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INVENTORY AND SURVEY OF FISHERIES IN LOWLAND LAKES AND RESERVOIRS OF THE RED ROCK, RUBY, BEAVERHEAD, AND BIG HOLE RIVER DRAINAGES OF SOUTHWEST MONTANA

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ABSTRACT

Fisheries data trends are updated for the 1994-1999 period for selected lakes and reservoirs in southwest Montana. Fisheries and storage data trends were gathered for Clark Canyon Reservoir. Analysis of plant success for wild strains of rainbow trout, rainbow trout spawning migrations, wild brown trout populations, and angler use trends are presented. Fisheries data, rainbow trout stock success, wild brown trout population information, and angler use trends are presented for Ruby Reservoir. Analysis of fisheries recovery in the aftermath of the 1994 dewatering event at Ruby Reservoir is presented and discussed. Evaluation of stocks of McBride Yellowstone strain cutthroat trout is presented for Elk Lake in addition to an analysis of native Arctic grayling, lake trout, and burbot populations. The wild lacustrine rainbow trout population of Hidden Lake is evaluated and discussed in terms of its unique stability and apparent ability to reproduce in a lacustrine environment. The effects of various management strategies are presented and discussed for two man-made spring ponds, Culver and McDonald, located on the Red Rock Lakes National Wildlife Refuge for brook trout, rainbow trout, and native species management. The fish populations of Twin Lakes, located in the upper Big Hole River drainage, are described with particular emphasis on native glacial relict populations of lake trout and burbot.

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INTRODUCTION

Southwest Montana provides a diversity of angling opportunity in lacustrine environments in the form of numerous lakes, reservoirs, and ponds. While the majority of these lentic fisheries are sustained in alpine lakes, a substantial amount of opportunity is provided by "lowland" lakes which are readily accessed by vehicle. Because of their accessibility, these waters tend to support relatively heavy angler use and require regular sampling to monitor fish populations. Concomitant with their accessibility, most of these lowland waters are provided with ample developed campground and boat launch facilities which also tends to increase angler use. In addition to their accessibility, many of the lowland lakes are noted for their productivity, trophy fisheries, unique species composition, scenic qualities, or some combination of these factors. These factors, when coupled with easy accessibility, can result in heavy angling pressure and high angler expectations. Many of these waters are stocked periodically with hatchery trout to support harvestable populations under heavy use. Such waters must be monitored to insure maximum survival and angler use of hatchery stocks. In cases where self sustaining wild populations or sensitive native species provide all or part of the angler use, they must be monitored on a regular basis to insure that regulations or stocking programs are tailored to maintain populations in balance with habitat limitations and angler use.

Waters discussed in this report include two major irrigation reservoirs constructed on mainstem rivers, two relatively large natural lakes, two man-made ponds, and a natural mountain lake. All seven of these waters have sustained heavy angling pressure relative to their size

Clark Canyon and Ruby Reservoirs are man made impoundments on the Beaverhead and Ruby Rivers. Both reservoirs were constructed to provide stored irrigation reserves and flood control. Clark Canyon is managed by the Bureau of Reclamation and two boards of water users It provides about 257,000 acre-feet of storage and 5,900 acres of surface at the top of the flood control pool although normal operating pools result in a lake of about 4,000 to 5,000 acres Clark Canyon provides sport fisheries for introduced rainbow and brown trout, native burbot and mountain whitefish. The occasional capture of westslope cutthroat trout and brook trout has occurred sporadically over time. Native nongame species occupying the reservoir include white and longnose sucker. Introduced nongame species include the common carp and the redside shiner which was recently discovered in 1998. The rainbow trout population is provided largely through annual plants of hatchery fish while other fish populations are wild and self sustaining The reservoir generally has supported about 40,000 angler-days of recreation per year although recent trends have demonstrated a marked increase. Dynamics of the trout populations of Clark Canyon were last reported by Oswald (1993). Ruby Reservoir is managed by the Montana Dept of Natural Resources and the board of water users. The reservoir stores about 39,000 acre-feet at full pool and provides fisheries for rainbow, cutthroat, and brown trout and mountain whitefish. Rainbow and cutthroat trout have been stocked to augment wild populations in the past and attempts have also been made to manage the reservoir as a wild self sustaining fishery. Ruby Reservoir has supported angler use of about 2,000 to 4,000 angler-days per year although the most recent management direction has resulted in a dramatic increase in pressure. The trout populations of Ruby Reservoir were last described by Oswald (1993). Land management agencies provide ample campground and boat launch facilities on both reservoirs

Elk and Hidden Lakes are accessed through the uppermost Centennial Valley and are located within the boundaries of the Beaverhead National Forest. Both lakes are natural and sit at elevations slightly over 6,500 feet. The fishery of Elk Lake was first described by Lund (1974) while Oswald (1989) described the rainbow trout fishery of Hidden Lake. Elk Lake is located in a glacial rift and occupies 283 acres with a maximum depth of 70 feet. The lake has been stocked with rainbow trout and, in more recent history, McBride Yellowstone cutthroat trout. Elk Lake also has supported a wild population of Arctic grayling, and currently supports wild populations of lake trout, and burbot The lake trout and burbot populations are considered native (Vincent 1963 and Holton 1990) while the status of the grayling population is unknown due to heavy stocking of the species in the 1950's Two national forest campgrounds are located on Elk Lake and a private lessee operates a fishing camp on national forest property. Elk Lake has supported an estimated 2,000 to 3,000 angler days of recreation per year. The trout populations of Elk Lake were last described by Oswald (1993). Hidden Lake is the uppermost of a chain of lakes which are in the Madison River drainage and occupies 149 acres. These lakes are located in the ancient river channel which drained a large Pleistocene lake which occupied the Centennial Valley (Feth 1961) and are not connected by tributary surface flow The lake received four limited plants of rainbow trout in the mid 1930's and 1940's From this base, a wild, self sustaining population of rainbow trout was established and persists to the present. Several undeveloped camp sites are scattered around the lake and a private lessee from the Elk Lake Camp provides boat rental and dock Hidden Lake supports about 1,000 to 2,000 angler-days of recreation per year. The status of the trout population was last described by Oswald (1993).

