as percent of females producing broods

[2] investigator felt that tagging method may have reduced productivity

Dzinbal (1982) estimated that 53-95% of females not producing broods were nonbreeders, although use of patagial tags

may have influenced his results (Dzinbal op. cit., Bustnes and Erikstad 1990). Bengston and Ulfstrand (1971) suggested that nearly all nonreproducing females were nonbreeders. We have little information on frequency of nonbreeding in Idaho. Two paired, marked females observed in May and April of 1989 and 1990, respectively, were not visible during the incubation period and were reobserved alone in late June or early July. This may indicate that these hens nested unsuccessfully. Another marked pair observed throughout the nesting season in 1988 and 1989 apparently left together at the beginning of June in both years, perhaps indicating they were nonbreeders. They returned and successfully raised a brood in 1990. One result of the presence of a relatively high percentage of nonbreeding or unsuccessful pairs is that not all breeding streams with harlequin ducks on them produce broods every year (Table 5).

Productivity

Average brood size at five weeks or older was similar to that observed in Glacier National Park, but less than that in Grand Teton National Park (Table 6). About 30% (seven of 24) broods observed at class IIc or older were not accompanied by the hen. Other hens were very attentive to their broods even after fledging. Females that stayed with broods appeared to delay molting wing feathers until after they had left breeding areas.

Brood abandonment prior to fledging is common in diving ducks (Hochbaum 1944). Wallen (1987a) observed similar rates of brood abandonment in Grand Teton National Park. Abandoned broods

Table 5. History of brood production on eight Idaho streams.

Stream	Year and number of broods observed			
	1987	1988	1989	1990
Lochsa River[1]	1	1	ns[2]	1
N. Fork Clearwater River	1	1	ns	1
St. Joe River	ns	1	ns	1
E. Fork Lightning Cr.	1	ns	1	0
Gold Creek - Lake Pend Oreille	ns	1	0	1
N. Fork Granite Creek	ns	1	0	1
Hughes Fork	0	0	0	3
Upper Priest River	ns	1	2	1

[1] some nesting areas are probably actually upstream of the Lochsa on White Sands Creek or Crooked Fork.

[2] ns = not surveyed during brood-rearing period.

were much less wary of humans than broods accompanied by a hen. These broods also tended to be smaller. Size of seven abandoned broods averaged 2.6 ducklings while that of 17 broods accompanied by a hen averaged 3.8 ($P = 0.09$). Abandoned broods remained together and no amalgamation or association was observed among

abandoned broods or broods with hens as reported elsewhere (Bengston 1966, Miller 1990).

Table 6. Average harlequin duck brood size at class IIc (five weeks) or older in four breeding areas.

Area	n	$\bar{x}$	range
Glacier National Park	8	3.9	na[1]
Grand Teton National Park	31	4.5	1 - 7
Sawmill Bay, Alaska	8	2.6	na
Idaho	24	3.4	1 - 7

[1] not available

We documented probable mortalities in only one of three broods first observed at less than three weeks of age (class IIa). Two ducklings of a brood of six presumably died between one and seven weeks of age. This brood had been abandoned by the hen at the second observation. No duckling losses were observed after three weeks of age, similar to observations in Glacier National Park (Kuchel 1977).

A total of eight ducklings were banded in 1988 and 1989 and another eight were banded and nasal marked in 1989. None have been reobserved, although the bands could have been overlooked in the field. Although harlequins usually do not reach sexual maturity until their second year, returns of female subadults to natal areas have been observed in oldsquaws (Clangula hyemalis)

(Alison 1977). In Glacier National Park, two of five banded ducklings (both females), returned after two years as paired adults (Kuchel 1977).

Wallen (1987a) reported the unusual return and successful breeding of one female duckling as a one-year old in Grand Teton. At least five females, of 103 ducklings banded in Grand Teton, have returned and nested successfully (Wallen 1991).

Adult Philopatry

Return rates of 18 adult harlequins marked in 1988 and 1989 averaged 50%, with returns of two of six males (30%) and seven of 12 females (58%) (Table 7). Only males that were paired when initially marked returned, and all returned with the same mate. One additional male return may have been overlooked, since his mate was not reobserved until she was seen with a brood in August. This was also the first time this female had been seen again after being marked two years previously.

Table 7. Returns of adult harlequins marked in northern Idaho, 1988-1989.

		YEAR MARKED			
		MALES		FEMALES	
		1988 n=2	1989 n=4	1988 n=5	1989 n=7
NUMBER REOBSERVED	1989	1	-	1	-
	1990	1	1	2	5

Kuchel (1977) reported returns of four of six marked males (both paired and unpaired) and four of six marked females (67%) over a two-year period. Return rates averaged 40% the year following marking in Grand Teton National Park and declined to at least 16% after two years and 15% after three years. One of 38 ducks was reobserved after four years, and one of 21 adults marked in 1985 was reobserved in 1990 (Wallen 1991). A minimum of 30% of marked ducks returned to streams on Sawmill Bay the following year. Some pairs returned together in both Glacier and Sawmill Bay (Kuchel 1977, Dzinbal 1982).

In Idaho, all marked harlequins were reobserved on the same stream reach where they were initially marked. In addition, two females were observed on both the Upper Priest River and the Hughes Fork, a tributary to the Upper Priest River.

Breeding area philopatry and mate fidelity have been observed in other sea ducks including oldsquaw (Alison 1975), common eider (Somateria mollissima) (Spurr and Milne 1976), Barrow's goldeneye (Bucephala islandica) (Savard 1985) and bufflehead (Bucephala albeola) (Gauthier 1987, 1990). Since males leave breeding areas while females are incubating this suggests philopatry to wintering areas or fall or spring staging areas where they can reunite. Fidelity to wintering areas has been documented in buffleheads and oldsquaw (Alison 1974, Limpert 1980). Savard (1985) documented the reunion of a marked Barrow's goldeneye pair on their wintering area in November.

WEIGHTS AND MEASUREMENTS

Adult harlequins trapped in Idaho weighed from 520-750 g. Males and females differed significantly only in total length, although males tended to weigh more as well (Table 8). Ducklings had reached adult body length and culmen length by 58 days (prefledging), but still weighed less and had shorter wing chords than adults after fledging (Table 9).

Wing chord and culmen lengths of adults were less than those in Sawmill Bay (Dzinbal 1982). Harlequins in Idaho were slightly larger and averaged 27 g heavier than those in Grand Teton National Park (1987a).

HABITAT USE

In Idaho, harlequins are strongly associated with swiftly flowing water and a cobble to boulder substrate in streams that are structurally controlled by bank morphology (reticulate "canyons") with an old-growth to mature western red cedar (Thuja plicata) - western hemlock or spruce (Picea engelmanii) - fir (Abies lasiocarpa) forest overstory (Figures 7 and 8). Most sites where harlequins are observed have rocks or logs in the stream that can be used by harlequins for resting (loafing sites) and some woody debris is often present in the stream. Most sites used by harlequins are over 50 m from roads with no maintained access or are accessible only by trail or boat.

Harlequins in northern Idaho tended to use different habitats than those on the west slope of the Teton Range in

Table 8. Body measurements of adult harlequin ducks in trapped in northern Idaho, 1988-1990.

	Males				Females				
	n	$\bar{x}$	s.e.[1]	range	n	$\bar{x}$	s.e.	range	p[2]
Length (mm)	6	421	10.89	400-431	11	401	12.61	380-422	0.006
Weight (g)	7	618	33.89	570-660	12	581	67.30	520-750	0.132
Culmen length (mm)	5	25.6	0.51	24.6-27.1	11	25.4	0.27	24.2-26.7	0.421
Wing length (mm)	7	202	2.59	190-212	11	199	1.24	190-212	0.348

[1] sample standard error

[2] probability of a difference between sexes

Table 9. Body measurements of ducklings trapped in northern Idaho, 1988-1989.

Estimated age	n	Fledged at trapping?	Body length (mm)		Culmen (mm)		Weight (g)		Wing chord (mm)	
			$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
25 days	4	no	333.33	3.23	21.62	0.18	363.33	13.77	105.67	5.51
46 days	6	no	396.60	6.33	24.86	0.38	472.00	19.45	173.60	1.18
58 days	4	no	403.50	9.67	24.00	0.55	497.50	26.89	187.00	5.49
67 days	4	yes	417.25	2.50	26.15	0.16	502.50	8.54	191.75	1.71

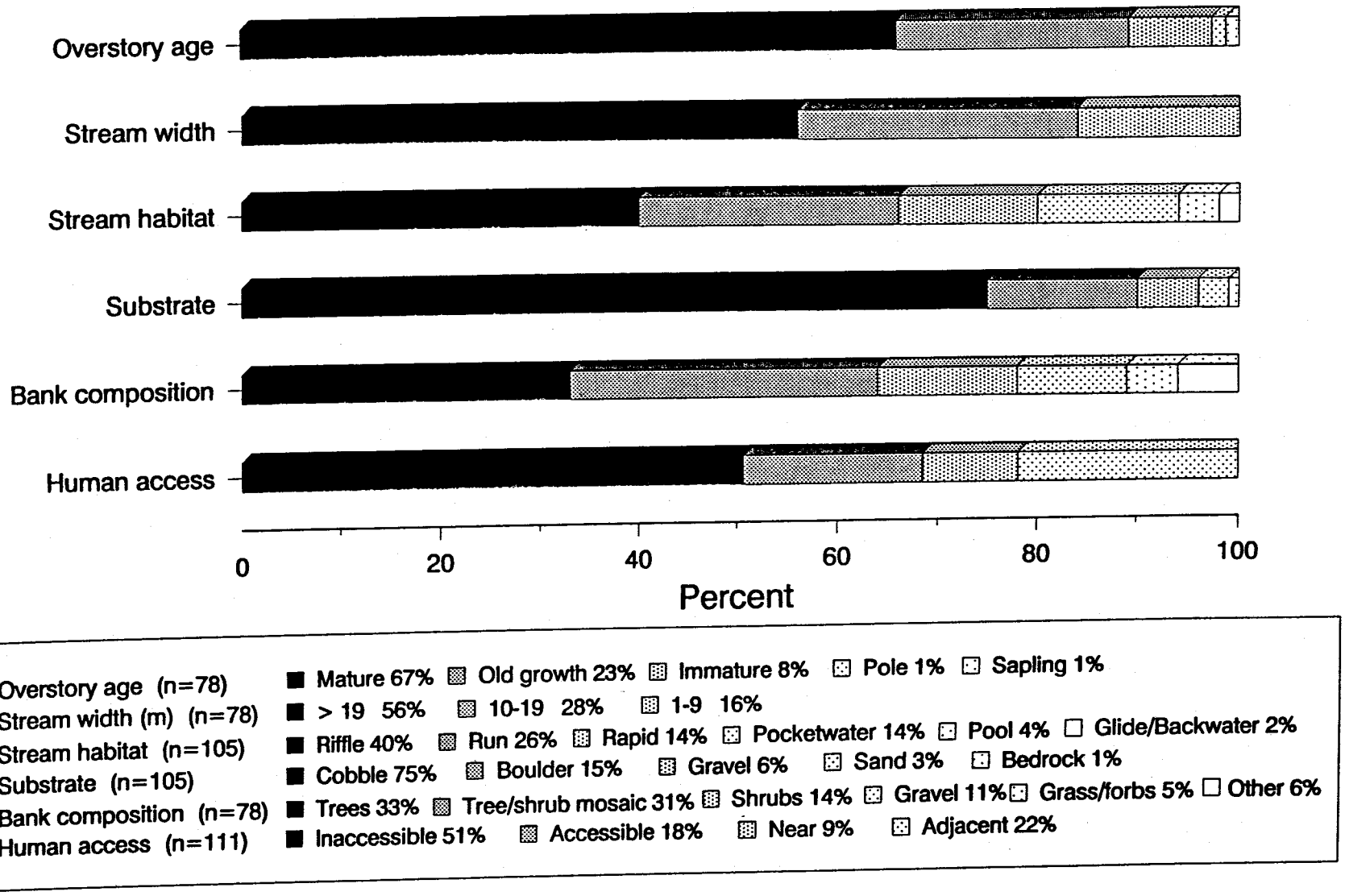


Figure 7. Habitats components used by harlequin ducks in northern Idaho and on the west slope of the Tetons, 1987-1990.

