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ENNIS RESERVOIR / MADISON RIVER FISHERIES INVESTIGATION

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by

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ABSTRACT

The range of the Arctic grayling in Montana has become increasingly restricted through the 20th century. Presently, only three endemic populations of grayling exist in Montana. Little is known about grayling inhabiting Ennis Reservoir and the Madison River. This study was initiated to investigate the fishery in Ennis Reservoir to determine the life history and requirements of grayling and rainbow trout in the system.

Grayling spawned in the Madison River throughout April, 1990. After spawning, grayling were found in the inlet areas and distributed throughout the reservoir. As aquatic vegetation increased in density in the shallow areas of the reservoir, grayling appeared to congregate in these areas. Young-of-the-year grayling appeared to migrate into the reservoir shortly after emergence in the Madison River. The current spawning population (>10 inches long) was estimated to be approximately 545.

Electrophoretic analysis of grayling collected from Ennis Reservoir and the Madison River indicated that the resident population is genetically similar to the Big Hole River stock. These results suggest three scenarios to explain the similarity: that both populations are remnants of the original grayling endemic to the headwaters of the Missouri River, that progeny of grayling derived from the Ennis Reservoir stock and planted into the Big Hole River hybridized with resident grayling, or that a random shift in the Ennis Reservoir/Madison River grayling genome occurred due to a recent bottleneck in population size which converged toward the Big Hole River genotype.

Rainbow trout also spawned in the Madison River throughout April 1990. Rainbow trout originating in Ennis Reservoir and spawning in the Madison River were estimated at approximately 1,032 fish. Scale analysis revealed that rainbow trout in this system may reside in either the river or reservoir at any life stage. Reservoir operations, therefore, are likely to affect rainbow trout resident in the reservoir as well as those residing in the river immediately upstream from the reservoir.

Creel census indicated that approximately 7,820 angler hours were exerted at Ennis Reservoir April through August, 1990. Rainbow trout provided the greatest catch rates and harvest, followed by brown trout and grayling, respectively.

Macrophyte density was mapped from aerial photographs taken in 1983, 1984, 1988, and August and September, 1990. The deep drawdown of 1983 apparently caused a severe decline in macrophyte abundance. By 1988, macrophytes had recovered to near maximal density.

Further research is needed to properly understand and assess the effects of reservoir operations on the fish community in Ennis Reservoir. In particular, the life history and habitat requirements of the grayling should be investigated more closely.

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INTRODUCTION

While the sport fishery of Ennis (a.k.a. Meadow) Reservoir relies primarily on rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta), the reservoir supports a population of Arctic grayling (Thymallus arcticus) which may be a native remnant. Grayling were native to the Missouri River and its tributaries above Great Falls, Montana, including the Madison, Jefferson, Gallatin, Smith, and Sun Rivers (Tryon 1947). Although the majority of indigenous populations were fluvial, only one documented self-sustaining fluvial population remains. This population inhabits the upper Big Hole River. An indigenous lacustrine population exists in Upper and Lower Red Rocks Lakes (Kaya 1990). Additional lakes have been successfully planted with grayling throughout Montana and in other states.

The Madison River/Ennis Reservoir grayling population represents a third potentially indigenous population in Montana. Although fluvial in origin, this population had adapted to lentic-like conditions prior to and expanded during construction of an impoundment at Ennis Reservoir at the turn of the century. Prior to impoundment, the Madison River in this area is thought to have run through a marshy pond-like area characterized by deep pools and low velocity. The alteration of the Madison River at Ennis Reservoir has provided an environment for development of a unique grayling population that exhibits fluvial behavior while residing primarily in the reservoir.

The grayling population in Ennis Reservoir and the Madison River has fluctuated in abundance throughout the late 1800's and 1900's. The most recent era of relatively high grayling numbers ended by 1983, apparently as a result of a late March-early April drawdown. Interviews of local residents indicated that grayling were abundant and easily captured until 1983, and rarely have been caught until the 1990 fishing season.

Reasons for these population fluctuations are unclear. In general, the decline of grayling in Michigan and Montana has been attributed to climatic change, introduction of non-native fishes, exploitation by humans, and habitat alteration (Vincent 1962). All of these changes have occurred and certainly could have affected grayling in the Madison River and Ennis Reservoir. Specific effects of reservoir operations on grayling are unknown.

The Federal Power Act (FPA) requires that all hydroelectric impoundments be licensed under jurisdiction of the Federal Energy Regulatory Commission (FERC). The act stipulates that an operational plan be established for licensing which includes, among its requirements, that adequate protection, mitigation, and enhancement be provided for fish and wildlife including spawning areas and habitat (FERC 1990). In accordance with FPA, the Montana Power Company (MPC) sponsored this study to investigate the effects of reservoir operations on the fishery in Ennis Reservoir, one of several impoundments in the Missouri River drainage designated for relicensing in 1994.

In order to meet FPA requirements in relicensing the Ennis project, baseline fisheries information is required. The purpose of this study was to collect baseline information on the relationship between reservoir management and the Ennis Reservoir fishery. Of particular interest were the characteristics of the grayling population including their movement, abundance, key spawning and rearing areas, and relationship with the macrophyte community. We believed it was imperative to determine the genetic origin of the Ennis Reservoir grayling, because future management of the fishery hinges upon whether the population has descended directly from native Madison River grayling or was derived from a combination of hatchery stocks and remnant endemic grayling. If this population is native, future management depends upon maintaining it through wild reproduction and habitat preservation and enhancement. Only if the population is confirmed to be of hatchery origin will further supplementation from hatchery stocks be considered.

Specifically, the objectives of the study were to:

1. determine abundance, spawning periods and locations, distribution, and movements of grayling and rainbow trout in Ennis Reservoir and the Madison River,

2. document the genetic origins of Ennis Reservoir/Madison river grayling,

3. determine angler use and contribution to catch of grayling, and

4. describe general physical and biological conditions in Ennis Reservoir with regard to food habits and availability, water temperature, and aquatic macrophyte abundance and importance to the fish community.

Data in this report were collected between April 1 and

October 1, 1990. Funding was provided by MPC under contract with Montana Department of Fish, Wildlife, and Parks (MDFWP).

STUDY AREA DESCRIPTION

Ennis Reservoir is located in Madison County in southwestern Montana (Figure 1). The reservoir was formed in 1903 by impounding the Madison River at the head of Beartrap Canyon 10 miles north of the town of Ennis. Ennis Reservoir lies at an elevation of 4,841 ft and covers 3,741 surface acres. Maximum depth is 32 ft, with approximately 50% of the reservoir less than 10 ft deep.

The study area encompassed Ennis Reservoir and the Madison River from the reservoir 3.3 miles upstream to Valley Garden Fishing Access Site (FAS). This reach of the river is extensively braided, creating a labyrinth of channels interspersed with brushy islands. Annual discharge flowing in and out of Ennis Reservoir varies from approximately 1,100 to 3,500 cfs. Water temperatures range from near freezing to over 70 f. Ennis Reservoir acts as a "heat trap" which may warm the Madison River below Ennis dam during the summer months (Vincent 1981). This warming was documented to affect catch rates of trout in the lower Madison River (McMichael 1989).

Other than the Madison River there a four significant tributaries to Ennis Reservoir: Meadow Creek entering the northwest corner, Jordain and St. Joe Creeks entering on the east shoreline, and Moores Creek Canal which enters in the southwest corner of the reservoir.

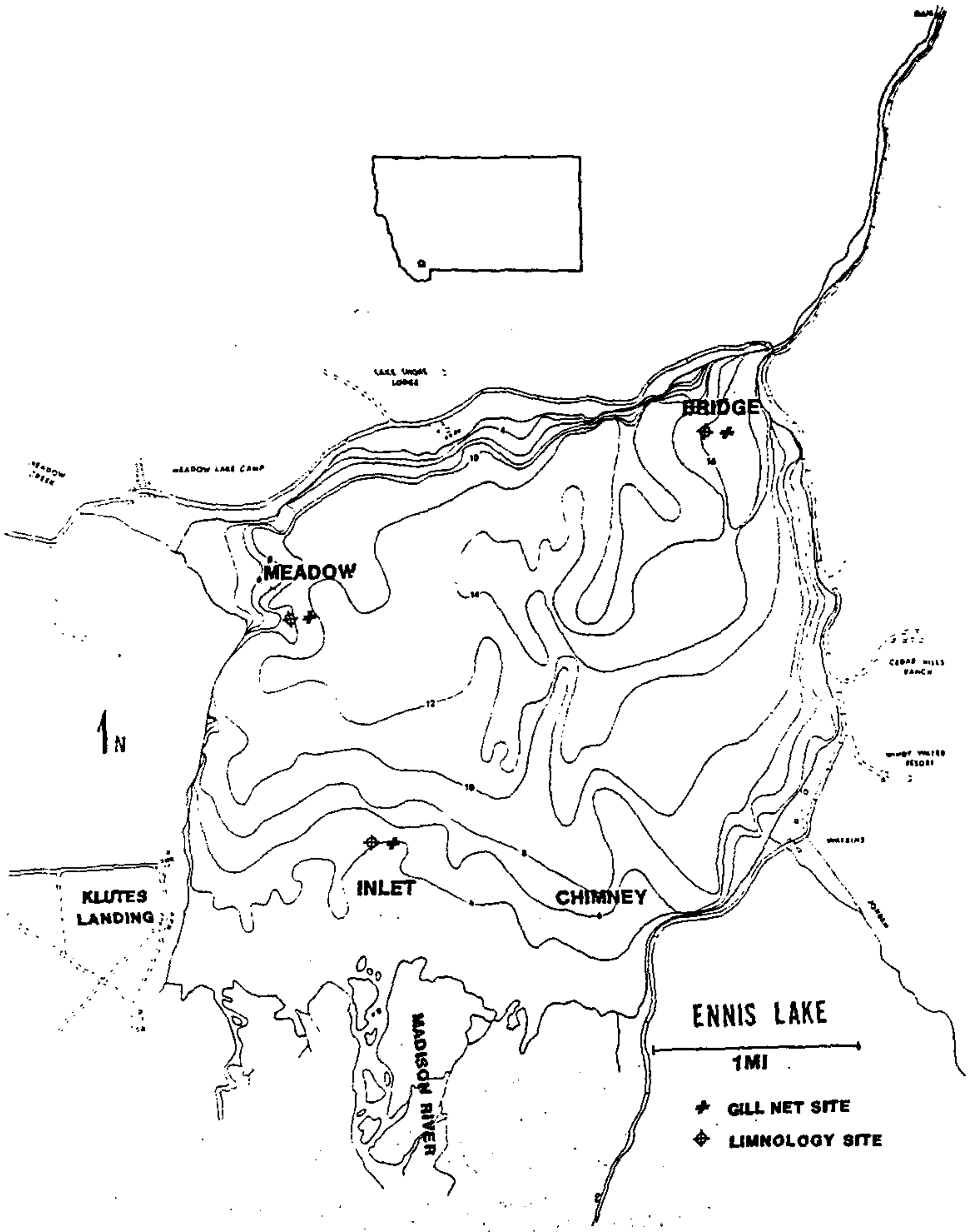

Figure 1. Map of Ennis Reservoir, showing gill netting and limnological sampling sites.

Resident fishes include grayling, rainbow trout, brown trout, mountain whitefish (Prosopium williamsoni), white sucker (Catostomas commersoni), longnose sucker (C. catostomus), Utah chub (Gila atraria), longnose dace (Rhinichthys cataractae), and an occasional brook trout (Salvelinus fontinalis).

The shallow south end of the reservoir is characterized by dense mats of macrophytes that appear in late June and peak in early September. Pondweeds (Potamogeton spp.), Elodea canadense, and widgeongrass (Ruppia maritima), have been observed in Ennis Reservoir (Eng 1988). Species of aquatic macrophytes observed in 1990 included: E. nuttalii, P. crispus, P. pectinatus, P. praelongus, Myriophyllum sibiricum, and Ceratophyllum demersum (Jourdonnais et al. 1990). Macrophytes have periodically created problems with dam operations and drawdowns have been used to control them.

METHODS

Electrofishing and Spawning Surveys

Electrofishing was conducted to estimate Madison River trout populations, to document use of the Madison river and its tributaries by spawning grayling and rainbow trout, and to determine patterns of fish use around the inlets to Ennis Reservoir. A 240 watt gas powered generator connected to a Harley Leach variable voltage DC pulsator were placed in a drift boat or Coleman Crawdad and a mobile anode was thrown to electrofish the Madison River. The electrofishing section was divided into 5 routes (Figure 2). Only grayling were netted in the first 0.5 miles of the section, while population estimates were derived for the remainder. Marking and recapture runs were made between April 5 and May 4, and July 16 and August 23, 1990, with at least one week between runs for any one route. Grayling, rainbow and brown trout were netted, anesthetized in ethyl 4-aminobenzoate dissolved in 95% ethyl alcohol, classified according to maturity (immature, mature ripe, mature non-ripe, or spent) measured to the nearest 0.1 inches, and weighed to the nearest 0.01 lb. Fish were marked with a fin clip and scale samples were taken for age determination. Population estimates were made on MDFWP Mark-Recapture program (Merry 1988).

All grayling were tagged with individually numbered visible implant (VI) tags (Northwest Marine Technology). Grayling longer

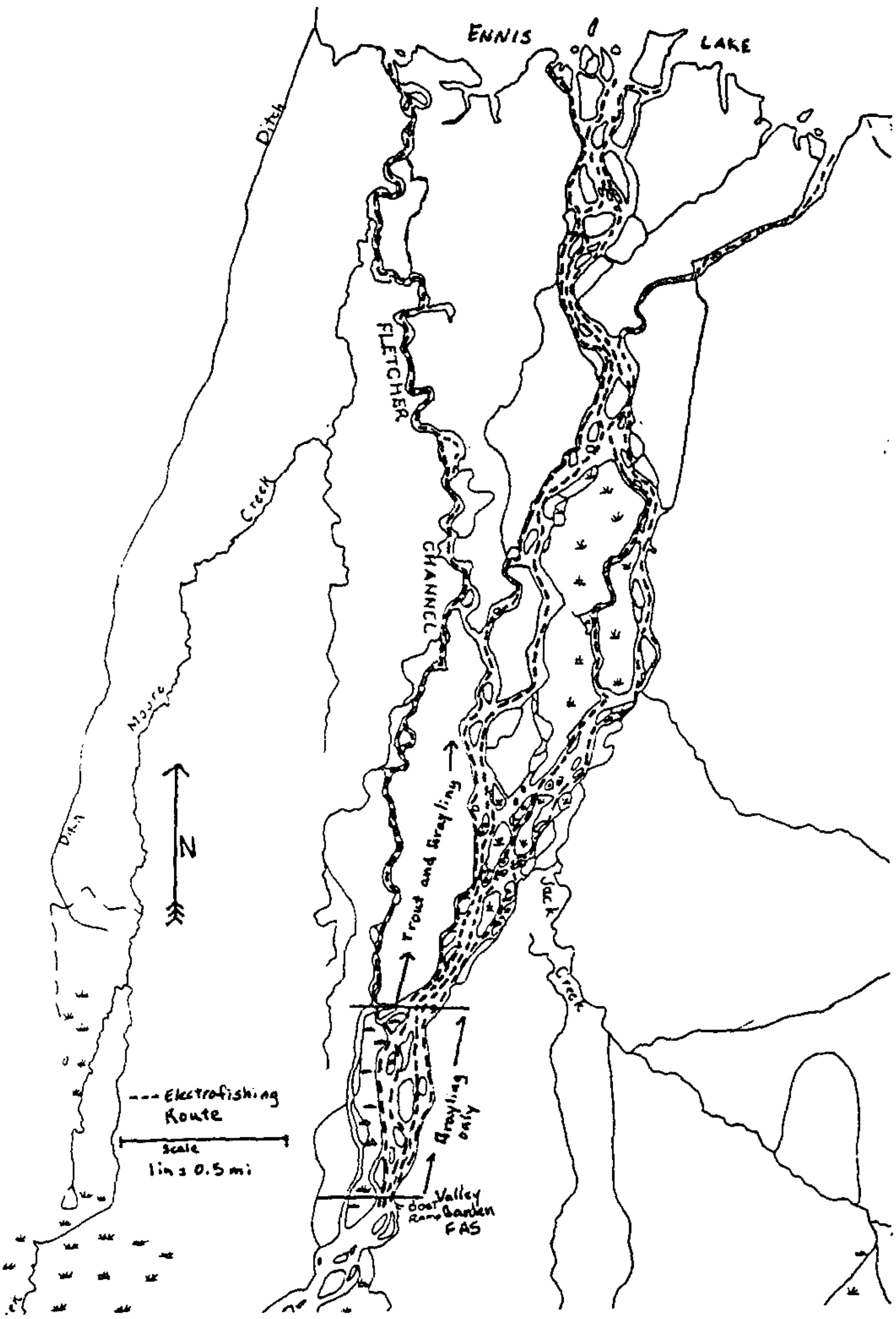

Figure 2. Map of Madison River study area indicating electrofishing routes.

than 10.0 inches were also tagged with numbered Floy "T" tags. Rainbow trout greater than 10.0 inches were tagged with red filament tags. Fish were allowed to recover from anesthesia and released.

Grayling capture sites were marked with fluorescent tape and visually classified according to general habitat type (riffle, run, pool), bank condition, and distance to cover. Photographs were taken of capture sites. At a later date, habitat parameters were measured under flow conditions similar to those on the date of capture. Habitat at sites where ripe grayling were captured was characterized by depth, average velocity (0.6 depth), substrate, and bank condition. Four transects, 6 ft apart, were established bracketing each capture site. Transects were divided into partial sections. Within each partial section depth and velocity were measured using a Gurley type AA current meter mounted on a graduated wading rod. Substrate was measured along each transect to determine occurrence of each substrate class relative to the length of the transect. Substrate was classified as cobble (2.5 to 10.0 inches), gravel (2.4 to 0.5 inches), fines (less than 0.5 inches), or in combination.

The inlets of Ennis Reservoir were surveyed to determine if fish used these areas pre- and post-spawning for staging. A jet-powered aluminum electrofishing boat equipped with a 240 watt gas generator, a Coffelt VVP-10 or 15 pulsating unit, and two anodes mounted on fiberglass booms was used to sample grayling and trout in the inlets. Grayling and trout were processed as above, except rainbow trout were tagged with blue filament tags to indicate capture in inlets.

Portions of Moores Creek, Moores Creek Canal, Jordain Creek, and St. Joe Creek were electrofished with a Coffelt BP-6 backpack unit to assess spawning activities of grayling and rainbow trout. Approximately 0.5 miles of Meadow Creek immediately upstream from the reservoir was visually surveyed for redds. A trap was installed in Meadow Creek to determine if grayling and/or rainbow trout spawned there. Two 5x5x4 ft rebar frame traps covered with 1/2 inch mesh hardware cloth were placed at each end of a 1/2 inch mesh by 4 ft hardware cloth lead installed diagonally to the current. The trap was checked each morning and evening during operation from April 9 to April 25, 1990.

Gill Netting

Gill nets were used to determine relative abundance and distribution of grayling and trout in Ennis Reservoir. Six experimental gill nets (3 sinking, 3 floating), each 125 ft long with graduated segments of mesh ranging from 0.75 to 2.0 inch bar mesh, were set at each of three sites in September 1989, and at four sites between May 29 and June 6, 1990 (Figure 1). Two (1 sinking , 1 floating) nets were also operated at each site July 31 to August 1, and September 24 and 25, 1990. Nets were fished overnight at depths ranging from 6 to 14 ft. Captured fish were retrieved the following morning, enumerated by species, weighed, and measured. Live trout were released after processing. Ocular analysis of stomach contents was recorded for trout killed during netting. A representative sample of rough fish were measured for total length.