Culver and McDonald Ponds are small man-made impoundments located on the Red Rock Lakes National Wildlife Refuge Both ponds are spring fed and represent very productive environments which provide trophy trout fisheries Culver Pond supports a self sustaining population of brook trout while McDonald Pond has supported a wild rainbow trout population. Both fisheries have been managed under limited special trophy regulations since 1986. Water levels in the ponds have been manipulated at various times to accommodate trumpeter swan management strategies on the refuge The ponds have recently been scrutinized by USFWS personnel for the Red Rock Lakes National Wildlife Refuge in order to determine their potential for native species restoration The trout populations of Culver and McDonald were most recently described by Oswald (1993)

Twin Lakes is a large alpine lake located on the Beaverhead National Forest. It is situated in the Beaverhead Mountains on the west side of the upper Big Hole River Valley. Unlike most alpine lakes in the vicinity, Twin Lakes is easily accessed by maintained roads and supports a large, developed public campground. Twin Lakes is located at an elevation of 7235 feet, has a surface of 75 acres, and is 72 feet deep It has received plants of cutthroat and rainbow trout and Arctic grayling in the past but all stocking ended after 1963 in favor of wild trout management. Currently Twin Lakes supports wild populations of lake trout, brook trout, and burbot. The lake trout population is considered to be one of four native populations in Montana (Vincent 1963 and Holton 1990). Due to developed access, scenic setting, and the unique lake trout population, Twin Lakes has supported 500 to 1,000 angler-days per year.

METHODS

Sampling of fish populations in lakes and ponds was largely accomplished through the setting of floating 6 X 125 foot experimental gill nets off defined points, rock formations, or other structural features. Sets were made at the same location and samples collected at the same time each year to minimize variation due to location or season The smallest bar mesh was always set inshore. Nets were fished overnight, generally for 10 to 12 hours. Experimental nets contained five bar mesh sizes ranging from 3/4 to 2 inch opening In Elk and Twin Lakes, sinking gill nets of similar construction to the floaters were set overnight to sample lake trout and burbot populations.

All salmonids captured in nets were enumerated, measured to the nearest 0 1 inch, and weighed to the nearest 0.01 pound. Scale samples were collected from selected fish, mounted on acetate slides, and examined on a microfiche viewer to determine age.

Characteristics of spawning migrations from Clark Canyon reservoir were gained primarily through electrofishing procedures and secondarily through a limited trapping operation Electrofishing sampling methods used a mobile anode and boat mounted cathode to draw fish for capture. A 3500 watt generator was employed as power source and current was rectified to continuous DC through the use of a Leach box Trapping methodology involved daily operation of a block weir across the river channel and trap bay operated through a headgate and three gated cells. The trap was operated successfully in 1995 but above average flows in subsequent years overwhelmed the trap structure and rendered efficient operation impossible All trout captured during spawning migrations were fitted with color coded individually numbered Floy type tags.

A limited winter creel census was conducted on Clark Canyon Reservoir through the report period and conducted on Ruby Reservoir since 1997 The creel census was conducted one day per week, for approximately 6 weeks per winter sample period, on weekend days to maximize the number of interviews. A roving creel clerk gathered information on numbers of anglers, residency, hours fished, catch, and harvest Due to the limited nature of the census, data were limited to catch and harvest rates and could not be used to estimate pressure or total harvest. All pressure estimates used in this report were generated from the MDFWP statewide mail creel census which is conducted on a regular basis.

Statistics describing storage volume, pool elevation, and surface acreage in Clark Canyon Reservoir were calculated from U.S. Bureau of Reclamation data Storage volumes for Ruby Reservoir were summarized from USGS Water Resources Data Reports Pond elevational data for Culver and McDonald Ponds was provided by the U S Fish and Wildlife Service from Refuge data files.

RESULTS

CLARK CANYON RESERVOIR

Reservoir Storage Trends

Minimum storage pool in Clark Canyon Reservoir, as determined from end of irrigation season storage, is depicted in Figure 1 for the 1987-1999 period. Minimal drought storage pools of the 1989-1992 period approached or dropped below 40,000 acre feet. Reservoir storage improved in 1993-1994 and recovered fully over the past five years, often exceeding 140,000 acre feet. Relationships depicted by Oswald (1993) showed that reservoir surface was reduced to 2,000 acres during severe drought drawdowns between 1989 and 1992. Under these same relationships, reservoir surface remained above 4,000 acres, and often exceeded 5,000 acres at minimum pool for the 1995-1999 period.

Rainbow Trout

Recent rainbow trout plants in Clark Canyon Reservoir are presented in Table 1. Oswald (1993) described the evaluation of the Arlee and DeSmet strains of rainbow trout and incipient data for the Eagle Lake strain in the reservoir. Plants since 1991 have been composed entirely of young-of-the-year Eagle Lake strain of rainbow trout which average about 4.0-4.5 inches in length at the time of plant. Plants are generally made in early June to coincide with a favorable thermal regime and the exponential growth phase of the cladoceran zooplankton community. Stocked fish are dispersed by boat to mitigate predation and encourage an efficient use of forage and habitat niche.

Table 1. Recent plants of young-of-the-year Eagle Lake strain rainbow trout in Clark Canyon Reservoir.