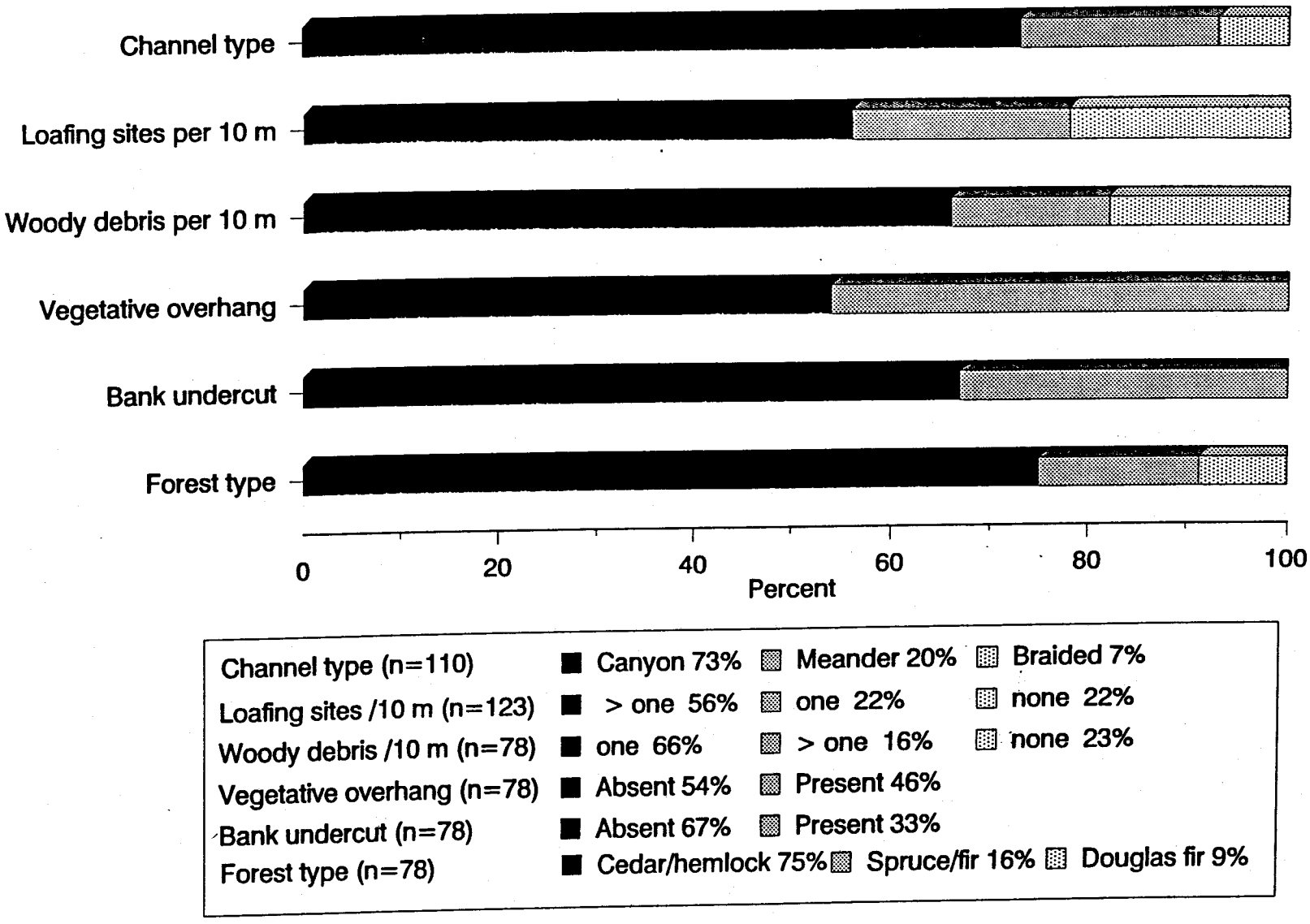


Figure 8. Habitats components used by harlequin ducks in northern Idaho and on the west slope of the Tetons, 1987-1990.

southeastern Idaho and northwestern Wyoming, although sample sizes were small (n=7) for the west slope of the Tetons. In the Teton Range, harlequins were more commonly observed in accessible stream reaches in a younger, Douglas-fir (Pseudotsuga menziesii) overstory, with shrubby riparian vegetation, vegetative overhang and little woody debris.

In northern Idaho we observed little selection of specific components relative to available habitat as measured in systematic transects. We observed significant selection for cedar-hemlock overstory and against immature overstory and shrub and grass/forb bank vegetation.

Brood Habitat

We made a concerted effort to locate young broods since brood habitat presumably changes as ducklings develop and move downstream. However, we have located only three broods younger than three weeks of age due to the wide range in hatching dates, the logistical constraints of a large study area and the secretiveness of young broods. Therefore all brood observations were analyzed together regardless of age, which may obscure some of the characteristics specific to early brood-rearing habitat. In general, broods tended to use narrower, meandering upstream reaches with slower water (lower gradient), smaller substrates, and more woody debris, vegetative overhang and loafing sites than adults (Figure 9).

Vegetative overhang and woody debris have also been described as components of brood-rearing habitat in other areas.

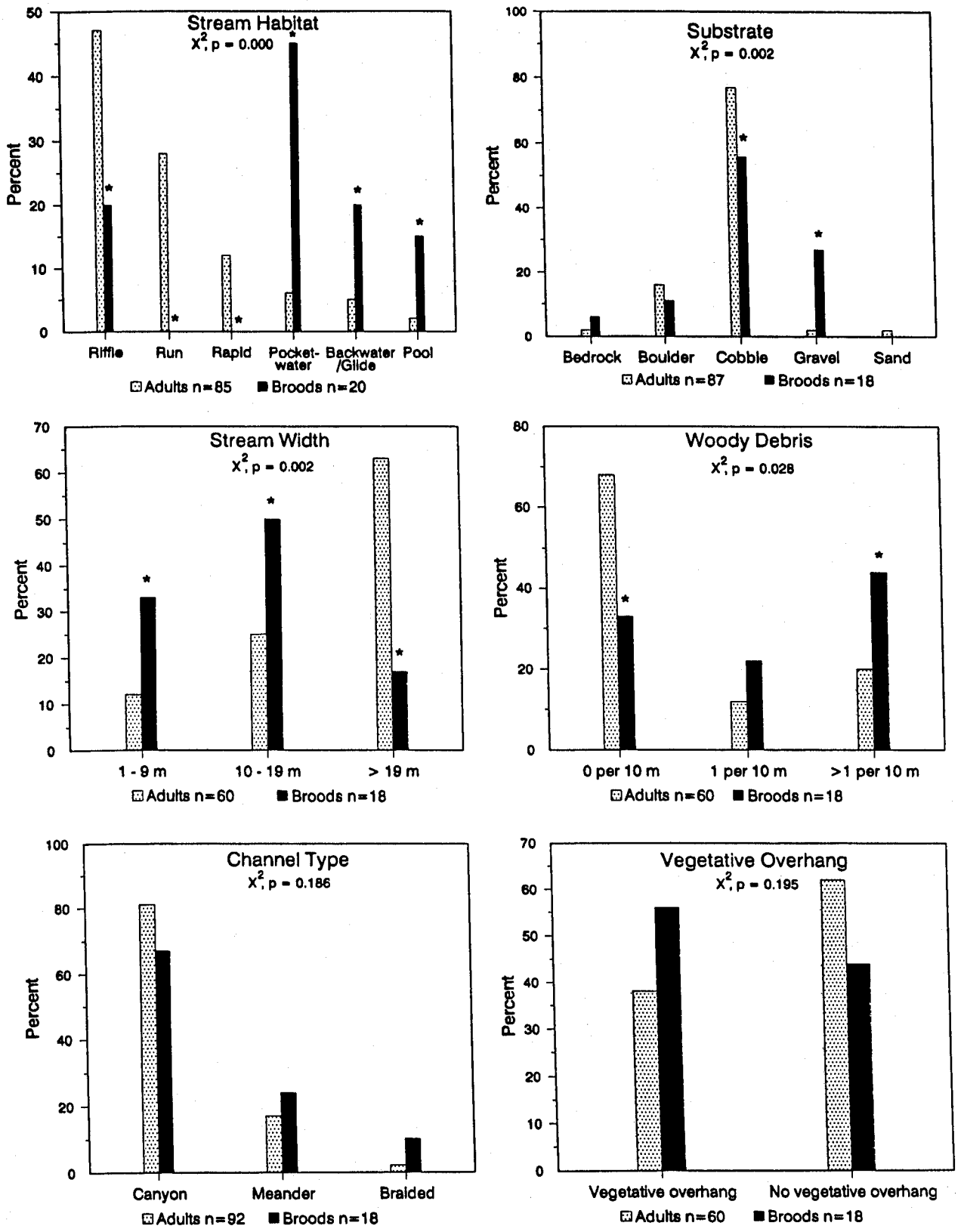


Figure 9. Habitats used by harlequin duck adults and broods in northern Idaho, 1989-1990. * denotes difference ($p \leq 0.05$).

Both of these elements, as well as undercut streambanks provide hiding cover and protection from predators.

Some of the same stream reaches were used by broods in different years, however a few reaches were used in some years and not others. Miller (1990) observed broods on different reaches among years.

Habitat and Pair Density

In order to test the hypothesis that streams with lower pair densities provide poorer habitat or only patchy areas of suitable habitat we compared characteristics of available habitat on the Lochsa and St. Joe Rivers with those of five other streams (Upper Priest River, Hughes Fork, N. Fork Granite Creek, E. Fork Lightning Creek and Gold Creek (L. Pend Oreille) with higher pair densities. We also compared used to available habitats on the St. Joe and Lochsa Rivers to assess whether harlequins were selecting for specific patches of suitable habitat on these rivers.

There were significant differences between the two classes of stream (Figures 10 and 11). Streams with higher pair densities were smaller, had more woody debris, vegetative overhang and bank undercut, and tended to have more areas with slower flow. These are characteristics of sites used by broods (Figure 9) which suggests that brood-rearing habitat may be limited on low pair density streams. Higher pair density streams also were less accessible by people and had a higher percentage of old-growth as opposed to mature overstory (Figure 10).