Stomach samples were also collected from grayling and rainbow trout mortalities in gill nets. Stomachs were preserved in a 5% formalin, 20% ethyl alcohol solution and analyzed under a microscope. Stomach contents were analyzed for relative occurrence of the following groups: adult aquatic macroinvertebrates (ADAM), immature aquatic macroinvertebrates (IMAM), adult terrestrial macroinvertebrates (ADTER), zooplankton, and fish.

Limnology

Limnological measurements were taken monthly at three sites (Inlets, Meadow, and Bridge) from June through September (Figure 1). Temperature profiles were derived from measurements made at 1 ft increments from surface to substrate with a marine temperature probe. Secchi depth was determined with a standard secchi disk in 3 replications. A Wisconsin plankton net was towed vertically from substrate to surface in 3 replications to sample zooplankton at each site. Samples were preserved in a 5% formalin/20% ethyl alcohol solution until diluted and subsampled for enumeration in the laboratory. Individual plankters were identified to genus and density per liter was calculated.

Vegetation Mapping

Relative density of submerged aquatic vegetation was mapped from aerial photographs taken September 15, 1983, September 13, 1984, October 11, 1988, and August 1 and September 11, 1990. Photographs were taken from fixed wing aircraft travelling at approximately 75 mph at elevations of 1,800 to 1,900 ft above datum. Photographers used a 35 mm camera with a 28 mm lens and Ektachrome 200 color film. Flight lines included 2 to 4 passes over the south end of the reservoir and 1 to 2 passes over Meadow Bay.

Individual slides were projected onto a blank screen and vegetation densities were mapped, by hand, onto a base map of similar scale. Vegetation density was classified according to Eng (1988):

Dense	-	Characterized by a deep russet color in dense mats.
Medium (Moderate)	-	Characterized by lighter, russet-green color.
Scattered	-	Characterized by tan, tannish-green and light green.

Vegetation density was then transferred from hand-drawn maps to Conputer-Assisted-Design software (Designer, version 2.1 (Micrografx, Inc. 1987)) to produce the final maps.

Creel Census

A creel census was conducted on Ennis Reservoir from April 16 through September 2, 1990. Fall and winter creel results will be reported later. The creel census consisted of instantaneous counts of anglers and interviews of anglers to determine catch rates and creel composition (Neuhold and Lu 1957). Information on angler's gear and preferred seasons to fish and species sought was also collected during interviews. During angler counts other reservoir users were also enumerated. Sample dates and times were randomly selected according to criteria presented below.

Sample Design

The spring through late summer period was broken into three strata: April 16 to June 3 (spring); June 4 to July 1 (early summer); and July 2 to September 2 (late summer). Sample periods consisted of four to eight week blocks starting on a Monday. Three weekend days (including holidays) and four weekdays were sampled within each four week period. Counts of anglers and other reservoir users were made at two hour intervals during each sample day. The hour of the first count was selected at random. Possible first count hours were segregated into two hour increments. The total hours of daylight in each sample period was used to determine how many possible first counts existed in a ten hour work day. Counts were conducted every hour after the first count for ten continuous hours. Only daylight hours were included. Possible hours of the first count by period were: 8:00 AM, 10:00 AM, and NOON for spring; 6:00 AM, 8:00 AM, 10:00 AM, NOON, and 2:00 PM for early and late summer. Sample days and first count hours were selected using a random numbers generator in the STATGRAPHICS statistical software package (STSC, Inc. 1986). The days and hours sampled are presented in Appendix A.

Reservoir User Counts

All counts were considered instantaneous counts because the entire reservoir could either be seen from a single point or two vantage points which required less than five minutes to travel between, depending upon where on the reservoir the creel clerk was stationed. The following types of reservoir users were counted: anglers on shore; anglers in boats; boats with at least one angler fishing; sailboards on the reservoir; swimmers; motorboats (other than those containing at least one angler); non-motorized boats(including float tubes); and other users. Clerks made detailed notations of other types of users including campers, sunbathers, etc. An example of the count form is presented in Appendix A2. Only people using the reservoir for recreation were counted.

Interviews

Angler interviews were conducted with individual anglers on the reservoir and included detailed questions. Angler interviews were conducted with as many anglers using the reservoir as could be contacted during each sample day. The creel clerk tried to obtain interviews with anglers completing their days fishing. The information obtained from "completed angler trips" is the most useful information in computing angler harvest statistics (Neuhold and Lu 1957). An "Angler Interview" form and detailed instructions for completing the form are presented in Appendices A2 and A3. Each angler was asked the following questions (unless indicated otherwise in parentheses):

the total number of anglers in the party (only recorded for one angler in each party); the time the angler started fishing for the day sampled; if the trip was completed; the origin of the angler; the number of miles traveled (one-way) to the reservoir; the number of hours fished during the day sampled; the number of fish kept by species (Appendix A3); the number of fish released by species; if the angler fished from the shore or boat or both; the type of terminal gear used (Appendix A3); fishing method angler used (for example, trolling from boat, still fishing from boat, etc.; see Appendix A3 for details); which seasons the angler fishes the reservoir; which species of fish the angler is after; which species of fish the angler would like to see in the reservoir; and whether the angler is primarily interested in catching a high number of fish or fish of a large size. Length and weight information was collected from creeled fish if time permitted. If length and weight information was collected, a code number was entered on the interview form so individual fish could be traced back to the angler which caught them. The name and address of each angler was entered to provide the Department with a mail contact for sending out questionnaires soliciting opinions on management of the reservoir.

Data Analysis

All count and interview data was entered into data files on PC computers using dBase III+ software (Ashton Tate 1985). These data were summarized using dBase III+ programs and a creel census program developed by MDFWP (McFarland and Roche 1987).

Public Participation

In addition to the formal creel census, an effort was made to gather reports of grayling captures in the Madison River and Ennis reservoir. Creel clerks recorded comments related to grayling population trends, as well as suggestions for future management. Several local businesses were asked to acquire information pertaining to grayling by posting signs requesting reported captures and tag returns. Log books were also provided to merchants for recording reports.

Electrophoresis

Twenty-one grayling were collected and sent to the University of Montana Genetics Laboratory for electrophoretic analysis. Grayling were collected from gill net mortalities, from anglers, and during river and reservoir electrofishing. Age classes 0 to IV were represented in the sample. The methods used are outlined in Everett and Allendorf (1986).

RESULTS

Grayling

Spawning

Twenty-four grayling were captured between April 5 and May 6, 1990 in the Madison River study section. Peak of spawning, based on capture of ripe female grayling, appeared to occur between April 20 and 25 (Figure 3). Female Grayling are ripe for a short period (Shepard and Oswald 1989). Spawning peaks may have been associated with increases in water temperature and discharge which occurred during the same period.

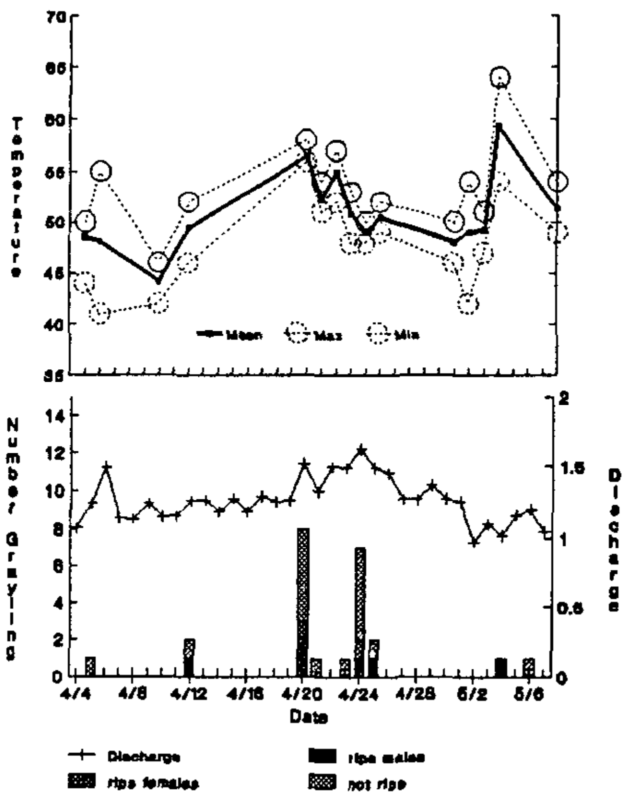

Figure 3. Timing of grayling spawning in the Madison River, with respect to discharge (cfs) and water temperature (°C), Spring, 1990.

Although grayling were captured throughout the study section, the majority were captured along the mid-west electrofishing route (Figure 4). We did not document that grayling spawned in Jordain, St. Joe, or Moore's Creeks in 5 electrofishing days, or in 16 trap days at Meadow Creek.

The majority of spawners were Age III (15), with mean total length of 13.8 inches (range: 13.6 to 15.6 inches). Four Age IV grayling, all males, were captured. They had a mean length of 14.4 inches (range: 13.1 to 15.4 inches). Age II grayling captured included one ripe female, and two non-ripe males. Average length of Age II grayling was 13.7 inches for which sex could be determined (range: 11.9 to 14.6 inches). The sex ratio for all grayling captured during the spawning run was 13 males to 5 females (2.6:1). Six grayling of unknown gender, including 2 Age I were also captured in the Madison River during spring electrofishing.

Habitat

General descriptions of capture sites indicated that spawning grayling sought habitat characterized as deeper riffles or runs, not necessarily in proximity to cover. Of 22 capture sites marked, 82% were located in riffles or runs. Distance from capture sites to cover varied from immediately adjacent, to as far as 40 yards away. The remainder of captures occurred in deeper pools or backwaters.

Specific habitat measurements at eight capture sites indicated that grayling generally used areas less than 3 ft deep

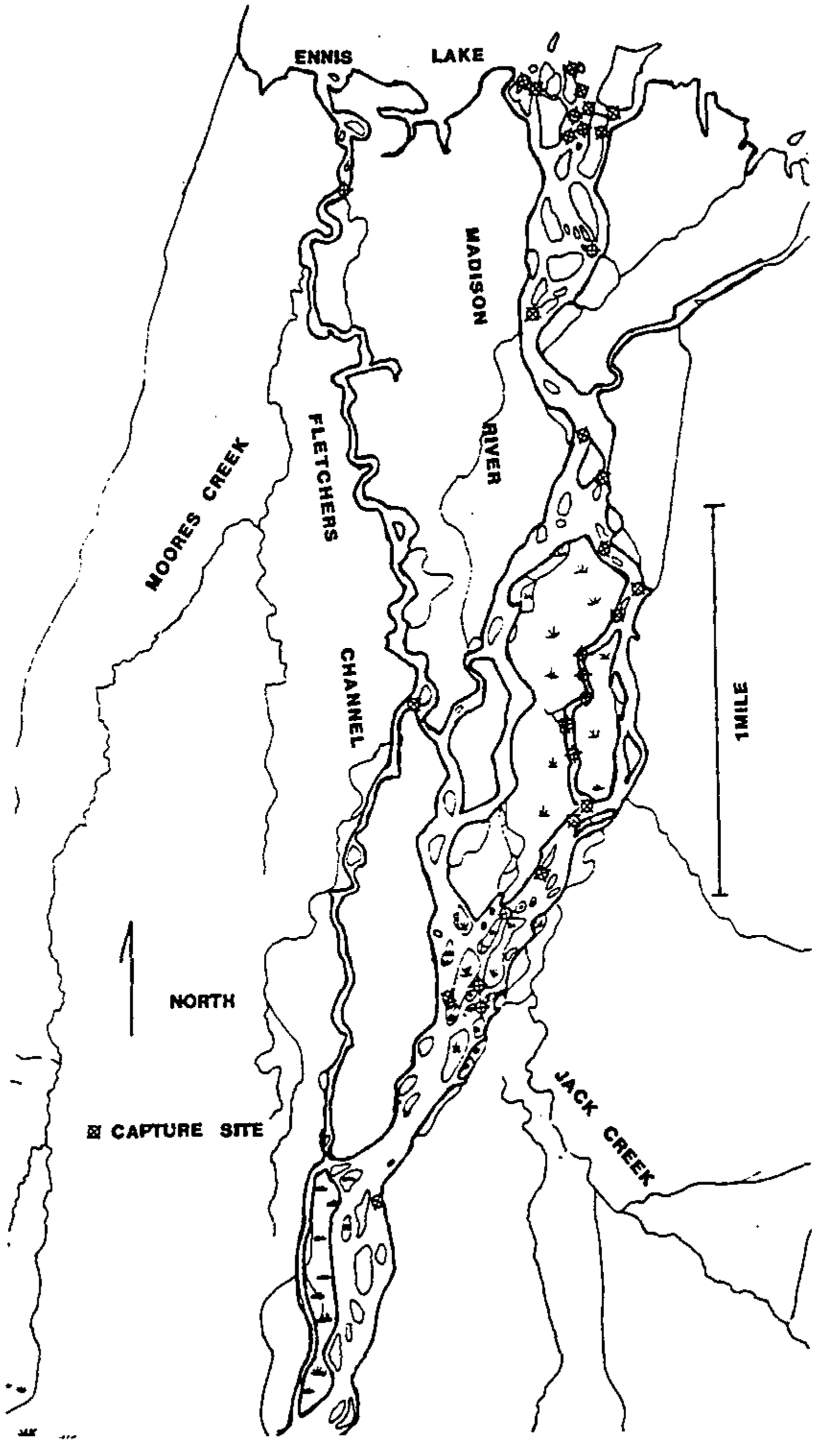

Figure 4. Distribution of grayling capture sites in the Madison River, Spring, 1990.

with velocities ranging from 4.87 to 0.18 ft/s. Substrate within transects at capture sites was dominated by aggregates of gravel and cobble virtually devoid of fine sediments.

Distribution and Movements

Distribution and movement information for grayling in Ennis Reservoir and the Madison River was gathered during river and reservoir electrofishing, tagging program, gill netting, creel census, and angler reports. As outlined above, grayling spawning occurred through April until mid-May and was observed only in the Madison River. Night electrofishing in the inlets area indicated a post-spawning concentration of grayling in the area, when 5 grayling were captured on May 14, 1990, whereas in 4 previous electrofishing nights, only 2 had been captured (4/18 and 5/2/90). Another night of electrofishing on July 2, 1990 yielded only 1 grayling.

In 10 electrofishing days on the Madison River during July and August, 1990, no adult grayling were captured. This implies that grayling may use the Valley Garden FAS to Ennis Reservoir section only during spawning. Five young-of-the-year (YOY) grayling were captured in the electrofishing section in the same 10 days of effort. We expected that large numbers of YOY grayling would rear in the channels, and should have been captured in fairly high densities. YOY grayling in the Big Hole River were found to rear in close proximity to their assumed natal spawning grounds through their first summer (Skaar 1987, McMichael 1990). However, the sparse catch of YOY in the Madison

River may indicate that some rear in the river only for a short time, and then emigrate to Ennis Reservoir shortly after emergence.

<u>Gill Netting</u>

Gill nets set in September, 1989 captured a single grayling at the Chimney site (Figure 1). The Bridge site was not netted. Netting efforts in Spring, 1990 yielded 12 grayling: 8 at the Bridge site, 3 at Meadow Bay, and 1 in the Inlets area. No grayling were captured in the Chimney set.

Summer netting, with its reduced effort, captured only one grayling, at the Inlet site. No grayling were captured in Fall, 1990 netting.

The grayling catch in gill nets, although few, suggest that after spawning, grayling are distributed throughout the reservoir, but are more concentrated in the deeper northern end.

<u>Angler Captures</u>

Anecdotal reports of grayling captured by anglers were recorded during creel census interviews and other conversations with anglers (Figure 5, Table 1). Early spring captures may reflect spawning movements and staging. June captures were distributed throughout the reservoir. As the macrophytes increased in surface area and density during July and August, grayling were captured more frequently by anglers within macrophyte beds. A large proportion of the captures were made in the inlets area, and in weedbeds near Klute's Landing. In September, grayling were still being caught in macrophyte areas.

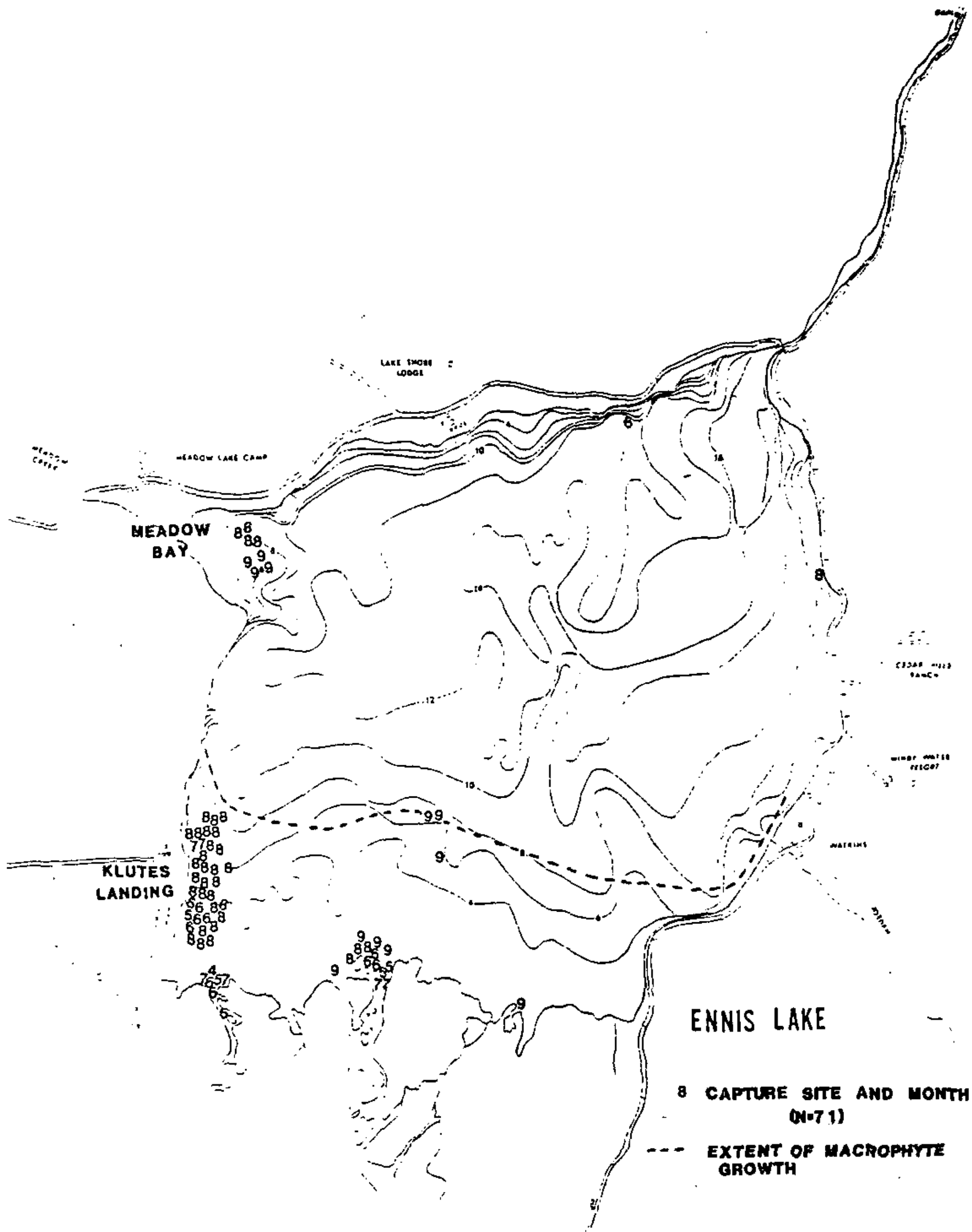

Figure 5. Locations of grayling captured by anglers in Ennis Reservoir, and month of capture.