YEAR	NUMBER	YEAR	NUMBER
1993	202,164	1997	186,718
1994	197,616	1998	200,368
1995	200,703	1999	193,074
1996	209,848		

Rainbow trout trends from 1980 through 1999 are depicted in Figure 2. The 1980-1984 period was marked by stable numbers of Arlee strain rainbow trout averaging approximately 4.5 per net. Numbers of rainbow trout began increasing in 1985, to a maximum per net density of 17.7 in 1988, with the addition of wild strain DeSmet rainbow to the plant. Following 1988, rainbow trout numbers declined dramatically with declining reservoir storage pools and surface acreage. In 1990, plants of domestic Arlee rainbow trout were abandoned followed by a 1991 shift from the wild De Smet strain to the wild Eagle Lake strain of rainbow trout. Recovering storage pools in 1993 (Figure 1) were accompanied by increased numbers of Eagle Lake strain rainbow trout per net. The 1992-1999 sampling period has been marked by relatively stable numbers of Eagle Lake rainbow trout per net ranging between 8.4 per net in 1994 and 14.0 per net in 1995 and averaging 11.4 per net for the period. Survival of rainbow trout plants to Age I (Figure 3) closely mimicked total rainbow trout abundance trends from 1980 through 1993.

During this period, Age I plant survivors composed the preponderance of the total rainbow trout sample for each year. In 1994 and 1996 through 1999, survival to Age I was relatively limited and older fish dominated the per net samples. While the 1995 sample exhibited good recruitment to Age I at 8.6 per net, Age II and older fish still composed 38.6% of the sample at 5.4 per net.

Rainbow trout spawning migrations from Clark Canyon Reservoir were monitored by multiple electrofishing sampling runs in the Red Rock River in 1994 and 1997-1999. The 1995 spawning migration was monitored through the use of a weir trap which could not be operated efficiently in 1996 due to extremely high flow regimes. Numbers of spawning Eagle Lake rainbow trout (Figure 4) were maximized under stable flow regimes in 1994 and declined to a minimum of about 100 per sample run in 1997 under conditions of high snowpack, high flow regimes and cold ambient temperature regimes which characterized the 1995 - 1997 period in southwest Montana. Number of spawning fish recovered in 1998 to slightly more than 200 per sample run but declined again in 1999 under cold ambient water temperatures. During the 1999 spawning season, water temperatures did not attain 50° F on any of the six sample dates in March, April and May. The 1995 trap data depict a relatively strong spawning run in 1995 (Figure 5). The data depict a steady increase in spawning activity from March 26 through April 7 followed by a slight decline between April 8 and April 11 with peak run activity occurring between April 12 and April 16. The trap was discontinued after April 18 due to high runoff flows. During sampling at the trap in 1995 and during electrofishing runs in 1998 and 1999, recaptured fish were recorded and included in the sample. Recapture rates (Figure 6) during the 1995 and 1998 samples were relatively low at approximately 14% while the recapture rate of 1999 elevated to 31.8% reflective of the cold water temperatures of that spring. Length frequency analyses of the rainbow trout spawning migrations of 1994-1995 and 1997-1999 are presented in Figures 7 through 11. Spawning runs were dominated by Age III and older fish in all years with a relatively high contribution of Age II fish occurring in 1994 and 1999. A slight increase in modal length was detected from 1994 to 1995 while a substantial increase in modal length occurred between 1997 and 1999. This is indicative of a spawning rainbow trout population dominated by older larger fish and is similar to the response of the De Smet rainbow population response observed between 1990 and 1993 (Oswald 1993). This age and size domination of the spawning Eagle Lake rainbow population is further demonstrated by substantial increases in the weight of the fish captured over the 1997-1999 period (Figure 12).

Brown Trout

Brown trout trends over the 1966-1999 period are depicted in Figure 13. Oswald (1993) described a gradual trend for decreasing numbers of brown trout following upon ageing of the reservoir, establishment of larger rainbow trout populations, and low storage pools and tributary flows associated with drought conditions. The recent trend has been reflective of increasing wild brown trout populations from 1995 through 1999 with relatively strong recruitment. The 1999 sample exhibited the highest per net sample of brown trout recorded over the history of Clark Canyon Reservoir sampling.

Angler Use Trends

Trends in angling pressure are presented in Figures 14 and 15. Recent pressure estimates depict a substantial increase in angler days over the 1993-1997 period to levels exceeding 50,000 angler days per year. Low angler participation in 1991 is reflective of low storage pools marking the 1989-1992 period (Figure 1). Nonresident angling pressure has increased at a higher rate than resident use (Figure 15) with the 1997 sample demonstrating virtually equal participation between resident and nonresident anglers.

Winter creel catch rates for rainbow trout from 1989 through 1999 are depicted in Figure 16. Very low catch rates in 1989 and 1990 were associated with low storage pools and declining populations but a similarly low rate was also associated with relatively high total rainbow trout and Age I rainbow trout numbers in 1993 (Figures 2 and 3). The highest rainbow trout catch rate of 0.5 per hour was recorded in 1992 and was associated with high spring numbers of Age I Eagle Lake rainbow but other high collection densities of Age I rainbow did not necessarily correlate with high winter catch rates. In most years, rainbow trout catch rates are 0.2 to 0.3 fish per hour and appear to be independent of rainbow trout density. This is certainly apparent for the 1994-1999 period under Eagle Lake rainbow trout management. The 1999 creel survey was reflective of the domination of the rainbow trout population by large fish with 16% of the rainbow trout harvest exceeding 5.00 pounds in weight.

Winter creel catch rates for the wild brown trout (Figure 17) are far lower than those observed for rainbow trout and remain extremely constant at approximately 0.03 fish per hour. This consistency in brown trout catch rate appears to be independent of brown trout density as reflected in Figure 13 for the 1989-1999 period.