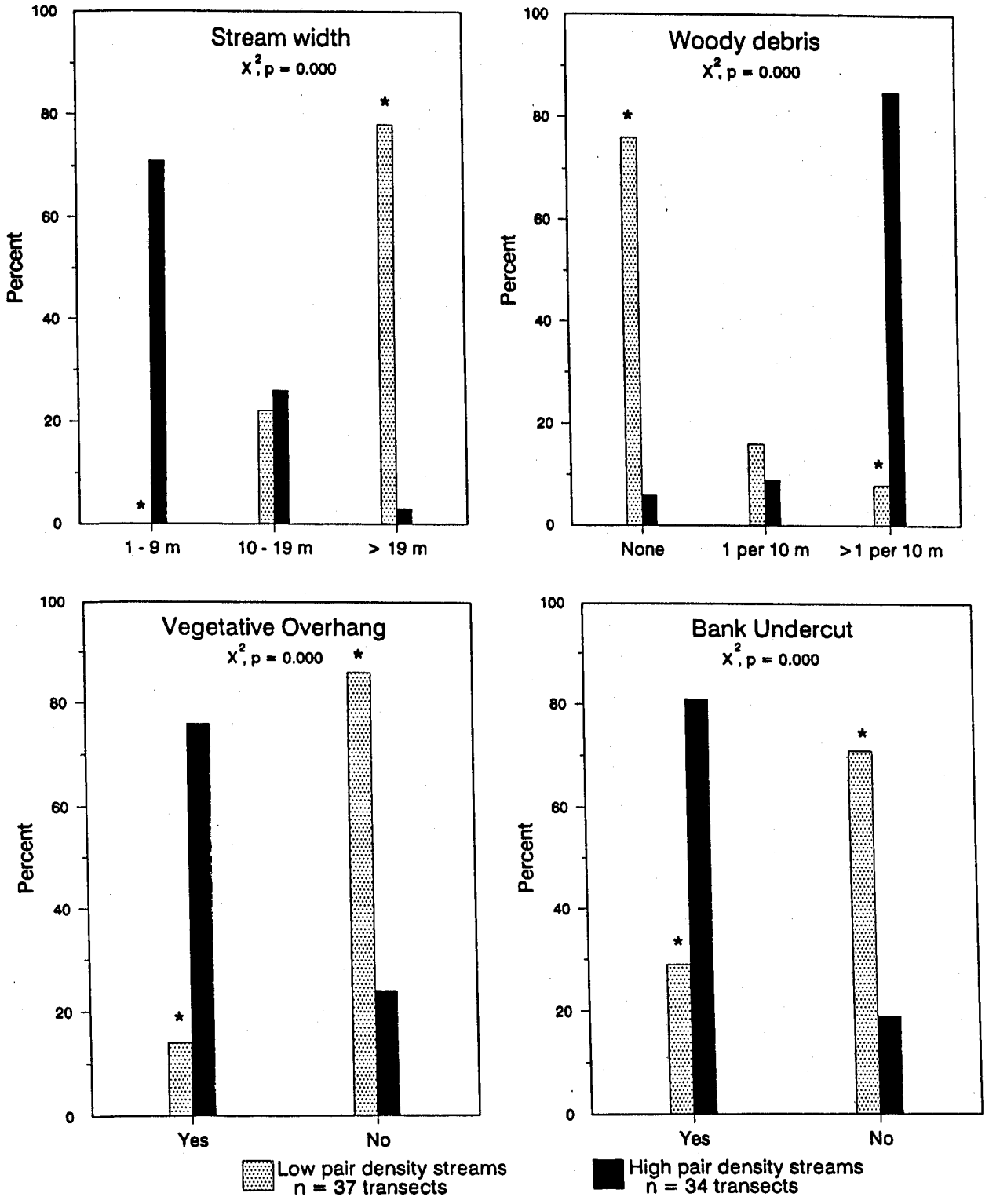


Figure 10. Availability of four habitat components on high and low harlequin duck density stream reaches in northern Idaho, 1990. * denotes difference ($p \leq 0.05$)

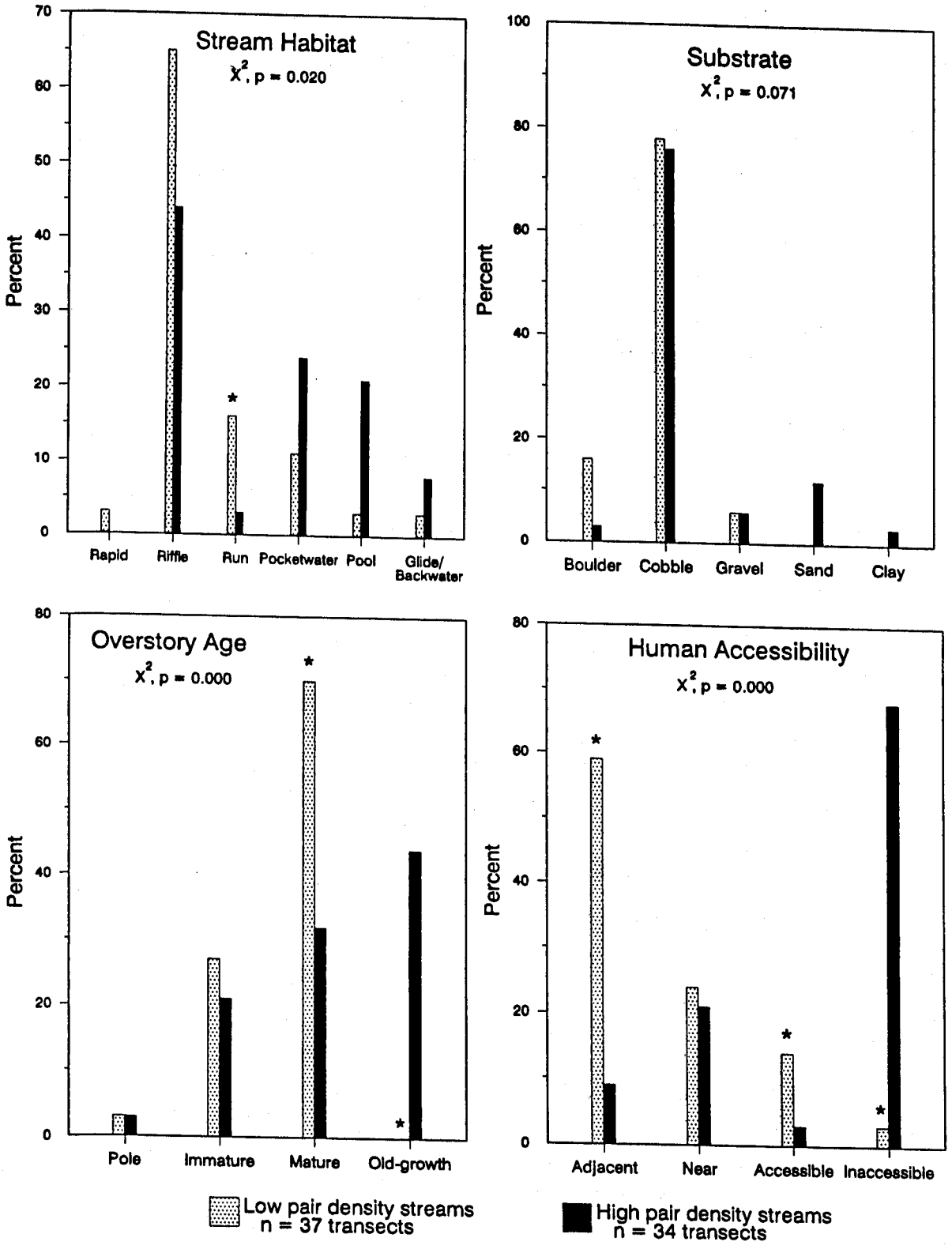


Figure 11. Availability of four habitat components on high and low harlequin duck density stream reaches in northern Idaho, 1990. * denotes difference ($p \leq 0.05$).

Comparison of used with available habitat on the Lochsa and St. Joe Rivers (low pair density streams) revealed few significant differences. Used sites differed significantly in only 7 of 53 categories of 12 characteristics measured. Harlequins did tend to be observed more frequently than expected in reaches 20 m or greater in width, with mature overstory and gravel and undercut banks and less frequently in immature overstory and shrub or grass/forb streambank vegetation. This does not strongly support the hypothesis of patchy suitable habitat, at least for adults (only 2 of 37 observations were of broods), on these streams.

Comparisons With Other Areas

Comparison of habitats used by harlequin ducks in different study areas illustrates the extent of adaptability of harlequins across their breeding range. Those characteristics which remain constant across areas may be critical components of harlequin duck habitat. However, interaction of groups of characteristics, differences in causes of mortality such as predation and differences in food abundance and availability as they affect habitat use must also be considered.

The use of relatively clear, rapidly flowing water and cobble to boulder substrates is universal to all studies and probably relates to the distribution of benthic macroinvertebrates which are usually most abundant in these areas.

Shrubby and overhanging vegetation are also common to all

studies in the Rocky Mountains, and at least some streams in Iceland, although these appear to be most prevalent in Grand Teton and Glacier National Parks. Mature and old growth forest, a typical component of harlequin duck habitat in northern Idaho, was not observed in all study areas. Forests in the two study areas in national parks fit this description but Bengston (1966) remarked that any original forest in Iceland was completely destroyed by early settlers. He described seeing harlequins on streams flowing through "sterile, lava-gravel deserts" with little bank vegetation. Mature and old growth forest in northern Idaho may be indicative of streams with high water quality, low sediment loads, intact riparian areas and relative inaccessibility to humans.

The potentially detrimental effects of human disturbance on harlequin ducks have been referred to throughout the literature, although the evidence is circumstantial. Most investigators have commented that harlequin ducks are disturbed by human activity and that human activity probably reduces reproductive success (Bengston 1972, Kuchel 1977, Wallen 1987a). Studies in the Rocky Mountains have measured the degree of human accessibility as it relates to harlequin habitat use. Wallen (op. cit.) found that although use-availablity analysis indicated harlequins preferred accessible areas with moderate human use, in fact breeding rates were lower on a stream with a trail next to it than a similar stream which was relatively inaccessible. Kuchel (op. cit.) found no selection against against areas of human activity by

adults in the spring, but significant avoidance of these areas by young broods. We found that most harlequins were observed in areas that were inaccessible to people or accessible only by boat or trail. Broods with hens were considerably more wary of humans than adults. Low pair density streams were more accessible to human activity than streams with relatively higher pair densities. Nesting appeared to occur above areas accessible by boat on the two streams that were used for rafting and five of 11 streams where breeding has been confirmed or reported in the past three years are closed to fishing or do not open until July 1.

FOOD HABITS

Bengston and Ulfstrand (1971) observed a strong relationship between macroinvertebrate biomass and breeding rate of harlequins in the food abundant waters of rivers in Iceland, although Inglis et al. (1989) noted that females on the Laxa river (in Iceland) spent little time feeding during the pre-nesting period and the time spent feeding by males and females was not significantly different.

Mountain streams are often relatively unproductive in terms of macroinvertebrate fauna. Macroinvertebrate analysis conducted in the Priest Lake and Upper Priest Lake drainages in Idaho indicated that benthic invertebrate biomass was quite low in these streams (Mangum 1988). We explored the possible relationship between pair density/breeding rate and food supply by sampling benthic macroinvertebrate on four streams in Idaho,

one stream in Glacier National Park and one in Grand Teton National Park during late August and early September 1990. Both streams in National Parks had higher harlequin pair densities than those in Idaho. The results of this analysis are not yet available.

MIGRATION

Twenty-six harlequins were nasal marked and banded on wintering areas in British Columbia in 1986; 54 were nasal marked and banded and 104 banded only in Grand Teton National Park from 1985-1990; 29 were banded in Glacier National Park in 1974-76 and 19 were nasal marked and banded and another 9 only banded in our study (Appendix E). Harlequins have also been banded in the Methow Valley, Washington (George Brady, Wash. Dept. of Wild., unpubl. data). Of the 99 nasal marked and banded and more than 142 banded individuals, only three marked harlequins have been reported outside the areas where they were marked.