Table 1. Records of grayling captured by anglers in Ennis Reservoir and the Madison River by month, 1990 (N=80).

Month	Number	Location of Capture
April	1	Mouth of Fletcher's Channel
May	2	Mouth of Fletcher's Channel
	1	Unknown
	1	1 mile upstream in Fletcher's Channel
	2	Mouth of Main Inlets
	1	Near Ennis Bridge FAS**
	1	Near Klute's Landing *
June	3	Mouth of Main Inlets
	1	Northeast corner of Ennis Lake
	2	Fletcher's Channel *
	5	Near Klute's Landing in weedbeds
	1	Valley Garden FAS**
July	2	Mouth of Fletcher's Channel
	2	Below Ennis Dam
	2	Mouth of Main Inlets
	2	Near Klute's Landing in weedbeds
August	2	Below Ennis Dam
	3	Mouth of Main Inlets
	1	East Shore 0.75 miles N of St. Joe Cr.
	28	Near Klute's Landing in weedbeds
	1	1 mile upstream in Fletcher's Channel
	4	Meadow Bay
September	1	Mouth of East Channel
	4	Meadow Bay
	3	Middle of Reservoir near weedbeds
	4	Mouth of Main Inlets

* Tag Return
** FAS = Fishing Access Site

Several captures were documented in the Madison River, both above and below the reservoir.

The information gathered from anglers from April through September, 1990 indicates the importance of the inlets areas to grayling. Angler success also suggests a seasonal shift in distribution toward areas of abundant macrophyte growth as they appear. These angler reports are subjective, and fishing pressure appeared to increase in the southern end of Ennis Reservoir as the summer progressed.

<u>Abundance</u>

Estimating grayling abundance was difficult due to the small sample size. Based on two tag returns, an extremely rough estimate of spawning grayling was derived. Using 22 grayling marked (M) during the spawning run with Floy tags, 70 total captures (C)(using only angler reports with specific reference to date, length, and area of capture), and 2 recaptured grayling (R), an estimate of 545 spawning grayling longer than 10 inches (95% CI: 533) was derived. Although the accuracy of the estimate is questionable, the population is certainly small (< 1000), and extremely vulnerable to extirpation. A more accurate estimate is needed.

<u>Age and Growth</u>

Ennis Reservoir/Madison River grayling exhibit rapid growth during their first two years (Figure 6). After their first year juvenile grayling average 7.38 (95% CI: 0.96) inches long. Mean length of Age II grayling captured through May was 13.86 (95% CI:

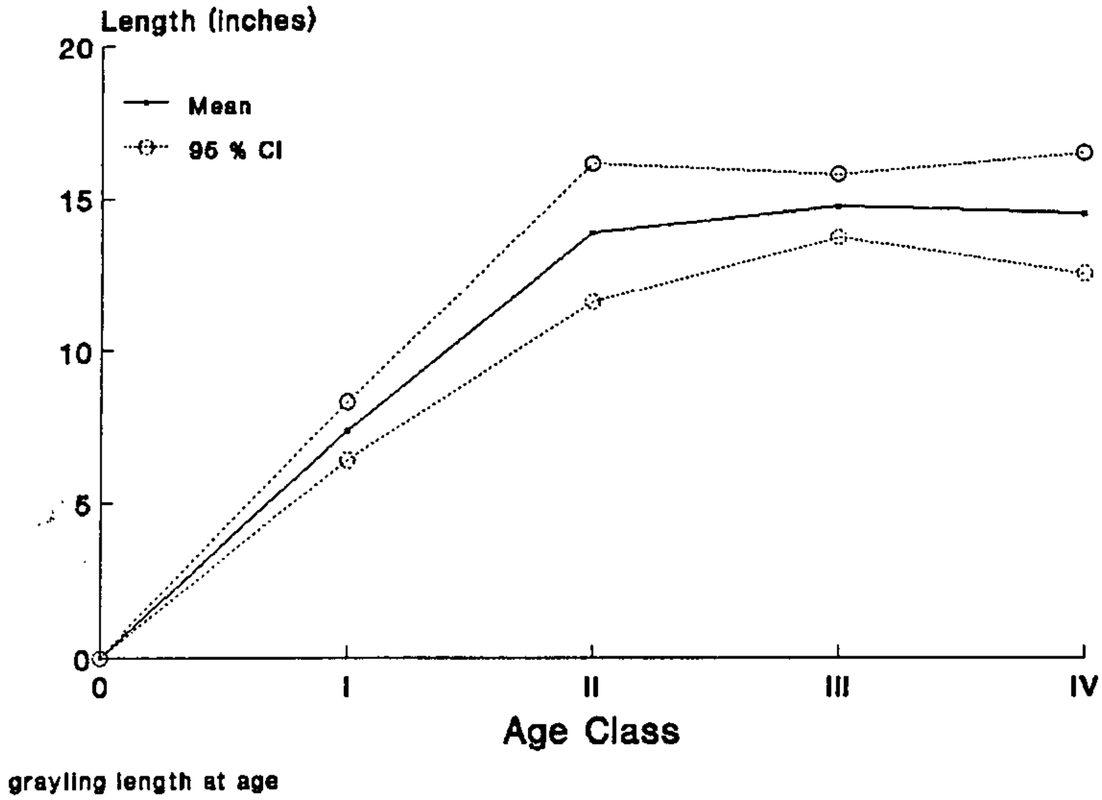

Figure 6. Length at age of Ennis Reservoir/Madison River grayling captured during 1990.

2.24) inches. At Age III mean length was 14.72 (95% CI: 1.02) inches. The maximum age observed was 4 years, and that age class averaged 14.5 (95% CI: 1.96) inches. The overlap from Age II through IV classes indicate great variability in growth rates (Figure 7). The length-frequency distribution is, however, biased toward spawning fish. Although Age II grayling were captured in spawning condition, it is likely that not all of them spawn, and sampling methods may have been biased against them.

Scales collected in spring (through May 31) were separated from later samples to avoid over-aging due to annulus formation. Annuli are formed in Ennis Reservoir/ Madison River grayling in

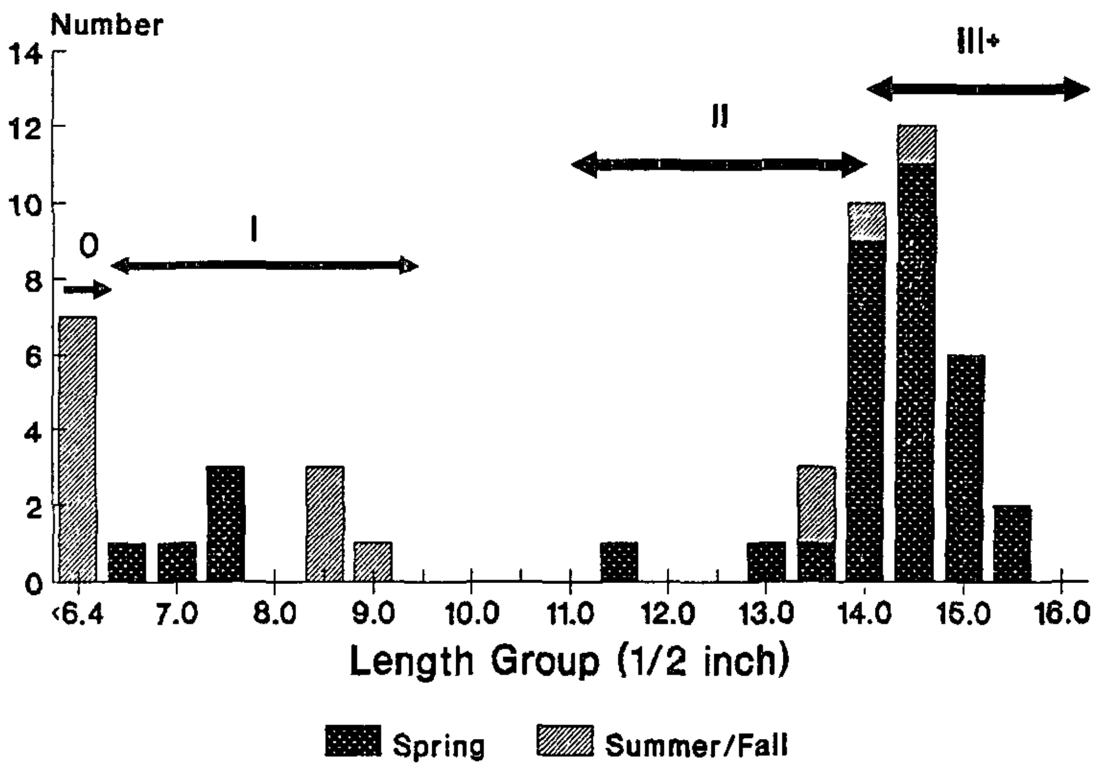

Figure 7. Length-frequency distribution of Ennis Reservoir/ Madison River grayling captured during 1990.

late April or early May (Brown 1943). Brown (1943) also reported that a large majority of grayling in the area exhibited scale marks he interpreted as false annuli induced by warm mid-summer temperatures.

<u>Genetic Analysis</u>

Electrophoretic analysis indicates that the Madison River/Ennis Reservoir grayling are a fairly unique population, more closely resembling Big Hole River grayling than any other population in Montana. A more detailed analysis is included in Appendix B.

Rainbow Trout

Spawning

Rainbow trout in spawning condition were captured throughout the Madison River electrofishing section throughout April. The actual peak of spawning, indicated by the ratio of ripe to spent females, appeared to have occurred in early April (Figure 8). Rainbow trout spawned earlier than grayling, and probably began immediately after ice-out. No rainbow trout spawning was documented in Jordain, St. Joe, Moores, and Meadow Creeks by rainbow trout for spawning was observed in spite of electrofishing and trapping efforts.

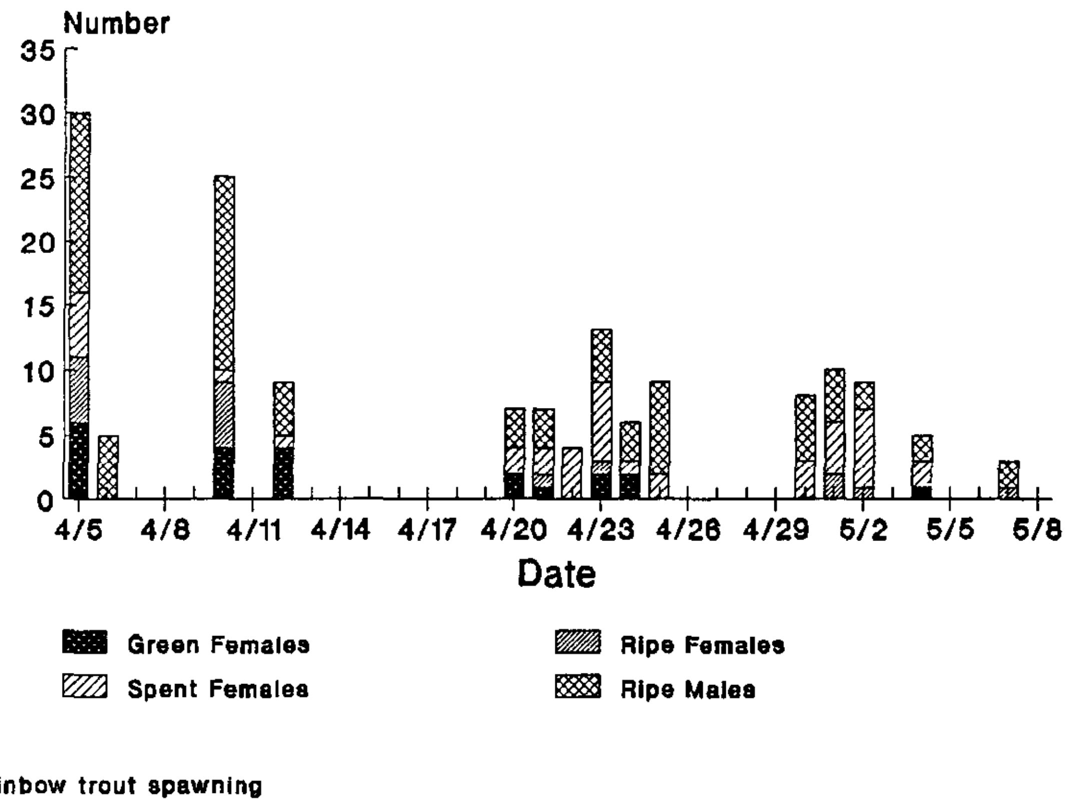

Figure 8. Timing of rainbow trout spawning in the Madison river, with respect to spawning condition and sex.

Abundance

Population estimates were calculated for the Madison River study section from 0.5 miles below Valley Garden FAS to Ennis Reservoir to quantify both resident and reservoir spawners, and recruitment. Spring estimates were 3,411 (95% CI: 737) rainbow trout longer than 2.5 inches. Over 79% were estimated to be Age III+, based on 178 scale samples (Table 2). Summer population estimate of the study section was 3,927 (95% CI: 1143) rainbow trout over 3.0 inches in length.

Table 2. Rainbow trout population estimates by age class, and average length and weight at age in the Madison River, 1990.

AGE CLASS	AVERAGE LENGTH (in.)	AVERAGE WEIGHT (lb.)	NUMBER ESTIMATE
I	4.1	0.04	199
II	8.3	0.23	454
III	12.8	0.75	972
IV	15.9	1.12	1067
V	16.9	1.31	484

Age and Growth

Aging rainbow trout captured in the study section was confounded by mixing of river and reservoir residents, and the release of several strains of rainbow trout planted into the reservoir. From reading scales it became evident that rainbow trout in this system may reside in either the reservoir or the river at any life stage. Growth rates during reservoir residence far exceeded growth in the river.

Differential growth rates and seasonal differences in population estimates provide two methods for estimating the contribution of Ennis Reservoir rainbow trout to spring river estimates. That is, it was feasible to estimate the magnitude of the reservoir spawning population.

Population Estimates

Based on scale growth, fish could be classified as being derived from primarily river or reservoir resident rainbow trout. The proportion of river to reservoir residents was applied to length groups to partition the population estimate according to contribution of river and reservoir fish (Table 3). An estimated 553 rainbow trout originating in the reservoir were included in the spring rainbow trout estimate.

Table 3. Estimated ratio of rainbow trout originating in Ennis Lake or the Madison River and estimated number, based on scale analysis, 1990.

Length Group (in.)	River to Reservoir Ratio	Estimates	
		Reservoir	River
2.5 - 7.4	all river	0	512
7.5 - 10.4	all river	0	464
10.5 - 13.9	all river	0	912
14.0 - 16.4	0.345 lake	396	751
16.5 - 18.4	0.333 lake	98	197
18.5 - 21.9	0.75 lake	59	20
Total		553	2858

The second method was to plot the spring and fall population estimates per 0.5 inch length group on common axes. Assuming that the population is stable, any difference between estimates should reflect immigration, emigration, mortality, recruitment, or growth. Figure 9 demonstrates differences in the spring and summer estimates, presumably due to the above factors. A difference is evident between the estimates for fish more than 13.0 inches long and for fish 5.0 to 9.0 inches long. The difference in areas between the curves should represent the surplus of fish created by immigration from the reservoir, or recruitment. Immigrants from Ennis Reservoir represented

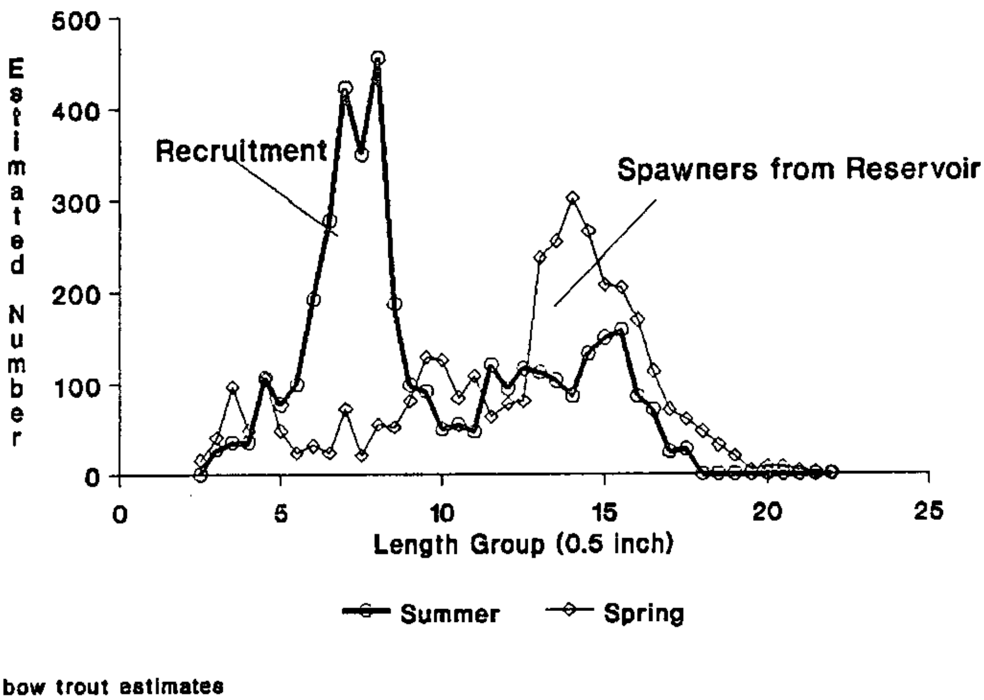

Figure 9. Estimated number of rainbow trout per 0.5 inch group in the Madison River, Spring and Summer, 1990, indicating recruitment and reservoir spawners.

approximately 1,032 rainbow trout over 13 inches in length. The difference in estimates for fish between 5.0 and 9.0 inches in the summer estimate should represent recruits growing into their second year. These 1,967 rainbow trout 5.0 to 9.0 inches could represent recruits shared by the river and reservoir populations. Comparing the two methods indicates approximately 550 to 1050 rainbow trout probably moved into or through the study section during spawning.

Brown Trout

According to population estimates, brown trout are more abundant in the Madison River study section than rainbow trout. Spring estimates were again somewhat higher at 6,789 (95% CI: 3,185) than the summer estimate of 4,989 (95% CI: 1,015) brown trout over 3.5 and 4.5 inches, respectively (Figure 10). The shift in brown trout populations between spring and summer is similar to the that of the rainbow trout. Approximately 800 fish under 10.0 inches long are unaccounted for by the summer estimate. Another 941 brown trout longer than 13.0 inches were also present in spring, but not fall estimates. The differences may be accounted for by a late winter, early spring migration into the river by reservoir browns seeking forage, perhaps feeding on rainbow trout eggs washed into the current.