RUBY RESERVOIR

Reservoir Storage Trends

Minimum storage pool in Ruby Reservoir, as determined from end of irrigation season storage, is presented in Figure 18. The drought period from 1988 through 1992 was marked by extremely low storage pools dropping to a minimum of only 500 acre feet in 1992. Storage in 1993 recovered strongly under very wet summer climatic conditions, but dropped precipitously in 1994 under extreme drought. In early September 1994, the reservoir was emptied resulting in a large fish kill in both the reservoir and the Ruby River immediately downstream from the dam (Oswald 2000). The resultant response included the formation of the Governor's Ruby River Task Force which impressed a minimal storage pool of 2,600 acre feet and fisheries target pools of 6,000 acre feet and 10,000 acre feet. Following the 1994 dewatering, storage remained relatively abundant from 1995 through 1998 based on wet climatic conditions and strong winter snowpack but dry climatic conditions in 1999 dropped the reservoir to the minimum fisheries target pool.

Rainbow Trout

Oswald (1993) described management of Ruby Reservoir under wild rainbow trout populations from 1981 through 1987. From 1988 through 1991, the reservoir was stocked with four different strains of rainbow including the domestic Arlee strain and the wild DeSmet, Hebgen Lake, and McConaughy strains in an attempt to maintain a fishery through conditions of drought and low storage pools. From 1992 through 1999, Ruby Reservoir has been stocked with the wild Eagle Lake strain of rainbow trout. Plants are composed of young-of-the-year fish which generally average approximately 5.0 inches in length and are stocked in late June or early July to minimize spillway loss from the reservoir. The recent stocking history of Ruby Reservoir is presented in Table 2.

Table 2. Recent plants of young-of-the-year Eagle Lake strain rainbow trout in Ruby Reservoir.

YEAR	NUMBER	YEAR	NUMBER
1993	50,105	1997	58,359
1994	50,358	1998	49,725
1995	45,347	1999	49,507
1996	51,668		

Trends in the abundance of rainbow trout in Ruby Reservoir are presented in Figure 19 for the 1979-1999 period. Rainbow trout densities over the 1979-1992 period were discussed by Oswald (1993). Despite low storage pools during the 1988-1992 period, rainbow trout numbers increased markedly in 1992-1994 attaining a maximum collection density of 31.0 per net in 1992. These high numbers were based largely on strong survival to Age I from the 1990-1992 plants. The complete dewatering of the reservoir in September 1994 left an impoverished fishery and nearly barren reservoir. In September 1994, approximately 3,000 surviving rainbow were captured by electrofishing in the Ruby River tailwater downstream from the dam. These fish were marked with a permanent adipose removal and returned to the reservoir. The 1995 gill net sample revealed a depleted rainbow trout population at a collection density of 5.2 per net. Of the 27 rainbow captured in the gill nets, 25 exhibited the permanent adipose removal indicative of a fishery that was virtually composed of rainbow trout that had been artificially returned to the reservoir the prior fall. From 1996 through 1999, survival of stocked Eagle Lake rainbow was high and numbers increased markedly to 101.3 per net in 1999 although the 1999 sample was collected in fall under low storage conditions and is not directly comparable to the spring samples of all of the prior years.

Length range and mean length of rainbow trout in Ruby Reservoir (Figure 20) has varied little since stocking of wild strains of rainbow commenced in 1989. Maximal mean length and minimal length range occurred in 1995 in the aftermath of the dewatering event. Despite reestablishment efforts required to maintain a rainbow trout fishery in the reservoir following 1994, mean length remained relatively constant from 1996 through 1999 at approximately 13.0 to 13.5 inches. Length frequency analyses are provided for the 1994-1999 period in Figures 21-26.

Prior to the 1994 dewatering, Figure 21 depicts a relatively high density population skewed heavily toward Age I fish from the first plant of Eagle Lake rainbow. Following the dewatering event of 1994, the 1996-1999 period demonstrates strong recruitment of Age I and II fish into the population and the reestablishment of a population age structure by 1998 and 1999 (Figures 23-26). Despite high population numbers, the bulk of the 1998 and 1999 populations remained dependant on Age I and Age II recruits.

Brown Trout

Population trends for wild brown trout in Ruby Reservoir are presented in Figure 27 for the 1979-1999 period. Brown trout numbers remain well below those observed for rainbow trout and declined markedly during the low reservoir storage pools of the 1988-1992 period. Following the 1994 dewatering event, no brown trout were captured in 1995 or 1996 as was the case for mountain whitefish, another wild game species. Recovery of brown trout began with the 1997 sample although numbers remained low through 1999 when compared with the period prior to 1990. Relatively strong recruitment of juvenile brown trout was noted in the 1998 sample.

The length range and mean length of brown trout (Figure 28) has varied widely over the sample period, dependant upon the strength of recruitment classes. The 1997 and 1999 post dewatering samples resulted in the highest mean brown trout length observed and some of the largest fish collected.

Angler Use Trends

The estimated angling pressure for Ruby Reservoir is presented in Figure 29 for the 1984-1997 period. Ruby Reservoir has sustained angling use averaging about 2,000 angler days per year prior to the 1997 pressure estimate. In 1989, angler use declined to 636 angler days based on low storage pools and declining trout populations but, in 1993, pressure rose to 3,297 angler days with burgeoning populations of rainbow trout. The 1997 pressure estimate of 9,405 angler days represents nearly a threefold expansion of the prior observed high and is based on the success of the rainbow trout recovery following 1994.

In 1997, a weekend winter roving creel survey was initiated on Ruby Reservoir. The survey was initiated based on relatively heavy observed angler use of the expanding rainbow trout population. Winter catch rates for rainbow trout (Figure 30) have steadily increased from 1997 through 1999 and have been very high when compared with other southwest Montana reservoirs. As rainbow trout numbers and catch rates have steadily increased since 1996, the average size of the rainbow trout harvested has steadily declined (Table 3).