A marked female from Grand Teton National Park paired with an unmarked male was photographed on Crooked River in the South Fork of the Clearwater River drainage, Idaho, in May 1988. She arrived in Grand Teton about a week later and nested successfully. This supports Bengston's (1966) statement that harlequins do not fly directly from wintering to breeding areas and also indicates that some individuals observed in Idaho nest elsewhere. The second report was a marked male from Grand Teton National Park observed and photographed August 2-12, 1989, off

San Juan Island, Washington. He returned to Grand Teton in 1990 as an unpaired male. This suggests a possible northward winter migration. Finally, a marked female was observed in Yellowstone National Park in August 1990. Although the individual identity was not determined, this duck was also probably marked in Grand Teton National Park which would confirm exchange between the two Parks across the continental divide.

RECOMMENDATIONS

Management Recommendations

Although it is difficult to distinguish between habitat preferences and habitat requirements, we assume as suggested by Ruggiero et al. (1988) that close association of harlequin ducks with specific habitat components indicates those components are necessary to the persistence of species. Therefore we recommend protecting all stream reaches used by harlequin ducks to maintain macroinvertebrate populations, woody debris and riparian vegetation. Human activity should be minimized, particularly in upstream sections suspected to be used for nesting and early brood-rearing.

In 1990, 90% of harlequin observations in northern Idaho were in mature or old-growth overstory. Some of these areas will likely be scheduled for timber harvest in the near future. Although we would recommend against logging, roading or otherwise disturbing stream reaches used by harlequin ducks for breeding, if management activities occur in or adjacent to these streams

they should be accompanied by intensive monitoring. A specific monitoring plan outlined in the biological evaluation should accompany each action. Monitoring should include documentation of behavioral responses by harlequins, pair density and reproductive success in that and subsequent years, and quantitative measurement of habitat modifications such as water quality and macroinvertebrate biomass and species composition.

Benthic macroinvertebrate populations decline when flow of sediment into streams increases unless stream velocity and flow are such that sediment is flushed downstream (Murphy et al. 1981). Sedimentation caused by logging and road-building can be reduced by protection of a buffer zone along the stream (Edgington 1969). Buffer zones also provide a source of woody debris in the stream and reduce human activity in riparian areas. We recommend buffer zones 100 m or greater on each side of the stream, with no logging or road construction adjacent to streams used by harlequin ducks. The extent of this zone is based on the minimum unlogged and unroaded buffer currently existing on harlequin duck breeding stream reaches. We also recommend against construction of roads or trails that increase accessibility of the stream, particularly in reaches used for nesting and early brood-rearing. Logging activity should be conducted from October-April when harlequins are absent from breeding streams.

Hiking trails should also be located over 100 m from and out of sight of the stream. Wallen (1987a) felt that angling was one

of the most disturbing activities to harlequin ducks in Grand Teton National Park. Harlequins tend to be observed on streams with fishing closures or delayed opening dates and we would support maintaining those regulations.

Inventory and Monitoring

Continued inventory and monitoring of Idaho streams are high priorities. Refining distributional information and collection of long term data are essential for both research and management. Monitoring is particularly critical for assessing the effects of any management actions. Where possible, coordination should also be established with research or monitoring programs in other states or provinces so that results are comparable.

Stream reaches used by harlequins (Table 10) should be surveyed a minimum of twice annually, once May 1-15 and once August 1-15. Surveys should be conducted by walking in or along the stream, or by boat. Survey of each stream should be completed in one day if possible to avoid recounting or missing ducks. Habitat data (Appendix B) should be collected at all harlequin observations. Kelly Creek, Smith Creek and the Little North Fork of the Clearwater deserve special attention because these are well-documented breeding streams where harlequins were not observed during 1990. An additional survey for young broods July 1-15 would provide data on possible nesting areas.

Additional streams need to be surveyed or resurveyed to ascertain use (Table 11). Preliminary surveys should be conducted at least once in May, and any streams where adults are

Table 10. Streams to monitor annually for harlequin ducks.

CLEARWATER RIVER DRAINAGE	
Crooked Fork	Shotgun Creek to Lochsa River
Lochsa River	White Sands Creek to Boulder Creek
White Sands Creek	Colt Creek to Lochsa River
N. Fork Clearwater River	Niagara Creek to Kelly Creek
Kelly Creek	N. Fork Kelly Creek to Kelly Forks
Little N. Fork Clearwater	Canyon Creek to Foehl Creek
Selway River	MacGruder to Moose Creek
ST. JOE RIVER DRAINAGE	
St. Joe River	Heller Creek to Marble Creek
Marble Creek	Cornwall Creek to St. Joe River
PRIEST LAKE AND UPPER PRIEST LAKE DRAINAGES	
Granite Creek	Granite Falls to Priest Lake
Hughes Fork	Hughes Meadow to Upper Priest River
Upper Priest River	Upper Priest Falls to 1013 bridge
Gold Creek	Hemlock Creek to Hughes Fork
COEUR D'ALENE DRAINAGE	
Coeur d'Alene River	Marten Creek to Teepee Creek
KOOTENAI DRAINAGE	
Long Canyon Creek	
Moyie River	Boundary Creek to Moyie Falls
Smith Creek	Bear Creek to Diversion Dam

Table 10 cont'd. Streams to monitor annually for harlequin ducks.

LAKE PEND OREILLE DRAINAGE	
East Fork Lightning Creek	Thunder Creek to Lightning Creek
Gold Creek	West Gold Creek to Lake Pend Oreille
SNAKE RIVER DRAINAGE	
Big Elk Creek	
Darby Creek	
Teton Creek	

Table 11. Streams to survey for harlequin ducks.

CLEARWATER RIVER DRAINAGE	Meadow Creek (Selway)
	Bear Creek (Selway)
	Whitecap Creek (Selway)
	S. Fork Clearwater River
	Crooked River
	Red River
	Potlatch River
	Orogrande Creek
	Brushy Fork
ST. JOE RIVER DRAINAGE	Slate Creek
	Mica Creek
	Simmons Creek
	N. Fork St. Joe River
COEUR D'ALENE RIVER DRAINAGE	Independence Creek
	Teepee Creek
LAKE PEND OREILLE DRAINAGE	N. Gold Creek
	Granite Creek
	Lightning Creek

Table 11 cont'd. Streams to survey for harlequin ducks.

SALMON RIVER DRAINAGE[1]	Rapid River
	Bargamin Creek
	Ebenezer Creek
PRIEST LAKE DRAINAGE	Beaver Creek
	Lion Creek
	Soldier Creek
	Two Mouth Creek
PACK RIVER DRAINAGE	Grouse Creek
KOOTENAI RIVER DRAINAGE	Boundary Creek
	Boulder Creek
SNAKE RIVER DRAINAGE	Bitch Creek

[1] because few surveys have been conducted in the Salmon River drainage future surveys should not be limited to the streams listed here.

observed should be resurveyed for broods in late July or August. Signs requesting reports of harlequins should also be posted along these streams and any reports followed up with a ground check.

Research

In additon to collecting longer term data on productivity, habitat use, breeding chronology and population trend through monitoring, we propose to more intensively address hypotheses regarding factors potentially limiting the Idaho harlequin duck population. This information would be very useful in determining management direction.

Bengston (1966) hypothesized that the density of harlequins on streams was determined primarily by food supply and secondarily by availability of nesting sites. We agree that food supply and nesting or brood-rearing habitat may be limiting components of harlequin habitat in Idaho. Other potentially limiting factors may be weather, stream flow and wintering habitat. We propose further research on the relative importance of these components in harlequin population dynamics in Idaho. Because sample sizes are going to be small due to the nature of the population, it is imperative that monitoring of pair densities, brood production and habitat use continue on all streams in Table 10 where intensive research is not being conducted in order to provide additional population and productivity data.

Hypothesis 1: Harlequin duck numbers in Idaho are limited by macroinvertebrate biomass.

To what extent do macroinvertebrate levels influence harlequin duck activities? Food supply, particularly during the pre-nesting period, can be important in determining waterfowl productivity. Harlequins may spend up to two months off wintering areas, and up to a month on breeding areas before nesting. This may be a critical time for accumulating energy for egg-laying. Bengston and Ulfstrand (1971) documented a correlation between breeding rates and benthic invertebrate biomass in Iceland. Goudie (1988), observed reductions in productivity that may have been associated with drought conditions which presumably reduced available habitat for benthic invertebrates. Eldridge and Krapu (1988) documented reduced clutch and egg size in mallards on lower quality diets. In addition, movements of broods may be dictated by the location of abundant food supplies (Einarsson 1988).

Pre-nesting food supply

1. Determine pair activity centers and sample stream macroinvertebrate biomass in those areas and areas on the same stream not used by pairs between May 1 - June 1.
2. Determine diurnal activity budgets for pre-nesting pairs. Assess whether females feed more than males and whether there are differences in feeding rates of successfully breeding females and

nonbreeding or unsuccessful females. This will only be feasible if done without disturbing the ducks.

3. Document clutch size, egg size, nesting success and breeding rates in relation to food supply and length of time on breeding streams prior to hatching.

4. Collect droppings as possible and analyze contents.

Note: Examining body weight of individuals at arrival on the breeding area and just prior to incubation could be very informative. Unfortunately, trapping and weighing females at the beginning of May and again in mid to late May just prior to incubation would possibly disrupt breeding activities and is logistically very difficult due to high water levels.

Brood-rearing food supply

4. Measure macroinvertebrate levels at preselected sites at weekly intervals during the brood-rearing period and at sites used by broods. Observe ducklings at least biweekly and document feeding behavior.

5. Compare duckling plumage development rates and body weights in August in relation to macroinvertebrate densities, hatching date and brood size.

Water levels and macroinvertebrate levels

7. Compare macroinvertebrate levels and harlequin productivity with NOAA weather records and with streamflows on streams where long term data have been collected by the U.S.G.S. and U.S.F.S..

Hypothesis 2: Harlequin duck numbers in Idaho are limited by suitable nesting and/or brood-rearing habitat.

High nonbreeding or unsuccessful breeding frequency may be due to a limited number of suitable nesting sites on Idaho streams. This is suggested by our preliminary data on the relationship between pair density and habitat characteristics.

1. Quantify early brood-rearing habitat. Collect habitat information at locations of young broods and systematically along streams and test for selection with use/availability anlaysis.
2. Collect long-term data to determine which stream reaches are used for nesting and characterize habitat on those reaches. These reaches may change among years.
3. Locate nests and collect habitat, clutch-size and nesting success information.

Hypothesis 3: Flood events or storms limit reproductive success in Idaho by washing young ducklings downstream and possibly by flooding out nests (Kuchel 1977).

Wiens (1977) and others have suggested that populations in variable environments may be limited by periodic catastrophic events, rather than by resource availability. Populations with low fecundity may only rarely achieve levels that are resource-limited between "ecological crunches" due to climatic factors.

Kuchel (1977) found that reproductive success was drastically reduced during a year with high spring runoof. Many streams in Iceland, where harlequin duck densities are high, have relatively stable flows because they are spring-fed as opposed to being fed primarily by snowmelt and precipitation.