Gill Netting

The operation of 4 gill net sets provide a complete year cycle which describe community composition, relative abundance of species, movement patterns, and population trends. A summary of catch rates of trout and grayling is provided in Appendix C. Catch rates of grayling, as previously mentioned, were quite low

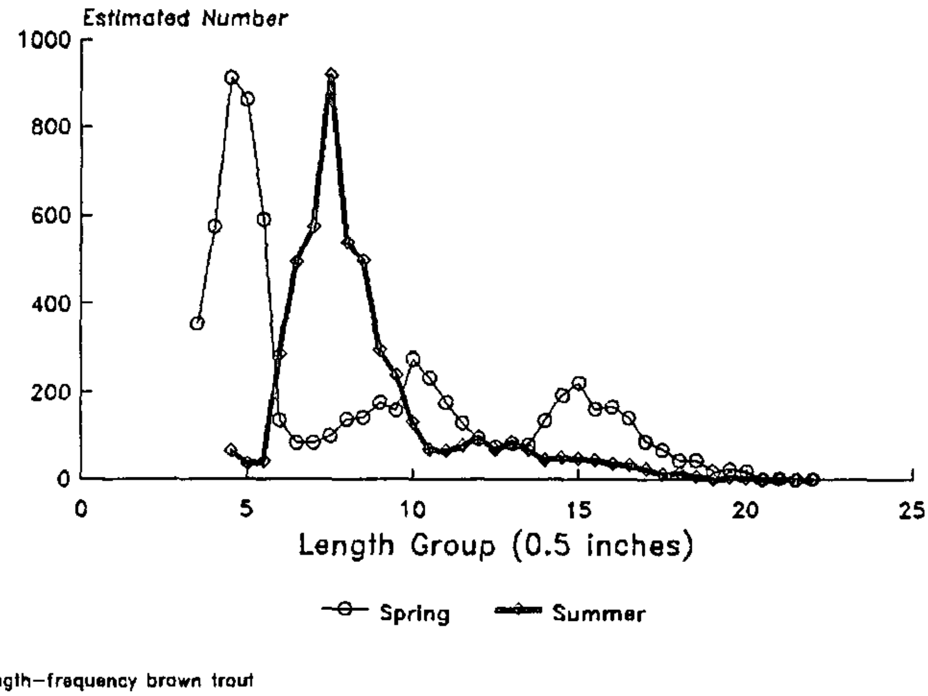

Figure 10. Estimated number of brown trout per 0.5 inch group in the Madison River, Spring and Summer, 1990.

ranging from 0 to 2.67 fish per net (Figure 11). Low catch rates support that the population of grayling in Ennis Reservoir is small. Grayling 1 to 3 years old were represented in the catch.

Rainbow trout catch rates declined at each site between September 1989 and 1990 (Figure 11). The length-frequency distribution of rainbow trout captured by netting is given in Figure 12.

Catch rates of brown trout also decreased slightly toward Fall, 1990 (Figure.11). Catch rates are provided in Appendix C. The length frequency distribution of brown trout catch is given in Figure 13.

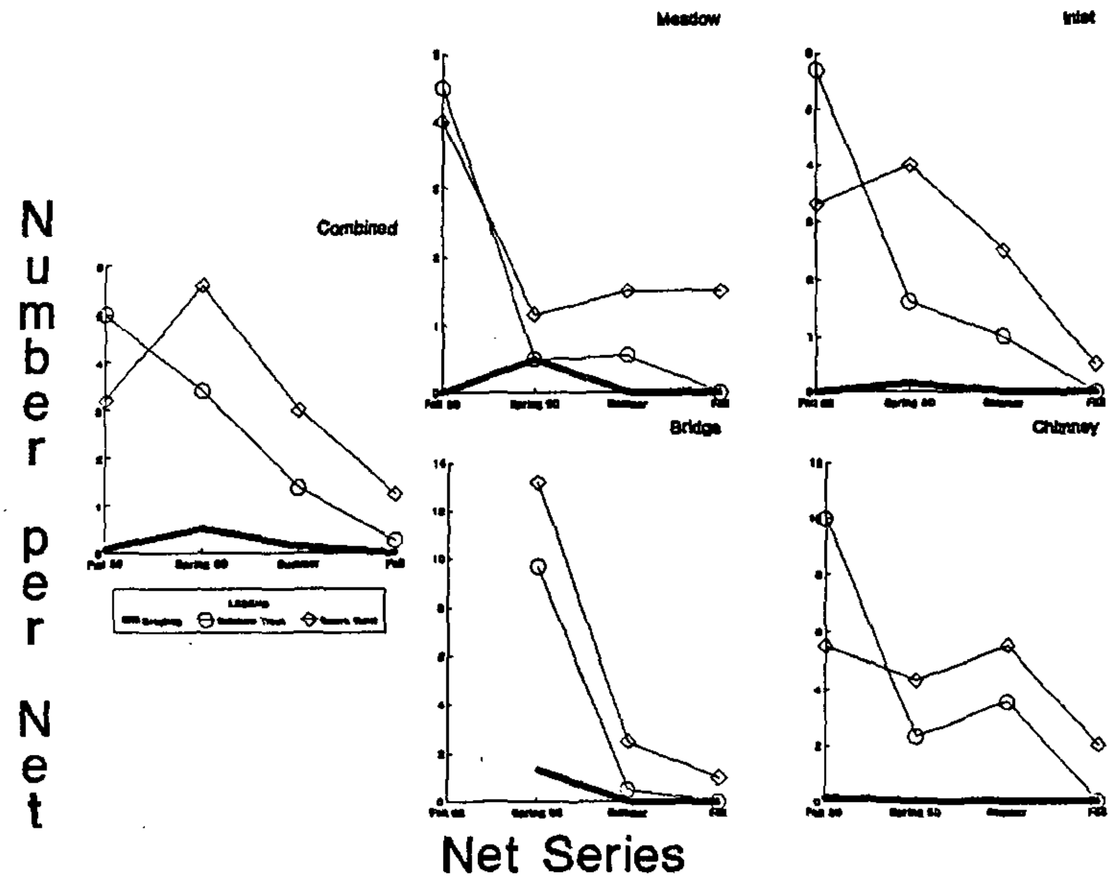

Figure 11. Catch rates of grayling, rainbow and brown trout, in gill nets: per site and combined, Fall, 1989 to Fall, 1990.

The greatest catch rates for grayling and trout during Spring, 1990 occurred at the bridge site. It appears that the deeper northern end may be used by the salmonids as a wintering area. Mountain whitefish were present in the catch only during the spring series, suggesting that they spend winter and spring in Ennis Reservoir, but move to the river in early summer to evade the increasing water temperatures in the reservoir.

Rough fish, particularly the introduced Utah chub, comprised up to 98% of the total catch. Utah chub averaged approximately

70% of the catch throughout the entire series. At present levels, Utah chub may compete with resident salmonids as well as with the native catostomids.

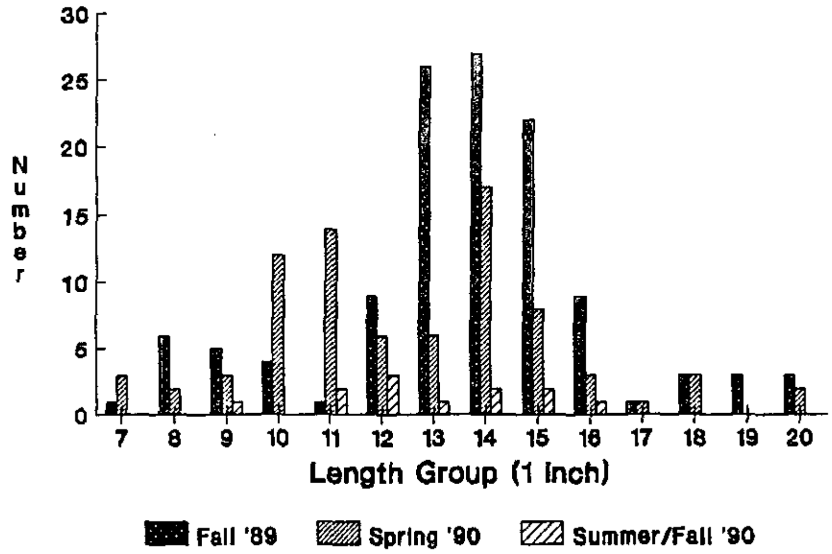

Figure 12. Length-frequency distribution of rainbow trout captured in gill nets in Ennis Reservoir, Fall, 1989 to Fall, 1990.

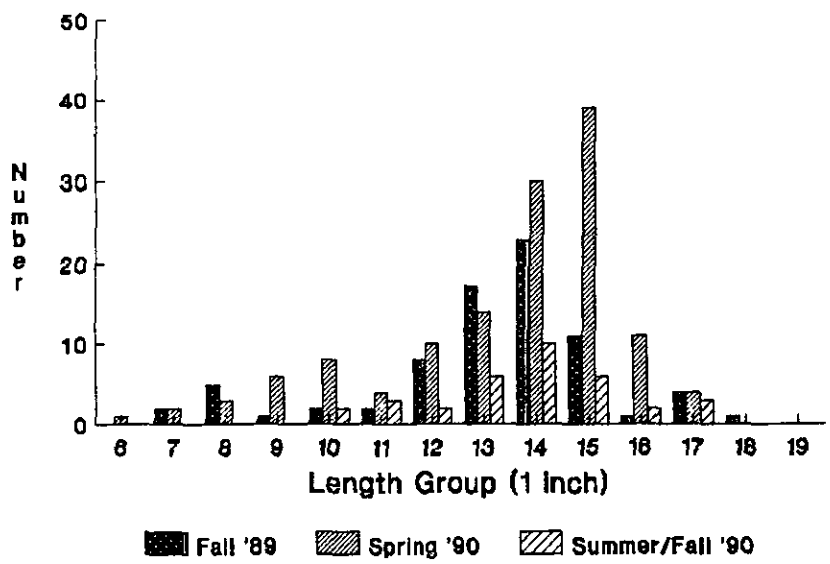

Figure 13. Length-frequency distribution of brown trout captured in gill nets in Ennis Reservoir, Fall, 1989 to Fall, 1990.

Creel Census

Pressure

An estimated total of 7820 (95% CI: 1247) angler hours were exerted at Ennis Reservoir between April 6 and September 2, 1990 (Table 4). Shore anglers contributed 41% and boat anglers 59% of the overall pressure.

Party size was similar between anglers in boats and on shore, averaging 1.2 anglers per party. For completed trips, an average of 2.34 (95% CI: 0.31) hrs were fished from shore, while trips from boats lasted an average of 2.7 (95% CI: 0.42) hrs. Approximately 2.0 anglers per count were observed for shore and boat anglers, respectively.

Fishing pressure (hrs/day) was greatest during early summer, and lowest in the spring (Table 4). However, the percent of total fishing pressure in each strata was not independent of the number of days within a stratum ($X^2=2.517, p=0.3$).

Boat anglers exerted less pressure during the spring stratum than shore anglers, but their effort increased through early and late summer strata. Boat anglers spent more time per trip than shore anglers during the spring strata, but trip length was nearly equal for both types during early and late summer strata.

Catch Rates

Catch rates and harvest for grayling and trout are summarized in Table 5. Grayling catch rates were extremely low (<0.04 fish/hr) as expected for such a small target population. Catch rates were greatest during the summer stratum. All of the

Table 4. Summary of creel census pressure and count data, with respect to strata and angler type (BT = boat, SH = shore, CM = combined) on Ennis Reservoir, 1990.

Strata	# Days	Boats per count	Mean Party Size		Mean Hours Fished		Anglers per count		Pressure (hrs)			Mean Pressure
			SH	BT	SH	BT	SH	BT	SH	BT	CM	hr/day
4/16-6/3	49	1.17	1.6	1.3	1.1	3.1	2.7	1.2	1562	688	2251	45.9
6/4-7/1	28	2.68	1.1	1.1	2.3	2.3	2.4	2.7	933	1049	1988	69.2
7/2-9/2	63	2.83	1.1	1.2	2.6	2.4	0.7	2.8	734	2851	3585	56.9
Combined	140	2.13	1.2	1.8	2.3	2.7	1.8	2.1	3230	4589	7820	55.9

Table 5. Catch rates and estimated harvest per stratum from creel census for grayling and trout in Ennis Reservoir, 1990.

Species	Mean Catch Rate (fish/hr)						Total Harvest (95% CI)*
	Landed			Creeled			
	SH	BT	CM	SH	BT	CM	
SPRING							
grayling	0	0.02	0.014	0	0	0	0
rainbow trout	0.68	0.35	0.45	0.56	0.18	0.29	999(651)
brown trout	0.44	0.26	0.26	0.44	0.15	0.24	796(654)
EARLY SUMMER							
grayling	0.04	0	0.02	0.04	0	0.02	42(56)
rainbow trout	0.47	0.13	0.25	0.45	0.11	0.23	534(349)
brown trout	0.13	0.12	0.12	0.13	0.11	0.12	241(61)
LATE SUMMER							
grayling	0.005	0.016	0.008	0	0	0	0
rainbow trout	0.20	0.30	0.22	0.005	0.18	0.05	520(587)
brown trout	0.09	0.13	0.10	0.002	0.02	0.02	58(87)
ALL STRATA COMBINED							
grayling	0.011	0.013	0.012	0.008	0	0.004	42(56)
rainbow trout	0.33	0.27	0.30	0.18	0.16	0.17	2052(944)
brown trout	0.16	0.15	0.15	0.11	0.11	0.11	1095(679)

* 95% Confidence Intervals (in brackets)

estimated harvest of 42 (95% CI: 56) grayling occurred during this stratum. As the variance suggests, the harvest was between 0 and 98 grayling. Only 4 grayling were reported creeled, 2 upon request by field personnel. Both grayling that were measured were 14.1 inches long and weighed 0.80 and 0.81 lb.

Rainbow trout provided the greatest catch rates and overall harvest. Catch rates ranged from 0.005 to 0.68 fish/hr, with highest catch rates occurring during the spring stratum. Catch rates decreased in the summer. A large proportion of rainbow trout were creeled, especially during spring and early summer. In general boat anglers landed rainbow trout at a greater rate than shore anglers, except during late summer. The 69 rainbow trout measured by creel clerks, had an average length of 16.4 inches (range: 9.3 to 30.0).

Brown trout were caught at a slower rate than rainbow trout, ranging from 0.11 to 0.47 fish/hr. Catch rates decreased substantially from spring through early and late summer. Shore anglers caught approximately 3 times more brown trout than boat anglers during spring, but landed them at similar rates during the summer. Most brown trout landed were creeled. Fifty brown trout were measured and had a mean length of 15.3 inches (range: 10.2 to 21.0).

Anglers

The majority (75%) of anglers interviewed at Ennis Reservoir came from within Montana. Resident anglers travelled an average of 75 miles although 25% came from within Madison County. Nonresident anglers comprised 23% of interviewees, and originated from as far away as North Carolina and Florida. The origin of 2% of anglers is unknown. Terminal gear used in order of preference were: live bait (39%), lures (38%), two or more gear types on the same day but not simultaneously, flies (7%), and those using some combination simultaneously (5%). Anglers fishing from shore comprised 48% of interviewees, while boat anglers (52%) were separated into those trolling (21%), drifting (24%), and anchored (7%).

Seasonal use preferences indicated that spring (31%) and summer (42%) were favored seasons for fishing, but 20% reported fishing on Ennis Reservoir in the fall, and 7% during winter. Responses to questions concerning species preferences were varied (Table 6). Brown trout was the most common first and second choice for species sought, while grayling were the clear third choice. Species that anglers would like to see were species already available. Rainbow trout were most common primary choice, brown trout second, and grayling were again the third choice.

Other responses in this category included: northern pike (Esox lucius), cutthroat trout (O. clarki), brook trout, walleye (Stizostedion vitreum), bass (Micropterus spp.), yellow perch (Perca flavescens), sunfish (Lepomis spp.), kokanee (O. nerka), and catfish (Ictalurus spp.)

When asked whether the angler preferred to catch few large fish or several smaller fish , 49% replied with some variation of "no preference", while 30% preferred "numbers", and 20% replied "size".

Table 6. Angler preference for species in Ennis Reservoir creel census, 1990; responses reported as percent occurrence as first (1) to third choice (3), for species actually sought and species they wish to see.

Rank of Preference			
Species	1	2	3
"Species Sought"			
Grayling	0	4	91
Rainbow Trout	26	36	9
Brown Trout	17	55	0
Any "Trout"	63	5	0
Responses (N)	140	53	11
"Wish to See"			
Grayling	15	5	70
Rainbow Trout	58	33	10
Brown Trout	27	63	20

Limnology and Food Habits

Water Quality

Ennis Reservoir remained homothermic at all three sites throughout the summer (Figures 14, 15, and 16). However a difference of up to 1.5 °C between surface and substrate was observed in summer. The maximum temperature recorded was 21.5 °C in July, 1990 at the Bridge site, although temperatures probably exceeded this. Temperatures increased progressively from the inlets to the bridge, heating as the reservoir gathers heat from the sun (Figure 17).

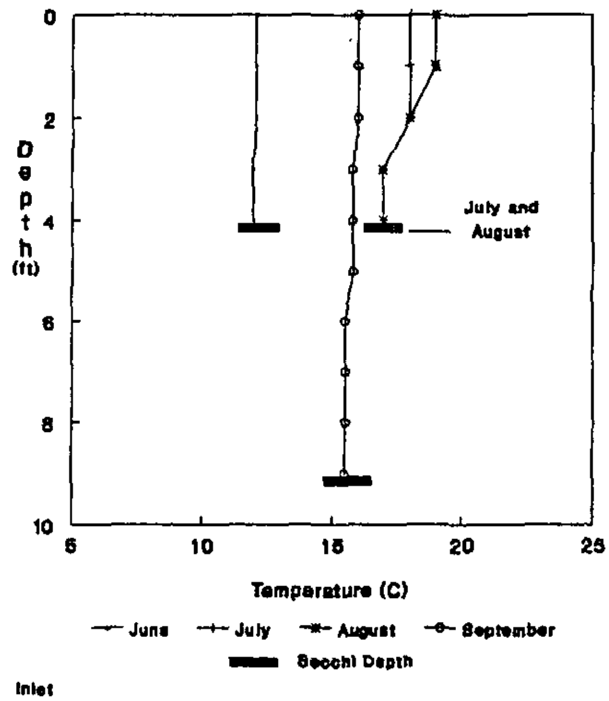

Figure 14. Water temperature (oC) profile and Secchi depth (ft) at Inlet site on Ennis Reservoir, 1990.

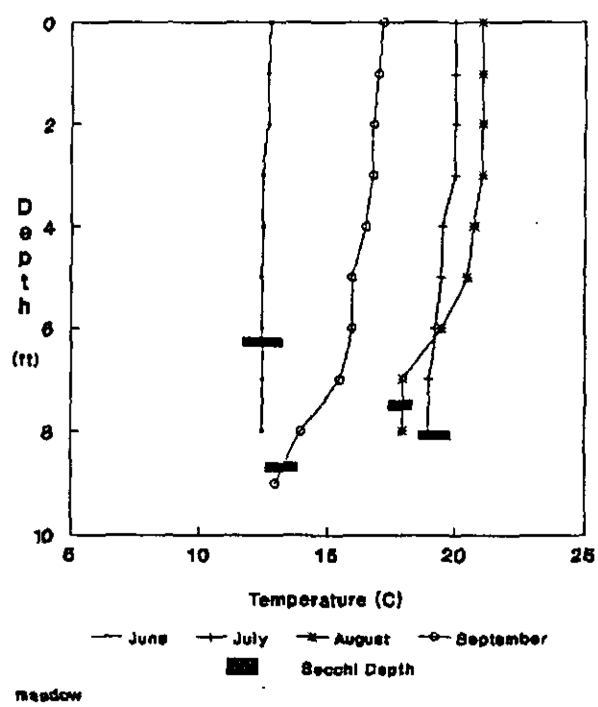

Figure 15. Water temperature (oC) profile and Secchi depth (ft) at Meadow Bay site on Ennis Reservoir, 1990.