Table 3. Average size of Eagle Lake strain rainbow harvested in winter creel census of Ruby Reservoir, 1997 - 1999

YEAR	MEAN LENGTH	MEAN WEIGHT
1997-1998	15.8 inches	1.30 pounds
1998-1999	15.4 inches	1.22 pounds
1999-2000	14.6 inches	1.04 pounds

ELK LAKE

Yellowstone Cutthroat Trout

Elk Lake has received plants of McBride Lake strain Yellowstone cutthroat trout since 1986. Oswald (1993) reported on experimental usage and varying success of overwintered yearling fish versus young-of-the-year fish in Elk Lake. The annual alternation of Age I and young-of-the-year plants was abandoned in 1994 in favor of annual plants of overwintered yearling fish. The yearlings can be planted earlier and at a much larger average size than the young-of-the-year plants. Recent Elk Lake cutthroat plants are summarized in Table 4.

Table 4. Recent plants of McBride Lake Yellowstone strain cutthroat trout in Elk Lake.

YEAR	YEARLING NUMBER	YOY NUMBER
1993		250,000
1994	9,867	
1995	10,125	251,512
1996	10,100	
1997	12,699	
1998	16,333	
1999	15,753	

Numbers of Yellowstone cutthroat trout collected in gill nets over the 1981-1999 period are presented in Figure 31. Oswald (1993) discussed trends associated with the failure of recruitment of YOY plants as opposed to the success of overwintered yearling plants. The recent trend since overwintered yearlings were used on an annual basis has been an increase in number per net. While 1995-1997 samples averaged near 20 per net, the 1998 sample yielded 47.7 per net, the highest capture rate since large consecutive yearling plants were made in 1982 and 1983. The missing age classes which typified the Elk Lake cutthroat trout population from 1983-1995 (Figure 32) have been filled by consecutive plants of a survivable age and size. The 1998 sample revealed a minimum of four age classes. The missing Age II class in 1999 was due to cold ambient temperature regimes which resulted in Age II fish avoiding capture due to small size. Subsequent samples on June 30 revealed an average length of only 8.4 inches for the Age II fish. This missing year class contributed to the low collection density for cutthroat trout observed in 1999.

Arctic Grayling

The status of the Arctic grayling of Elk Lake was last reported by Oswald (1993). Trends in numbers of Arctic grayling collected through the 1981-1999 sampling period are depicted in Figure 33. Grayling numbers most frequently held at 10 to 12 per net through 1987. As drought conditions dominated the climate from 1985 through 1994, flows in Narrows Creek during the spawning season became sporadic or nonexistent. As a result of this lack of spawning habitat over a prolonged period, Arctic grayling numbers declined rapidly from 1989 through 1994. No grayling have been collected from 1995 through 1999 leading to the presumption that Arctic grayling have been eliminated from Elk Lake.

Lake Trout

The status of the Elk Lake lake trout population was last reported by Oswald (1993). Lake trout numbers appear relatively stable at low density (Figure 34) varying between about 0.8 and 1.6 per net since 1991 when sinking gill nets were incorporated into the sampling program to increase lake trout capture efficiency. This increased sampling efficiency has eliminated the extremely low collection rates, or absence of lake trout from the sample, which marked the 1984-1988 period. Analyses of mean length, length range, and composite length frequency over the 1991-1999 period (Figures 35 and 36) also demonstrate stability within the sample population. Mean length varied only slightly with length frequency analysis demonstrating that the majority of lake trout sampled range between 16.5 and 19.5 inches in length. The collection of juvenile fish was limited to the 1994 and 1998 samples limiting any speculation on recruitment into the population. In 1999, genetic samples were collected, preserved, and mailed to the USGS Great Lakes Science Center in Ann Arbor, Michigan for analysis. The purpose of this endeavor is to gain more insight into the native status of the Elk Lake lake trout population. Results of the genetic analysis will be forthcoming during the summer of 2000.

Burbot

The incorporation of sinking gill nets into the Elk lake sampling program in 1991 provided for the sampling of a second native glacial relict species, the burbot. The burbot population of Elk Lake has not been described in previous reports. Collection trends for Elk Lake burbot are presented in Figure 37. Collection rates have varied between 5.5 and 23.0 per net with no evidence of any dominating trends in burbot numbers in May samples. In 1999, additional genetic sampling of lake trout provided for burbot samples from overnight sets in late June and September. The June sample yielded a capture of 26.5 burbot per net and the September sample yielded 31.8 burbot per net, both samples exceeding the highest observed prior capture rate in May.

The length range and mean length for burbot in Elk Lake (Figure 38) suggest a relatively slow rate of growth and limited ultimate size for the species. Low mean lengths observed in 1993 and 1998 were associated with relatively high burbot collection densities (Figure 37) and suggested relatively strong recruitment into the population. A composite length frequency analysis (Figure 39) indicates a pronounced age structure within the population which was not apparent in the lower density lake trout.

HIDDEN LAKE

Hidden Lake has been managed as a wild rainbow trout fishery since limited plants were introduced in the mid 1930's and 1940's. Trends in wild rainbow trout populations were last reported by Oswald (1993). Recent trends in Hidden Lake rainbow trout populations (Figure 40) reflect increasing rainbow trout numbers from a relatively strong and stable population base. The high per net densities observed in 1997 and 1998 were accompanied by evidence of strong recruitment of Age II fish into populations that maintained strong bases of Age III and Age IV fish. The slight population decline suggested in the 1999 sample was primarily due to lower numbers of Age II and Age III fish in the sample. Length range and mean length of the rainbow trout collected (Figure 41) has demonstrated a highly stable population structure throughout the sample period. Length frequency analysis (Figure 42) for the 1993-1999 period depicts the age structure of the population and demonstrates a sample population dominated by mature, Age IV and older, fish.