1. Collect multi-year data on population size and productivity.
2. Analyze annual variation in reproductive success in relation to magnitude and timing of peak flows. Daily flows are collected by the U.S.F.S. and U.S.G.S. at gauging stations on seven breeding streams used by harlequin ducks. Correlate the period of peak flow and the number of events of greater than average flow June 15-July 30 with productivity.
3. Examine the relationship between amount of precipitation June-15-July 30 and productivity.
4. Document timing of duckling mortality.
5. Locate nests and document causes of failure.

Hypothesis 4: Harlequin duck numbers in Idaho are limited by factors outside breeding areas.

If harlequins breeding in the same area also use the same wintering area and migration route, habitat degradation, storms, hunting or other mortality factors in these locations may affect population dynamics on a specific breeding area. Goudie and Ankney (1986) suggested harlequins may have difficulty aquiring

sufficient energy to survive winter storms. Harlequins are also a species that is susceptible to oiling. More information on this in relation to the Valdez oil spill in Prince William Sound, Alaska should be available this year (S. Patten, A.D.F.G., pers. comm.).

1. Radio-mark individuals on the breeding grounds and follow them to wintering areas. Survey wintering areas for marked individuals. Obtain weather records for wintering areas.
2. Mark all ducks on selected streams and collect information on return rates of adults and ducklings.
3. Continue to use posters and cooperate with other agencies to locate marked harlequins.
4. When wintering areas are located, the possibility of a cooperative winter study between the state of Idaho and the agency responsible for managing the wintering area should be explored.

LITERATURE CITED

Alford, C.E. 1920. Some notes on the harlequin duck. British Birds. 14:14-17.

Alison, R.M. 1974. Oldsquaw homing in winter. Auk 91:188.

_____. 1975. Breeding ecology and behavior of the Oldsquaw (Clangula hyemalis L.). Ornithol. Monogr. No. 18.

_____. 1977. Homing of subadult oldsquaws. Auk 94:383-384.

American Ornithologists' Union. 1983. Checklist of North American birds. 6th ed. American Ornithologists Union, Washington, D.C.

Atkinson, E.C. and M.L. Atkinson. 1990. Distribution and status of harlequin ducks (Histrionicus histrionicus) on the Targhee National Forest. Idaho Dept. of Fish and Game, Nongame and Endang. Wildl. Prog. 25 pp.

Bartonek, J.C. and C.W. Dane. 1964. Numbered nasal discs for waterfowl. J. Wildl. Manage. 28:688-692.

Bellrose, F.C. 1980. Harlequin Duck. Pp. 380-384 in Ducks, geese and swans of North America. Stackpole Books. Harrisburg, PA. 540 pp.

Bengston, S.A. 1966. Field studies on the Harlequin Duck in Iceland. Wildfowl Trust Ann. Rep. 17:79-94.

_____. 1972. Breeding ecology of the Harlequin Duck Histrionicus histrionicus (L.) in Iceland. Ornis Scand. 3:1-19.

_____ and S. Ulfstrand. 1971. Food resources and breeding frequency of the harlequin duck Histrionicus histrionicus in Icealand. Oikos 22:235-239.

Burleigh, T.D. 1972. Histrionicus histrionicus (Linnaeus): Harlequin Duck. Pp. 52 in Birds of Idaho. The Caxton Printers, Ltd. Caldwell, ID.

Bustnes, J.O. and K.E. Erikstad. 1990. Effects of patagial tags on laying date and egg size in common eiders. J. Wildl. Manage. 54:216-218.

Byrd, V., pers. comm., U.S. Fish and Wildlife Service, Aleutian Islands National Wildlife Refuge. Adak, AK.

Campbell, W., Dawe, N.K., McTaggart-Cowan, I., Cooper, J.M. Kaiser, G.W. and M.C.E. McNall. 1990. Harlequin duck. Pp. 195-298 in The birds of British Columbia. Royal British Columbia Museum, Victoria, B.C.

Cassirer, E.F. 1989. Distribution and status of harlequin ducks (Histrionicus histrionicus) on the Nez Perce National Forest, Idaho. Idaho Dept. of Fish and Game, Nongme and Endang. Wildl. Prog. 19 pp.

_____ and C.R. Groves. 1989. Breeding ecology of harlequin ducks (Histrionicus histrionicus) on the Kaniksu National Forest, Idaho. Idaho Dept. of Fish and Game, Nongame and Endang. Wildl. Prog. 48 pp.

_____ and _____. 1990a. Distribution, habitat use and status of harlequin ducks (Histrionicus histrionicus) in northern Idaho, 1990. Idaho Dept. of Fish and Game, Nongame and Endang. Wildl. 54 pp.

_____ and _____. 1990b. A summary of harlequin duck sightings in Idaho, 1989. Idaho Dept. of Fish and Game, Nongame and Endang. Wildl. Prog. 11 pp.

_____ and G. Schirato. 1990. Harlequin duck boat surveys, northwest Washington coast, 9/24-9/29/90. Washington Dept. of Wildl. 1 p.

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

Edgington, J.R. 1969. The impact of logging on the ecology of two trout streams in north Idaho. M.S. Thesis, Univ. of Idaho, Moscow. 73 pp.

Einarsson, A. 1988. Distribution and movements of Barrow's Goldeneye Bucephala islandica young in relation to food. Ibis 30:153-163.

Eldridge, J.L. and G.L. Krapu. 1988. The influence of diet quality on clutch size and laying pattern in mllards. Auk 105:102-110.

Fleischner, T.L. 1983. Natural history of harlequin ducks wintering in northern Puget Sound. M.S. Thesis. Western Wash. Univ., Bellingham. 49 pp.

Gaines, W.L. and R.E. Fitzner. 1987. Winter diet of the harlequin duck at Sequim Bay, Puget Sound, Washington. Northwest Sci. 61(4):213-215.

Gauthier, G. 1987. Further evidence of long-term pair bonds in ducks of the genus Bucephala. Auk 104:521-522.

_____. 1990. Philopatry, nest-site fidelity, and reproductive performance in buffleheads. Auk 107:126-132.

Gollop, J.B. and W.F. Marshall. 1954. A guide to aging duck broods in the field. Miss. Flyway Counc. Tech. Sect. Rept. 9 pp.

Gniadeck, S., pers. comm., U.S. National Park Service, Resource Mgmt., Glacier National Park, W. Glacier, MT.

Goudie, R. I. 1984. Comparative ecology of Common eiders, black scoters, oldsquaws and harlequin ducks wintering in southeast Newfoundland. Thesis. Univ. of W. Ontario, London, Ontario, Canada.

_____. 1988. Breeding distribution of harlequin ducks in northern Labrador. Atlantic Soc. of Fish and Wildl. Biologists. 4(2):17-21.

_____. 1989. Historical status of harlequin ducks wintering in eastern North America-a reappraisal. Wilson Bull. 101:112-114.

_____. pers. comm., Canadian Wildlife Service, St. John's, Newfoundland, Canada.

_____ and C.D. Ankney. 1986. Body size, activity budgets, and diets of sea ducks wintering in Newfoundland. Ecology 67:1475-1482.

_____ and _____. 1988. Patterns of habitat use by sea ducks wintering in southeastern Newfoundland. Ornis. Scand. 19:249-256.

Gudmundsson, F. 1971. Straumendur (Histrionicus histrionicus) a Islandi ("The harlequin duck in Iceland") Natturufraedingurinn 41:1-28, 64-98. (English summary pp. 84-98).

Hand, R.L. 1932. Notes on the occurrence of water and shore birds in the Lochsa region of Idaho. Condor 17:118-129.

_____. 1941. Birds of the St. Joe National Forest, Idaho. Condor 43:220-232.

Harrison, J. 1967. Drake Harlequin escorting its family. Wildfowl Trust Ann. Rept. 18:155-156.

Hirsch, K.V. 1980. Winter ecology of sea ducks in the inland marine waters of Washington. M.S. Thesis, Univ. of Wash., Seattle. 92 pp.

Hochbaum, H.A. 1944. The canvasback in a prairie marsh. Wildl. Manage. Inst., Wash., D.C. 207 pp.

Inglis, I.R., J. Lazarus and R. Torrance. 1989. The pre-nesting behavior and time budget of the harlequin duck (Histrionicus histrionicus) Wildfowl 40:55-73.

Koontz, R., pers. comm., U.S. National Park Service, Resource Mgmt., North Cascades National Park, Sedro Woolley, WA.

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

Laing, K., pers. comm., U.S. Fish and Wildlife Serv., Oil spill damage assessment, Anchorage, AK.

Larrison, E.J., J.L. Tucker and M.T. Jollie. 1967. Harlequin duck. Pp. 85 in Guide to Idaho Birds. J. Idaho Acad. of Sci. 5:1-220.

Limpert, R.J. 1980. Homing success of adult buffleheads to a Maryland wintering site. J. Wildl. Manage. 44:905-908.

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

McEneany, T., pers. comm., U.S. National Park Service, Resource Mgmt., Yellowstone National Park, WY.

Mangum, F.A. 1988. Macroinvertebrate analysis, Panhandle National Forest, Priest Lake Ranger District. U.S.D.A. Forest Serv. Int. Mt. Reg., Aquatic Ecosystem Anal. Lab., Brigham Young Univ., Provo, UT. 40 pp.

Marcum, C.L. and D.O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44:963-968.

Markum, D. 1990. Distribution and status of the harlequin duck on the Gallatin National Forest, Montana. Mt. Natural Heritage Prog., Helena, MT. 21 pp.

Merrill, J.C. 1897. Notes on the birds of Fort Sherman, Idaho. Auk. 14:347-357.

Merriam, C.H. 1883. Breeding of the harlequin duck (Histrionicus minutus). Bull. Nutall. Ornith. Club 8:220.

Miller, G. 1988. Field survey summary report, harlequin duck (Histrionicus histrionicus), Cabinet Ranger District, Kootenai National Forest. Mt. Natural Heritage Prog., Helena, MT. 5 pp.

_____. 1989. 1989 field survey report, harlequin duck (Histrionicus histrionicus), lower Clark Fork river drainage, west-central Montana. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula. 58 pp.

_____. 1990. 1990 harlequin duck field survey, final summary report. Mt. Nat. Heritage Prog., Helena, MT. 20 pp.

Mittlehauser, G. 1989. The ecology and distribution of the harlequin duck (Histrionicus histrionicus) wintering off Isle au Haut, Maine. Nat. Park Ser., Acadia Nat. Park 69 pp.

_____. 1990. Survey of harlequin ducks along the Isle au Haut shoreline and adjacent offshore islands, 1989-1990. Nat. Park Ser., Acadia Nat. Park. 25 pp.

_____ and J. Hazen. 1990. Monitoring harlequins at Acadia. Park Sci. 10(1):18.

Mosely, R. and C. Groves. 1990. Rare, threatened and endangered plants and animals of Idaho. Idaho Dept. of Fish and Game, Nongame and Endang. Wildl. Prog. 33 pp.

Murphy, M.L., L.P. Hawkins and N.H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Trans. Am. Fish. Soc. 11:469-478.

Myres, M.T. 1959. The behavior of sea ducks and its value in the systematics of the tribes Mergini and Somaterini of the family Anatidae. Ph.D. diss. Univ. of British Columbia, Vancouver.

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

Patten, S. pers. comm., Alaska Dept. of Fish and Game, Anchorage, AK

Pearse, T. 1945. Mating of the pacific harlequin duck. Can. Field-Nat. 59:66-67.

Pool, W. 1962. Feeding habits of the Harlequin Duck. Wildfowl Trust Ann. Rep. 13:126-129.