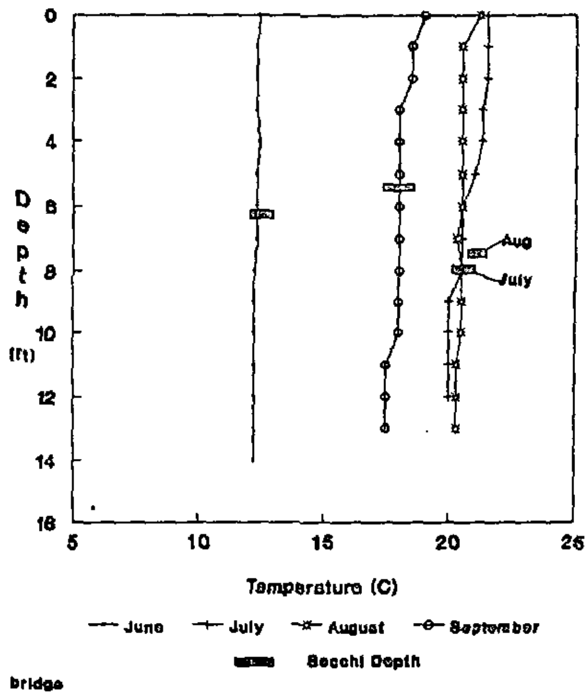

Figure 16. Water temperature (°C) and Secchi depth (ft) at Bridge site on Ennis Reservoir, 1990.

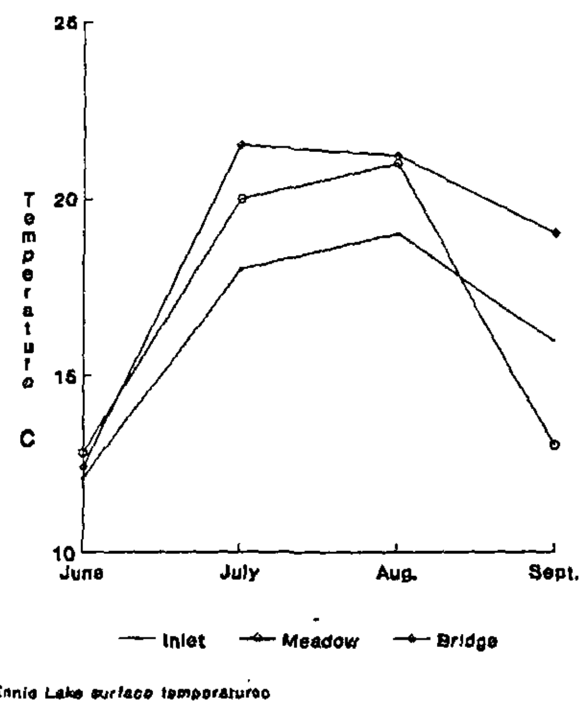

Figure 17. Surface water temperatures (°C) at limnological sites on Ennis reservoir, 1990.

Secchi depths were consistently greater than water depth at the inlets area (Figure 14). Meadow and Bridge sites were fairly turbid in June, due to run-off. Secchi depth exceeded total depth in July and August at Meadow (Figure 15). Bridge secchi depths were 8.1 and 7.5 ft in July and August, respectively, but decreased to 5.3 ft in September when a filamentous algae bloom occurred (Figure 16).

Zooplankton

Five groups of zooplankters were identified, 4 to genus; Daphnia, Cyclops, Leptodora, and Bosmina. One unidentified calanoid copepod (Cal) was also observed. Monthly densities are provided in Table 7.

In general 2 pulses in zooplankton density occurred: in July and again in September (Figures 18, 19, and 20). Daphnia and Cyclops were the predominant plankters. However, Bosmina bloomed in September at the Inlet site, and was second in density at the Bridge site in July. The Inlet site, with its abundant macrophytes and stronger current, appears to be less suitable for plankton production.

Food Habits

Aquatic macroinvertebrates were the preferred food of both grayling and rainbow trout. Of 13 grayling and 10 rainbow trout stomachs collected during spring netting and examined under a microscope, immature aquatic macroinvertebrates (IMMAM) occurred as the most abundant food item (Table 8). Unidentified debris was, with one exception, the second most predominant item.

Table 7. Plankton densities at Ennis Reservoir limnological sites, 1990.

Date	Plankton Density (#/l)				
	Genus				
	Daphnia	Cyclops	Calanoid	Bosmina	Leptodora
INLETS					
6/6	60	10	0	0	0
7/13	2000	3200	0	0	0
8/9	50	0	240	270	0
9/11	60	150	280	8000	0
MEADOW					
6/6	21000	12300	0	0	0
7/13	33000	6800	73	1	0
8/9	8000	1290	18	0	9
9/11	15000	11000	36	28	2
BRIDGE					
6/6	200	470	0	0	0
7/13	5000	1770	0	50	8
8/9	2000	1670	7	460	4
9/11	3000	1075	200	400	1.7

Nearly half of the grayling stomachs and over half of rainbow trout stomachs contained adult aquatic macroinvertebrates (ADAM) as the third most prevalent group. Second to ADAM, zooplankton also occurred in grayling stomachs. Rainbow trout made some use of adult terrestrial macroinvertebrates (ADTER). In rank of lowest abundance ADAM, ADTER, and zooplankton were represented in grayling and rainbow trout stomachs.

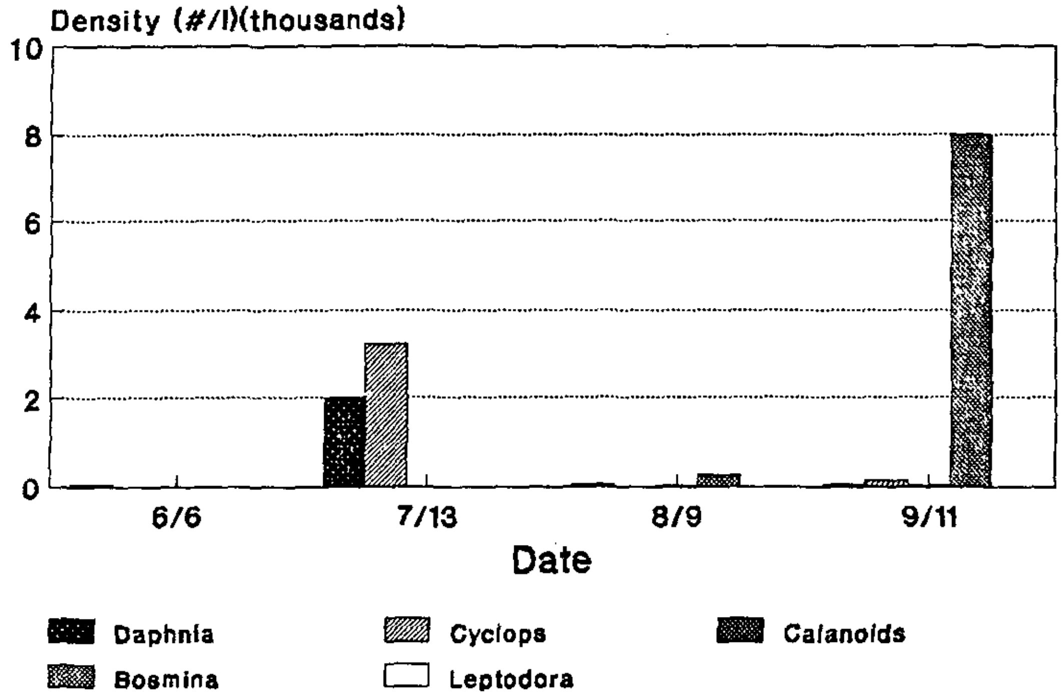

Figure 18. Zooplankton density (#/l)(thousands) at Inlet site on Ennis reservoir, 1990.

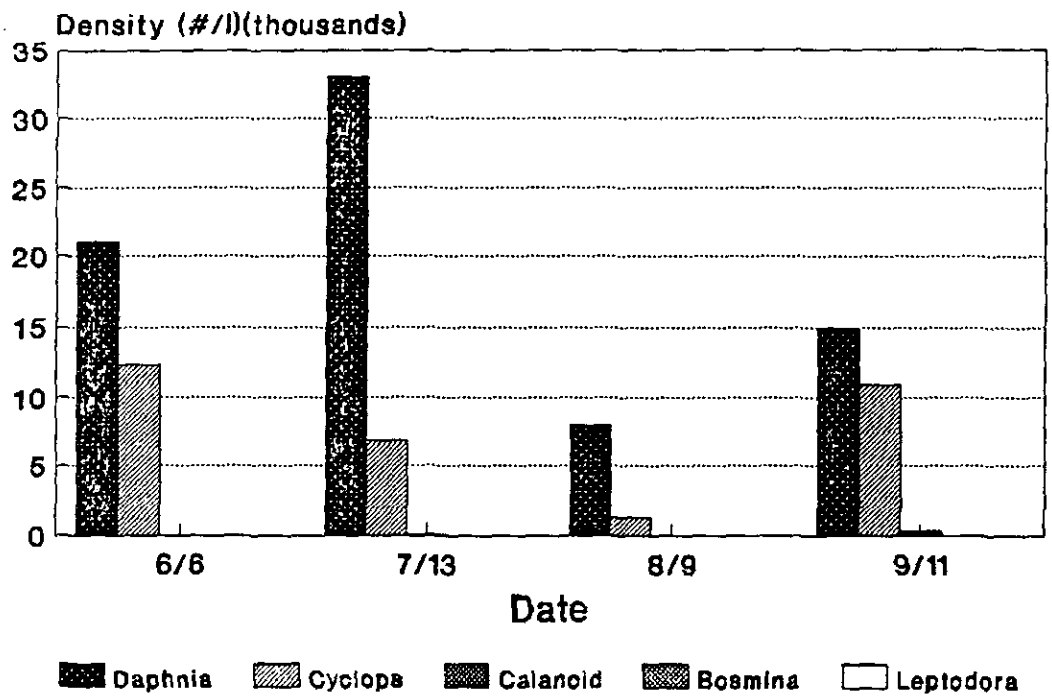

Figure 19. Zooplankton density (#/l)(thousands) at Meadow Bay on Ennis Reservoir, 1990.

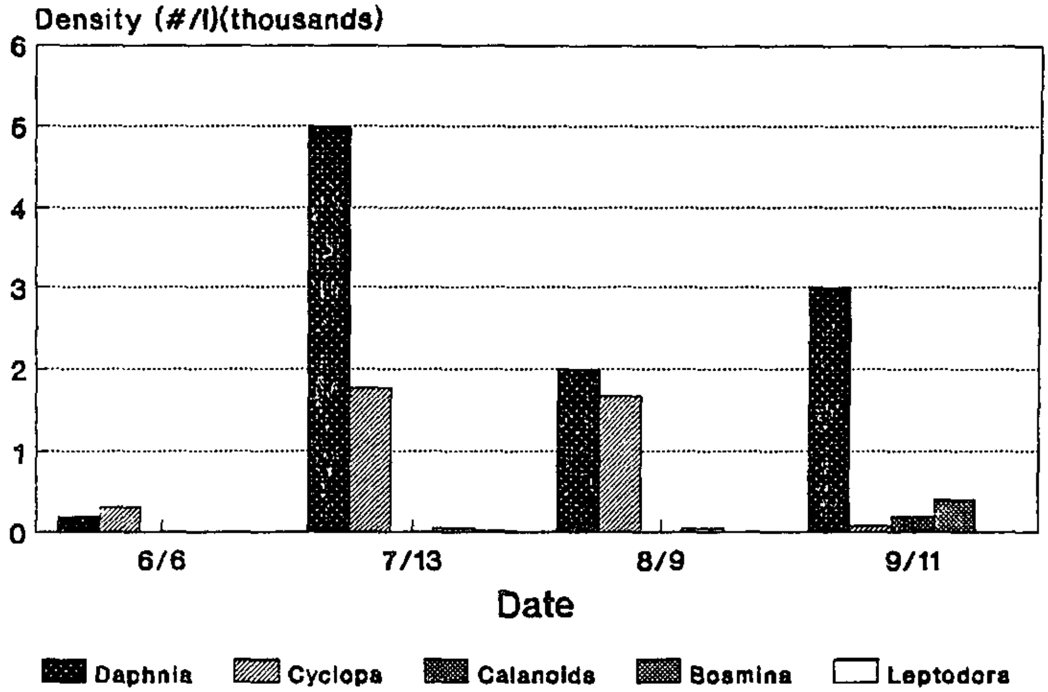

Figure 20. Zooplankton density (#/l)(thousands) at Bridge site on Ennis Reservoir, 1990.

Table 8. Occurrence of forage types in 13 grayling (GR) and 10 rainbow trout (RB) stomachs ranked 1 (most common class) to 4 (least common class) collected at Ennis Reservoir, Spring, 1990.

Forage Class*	Relative Rank of Occurrence							
	1		2		3		4	
	GR	RB	GR	RB	GR	RB	GR	RB
ADAM	-	-	1	-	6	6	2	1
IMAM	12	10	-	-	2	-	-	-
ADTER	-	-	-	-	-	2	1	2
Zooplankton	-	-	1	-	4	1	1	2
Debris	1	-	11	10	1	-	-	-

* ADAM = adult aquatic macroinvertebrates
IMAM = immature aquatic macroinvertebrates
ADTER= adult terrestrial macroinvertebrates

Based on ocular analysis of rainbow trout stomachs collected during Fall, 1989 and Spring, 1990, insects combined occurred in the largest number of stomachs. Zooplankton were observed in second greatest frequency, and occupied a slightly greater number of stomachs from Spring, 1990 nets. Fish were observed in only a few stomachs. Inherent biases existed in stomach analyses, based on differential visibility and digestibility of food items, as well as subjectivity of the observer.

Macrophytes

Macrophyte densities were mapped from aerial photographs taken in September, 1983, September, 1984, October, 1988, and August and September of 1990. Maps are included as Appendix D. It is readily apparent from vegetation maps that the 1983 drawdown had a severe impact on macrophyte density. In September, 1983 and 1984 photographs, macrophyte beds classified as dense were almost non-existent. Macrophyte density appeared to steadily increase through 1990.

DISCUSSION

Grayling

Historic Abundance

The Madison River/Ennis Reservoir grayling population has fluctuated from abundant to rare throughout this century. Although precise causal relationships are unclear, a combination of habitat alteration and competition with exotic fishes is likely to have affected the population.

Vincent (1962) collected reports on the relative abundance of grayling in the Madison River, and later in Ennis Reservoir (Table 9). Dam construction at the head of Beartrap Canyon at the turn of the century may have shifted the "plentiful" grayling of 1880 - 1897 to "few". Vincent (1962) noted that the newly constructed Ennis Dam provided a barrier to grayling and that "early settlers reported scooping up boxes full of grayling at the base of Ennis Dam the year after it was constructed". The population rebounded quickly and remained strong until 1915 when another decline began. By 1915, rainbow and brown trout had drifted downstream from plants in Yellowstone National Park and invaded Ennis Reservoir. Interspecific competition, particularly with non-native fishes has been identified as a factor leading to declining grayling populations in Montana and Michigan (Brown 1943, Liknes 1981, Kaya 1990). Furthermore, Vincent (1962) suggested a direct relationship existed between the increase in rainbow and brown trout to the decline of grayling in the central

Table 9. Records of grayling abundance in the central Madison River, Montana, from Vincent (1962).

Date	Observation
1875	Poor Fishing
1880	Plentiful
1897	Many
1898	Few
1899	None
1903	Lots
1905	Best grayling fishing in U.S.
1905	Buckets full
1908	Boxes full (below dam)
1908	Pitch forked out of O'Dell Creek
1912	Very Abundant
1913	Par excellence grayling stream
1913	Catch many
1913	Good fishing for grayling in O'Dell Creek
1913	Ennis Lake, fine grayling fishing
1915	Pitch forked out of O'Dell Creek
1915	Big decline
1920	Trout most abundant
1921	Caught many grayling
1929	Can catch out of any hole
1933	Completely gone
1934	Some in Meadow Creek
1936	Eggs taken at O'Dell fish trap
1943	Rare, Ennis Lake
1951	Rare
1954	Rare

Madison River. Although rainbow and brown trout remained the dominant species in the area, grayling were again plentiful by 1921 and maintained a strong population until 1929. By 1933, grayling were sparsely distributed, but eggs were taken from O'Dell and Meadow Creeks as late as 1936 (Brown 1938). Nelson (1954) reported grayling to be "rare in the Madison River drainage" in the early 1950's. In 1959, Brown (MDFWP files) reported that grayling were "just as abundant as they were 20 years ago", and that they were the most abundant game fish in Ennis Reservoir.

Records of grayling abundance in the study area are rare after 1960. Fisherman's log records from 1965 through 1984 indicate that grayling catch rates were low in the Madison River from the mid-1960's through the mid-1970's (Figure 21). In the late 1970's, catch rates increased especially in Ennis Reservoir. Grayling were quite abundant from circa 1977 to 1983, after which they all but disappeared. Grayling were apparently rarely caught until 1990, when interviews conducted for this study revealed an increase in the number of grayling captured. Several anglers commented on catching their "first grayling in years".

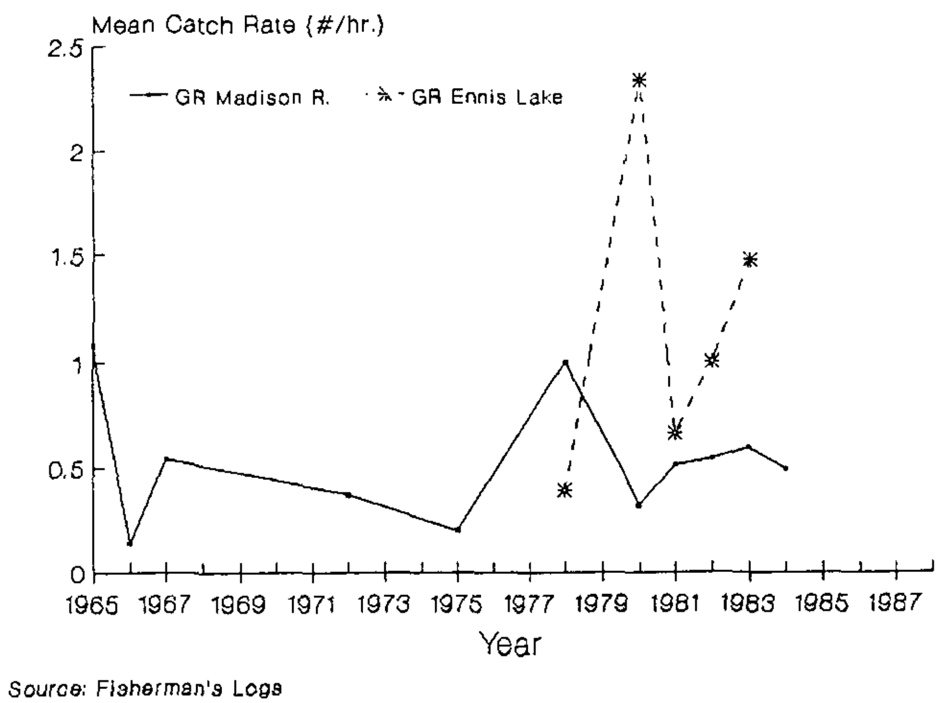

Figure 21. Catch rates of grayling in Ennis Reservoir and the Madison River, derived from Fisherman's Logs, 1965 through 1964.