CULVER POND

The wild brook trout populations of Culver Pond were last described by Oswald (1993) and the system was last sampled by Montana Fish, Wildlife and Parks in 1997. Recent trends in brook trout numbers (Figure 43) are descriptive of a declining population. While brook trout numbers remained relatively abundant at 19 per net in 1997, brook trout numbers often exceeded 30 per net to an observed high of 60 per net in past samples. Recent declines in brook trout numbers were associated with winter pond drawdowns (Oswald1993). Subsequent samples from Culver Pond have been collected by U.S. Fish and Wildlife Service personnel (Boltz 2000).

MCDONALD POND

The rainbow trout populations of McDonald Pond were last described by Oswald (1993) and were last sampled by Montana Fish, Wildlife and Parks in 1997. Numbers of rainbow trout collected in experimental gill nets are depicted in Figure 44. Rainbow trout numbers declined markedly between 1985 and 1988 triggering a plant of Eagle Lake strain rainbow in 1988. Following this plant, rainbow trout numbers increased markedly and Oswald (1993) documented the presence of wild recruitment of Ages I, II, and III fish into the population by 1992. Subsequent winter pond drawdowns resulted in a rapid decline in rainbow trout numbers with the result that no rainbow trout were collected in the 1994 and 1997 samples and only one Age I fish composed the 1996 sample. Rainbow trout redd counts conducted in Elk Springs Creek since 1987 revealed no observable redds in 1996 and 1997. Subsequent samples from McDonald Pond have been collected by U.S. Fish and Wildlife Service personnel (Boltz 2000).

TWIN LAKES

The fish populations of Twin Lakes have been sampled sporadically since 1964 and were last reported by Oswald (1993). In the interest of better determining the native genetic status of the lake trout of Twin Lakes, an intensive sampling effort was conducted in 1998 (Oswald and Roberts 1998) resulting in the setting of 20 overnight experimental gill nets between July 17 and October 8, 1998. The 1998 sampling effort resulted in a clearer description of the fish populations of Twin Lakes than had previously existed. The percent composition and catch-per-unit-effort, or relative abundance, for six species of fish collected in Twin Lakes are presented in Figures 45 and 46. Species collected in the samples included the native lake trout, westslope cutthroat trout, burbot, and longnose sucker and nonnative species including brook, rainbow, and Yellowstone cutthroat trout. The fish population composition of Twin Lakes was dominated by the introduced brook trout followed by the native burbot and longnose sucker. The native lake trout composed only 4.7% of the catch while the rainbow and cutthroat trout, both of which have been actively planted in the lake, composed only 0.8 and 3.9% of the sample, respectively. Numbers of fish captured per net were relatively low for all six species with the dominant brook trout averaging 7.25 per net. The lake trout catch rate of 0.6 per net was comparable to the catch per overnight gill net in Elk Lake but the burbot catch of 2.9 per net was far less than that of Elk Lake.

Lake Trout

The lake trout population of Twin Lakes has been sampled sporadically since 1964 and were last included in a report by Oswald (1993) and Oswald and Roberts (1998). Trends in lake trout numbers over the 1964-1998 period are presented in Figure 47. Prior to 1998, lake trout numbers varied between 1.0 and 5.0 per net. The highest capture rates were noted in the 1964, 1986 and 1990 samples. Intensive sampling in 1998 revealed a capture rate of 0.6 per net. The length frequency distribution of fish collected in the 1998 sampling program(Figure 48) reveals the presence of only two age classes of fish. The juvenile year class was composed of fish in the 12.0-13.9 inch length range while the mature age group consisted entirely of fish in excess of 30 inches in length. The disparate size classes indicative of sporadic success in lake trout recruitment was also observed in the 1964 and 1986 samples. In contrast with Elk Lake, the length range and mean length of the lake trout from Twin Lakes samples has varied widely over the sample period (Oswald 1993).

Burbot

While the native burbot of Twin Lakes were included in the sampling program since 1964, their status was not reported in prior documents. Trends in the numbers of burbot collected over the 1964-1998 period are presented in Figure 49. The highest capture rates for burbot were observed in 1970 and 1998 at 3.5 and 2.9 per net. Capture rates for burbot in Twin Lakes were generally similar to those observed for lake trout. In comparison with lake trout collection rates (Figure 48), burbot reached their highest abundance in 1970 and 1998 when lake trout collection rates were low and lake trout reached their highest abundance in 1964, 1986, and 1990 when burbot density appeared low. In contrast with the lake trout, length frequency analysis for the burbot captured in 1998 (Figure 50) depicts a relatively complete age structure and distribution of distinct age classes.

Brook Trout

Brook trout populations in Twin Lakes were last described by Oswald (1993) and Oswald and Roberts (1998). While brook trout have been the most abundant species in most of the Twin Lakes samples (Figure 51) their numbers per net have generally been less than ten. The general sampling trend has suggested declining population abundance since 1978 although the more intensive sampling of 1998 revealed a collection rate of 7.25 per net. Brook trout have not been stocked in the lake but pioneered the system via Big Lake Creek, therefore, higher collection densities between 1964 and 1978 are not a product of active management. Brook trout length frequency analysis from the 1998 sample does not clearly define age classes beyond Age II and is probably associated with a low rate of growth due to elevation and productivity.