Reel, S., L. Schassberger and W. Ruediger. 1989. Caring for our natural community, Region 1 threatened, endangered and sensitive species program. U.S.D.A. Forest Service, Northern Region. 309 pp. plus appendices.

Reese, K.P. and W.E. Melquist. 1985. Distribution and status of 27 avian species of special concern in Idaho. Univ. of Idaho, Moscow. 235 pp.

Ruggiero, L.F., Holthausen, R.S., Marcot, B.G., Aubry, K.B., Thomas, J.W. and E.C. Meslow. 1988. Ecological dependency: the concept and its implications for research and management. Trans. N. Am. Wildl. & Nat. Res. Conf. 53:115-126.

Rust, H.J. 1915. An annotated list of the birds of Kootenai County, Idaho. Condor. 17:118-129.

Savard, J. L. 1985. Evidence of long-term pair bonds in Barrow's goldeneye (Bucephala islandica). Auk 102:389-391.

Schirato, G. pers. comm., Wash. Dept. of Wildlife, Aberdeen, WA.

Spurr, E. and H. Milne. 1976. Adaptive significance of autumn pair formation in the Common Eider (Somateria mollissima L.). Ornis. Scand. 7:85-89.

Stephens, D. and Sturtz. 1990. Latilong distribution of birds in Idaho. Idaho Dept. of Fish and Game, Nongame and endangered wildlife program.

Thomas, D.L. and E.J. Taylor. 1990. Study designs and tests for comparing resource use and availability. J. Wildl. Manage. 54:322-330.

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

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Vermeer, K. 1983. Diet of the harlequin duck in the Strait of Georgia, British Columbia. Murrelet 64:54-57.

Vickery, P.D. 1988. Distribution and population status of Harlequin Ducks (Histrionicus histrionicus) wintering in eastern north America. Wilson Bull. 100:119-126.

Wallen, R.L. 1987a. Habitat utilization by harlequin ducks in Grand Teton National Park. M.S. Thesis, Montana State Univ., Bozeman. 67 pp.

_____. 1987b. Annual brood survey for harlequin ducks in Grand Teton National Park. Grand Teton Nat. Pk., Resource Manage. 15 pp.

_____. 1991. Annual variation in harlequin duck population size, productivity and fidelity to Grand Teton National Park. Off. of Science and Res. Mgmt. Grand Teton National Park, WY. 7 pp.

_____ and C.R. Groves. 1988. Status and distribution of harlequin ducks in northern Idaho. Idaho Dept. of Fish and Game, Nongame and Endangered Wildl. Prog. 34 pp.

_____ and _____. 1989. Distribution, breeding biology and nesting habitat of harlequin ducks (Histrionicus histrionicus) in northern Idaho. Idaho Dept. of Fish and Game, Nongame and Endangered Wildl. Prog. 39 pp.

Wiens, J.A. 1977. On competition and variable environments. Am. Sci. 65:590-597.

APPENDIX A

Posters distributed requesting harlequin duck reports

ATTENTION WILDLIFE WATCHERS

WE NEED SIGHTINGS OF

HARLEQUIN DUCKS

WE NEED YOUR HELP

The Nongame and Endangered Wildlife Program of the Department of Fish and Game is surveying Idaho's mountain streams for harlequin ducks—one of the state's rarest and shyest wildlife species.
We need your help in locating these mountain ducks. Please turn in any sightings you make as soon as possible!

WHERE TO LOOK

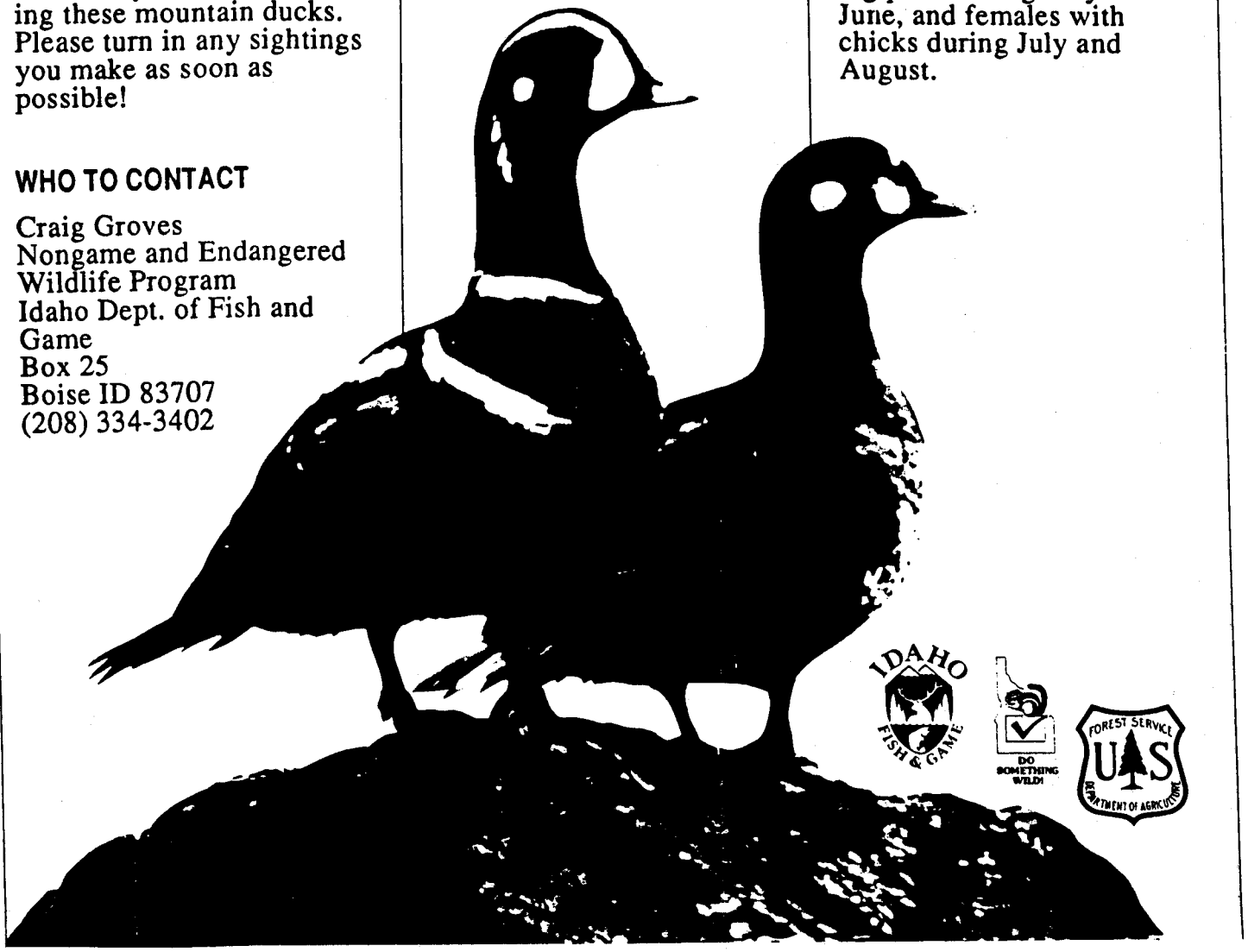
Harlequins nest on forested, mountain streams usually 10 yards or greater in width. They prefer streams with good water quality, away from human disturbance, and with dense shrubs along the stream edge.

WHAT TO LOOK FOR

Harlequins are small ducks (16'' in length). Males are blueish-gray with rusty sides and various shaped white patches on the head. Females are light brown with a distinct white spot behind the eye. Look for breeding pairs during May and June, and females with chicks during July and August.

WHO TO CONTACT

Craig Groves
Nongame and Endangered Wildlife Program
Idaho Dept. of Fish and Game
Box 25
Boise ID 83707
(208) 334-3402



IDAHO FISH & GAME

DO SOMETHING WILD!

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Photo Courtesy of Michael Quinton

HARLEQUIN DUCK OBSERVATIONS

WANTED

YOUR OBSERVATIONS CAN HELP

The Nongame and Endangered Wildlife Program of the Department of Fish and Game, in cooperation with the U.S. Forest Service, has been conducting a study of harlequin ducks on nesting streams in northern Idaho. A similar study has been ongoing for several years in Grand Teton National Park. We need your help in locating individually marked harlequin ducks on their winter range along the Pacific Coast and in their migration routes to the northern Rockies.

WHAT TO LOOK FOR

Harlequin ducks have been marked with nasal discs of various shapes (see box) and colors in order to identify individual birds on nesting streams. Markers are blue, red, gray, white, orange, green, yellow, and black in color. Triangles, ovals, squares, pluses, and circles have been used. Marking of birds will continue in 1990.

Male harlequin duck with nasal markers.

WHAT WE NEED

If you observe a harlequin duck with nasal markers, we would appreciate you calling or sending us your observation. Please make note of:

- Sex and number of harlequin ducks seen
- Color and shape of the nasal markers
- Exact location of sighting

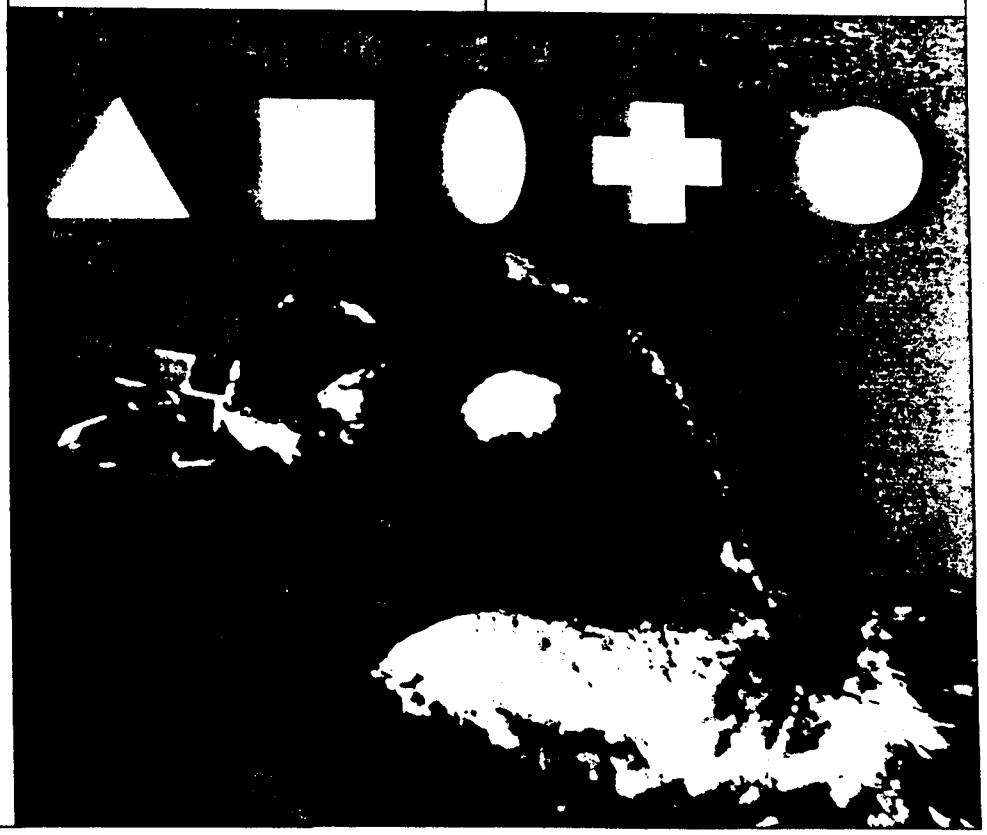
If possible, please try to take a photograph of the marked bird(s). Thank you for your cooperation.