Effects of Drawdowns

Ennis Reservoir is drawn down annually for various reasons; however, several drawdowns were more severe and may have affected grayling populations (Figure 22). A maximum drawdown of 11.65 ft occurred in August, 1964, followed by a September, 1965 drawdown of 7.3 ft. Those drawdowns reduced reservoir surface area by approximately 50% and 30% in 1964 and 1965, respectively. The reservoir was drawn down 3.6 ft in September 1971, 4.9 ft in the winter of 1972-1973, 4.35 ft in May, 1974, and 6.5 ft in October, 1974. The range of surface area reduction caused by the drawdowns was approximately 15 to 27%.

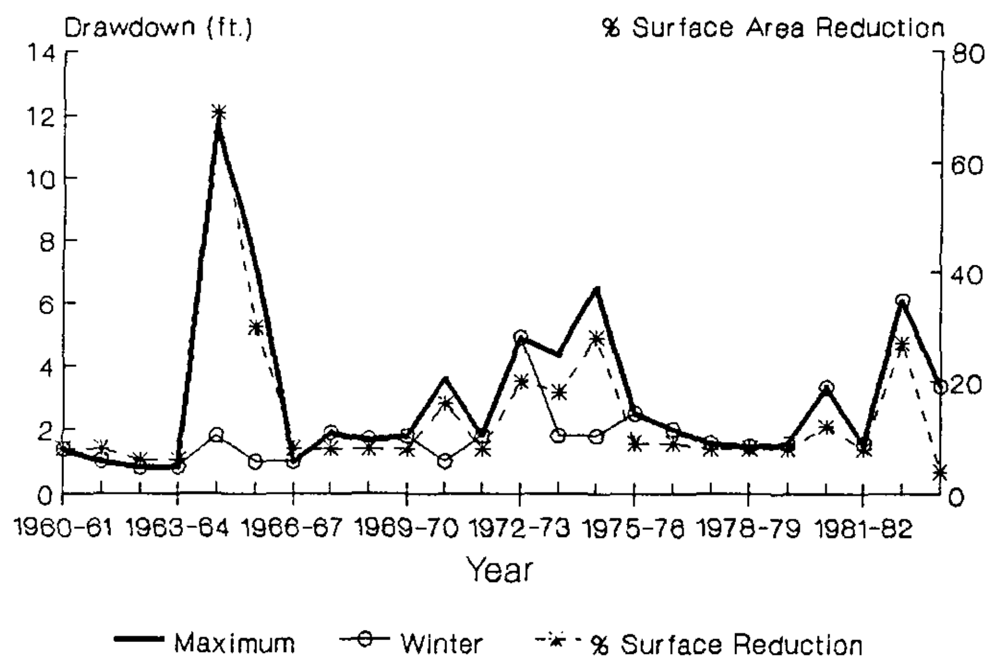

Figure 22. History of drawdowns of Ennis Reservoir and percent surface area reduction, 1960 through 1964.

Another major drawdown occurred in the winter of 1982-1983. Macrophytes, Elodea canadense in particular, created problems with hydroelectric operations at Ennis Dam. Reservoir elevation was dropped 6.1 ft in late March to Early April for 3 to 4 weeks while temperatures were near freezing (OEA Research, Inc. 1987). Soon thereafter, grayling became extremely scarce in Ennis Reservoir and the Madison River.

The relationship between the series of drawdowns and the cyclical grayling population is unclear. Detrimental effects of drawdowns could include depletion of forage, loss of rearing cover in macrophyte beds, and/or interruption of spawning cycles.

Grayling food habits analysis in this study indicated that immature and adult macroinvertebrates were important food items. Dipteran larvae comprised the majority of spring stomach contents. Because drawdowns expose benthos, a reduction in density and diversity of benthic organisms is often observed (Baxter 1977). Chisholm et al. (1989) found that benthic invertebrate density was much lower in dewatered areas than in deeper zones of Libby Reservoir. Extensive drawdowns in a shallow basin reservoir such as Ennis Reservoir could feasibly deplete benthic forage.

Production of macroinvertebrates in macrophyte beds, although not measured in this study, is assumably substantial. Given the observed propensity of grayling to associate with macrophyte beds, the depletion of rooted aquatic vegetation after drawdowns may have resulted in loss of an important forage resource.

Many streams and lakes harboring grayling have abundant aquatic vegetation (Vincent 1962). Upper Red Rocks, Georgetown, Rogers, and Grebe Lakes have also supported substantial grayling populations in the midst of dense macrophyte growth (Brown 1943).

Macrophyte beds may provide important security cover for rearing grayling. In the Big Hole River, aquatic vegetation was the cover type with which the majority of young grayling were associated (McMichael 1990). Nelson (1954) captured YOY grayling in aquatic vegetation on the banks of Upper Red Rocks Lake. The YOY grayling hatched in the Madison River above Ennis Reservoir may have moved into the reservoir prior to late July. It is at this time that macrophyte beds became relatively dense.

The severe drawdown of 1983 may have also affected the grayling spawning cycle. Grayling spawned in the Madison River throughout April, 1990. The 1983 drawdown occurred in March and April, probably just prior to, or early in the spawning season. While spawning is physiologically stressful, the additional stress induced by low reservoir levels may have hindered spawning. A poor 1983 year class would have affected recruitment at least through 1986, by providing few 2 year-old spawners in 1985, and even fewer 3 year-olds in 1986. The deep drawdown of 1983 probably reduced fish food production, rearing habitat, and may have lead to poor recruitment, especially for spring spawners. This drawdown likely resulted in the reduced numbers of grayling in the Ennis Reservoir/Madison River system from 1983 to 1990.

Current Abundance

The Madison River/Ennis Reservoir grayling population, with an estimated spawning population of approximately 550 over 10.0 inches long (95% CI: 525), is extremely low. At present levels, the future of the population is tenuous, at best. However, the trend may be toward recovery. Grayling re-entered the angler's catch and creel in 1990, apparently after 6 or 7 years of absence.

Although the majority of grayling caught by anglers were released, the potential for overharvest exists. Grayling are vulnerable to anglers, and considered easy to catch (Peterson 1981). The estimated total catch of grayling during the April through August creel survey was 94, approximately 17% of the estimated population. In response to potential over harvest, MDFWP proposed a catch-and-release-only regulation on the Madison River and Ennis Reservoir, effective March 1, 1991.

Genetic Analysis

Electrophoretic analysis of Madison River/Ennis Reservoir grayling indicates they are closely aligned with grayling native to the Big Hole River. Leary (1990)(Appendix B) outlines three theories to explain this relationship.

The results of the electrophoretic analysis suggests that the extant population of grayling in Ennis Reservoir is either directly descended from the original Madison River fluvial stock, which has adapted to the lacustrine environment created by the reservoir, or it has undergone genetic convergence toward the Big Hole River stock.

In light of the preliminary results of the genetic analysis, the Madison River/Ennis Reservoir grayling appears to be a rare stock closely related to the declining Big Hole River stock, regardless of any possible influence of planted fish. In the future, MDFWP will regard this population as unique, and as a naturally reproducing population of rare grayling it will be managed as such, with emphasis placed on protection of the population, enhancement by wild reproduction, and habitat enhancement.

Planting History

Grayling in Ennis Reservoir and the Madison River indirectly provided the egg source for a majority of early grayling plants throughout the state of Montana. Eggs were taken from traps in Meadow and O'Dell Creeks as late as 1936 (Brown 1938). One particularly successful, albeit temporary, plant occurred in Georgetown Reservoir, where the population expanded quickly and soon became the major grayling egg source. From Georgetown Lake, grayling fry were planted into lakes across Montana (Kaya 1990).

Approximately 200,000 grayling fry were stocked in Ennis Reservoir and O'Dell Creek between 1948 and 1962. Either these stocks failed in a manner similar plants in the Big Hole River, presumed to have failed, or survived and evolved into the existing stock.

Rainbow Trout

Rainbow trout have been, and remain, the mainstay of the fishery at Ennis Reservoir. The 1990 creel census indicated that rainbow trout provided the highest catch rates and harvest.

Characterization of the rainbow trout population in the central Madison system is difficult. The population in Ennis Reservoir is tied directly to the population immediately upstream in the Madison River. Reservoir rainbow trout may spawn and rear, or even reside in the river at any life stage. Because reservoir and river rainbow trout are closely associated, reservoir operations will be likely to affect both populations. Study of the rainbow trout is further muddled by releases of nearly 1.5 million hatchery fish, including seven different strains, into Ennis Reservoir from 1928 to 1989.

The current magnitude of the rainbow trout population in Ennis Reservoir is unknown. The spawning run was estimated to be between 550 and 1050 fish. The tagging program initiated in this study should provide a basis for more refined estimates in the future.

Gill netting catches per net declined between Fall, 1989 and 1990. Continued monitoring of long term trends is necessary to determine whether or not the decline is a short term or seasonal fluctuation.

RESEARCH NEEDS AND MANAGEMENT IMPLICATIONS

1. Results of genetic analysis emphasizes the uniqueness of this grayling population. As a remnant of the native Madison River grayling, closely allied to the dwindling Big Hole River stock, it represents another population in need of special attention. Both populations should be given high priority for protection, enhancement, and further research to determine specific life history requirements and limiting factors.

2. The size of the Ennis Reservoir grayling population has not yet been adequately measured. A continued effort should be made to estimate and monitor population trends.

3. Baseline information gathered in this study suggest that most grayling spawn in the Madison River, return to the reservoir shortly thereafter, and shift toward areas of macrophyte growth as it emerges. Because the evidence is indirect, a more intensive study of movements and seasonal distribution will be required. The connection between the grayling and vegetation should be better documented.

4. Spawning and rearing habitat was given only cursory attention in this study. Future research should include an assessment of specific requirements for these life stages. Little is known of rearing areas and migratory tendencies of YOY grayling. Understanding and protecting these habitats necessitates a more in-depth analysis.

5. The potential for competitive exclusion of grayling by introduced salmonids and Utah chub may exist. Dietary overlap and spatial limitations may depress grayling numbers. Research in this area should be considered.

6. Although this study concentrated on grayling, some information was gathered on rainbow trout. Reservoir operations will affect both reservoir and river populations, and potential effects should be considered, as rainbow trout provide the basis for the fishery.

7. Further assessment of rainbow and brown trout abundance, movements, and relationships to the macrophytes should be investigated.

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APPENDIX A

CREEL CENSUS

Table A1. Creel census strata, sampling dates, and count times (military time) for Ennis Reservoir, Montana, 1990.

Date	Start Time	Count Times				
Spring (April 16 to June 3)						
Monday, April 16	800	800	1200	1400	1600	1800
Wednesday, April 18	800	800	1200	1400	1600	1800
Saturday, April 28	1200	1200	1400	1600	1800	2000
Monday, April 30	1000	1000	1200	1400	1600	1800
Tuesday, May 8	1200	1200	1400	1600	1800	2000
Thursday, May 10	1000	1000	1200	1400	1600	1800
Sunday, May 13	1200	1200	1400	1600	1800	2000
Saturday, May 19	1000	1000	1200	1400	1600	1800
Sunday, May 20	1000	1000	1200	1400	1600	1800
Tuesday, May 22	800	800	1000	1200	1400	1600
Saturday, May 26	1000	1000	1200	1400	1600	1800
Monday, May 28	1000	1000	1200	1400	1600	1800
Wednesday, May 30	1000	1000	1200	1400	1600	1800
Friday, June 1	800	800	1000	1200	1400	1600
Sunday, June 3	600	600	800	1000	1200	1400
Early Summer (June 4 to July 1)						
Monday, June 4	1400	1400	1600	1800	2000	2200
Saturday, June 9	800	800	1000	1200	1400	1600
Sunday, June 10	600	600	800	1000	1200	1400
Tuesday, June 14	1400	1400	1600	1800	2000	2200
Sunday, June 17	600	600	800	1000	1200	1400
Monday, June 18	1200	1200	1400	1600	1800	2000
Friday, June 29	600	600	800	1000	1200	1400

Date	Start Time	Count Times				
Table A1. (continued)						
Late Summer (July 2 to September 2)						
Thursday, July 5	1400	1400	1600	1800	2000	2200
Friday, July 13	600	600	800	1000	1200	1400
Wednesday, July 18	1000	1000	1200	1400	1600	1800
Sunday, July 22	1000	1000	1200	1400	1600	1800
Sunday, July 29	1200	1200	1400	1600	1800	2000
Thursday, August 2	1400	1400	1600	1800	2000	2200
Saturday, August 4	1000	1000	1200	1400	1600	1800
Sunday, August 5	800	800	1000	1200	1400	1600
Monday, August 6	1400	1400	1600	1800	2000	2200
Wednesday, August 8	1400	1400	1600	1800	2000	2200
Monday, August 13	1000	1000	1200	1400	1600	1800
Saturday, August 18	1400	1400	1600	1800	2000	2200
Friday, August 24	1200	1200	1400	1600	1800	2000
Saturday, August 25	1000	1000	1200	1400	1600	1800

ENNIS LAKE (1990)
Angler Counts

Date	Time	Anglers			Other users				
		Shore	In boats	Boats	Brds	Swms	MBt	Row	Oth

Date	Time	Anglers			Other users				
		Shore	In boats	Boats	Brds	Swms	MBt	Row	Oth

Date	Time	Anglers			Other users				
		Shore	In boats	Boats	Brds	Swms	MBt	Row	Oth

Date	Time	Anglers			Other users				
		Shore	In boats	Boats	Brds	Swms	MBt	Row	Oth

Date	Time	Anglers			Other users				
		Shore	In boats	Boats	Brds	Swms	MBt	Row	Oth

ENNIS RESERVOIR CREEL (1990)
Angler Interview Form

Date: / / ¦Party size: ¦Start time: : ¦Trip done: ¦

Origin: ¦Miles traveled: ¦Hours fished: . ¦

Fish kept - GR: ;RB: ;LL: ; (other): ¦

Fish released GR: ;RB: ;LL: ; (other): ¦

Fish measured (T or F): ¦Code #: ¦Shore or Boat: ¦

Bait type (T for those used)- Live: ¦Lures: ¦Flies: ¦Combo: ¦

Fish meth (T for those used)-Troll: ¦Anchor: ¦Drift: ¦Shore: ¦

Season fish (T for those used) - Spr: ¦Sum: ¦Fall: ¦Winter: ¦

Species fished for: ¦ ¦ ¦ Species like to see: ¦ ¦ ¦

Interested in number or size: ¦Economic (T or F): ¦

Name and address: ¦

for economic : ¦

survey : ¦

Appendix A2. Examples of creel census angler count and angler interview forms used at Ennis Reservoir, 1990.

Appendix A3. Instructions for filling out angler interview forms used at Ennis Reservoir, 1990.

Name of Field	Instructions
Date	Fill in date in the MM/DD/YY format
Party size	The number of people fishing in the angler's party. Only record for one angler in party.
Start time	Enter the time the angler started fishing (military time).
Trip done	Is the fishing trip for that day completed? (T)rue or (F)alse.
Origin	For Montana residents, use the number of the county on their license plate. If number not known write down county name or largest city in their county of origin. For out-of-state residents, write down the name of the state of origin. For out-of-county residents, write down the country of origin.
Miles traveled	The number of miles the party traveled (one-way) from their home to Dailey Lake. Home is defined as residence for at least 6 months.
Hours fished	The hours fished from the time the angler started until the interview or they finished angling. It is best to ask them the time they started fishing and then figure out the hours fished.
Fish kept	Write down the number of fish the angler kept by species code. You need to interview each member of the party. Species codes are: WE = walleye; YP = yellow perch; RB = rainbow trout; LL = brown trout; GR = grayling; LMB = large mouth bass; KOK = kokanee salmon; MWF = mountain whitefish.
Fish released	The number of fish the angler released by species code. See the note under "fish kept" above about non-completed trips and species codes. NOTE: The total fish caught will equal the number of fish kept plus the number of fish released.

Appendix A3. (continued)

Fish measured — If you actually measure the kept fish mark a T here. If you do not have time to measure kept fish mark a F here. Even if you do not measure any fish, try to examine kept fish to look for marked fish. If you do examine kept fish, mark down the number of fish examined, by species, and the number of fish that do have marks, by species and mark type.

Code # — If you do measure fish, use a unique sequential code number here to identify which angler fish apply to. You are responsible for keeping track of these numbers to be sure no Code # is used for more than angler. That same Code # will be used for each fish measured from the party.

Shore or Boat — Did the angler fish primarily from the shore (S) or boat (B) or both (C).

Bait type — Which terminal gear (bait) did the angler use. Mark a True (T) for each type used. Bait is any live or dead natural bait. Lures are all lures to include jigs, spoons, crankbaits, surface lures, trolling flashers, etc. Flies are any fly casted with a fly rod or with a spinning rod and fly bobber. Combination is using two or more of the above gears at the same time.

Fish method — How did the angler primarily fish? Mark a True (T) beside each method the party used. Troll = trolling; Anchor = anchored and casting or still fishing; Drift = drifting in a boat (with or without a trolling motor, but not trolling) and casting or still fishing with bait; Shore = fishing from shore.

Season fish — Ask which seasons the angler primarily fishes the lake. Spr = spring (March 1 to May 31); Sum = Summer (June 1 to August 31); Fall = Fall (September 1 to October 31); Winter = Winter (November 1 to February 28).

Species fished for — Write down the codes (see "Fish kept") in the order of preferance that the angler is seeking. For example, the party is primarily interested in catching walleye, but they will fish for yellow perch. Write down WE first then YP.

Appendix A3. (continued)

Species like to see	Same as above ("Species fished for") but which species the angler would like to see in the lake which they either do not know is in the lake, or which actually aren't in the lake.
Interested in number or size	Ask the angler if they would be more interested in catching lots of small fish (ie. perch) or a few large fish (ie. walleye or rainbow).
Economic	Ask if the angler would be interested in receiving and filling out an economic survey questionnaire at a later date. Explain that we may not send out questionnaires, but, if funds are available, we may send out questionnaires during the coming year.
Name and address	Get their name and address for the public participation portion of the Dailey Lake management planning process. Explain the process. For Ennis Lake, only get their name and address if they want to participate in the economic questionnaire survey.

Appendix B. Results of electrophoretic analysis of grayling collected from Ennis Reservoir and the Madison River, 1990 (Leary 1990).

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September 27, 1990

Pat Byorth
Montana Department of Fish, Wildlife, and Parks
1400 South Nineteenth Avenue
Bozeman, Montana 59715

Pat:

We have completed the electrophoretic analysis of the grayling (N=21), Thymallus arcticus, collected from the Madison River during the spring and summer of 1990. Horizontal starch gel electrophoresis was used to determine each fishes genetic characteristics (genotype) at 67 loci (genes) coding for enzymes present in eye, kidney, liver, or muscle tissue (Table 1). These data were used to compare the genetic characteristics of the Madison River grayling to other Montana and Wyoming populations.

Only four of the 67 loci analyzed in the Madison River grayling were polymorphic (genetically variable, Table 2). Data from 39 of these loci are available from 14 other Montana and Wyoming populations (Tables 1 and 2, Everett 1986). In order to compare the genetic characteristics of the Madison River to these other populations, we used the information from these loci to calculate Nei's genetic distance between each pair of samples. This parameter ranges from zero to infinity. A value of zero represents complete genetic identity; two samples have the same alleles (form of a gene) at the same frequencies at all loci examined. A value of infinity represents complete genetic divergence, two samples share no alleles in common at all loci examined.