Rainbow and Cutthroat Trout

Low densities of rainbow or cutthroat trout in Twin Lakes samples precluded prior reporting on these species. Oswald and Roberts (1998) included these species in their analysis due to active stocking programs for both species. Rainbow trout were stocked into Twin Lakes on an annual basis from 1940 through 1963. Only one plant of cutthroat trout occurred in 1934, however, plants of 3,000 young-of-the-year McBride Yellowstone cutthroat trout commenced in 1994 on a four year rotation. Cutthroat trout plants were added in 1994 to provide additional angler opportunity and a more pelagic component for lake trout forage. The trends for rainbow trout and cutthroat trout collections are presented in Figure 53. Rainbow trout numbers have remained low throughout the entire sampling period. Despite long term efforts to establish the species through annual stocking and despite ample spawning habitat in both inlet and outlet streams, rainbow trout were only collected at rates of 1.0 and 1.5 per net in the 1964 and 1970 samples. No rainbow trout appeared in the 1978-1992 samples while the intensive effort of 1998 revealed only two rainbow trout representing a collection rate of 0.1 per net. Cutthroat trout did not appear in any of the Twin Lakes samples prior to 1998. In 1998 cutthroat trout were collected at a rate of 0.5 per net. By the time of the 1998 sampling effort, only one plant of McBride Yellowstone cutthroat trout had been made into Twin Lakes in 1994 with the second plant occurring in 1998. The sample revealed three distinct age classes of cutthroat based on length distributions of 7.3-9.3 inches, 12.7-13.1 inches, and 15.5-17.2 inches. This distribution was indicative of recruitment beyond that provided by stocking. Additional sampling would be required to determine if the cutthroat trout recruits were generated from stocked survivors or from residual wild cutthroat trout stocks within the system.

DISCUSSION

CLARK CANYON RESERVOIR

Minimum storage pools in Clark Canyon Reservoir recovered markedly from the 1985 - 1994 drought period generally exceeding 140,000 acre feet of storage representing surface areas of 4,000 to 5,000 acres. Oswald (1993) generated relationships linking poor rainbow trout plant survival and poor rainbow and brown trout condition factors to limited reservoir surface acreage at low storage pools. Oswald further suggested that 3,000 surface acres was an adequate minimum to provide sufficient production to insure good rainbow trout plant survival and good adult trout condition. Storage pools over the 1995-1999 period were abundant and far exceeded this minimum.

Total rainbow trout numbers have recovered significantly since the low storage pools which marked the 1989-1992 period. Rainbow trout numbers rebounded to average 10.0 per net during the 1992-1994 period and became relatively stable to average 12.2 per net during the 1995-1999 period. This most recent average is indicative of a near threefold improvement in rainbow trout density over the era in which the reservoir was managed with the domestic Arlee strain and a twofold improvement over conditions of low storage pools in the 1989-1991 period.

Stocks of the domestic Arlee strain and wild DeSmet and Eagle Lake strains were evaluated in Clark Canyon Reservoir over the 1980-1993 period (Oswald 1993). Plants since 1991 have been composed entirely of the wild Eagle Lake strain of rainbow trout which has performed in a manner comparable to the DeSmet. Plants have continued to be composed of young-of-the-year fish but planting dates have been advanced to early June to take advantage of the exponential growth phase of the cladoceran zooplankton community and favorable surface temperatures (Berg 1974). Plants have also been dispersed by boat to mitigate predation and more rapidly expand habitat niche availability.

Despite ample storage pools and modified stocking protocol, survival of planted fish to Age I has been relatively low or moderate for 1996-1999 period. High plant recruitment was noted in 1992, 1993, and 1995 following declining rainbow populations in the 1989-1991 period. While plant recruitment to Age I has recently been limited, total rainbow trout numbers and total numbers of large fish greater than 4.0 pounds in weight have been high. In the substantial majority of years from 1980 through 1995, Age I rainbow trout composed 50% or more of the rainbow trout sample population. The percentage of Age II and older fish averaged 74.7% of the rainbow trout sample population over the 1996-1999 period. Moreover, recent samples have exhibited some of the highest collection densities of wild brown trout observed over the sampling history of the reservoir. The data strongly suggest that ample storage pools have provided for an immediate recovery of plant survival and rainbow trout condition, however, large numbers of older, larger fish may be limiting plant survival and recruitment in recent years through competition and predation.

Rainbow trout spawning runs have been monitored in the Red Rock River since management strategies shifted to the use of wild strain DeSmet and Eagle Lake stocks. Oswald (1993) last described the composition of DeSmet strain spawning migrations. Efforts to install and operate a permanent upstream migration trap were successful in 1995 but high spring flow regimes in 1996 rendered the trap ineffective and its use was discontinued in 1997 after efforts to operate the trap were again frustrated by high flows. The spawning runs of 1994, 1995 and 1998 were relatively strong while the spawning runs of 1997 and 1999 were somewhat limited by cold ambient thermal regimes. Multiple electrofishing runs in 1999 resulted in a very high incidence of recapture of fish participating in the run and were marked by water temperatures that never attained the 50°F mark. Modal length frequency and numbers of fish greater than four pounds in weight advanced substantially over the 1997-1999 spawning runs demonstrating increased numbers of larger, mature rainbow trout at ample reservoir storage. The monitoring of the spawning migrations has also incorporated an Eagle Lake strain egg collection since 1995. The Clark Canyon Eagle Lake rainbow trout population has become an effective wild brood source to provide fertilized eggs for rearing as overwintered yearlings for plants in other reservoirs. The Clark Canyon source has provided 300,000 to 500,000 fertilized Eagle Lake strain eggs annually for this purpose since the program was incorporated.

Angler use of Clark Canyon Reservoir has increased substantially of the recent past. While pressure has increased substantially, plants into Clark Canyon have remained relatively constant and numbers of rainbow trout have stabilized at approximately 12 fish per net with recent years dominated by older large fish. Angler success, as measured via winter creel census has remained relatively constant also, however, an increasing amount of angler dissatisfaction has been expressed during creel census sampling. While anglers have been satisfied with the large average size of fish in the catch, most of the dissatisfaction has revolved around lower numbers of Age I and Age II fish which tend to increase the catch rate of the average angler. In order to increase plant survival with burgeoning populations of large rainbow trout and increased numbers of brown trout, it might be advantageous to incorporate an additional plant of overwintered yearling Eagle Lake strain rainbow into the current management program. This would provide some increase in survival advantage and utilize some of the progeny of the Red Rock egg collection in the natal system while providing a means of compensating for increases in pressure.