WHO TO CONTACT

Craig Groves
Nongame and Endangered Wildlife Program

Idaho Dept. of Fish & Game
P.O. Box 25
Boise, ID 83707

(208) 334-3402



APPENDIX B

1990 habitat use data form and definitions

HARLEQUIN DUCK HABITAT DATA FORM

DATE_____ STREAM_____ OBSERVER_____

HARLEQUIN OBSERVATION? Y N TYPE_____ ACTIVITY_____

CIRCLE ONE	CIRCLE ONE	CIRCLE UP TO TWO
HABITAT	SUBSTRATE	BANK COMPOSITION
PO POOL	**CL** CLAY	**TR** TREES
RI RIFFLE	**SA** SAND	**SH** SHRUB
RU RUN	**GR** GRAVEL	**GF** GRASS/FORB
PW POCKETWATER	**CO** COBBLE	**MO** TREE/SHRUB MOSAIC
GL GLIDE	**BO** BOULDER	**BE** BEDROCK
RA RAPID	**BE** BEDROCK	**SA** SAND
BA BACKWATER		**SI** SILT
		GR GRAVEL
		DE DEBRIS

OVERSTORY	CHANNEL TYPE	HUMAN ACCESS
SE SEEDLING	**ME** MEANDER	**AD** ADJACENT
SA SAPLING	**BR** BRAIDED	**NE** NEAR
PO POLE	**ST** STRAIGHT	**AC** ACCESSIBLE
IM IMMATURE	**CU** CURVED	**IN** INACCESSIBLE
MA MATURE		
OG OLD-GROWTH		

CIRCLE AS APPROPRIATE

TYPE OF HUMAN ACTIVITY	DEBRIS / 10 M ENTER # OF EACH TYPE	
BO BOATING	**BR** BRIDGE_____	LOAFING SITES/10M____
RO ROAD	**CB** COLLAPSED BR.___	ISLANDS_____
FI FISHING	**RA** RAMP_____	STREAM WIDTH (M)_____
HI HIKING	**DR** DRIFT_____	OVERSTORY SPP._____
NO NONE		

VEGETATIVE OVERHANG Y N BANK UNDERCUT Y N

UTMN_____ UTME_____

T_____ R_____ S_____ 1/4_____

COMMENTS_____

HABITAT

POOL- deep slow water areas, created by obstructions such as boulders or logs.
RIFFLE- shallow water areas where the water surface is influenced by the stream bottom, (whitewater).
RUN- deeper than a riffle, no whitewater but velocity greater than .3 m / sec., too fast to be a pool.
POCKETWATER- a run or riffle with boulders (> 30 cm in diameter), which create numerous small pools.(
GLIDE- run areas with velocities < .3 m / sec.
RAPID- deep water, but water surface still influenced by stream bottom and/or streambank, (whitewater).
BACKWATER- slow water area out of the main stream channel.

SUBSTRATE

GRAVEL- .2-7 cm, (.1"-3")
COBBLE- 8-30 cm, (3"-12")
BOULDER- >30 cm, (>12")

OVERSTORY

SEEDLING- 1-10 yrs old, < 4.5' tall.
SAPLING- 10-40 yrs old, > 4.5' DBH < 5".
POLE- 40-70 yrs old, DBH 5"-9".
IMMATURE- 70-100 yrs old, DBH 9"-14".
MATURE- 100-160 yrs old, DBH 14"-20"
OLD GROWTH- over 160 yrs 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 dived the stream into several intersecting and shifting channels.
STRAIGHT- stream channel linear, structurally controlled by "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 10-50m.
ACCESSIBLE- >50m from human activity, accessible by boat or trail.
INACCESSIBLE- >50m from human activity, inaccessible 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 sites.

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

APPENDIX C

Reports of harlequin ducks in Idaho, 1960-1986

Appendix C. Reports of harlequin ducks in Idaho, 1960-1986.

Location	Date	Observation	Observer
Selway River	1976	5 or 6	Gary Gadwa
	May 1981	pair	Larry Hlavaty
Lochsa River	March 1973	pair near 9-mi. rest area	Mike Schlegel
	March 1973	pair midway upriver	W. Mullins
	5/31/83	4 males at Warm Spr. Cr.	C.& S. Campbell
	5/18/84	pair	C.& S. Campbell
	5/22/85	2 pairs and 1 male	C.& S. Campbell
	May 1985	6 individuals	Jim Unsworth
	5/28/86	1 pair and 1 male	C.& S. Campbell
	none	some on White Sand Pond near Wendover CG	Paul Sommerfeld
	none	1 individual	Tom Leege
N. Fork Clearwater River	1977	1 individual at Washington Creek	Dwight Kilgore
	June 1980	drakes near Elizabeth Cr.	Steve Babler
	1981	1 drake at Elizabeth Cr.	Steve Babler
	May 1982	pair and male Kelly Forks- 2 miles up	Steve Babler

Appendix C. Reports of harlequin ducks in Idaho, 1960-1986.

Location	Date	Observation	Observer
Moose Cr. (N. Fork Clearwater)	May 1982	males	Steve Babler
	May 1983	1 male	Steve Babler
	May 1984	1 male	Steve Babler
Kelly Creek	none	several at old Ranger St.	Dan Davis
	August 1979	brood at Clayton Cr.	Steve Babler
	August 1980	brood at Junction Pack Bridge	Steve Babler
	May/June 1981	pairs and adults Junction Cr.- above Clayton Cr.	Steve Babler
	May/June 1982	pairs and adults Barnard Cr.-above Clayton Cr.	Steve Babler
	May/June/August 1983	pairs and adults Barnard Cr.- Clayton Cr.	Steve Babler
	May 1984	males, Scurvy Cr.- Moose Cr.	Steve Babler
	June 1984	1 male at Grasser Mdw.	Wayne Melquist
Dworshak Rsvr.	None	2 individuals	Mark Orme

Appendix C. Reports of harlequin ducks in Idaho, 1960-1986.

Location	Date	Observation	Observer
Little N. Fork Clearwater R.	April 27, 1978	1 male	Kim Nelson
	July 1984	brood above Trapper Cabin	Harry Jageman
	July 1985	brood above Trapper Cabin	Harry Jageman
East Fork Potlatch Creek	April 1980	1 male	Larry Hlavaty
St. Joe River	1975	pair	Gary Gadwa
	May 10, 1976	1 male	Kim Nelson
	June 1978	1 adult	Tracy Trent
	April 25, 1979	2 males at Storm Creek	Steve Babler
	July 1982	1 female	Wayne Weseman
	none	2-3 pairs	Mike Gertsch
Red Ives Creek	April 28, 1978	pair	Kim Nelson
Chatcolet Lake	April 1983	pair	Brian Janosik
	May 1983	pair	Don Johnson
Lake Pend Oreille	May 1977-78	pair	Ward Tollbom
Gold Creek L. PDO	1974-75	pair, brood	P.A. Printz
	1977	pair, brood	P.A. Printz
	May 1985	adults	Ned Horner
Grouse Creek (Pack River)	1980's	female, nest	Ken Jacobsen

Appendix C. Reports of harlequin ducks in Idaho, 1960-1986.

Location	Date	Observation	Observer
Teepee Creek	June 1982	pair	Doyle Reynolds
Coeur d'Alene R.	1978	pair	Dwain Lowry
	1983	4 individuals	Dwain Lowry
Clark Fork River	April 1982	pair	Paul Hanna
Lightning Creek	May 1984	pair	Paul Hanna
	May 1985	pair	Kathleen Fulmer
East Fork Lightning Creek	May 1976	pair	Jack McNeel
	July 1986	male	Brian Hoeschler
	none	pair	Dave Thorson
N. Gold Creek	Spring 1960's	pair	Bill Davidson
Spring Creek	April 1982	pair	Paul Hanna
Priest Lake	1978	1 individual	Mike McElhatton
	April 29, 1980	pair in Thorofare	Jan Rose
	July 1980	2 males	Wayne Weseman
Soldier Creek	July 1972	1 female	Wayne Weseman
Lion Creek	summer 1977	1 female	Wayne Weseman
Hughes Fork	May-July 1983	male	Jon Almack
	May-July 1984	male	Jon Almack
Smith Creek	July 1973	pair	H. McConnaughey
Rapid River	spring	pair	Dick Welch
Salmon River	May 1976	1 near Salmon	

Appendix C. Reports of harlequin ducks in Idaho, 1960-1986.

Location	Date	Observation	Observer
Ebenezer Creek (Salmon River)	1972	1	D. Swensen
N. Fork Big Cr. (Pahsimeroi)	1974	brood	Roger Williams
Snake River	winter 1977-78	1 near Marsing	
Big Elk Creek	June 1983	pair	Jim Hayden

APPENDIX D

Distribution and population status of harlequin ducks in Idaho

Distribution and population status of Harlequin Ducks in Idaho

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Distribution and population status of Harlequin Ducks in Idaho.- Harlequin Ducks (Histrionicus histrionicus) occur in two distinct populations in North America, an eastern population wintering along the northern Atlantic coast and a western population wintering along the northern Pacific coast. The wintering population of Harlequin Ducks in eastern North America has declined substantially (Goudie 1989). Although the western population is much larger (Bellrose 1976), population size and trend are unkonwn.

Harlequin Ducks migrate inland to nest along swiftly-flowing, mountain streams (Bellrose 1976). In Idaho, they are

considered uncommon summer residents in the northern part of the state (Burleigh 1972). Although the AOU check-list (1983) reports that Harlequin Ducks breed from the Canadian border south to the central Idaho, we found only one Idaho breeding record (Hand 1941) and four sight records (Merrill 1897, Rust 1915, Hand 1932, 1941) in published literature.

Due to their apparent scarcity in Idaho, Harlequin Ducks were classified as a Sensitive Species by Region 1 and 4 of the U. S. Forest Service in 1987 and 1990, respectively, and a Species of Special Concern by the state of Idaho in 1989 (Moseley and Groves 1990). In 1987, we initiated studies on the distribution, population status, habitat use, and breeding biology of Harlequin Ducks in Idaho. Here we report results on breeding distribution and population size.

Methods.-We surveyed 75 mountain streams in northern, north-central, and southeastern Idaho between April and August, 1987-1990, for Harlequin Ducks. Streams were selected for survey based on the availability of suitable habitat (Wallen 1987), personal knowledge or reports of Harlequin Duck use, and proximity to streams known to be used by Harlequin Ducks. Surveys were conducted by hiking, rafting, inner-tubing or driving along streams. Most streams were surveyed several times in at least two of the four years. We also distributed a poster to natural resource agency personnel and river guides statewide

requesting information on sightings of Harlequin Ducks. Below we include results of our own field surveys and reports from U. S. Forest Service biologists, state fish and game biologists, and other experienced observers made between May and September 1987 - 1990.

Results and Discussion.-We observed adult Harlequin Ducks on 16 streams and broods on eight of those streams; we received reports of adults on 17 additional streams and broods on five other streams. The majority of streams (73 %) where Harlequin Ducks were sighted and all streams where broods were observed are located between the Lochsa River (46° 30'N, 114° 57'E) in north-central Idaho and the upper Priest River (48° 58'N, 115° 56'E) near the Canadian border.