The matrix of genetic distance estimates between samples was subjected to cluster analysis in order to summarize the relative amount of genetic divergence among the samples. The resulting dendrogram (Fig. 1) has three salient features. First all the populations cluster together at an average distance of only 0.0132. This small value indicates that the populations are all genetically very similar to each other.

The next noteworthy feature is the presence of a cluster of nine populations at an average distance of 0.007. Elk Lake in the Red Rocks River drainage and Red Rocks Lake are the only waters in this cluster to which grayling are believed to be native, but both have been stocked with grayling originating from Madison River tributaries. The other populations were all directly or indirectly established from Madison River tributary and Red Rocks Lake grayling. The small amount of genetic divergence among these populations, therefore, probably most likely reflects their recent common ancestry. Genetic divergence among them probably has resulted from random changes in allele frequencies caused by founder events and genetic drift.

Appendix B. (continued)

Another group of six populations cluster at an average distance of 0.0048. This group includes five water bodies within the Big Hole River drainage suspected or known to have contained native grayling populations: Big Hole River, Bobcat Lake, Miner Lake, Mussigbrod Lake, and Steel creek. Surprisingly, this cluster also contains the Madison River population which is genetically very similar, but not identical, to the Big Hole River, Bobcat Lake, and Steel Creek populations.

There are a number of explanations that could account for the genetic similarity between the Madison River and Big Hole River drainage populations. First, millions of grayling derived from Madison River tributary fish were introduced into the Big Hole River, Miner Lake, and Mussingbrod Lake. If an appreciable number of these fish survived and reproduced with the native fish this would result in increased similarity among the populations within the drainage as well as between the Big Hole River drainage and Madison River populations.

Another possibility is that the Big Hole River drainage and Madison River populations were historically very similar to each other. The differences observed between these populations and those in the other cluster may largely reflect genetic changes induced by founder events and possibly subsequent genetic drift when Madison River grayling were introduced into Georgetown Lake. These differences would be perpetuated and possibly magnified when grayling from Georgetown Lake were used to establish the other populations except those in Elk and Red Rocks Lake. These latter two populations may historically have been different from the Big Hole and Madison River populations or, their genetic characteristics could have been altered by grayling introductions.

The similarity observed between the Madison River and Big Hole drainage populations may not represent successful introductions into the latter or the historical situation. Instead it could reflect recent genetic changes at polymorphic loci in the Madison River population. Presumably, this population almost became extinct in the mid 1980's when Ennis Reservoir was nearly dewatered to reduce macrophyte abundance. This large reduction in population size is expected to induce random genetic changes. These changes may fortuitously have caused allele frequencies in the population to become very similar to those in Big Hole drainage populations.

Which of the above, if any, explanations mainly accounts for the observed similarity between Madison River and Big Hole drainage populations cannot be determined from the available data. We suspect, however, that the first explanation is the least likely of the three. Grayling introduced into the Big Hole drainage populations were also introduced into or

Appendix B. (continued)

derived from most populations in the other cluster. If the introductions into the Big Hole drainage populations were highly successful, these populations would not be expected to form a genetically distinct group.

Sincerely,

Robb Leary

RL:jmc

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Appendix B. (continued)

TABLE 1

Enzymes and loci examined in Arctic grayling. Designation of loci generally follows the recommendations of Shaklee et al. (1990). E=eye, K=kidney, M=muscle.

Enzyme	Loci	Tissue	Analyzed by Everett (1986)
Acid phosphatase	ACP-1*	L	No
Aconitate hydratase	sAH-2*	L	No
Adenylate kinase	AK-1,2*	M	Yes
Alanine aminotransferase	ALAT-1*	L	No
	ALAT-2*	M	No
Alcohol dehydrogenase	ADH*	L	Yes
Aspartate aminotransferase	sAAT-1,2*	L	Yes
	sAAT-(3,4)*	M	Yes
Creatine kinase	CK-A*	M	Yes
	CK-B*, CK-C(1,2)*	E	Yes
Dipeptidase	PEPA-1,2*	E	Yes
Fructose-bisphosphatase	FBP-1,2*	L	No
	FBP-3*	K	No
Fumarate hydratase	FH-1,2*	L	No
beta-Glucosidase	bGlu*	L	No
Glucose-6-phosphate isomerase	GPI-A1,2*	E	Yes
	GPI-B1,2*	M	Yes
Glyceraldehyde-3-phosphate dehydrogenase	GAPDH-3,4*	E	Yes
Glycerol-3-phosphate dehydrogenase	G3PHD-(1,2)*	L	Yes
L-Iditol dehydrogenase	sIDDH-1,2*	L	No
Isocitrate dehydrogenase	mIDHP-1,2*	M	Yes
	sIDHP*	L	Yes

Appendix B. (continued)

Enzyme	Loci	Tissue	Analyzed by Everett (1986)
L-Lactate dehydrogenase	LDH-A*	M	Yes
	LDH-B1,2*, LDH-C	E	Yes
Malate dehydrogenase	sMDH-A(1,2)*	L	Yes
	sMDH-B(1,2)*	M	Yes
Malic enzyme	mMEP*	M	Yes
	sMEP-1,2*	L	No
Mannose-6-phosphate isomerase	MPI-2*	L	No
Phosphoglucomutase	PGM-1,2*	M	Yes
Phosphogluconate dehydrogenase	PGDH*	M	Yes
Phosphoglycerate kinase	PGK-1,2*	L	No
Phosphoglycerate mutase	PGAM-1,2,3*	E	No
Pyruvate kinase	Pk-(1,2)*	M	No
	Pk-3,4*	E	No
Superoxide dismutase	sSOD-1*	L	Yes
Triose-phosphate isomerase	TPI-1,2,3,4*	E	No
Tripeptide aminopeptidase	PEPB*	E	Yes
Xanthine dehydrogenase-like	XDH?*	L	Yes

Note: The common alleles at the pairs of loci in parentheses presumably produce a protein with identical function and electrophoretic mobility. For example, sAAT-3* and sAAT-4* both produce an aspartate aminotransferase present in muscle and the common proteins produced from each locus occupy the same position in the gel after electrophoresis. Such pairs of loci are commonly termed isoloci and their existence can be conclusively detected only when genetic variation exists at one or both loci. In these situations, however, it is not possible to determine at which locus of the pair a variant allele exists. In order to estimate allele frequencies at the isoloci, therefore, each pair was considered to be a single gene with four instead of two copies per individuals.

Appendix B. (continued)

TABLE 2

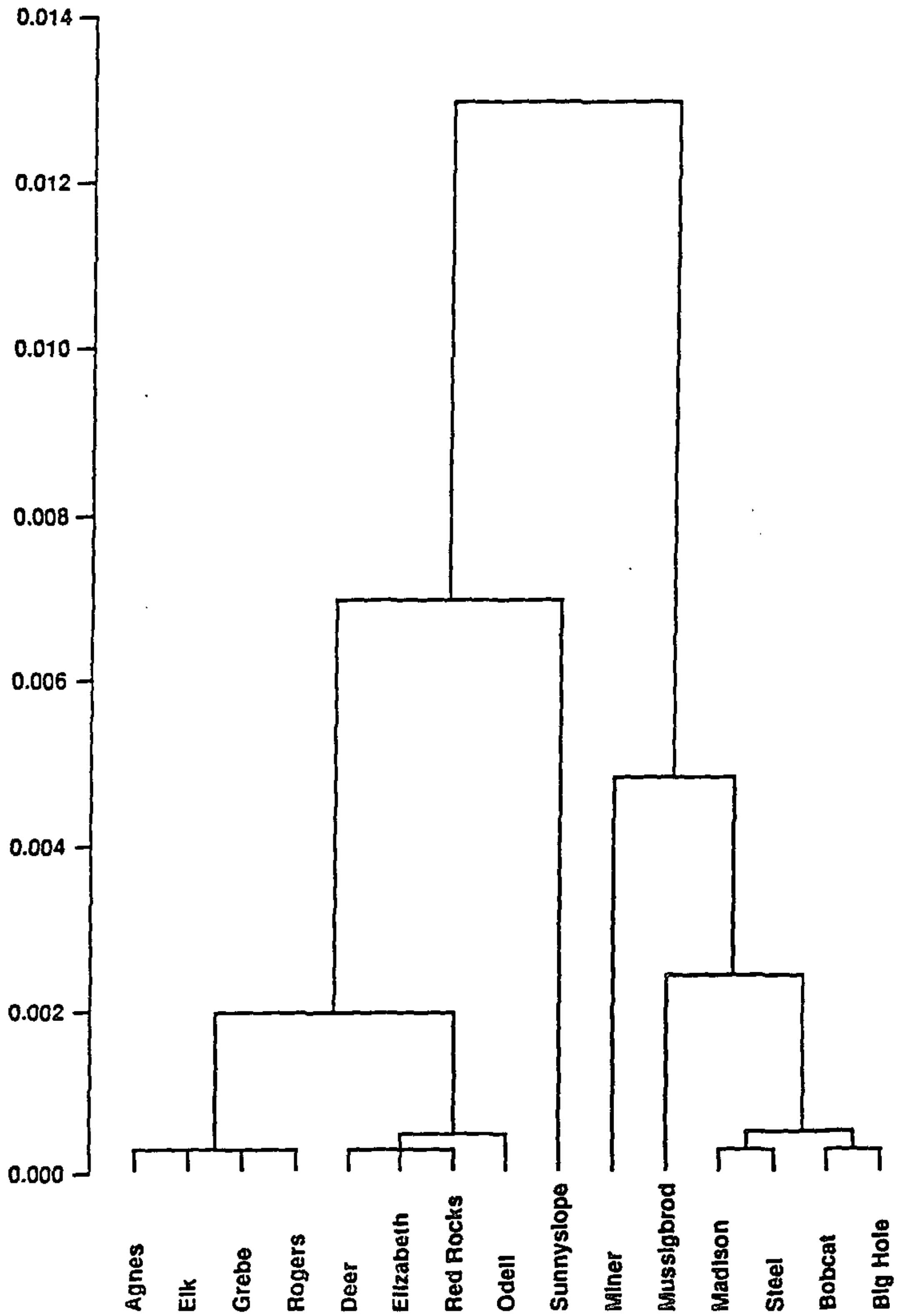
Allele frequencies at the polymorphic loci in Montana and Wyoming Arctic grayling populations. Variant alleles not listed are CK-A*103, FH-2*(53), GAPDH-3*88, LDH-A*131, PGM-1*49, sIDHP*83 (Rogers), sIDHP*123 (Madison), and sSOD-1*97. NA=locus not analyzed in a particular sample.

Presumed drainage of origin & sample	Alleles and allele frequencies						
	CK-A*116	FH-2*100	GAPDH-3*null	sIDHP*100	LDH-A*85	PGM-1*85	sSOD-1*145
Big Hole							
Bobcat	1.000	NA	0.600	1.000	1.000	1.000	0.900
Steel	1.000	NA	0.750	1.000	1.000	1.000	0.875
Big Hole	0.967	NA	0.756	1.000	1.000	1.000	0.922
Miner	1.000	NA	0.900	1.000	1.000	0.700	0.633
Mussigbrod	1.000	NA	1.000	1.000	1.000	1.000	0.885
Madison-Red Rocks							
Madison	1.000	0.833	0.825	0.952	1.000	1.000	0.857
Deer	1.000	1.000	0.083	1.000	1.000	1.000	0.614
Red Rocks	1.000	NA	0.143	1.000	0.982	1.000	0.552
Elizabeth	1.000	NA	0.167	1.000	1.000	1.000	0.528
Elk	1.000	NA	0.286	1.000	0.990	1.000	0.650
Odell	1.000	1.000	0.300	1.000	1.000	1.000	0.475
Grebe	1.000	NA	0.366	1.000	1.000	1.000	0.768
Sunnyslope	1.000	NA	0.366	1.000	1.000	1.000	0.122
Rogers	1.000	NA	0.384	0.994	0.953	1.000	0.581
Agnes	1.000	NA	0.444	1.000	0.986	1.000	0.552

Appendix B. (continued)

Figure 1. Dendrogram produced by cluster analysis of *Nei's* genetic distance based on information from 39 protein coding loci analyzed in Montana and Wyoming Arctic grayling populations.

Appendix B. (continued)



Appendix C. Catch Rates from Ennis Reservoir gill net series.

Table C1. Catch rate (number per net), mean length and weight (range) of grayling captured in gill nets on Ennis Reservoir, 1990.

Date	Site	# Nets	Net type	# per net	Mean length (range)	Mean weight (range)
Fall 1989						
9/18/89	Chimney	3	F	0	-	-
		3	S	0.33	11.2	0.54
9/19/89	Inlet	3	F	0	-	-
		3	S	0	-	-
9/20/89	Meadow	3	F	0	-	-
		3	S	0	-	-
Spring 1990						
5/29/90	Chimney	3	F	0	-	-
		3	S	0	-	-
5/30/90	Inlet	3	F	0	0	-
		3	S	0.33	14.8	0.70
5/31/90	Meadow	3	F	0	-	-
		3	S	1	10.0 (7.5-14.3)	0.49 (0.14-1.2)
6/6/90	Bridge	3	F	0	-	-
		3	S	2.67	11.8 (8.0-14.8)	0.68 (0.20-1.0)
Summer 1990						
7/31/90	Chimney	1	F	0	-	-
		1	S	0	-	-
7/31/90	Inlet	1	F	0	-	-
		1	S	1	14.6	1.08
7/31/90	Meadow	1	F	0	-	-
		1	S	0	-	-

Table C1. (continued)

Summer 1990 (continued)							
7/31/90	Bridge	1	F	0	-	-
		1	S	0	-	-
Fall 1990							
9/25/90	Chimney	1	F	0	-	
		1	S	0	-	-
9/25/90	Inlet	1	F	0	-	-
		1	S	0	-	-
9/25/90	Meadow	1	F	0	-	-
		1	S	0	-	-
9/25/90	Bridge	1	F	0	-	-
		1	S	0	-	-

Table C2. Catch rate (number per net), mean length and weight (range) of rainbow trout captured in gill nets on Ennis Reservoir, 1990.

Date	Site	# Nets	Net type	# per net	Mean length (range)	Mean weight (range)
Fall 1989						
9/18/89	Chimney	3	F	7.3	15.2 (8.5-22.5)	1.39 (0.25-4.9)
		3	S	12.6	13.6 (8.0-21.6)	1.73 (0.23-3.52)
9/19/89	Inlet	3	F	6	14.0 (12.9-18.1)	1.09 (0.74-2.05)
		3	S	5.3	14.4 (13.4-16.3)	1.10 (0.59-2.05)
9/20/89	Meadow	3	F	6	14.2 (7.1-19.6)	1.24 (0.16-2.62)
		3	S	3	13.6 (7.1-19.6)	1.10 (0.16-2.62)
Spring 1990						
5/29/90	Chimney	3	F	3.33	13.8 (8.6-28.5)	1.33 (0.42-8.0)
		3	S	1.3	9.4 (9.1-10.6)	0.37 (0.32-0.45)
5/30/90	Inlet	3	F	2	13.9 (12.2-15.2)	0.98 (0.75-1.24)
		3	S	1.33	12.9 (10.5-14.6)	0.75 (0.35-1.24)
5/31/90	Meadow	3	F	0.33	14.3	0.98
		3	S	0.67	13.4 (11.7-15.1)	0.80 (0.56-1.05)
6/6/90	Bridge	3	F	17.3	13.0 (8.9-22.0)	0.80 (0.18-3.1)
		3	S	6.0	12.7 (7.1-15.3)	0.61 (0.18-1.24)

Table C2.(continued)

Summer 1990						
7/31/90	Chimney	1	F	1.0	13.0	0.88
		1	S	0	-	-
7/31/90	Inlet	1	F	1.0	11.7	0.62
		1	S	0	-	-
7/31/90	Meadow	1	F	2.0	13.8 (12.5-15.9)	1.10 (0.8-1.41)
		1	S	0	-	-
7/31/90	Bridge	1	F	6.0	14.7 (11.8-16.7)	1.48 (0.63-1.91)
		1	S	1.0	12.9	0.77
Fall 1990						
9/25/90	Chimney	1	F	0	-	-
		1	S	0	-	-
9/25/90	Inlet	1	F	1.0	14.7	1.20
		1	S	0	9.2	0.33
9/25/90	Meadow	1	F	0	-	-
		1	S	0	-	-
9/25/90	Bridge	1	F	0	-	-
		1	S	0	-	-

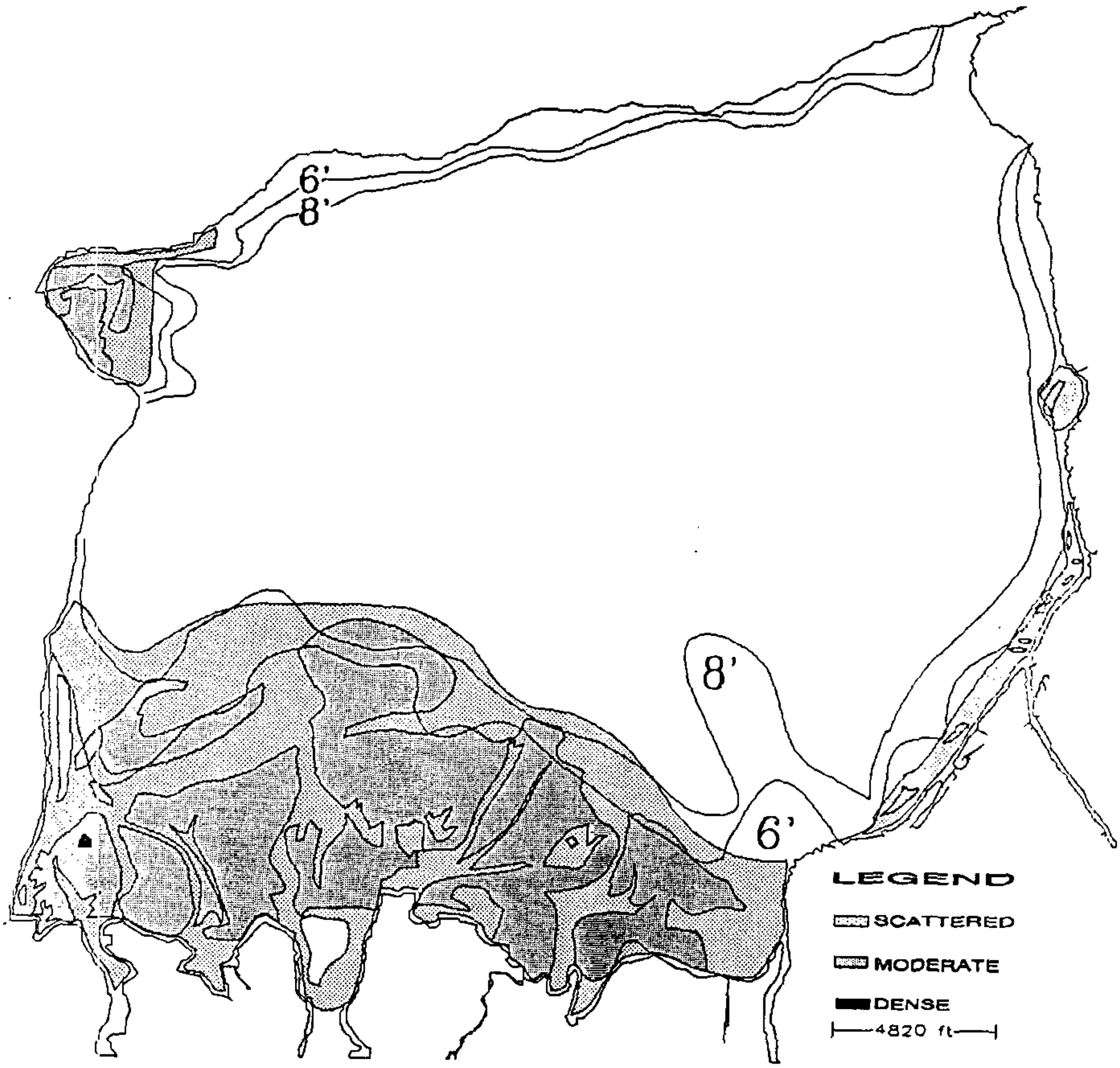
Table C3. Catch rate (number per net), mean length and weight (range) of brown trout captured in gill nets on Ennis Reservoir, 1990.