In northern and north-central Idaho, Harlequin Ducks were observed at elevations from 600 to 1200 m. These streams were usually associated with riparian habitat dominated by an overstory of western red cedar (Thuja plicata) - western hemlock (Tsuga heterophylla). In southeastern Idaho Harlequin Ducks were observed from 1770 to 1890 m in elevation with riparian habitat dominated by shrubs (Salix sp.) and a canopy of Douglas-fir (Pseudotsuga menziesii). Although breeding has not been confirmed in southeastern Idaho, breeding does occur just across the border in northwestern Wyoming.

Harlequin Ducks have a relatively high unsuccessful or nonbreeding rate (Kuchel 1977, Bengston 1972, Wallen 1987) and

not all streams where breeding occurs produce broods every year. Therefore, breeding may be occurring on some streams where we only observed adults. However, other streams are probably only used during migration between coastal wintering areas and breeding areas farther east in Wyoming and Montana (Wallen and Groves, unpubl. data). Early spring observations and observations of adults in mid- to late-summer in particular may be migrating ducks. Thus, a breeding distribution based upon the presence of pairs on streams during early spring or of single birds later in the season can overestimate actual breeding range.

Our surveys indicate that only a small number of Harlequin Ducks breed successfully in Idaho. During 1990, the year of our most extensive surveys, we observed only 32 pairs and 11 broods. We estimate that the adult population is less than 100 individuals which are distributed primarily on 27 streams over approximately 38,000 km2 in northern and north-central Idaho.

Unfortunately, as Goudie (1989) noted, the Harlequin Duck has received little scientific attention and there are few data to compare our population estimates either historically in Idaho or elsewhere. Although Harlequin Duck breeding surveys are currently being conducted in Montana (D. Genter, pers. comm.), almost nothing is known of their breeding status in adjacent Oregon (K. Durbin, pers. comm.), Washington (D. Kraege, pers. comm.) or British Columbia (W. Campbell, pers. comm.) Densities of Harlequin Ducks on streams Grand Teton National Park, WY

(Wallen 1987), Glacier National Park, MT (Kuchel 1977), and Iceland (Bengston 1972) are higher than those in Idaho.

Goudie (1989) cited evidence that hunting of Harlequin Ducks may have been responsible for declines in eastern North America. However, further investigation into factors limiting Harlequin Duck populations is warranted. Conservation of nesting and brood-rearing habitat along streams where they breed may be critical to their continued existence in Idaho and elsewhere.

Acknowledgments.- This work was funded by the Idaho Panhandle, Clearwater, Nez Perce, and Targhee National Forests under the Challenge Cost-Share Program. The Nongame and Endangered Wildlife Program of the Idaho Department of Fish and Game contributed in-kind matching support. We thank Eric and Melonie Atkinson, Kitty Russell, numerous volunteers, many individuals in the Forest Service and Department of Fish and Game, river guides, and the general public for their assistance with field surveys and reporting of Harlequin Duck sightings.

LITERATURE CITED

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. American Ornithologists' Union, Washington, D. C.

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

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

Burleigh, T. D. 1972. Birds of Idaho. The Caxton Printers, Ltd. Caldwell, Idaho.

Goudie, I. A. 1989. Historical status of Harlequin Ducks wintering in eastern North America - a reappraisal. Wilson Bull. 10:112-114.

Hand, R. L. 1932. Notes on the occurrence of water and shore birds in the Lochsa region of Idaho. Condor 17:118-129.

_____. 1941. Birds of the St. Joe National Forest, Idaho. Condor 43:20-232.

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

Merrill, J. C. 1897. Notes on the birds of Fort Sherman, Idaho. Auk 14:347-357.

Moseley, R. M. and C. R. Groves. 1990. Rare, threatened, and endangered plants and animals of Idaho. Idaho Department of Fish and Game. Boise, Idaho.

Wallen, R. L. 1987. Habitat utilization by harlequin ducks in Grand Teton National Park. M.S. thesis, Montana State University, Bozeman, Montana.

APPENDIX E

Harlequin duck nasal markers used in Idaho, Grand Teton National Park and British Columbia, 1985-1990.

Appendix E. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	LEFT	RIGHT	BAND NO.	LOCATION
				Plusses		
May-88	AHY	F	Black	White	805-90202	ID
May-89	AHY	M	Black	Yellow	805-90211	ID
Aug-86	AHY	M	Blue	Orange	785-50524	BC
May-89	AHY	M	Blue	Yellow	805-90212	ID
Jun-89	AHY	F	Blue	Green	805-90217	ID
May-89	AHY	M	Gray	Orange	805-90215	ID
May-89	AHY	F	Gray	Blue	805-90216	ID
Jul-89	AHY	F	Gray	Green	805-90219	ID
May-88	AHY	M	Green	Yellow	805-90201	ID
July-88	AHY	F	Orange	Black	805-90207	ID
Aug-86	AHY	M	Orange	Orange	785-50519	BC
Aug-86	AHY	M	Orange	Yellow	785-50503	BC
May-89	AHY	M	Red	Blue	805-90213	ID
May-89	AHY	F	Red	Red	805-90214	ID
July-88	AHY	F	Yellow	Blue	805-90205	ID
Aug-86	AHY	M	Yellow	Blue	785-50513	BC
Aug-86	AHY	M	Yellow	Gray	785-50510	BC
May-88	AHY	F	Yellow	Orange	805-90204	ID
May-88	AHY	M	Yellow	White	805-90203	ID
Aug-86	AHY	M	Yellow	Yellow	785-50526	BC
July-88	AHY	F	White	Black	805-90206	ID
Jul-89	AHY	F	White	White	805-90218	ID

Appendix E cont'd. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	LEFT	RIGHT	BAND NO.	LOCATION
				Ovals		
Aug-89	YOY		Black	Blue	805-90232	ID
May-90	AHY	M	Black	Red	805-90235	ID
Aug-89	YOY		Blue	Blue	805-90233	ID
Aug-86	AHY	M	Blue	Blue	785-50505	BC
Aug-89	YOY		Gray	Blue	805-90231	ID
Aug-89	YOY		Gray	Orange	805-90229	ID
Aug-86	AHY	M	Gray	Yellow	785-50515	BC
Aug-89	AHY	F	Green	Blue	805-90230	ID
June-86	AHY	M	Green	Green	655-07251	GT
Aug-89	YOY		Green	White	805-90227	ID
Aug-89	YOY		Orange	Black	805-90226	ID
Aug-86	AHY	M	Orange	Orange	785-50520	BC
Aug-89	YOY		Red	Blue	805-90234	ID
Aug-89	YOY		White	Orange	805-90228	ID
				Ys		
Aug-86	AHY	F	Gray	Orange	785-50506	BC
Aug-86	AHY	M	Orange	Blue	785-50504	BC

Appendix E cont'd. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	LEFT	RIGHT	BAND NO.	LOCATION
				Squares		
June-85	AHY	M	Black	White	655-07208	GT
May-85	AHY	M	Blue	Orange	655-07202	GT
June-85	AHY	F	Blue	White	655-07218	GT
May-86	AHY	M	Gray	Blue	655-07245	GT
June-85	AHY	M	Gray	Gray	655-07209	GT
May-85	AHY	F	Green	White	655-07202	GT
June-86	AHY	F	Green	Yellow	655-07254	GT
Aug-86	AHY	M	Orange	Gray	785-50518	BC
May-85	AHY	F	Orange	Green	655-07201	GT
June-86	AHY	M	Orange	White	655-07252	GT
June-85	AHY	M	Red	Green	655-07214	GT
June-85	AHY	M	Yellow	Blue	655-07210	GT
June-85	AHY	M	Yellow	Orange	655-07211	GT
Aug-89	AHY	F	Yellow	Yellow	655-07270	GT
May-86	AHY	M	White	Red	655-07246	GT
1988,89	AHY	F	White	Yellow		GT

Appendix E cont'd. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	LEFT	RIGHT	BAND NO.	LOCATION
				Circles		
Aug-85	AHY	F	Black	White	655-07221	GT
Aug-85	AHY	F	Blue	Blue	655-07224	GT
1988,89	AHY	F	Blue	Red		GT
June-85	AHY	M	Gray	White	655-07207	GT
May-86	AHY	M	Green	Blue	655-07244	GT
May-86	AHY	M	Green	Yellow	655-07247	GT
Aug-86	AHY	F	Green	White	655-07261	GT
1988,89	AHY	M	Orange	Gray		GT
1988,89	AHY	M	Orange	Green		GT
July-85	AHY	F	Orange	Orange	655-07219	GT
June-85	AHY	M	Red	Red	655-07205	GT
Aug-85	AHY	F	White	Blue	655-07232	GT
June-85	AHY	F	White	Orange	655-07215	GT
May-86	AHY	M	White	White	655-07248	GT
Aug-86	AHY	F	Yellow	Blue	655-07269	GT
1988,89	AHY	M	Yellow	Gray		GT
1988,89	AHY	M	Yellow	Orange		GT
June-86	AHY	F	Yellow	White	655-07250	GT
July-86	AHY	F	Yellow	Yellow	655-07255	GT

Appendix E cont'd. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	LEFT	RIGHT	BAND NO.	LOCATION
				Triangles		
1988,89	AHY	F	Black	Orange		GT
June-86	AHY	F	Black	White	655-07249	GT
1988,89	AHY	F	Blue	Blue		GT
Aug-86	AHY	M	Gray	Orange	785-50507	BC
1988,89	AHY	F	Gray	Orange		GT
July-85	AHY	F	Green	Green	655-07220	GT
1988,89	AHY	M	Green	Orange		GT
1988,89	AHY	F	Green	Yellow		GT
June-85	AHY	F	Orange	Blue	655-07217	GT
June-85	AHY	F	Orange	Yellow	655-07216	GT
Aug-86	AHY	M	Orange	Yellow	785-50502	BC
June-85	AHY	M	Yellow	Blue	655-07212	GT
1988,89	AHY	F	Yellow	Yellow		GT
1988,89	AHY	M	White	Blue		GT
June-85	AHY	F	White	Green	655-07213	GT
1988,89	AHY	M	White	Orange		GT
1988,89	AHY	M	White	Red		GT
June-86	AHY	F	White	White	655-07253	GT

Appendix E cont'd. Harlequin duck nasal markers used in Idaho (ID), Grand Teton (GT), and British Columbia (BC), 1985-90.

DATE	AGE	SEX	MARKER[1]	LEFT	RIGHT	BAND NO.	LOCATION
			Mixed				
Aug-86	AHY	M	LC RT	Yellow	Orange	785-50512	BC
Aug-86	AHY	M	LO RT	Gray	Yellow	785-50514	BC
Aug-86	AHY	M	LO RT	Orange	Yellow	785-50527	BC
Aug-86	AHY	M	LO RP	Gray	Gray	785-50516	BC
Aug-86	AHY	M	LO RP	Yellow	Orange	785-50527	BC
Aug-86	AHY	M	LO RT	Orange	Blue	785-50521	BC
Aug-86	AHY	M	LS RC	Yellow	Orange	785-50501	BC
Aug-86	AHY	M	LS RO	Gray	Blue	785-50517	BC
Aug-86	AHY	M	LS RO	Yellow	Yellow	785-50509	BC
Aug-86	AHY	M	LS RO	Yellow	Gray	785-50511	BC
Aug-86	AHY	F	LS RP	Blue	Yellow	785-50522	BC
Aug-86	AHY	M	LS RT	Yellow	Yellow	785-50508	BC
Aug-86	AHY	M	LT RP	Blue	Gray	785-50523	BC

[1] Mixed markers first letter indicates left or right, C=circle, O=Oval, P=Plus, S=Square, T=Triangle.

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