Date	Site	# Nets	Net type	# per net	Mean length (range)	Mean weight (range)
Fall 1989						
9/18/89	Chimney	3	F	5.3	13.0 (8.1-15.2)	0.88 (0.21-1.38)
		3	S	5.7	13.7 (11.4-15.8)	0.97 (0.48-1.27)
9/19/89	Inlet	3	F	3.3	14.9 (10.2-18.3)	1.42 (0.35-2.84)
		3	S	3.3	14.1 (8.3-17.9)	1.19 (0.21-2.84)
9/20/89	Meadow	3	F	3.0	12.3 (7.0-15.3)	0.76 (0.13-1.15)
		3	S	5.0	13.4 (8.8-17.0)	0.95 (0.13-1.16)
Spring 1990						
5/29/90	Chimney	3	F	5.0	13.6 (7.7-16.3)	0.93 (0.18-1.4)
		3	S	3.67	14.8 (9.5-16.8)	1.11 (0.28-1.5)
5/30/90	Inlet	3	F	7.3	13.3 (10.0-17.4)	0.82 (0.3-1.64)
		3	S	0.67	14.0 (12.5-15.4)	0.84 (0.63-1.05)
5/31/90	Meadow	3	F	1.33	10.8 (7.3-14.4)	0.55 (0.12-0.96)
		3	S	1.0	11.2 (8.1-15.4)	0.57 (0.2-1.2)
6/6/90	Bridge	3	F	16.0	14.1 (9.1-17.8)	0.98 (0.28-1.75)
		3	S	10.3	14.2 (6.7-16.6)	1.0 (0.11-1.8)

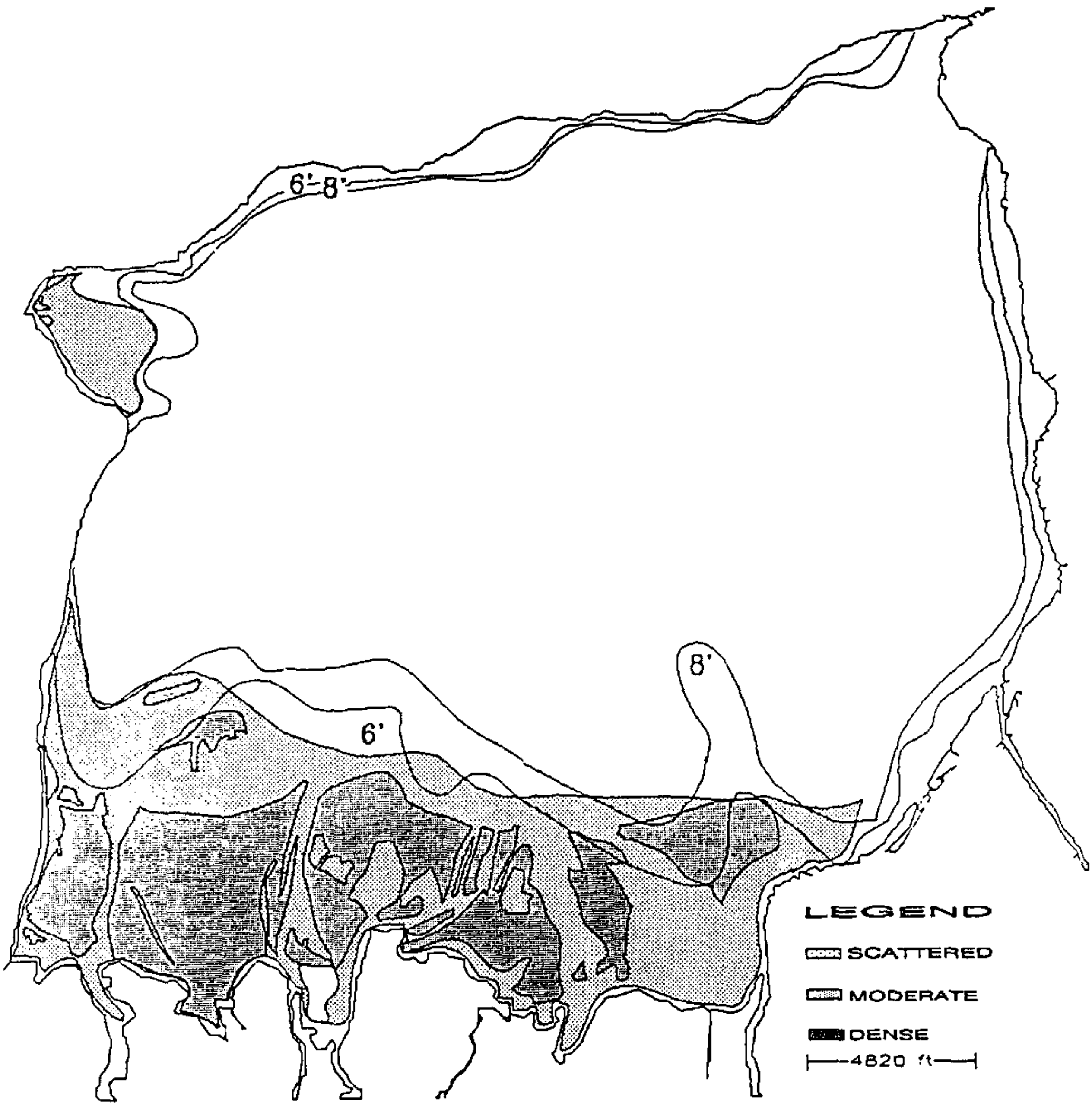
Table C3. (continued)

Summer 1990						
7/31/90	Chimney	1	F	3.0	12.0 (10.2-16.7)	0.66 (0.4-1.03)
		1	S	8.0	14.2 (11.1-1.58)	1.0 (0.59-1.47)
7/31/90	Inlet	1	F	1.0	14.5	-
		1	S	4.0	13.4 (11.7-14.3)	1.08
7/31/90	Meadow	1	F	1.0	13.0	0.88
		1	S	2.0	13.0 (12.1-13.9)	-
7/31/90	Bridge	1	F	3.0	14.9 (12.5-17.1)	1.29 (0.73-1.97)
		1	S	2.0	16.2 (15.4-17.0)	1.55 (1.2-1.9)
Fall 1990						
9/25/90	Chimney	1	F	1.0	14.4	0.93
		1	S	3.0	15.4 (14.7-16.7)	1.35 (1.1-1.2)
9/25/90	Inlet	1	F	1.0	16.6	13.7
		1	S	0	-	-
9/25/90	Meadow	1	F	0	-	-
		1	S	3.0	14.5 (13.5-15.3)	1.11 (0.88-1.32)
9/25/90	Bridge	1	F	0	-	-
		1	S	2.0	15.7 (15.5-15.9)	1.35 (1.31-1.38)

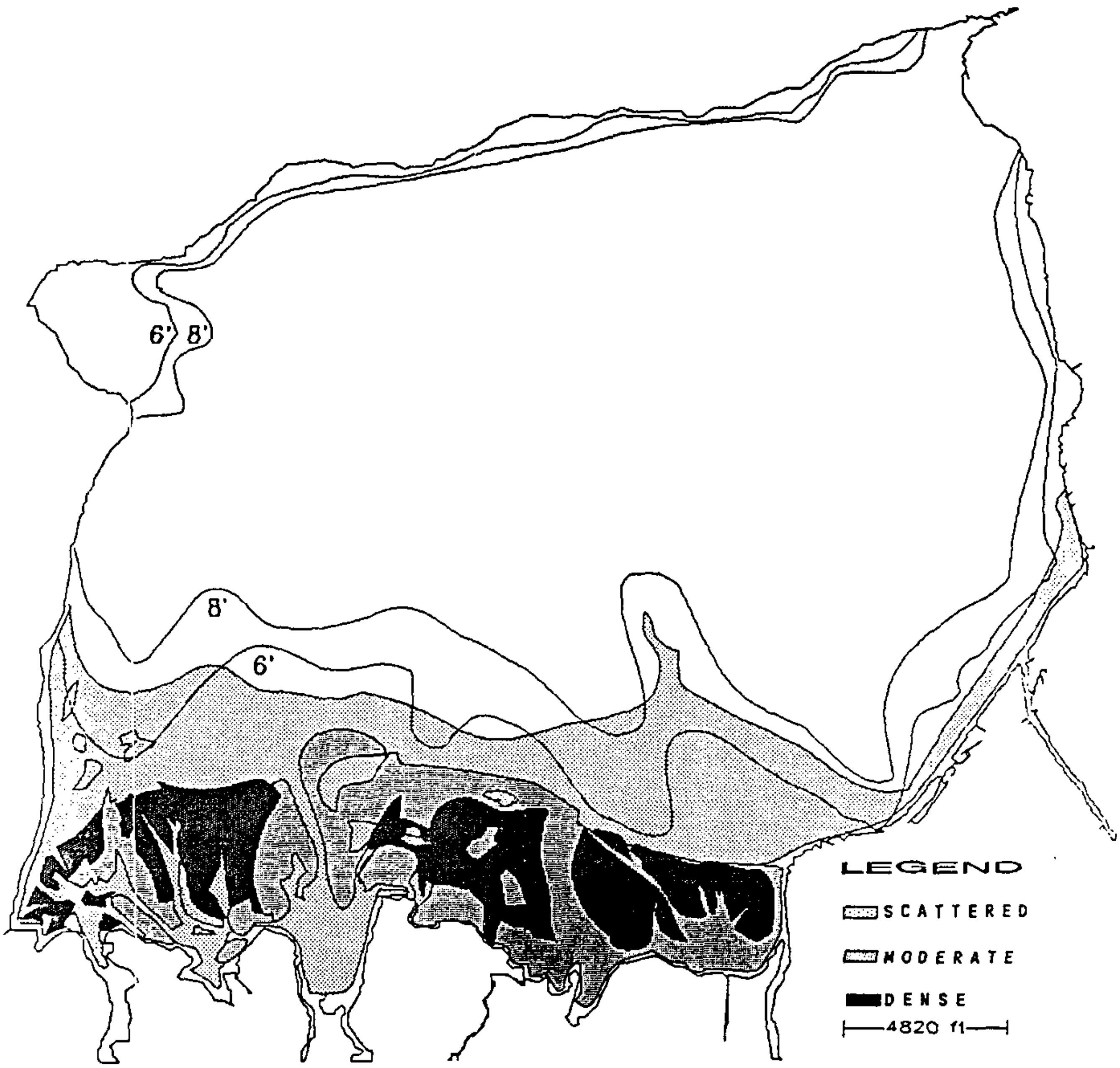
Appendix D. Maps of aquatic vegetation in Ennis Reservoir, 1983 to 1990.



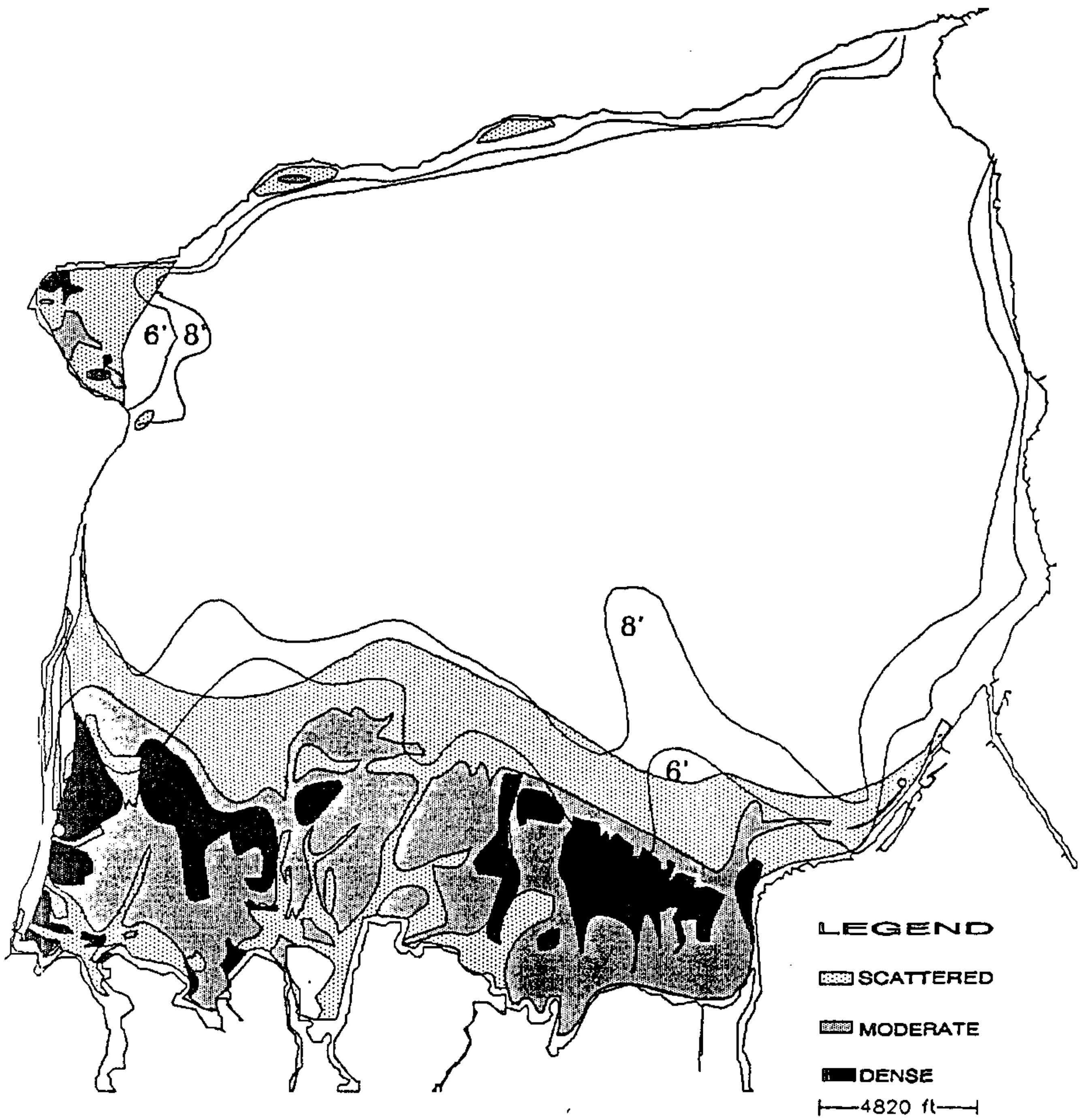
APPENDIX D1. MAP of Aquatic Macrophyte Density in Ennis Lake, Derived From Aerial Photographs Taken September 15, 1983



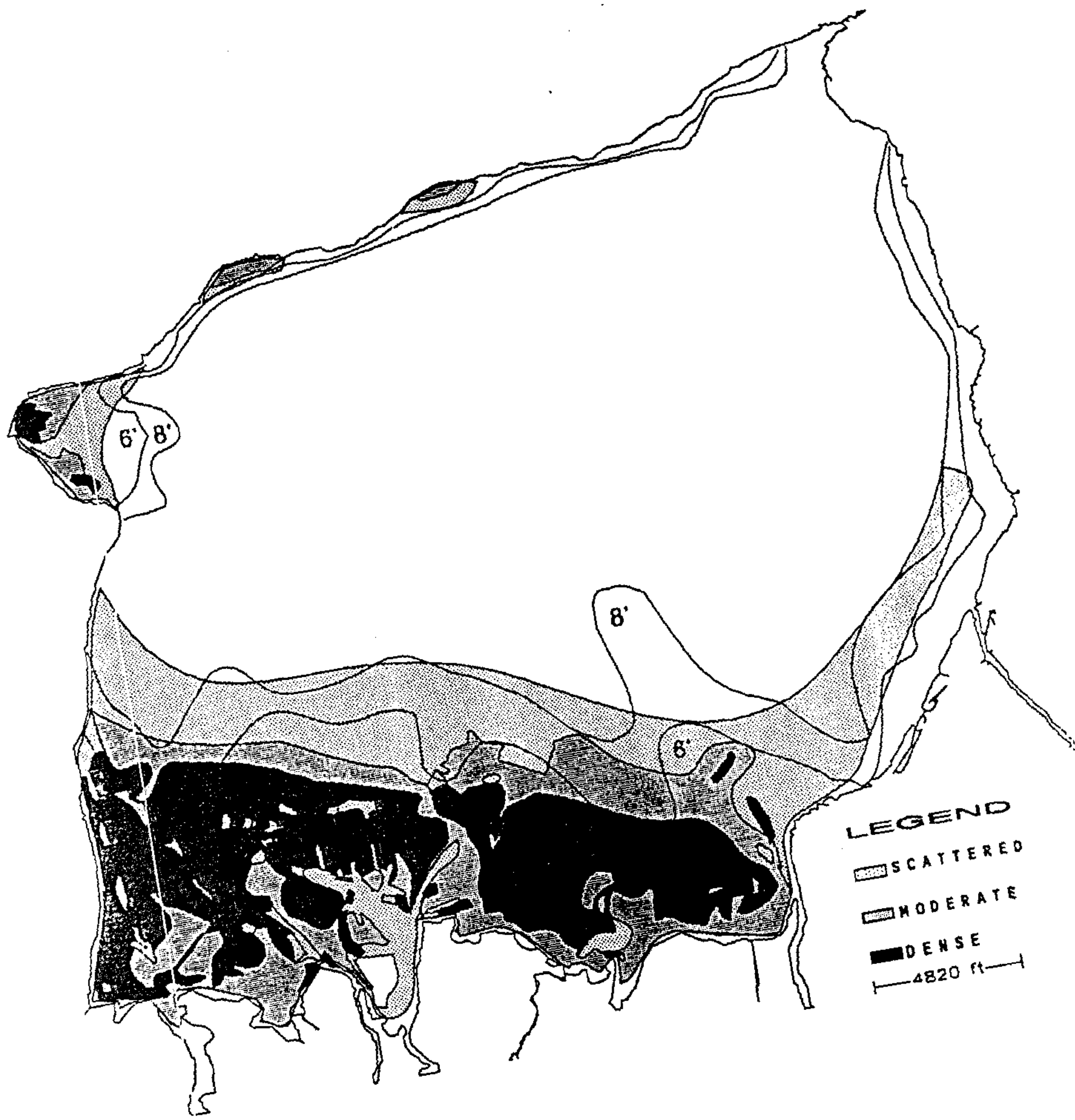
APPENDIX D2. Map of Aquatic Macrophyte Density in Ennis Lake, Derived From Aerial Photographs Taken September 15,1984..



APPENDIX D3. Map of Aquatic Macrophyte Density in Ennis Lake, Derived From Aerial Photographs Taken October 11, 1988



APPENDIX D4. Map of Aquatic Macrophyte Density in Ennis Lake, Derived From Aerial Photographs Taken August 1, 1990.



APPENDIX D5. Map of Aquatic Macrophyte Density in Ennis Lake, Derived From Aerial Photographs Taken September 1990.