Recent abundant populations of wild brow trout exceeded former collection highs observed shortly after Clark Canyon was impounded in 1964. The brown trout population dropped to observed lows over the drought influenced 1988-1994 period but recovered significantly during the abundant flow years of 1995-1999. High numbers of rainbow trout combined with record high numbers of brown trout have resulted in the highest observed trout populations in the history of the reservoir.

RUBY RESERVOIR

The rainbow trout populations of Ruby Reservoir increased markedly through 1994 under management with multiple wild strains of rainbow trout following rapid population declines in the late 1980's (Oswald 1993). In September of 1994, Ruby Reservoir was completely dewatered resulting in a large fish kill in the reservoir and the downstream Ruby River. This event precipitated the formation of a Governor's Ruby River Task Force in 1995 which established a minimum reservoir pool and fisheries target pools (RRTF Final Report 1995). Since the inception of this pool management program, reservoir storage pools have remained relatively ample and plants of Eagle Lake rainbow from 1995 through 1998 have flourished resulting in record high rainbow trout populations observed in 1997, 1998, and 1999. Wild brown trout populations have also recovered although the brown trout did not appear in samples until 1997 at extremely large size. The reservoir was essentially under populated for the 1995 and 1996 plants and growth of stocked Eagle Lake Rainbow trout to Age I and Age II was exceptional. Growth in 1998 and 1999 declined somewhat under burgeoning populations and a lower storage pool in 1999.

Under recent high rainbow trout populations, angler use of Ruby Reservoir has increased dramatically. While angling pressure has soared, rainbow trout populations have remained very high and winter creel catch rates have been extremely high. Recent samples have shown a slight decline in numbers of older, larger fish and the average size of fish in the harvest has declined. This suggested that heavy angler use is having a slight influence on the size and age structure of the population. Numbers of Age I and Age II fish remain high, however, indicating that the plant of approximately 50,000 young-of-the-year rainbow trout is sufficient to stock the reservoir and satisfy angler needs.

ELK LAKE

Oswald (1993) evaluated the use of young-of-the-year versus overwintered yearling plants of McBride Yellowstone strain cutthroat trout in Elk Lake. This evaluation showed that vastly increased numbers of young-of-the-year fish did not result in increased survival to Age II while limited numbers of yearling plants could result in high survival to Age II. Since 1994, consistent plants of overwintered yearlings has resulted in greater stability within the Elk Lake cutthroat trout fishery in terms of age and size structure. Limits in size of young-of-the-year fish, productivity of the lake, and annual cycles in thermal regime and zooplankton abundance, as well as predation factors probably limit the use of young-of-the-year plants in Elk Lake. Angler use in Elk Lake has declined somewhat in the recent past. During the 1980's angler use averaged 2,468 angler days per year over four sample years from 1983-1989. During the 1990's, angler use declined to average 1,174 angler days per year over four sample years between 1991 and 1997. This decline in use is similar to that observed on nearby Hidden Lake and could be related to the remote location of these lakes.

Data suggest that the Arctic grayling population of Elk Lake has undergone extinction due to lack of spawning flows in extremely limited spawning habitats over a prolonged period of drought. While the presence of native lake trout and burbot in Elk Lake and the proximity of a native adfluvial grayling population in nearby Red Rock Lake strongly suggest that grayling were native to the system, subsequent plants probably were responsible for the maintenance of the most recent grayling population. Attempts are currently being made to form a viable brood stock of adfluvial lacustrine Arctic grayling by using Red Rock Lake as the source. After the brood stock is mature, it should be used a source to refound an Elk Lake arctic grayling population and return this glacial relict species to the fishery.

The lake trout of Elk Lake have long been accepted as representing a native population. Recent examination of the literature and genetic analysis lend credence to this assumption. Vincent (1963) cited numerous authors from the late 1800's which described collections of native lake trout from Elk Lake prior to 1890 when the species was first brought to the intermountain west for introduction. He also referenced a type collection of three lake trout sent to the U.S. National Museum listing Elk Lake as the specimen locality. He concluded that the lake trout of Elk Lake were a glacial relict population and native in origin. Khan and Quadri (1971) in a meristic and morphological examination of lake trout from across its range of distribution determined that the lake trout of Elk and Twin Lakes represented a glacial refuge population in the upper Missouri River drainage. Genetic examination of lake trout collected from Twin Lakes in 1994 led Wilson and Hebert (1998) to conclude that the fish were of a distinct haplotype and represent a glacial relict native population. More recent genetic examination of 14 fish from Elk Lake and 14 fish from Twin Lakes led to agreement with Wilson and Hebert's findings and the conclusion that the lake trout populations of both lakes represent native populations of the same glacial origin (M. B. Curtis, USGS, Personal Communication 2000). Examinations of mitochondrial DNA by Curtis also suggest that low variation is associated with a genetic "bottleneck" caused and maintained by low populations of breeding individuals in both lakes. This is certainly substantiated by lake trout collection densities in Elk Lake and also by age and size structure of the sample population. This unique native population of lake trout has been managed under a restrictive two fish bag limit but data suggest a need for increased protection, most probably under catch and release angling regulations.

The burbot of Elk Lake represent another unique native species occupying a habitat niche somewhat similar to the lake trout. While sampling of burbot through the use of sinking gill nets began in 1991, data on the species had not been included in prior reports. Collection densities of burbot far exceed those observed for lake trout, the other deep water native piscivore in the system, and appear to trend upward or downward with the strength of recruitment classes. Length frequency analysis are indicative of a relatively slow growth rate for the species compared with lower elevation reservoirs in southwest Montana. Limits on ultimate size of the burbot in Elk Lake probably preclude the value of the species in the sport fishery, particularly when compared with the more popular and abundant cutthroat trout.

HIDDEN LAKE

Oswald (1993) reported on the extremely stable nature of the wild Hidden Lake rainbow trout population. Sampling conducted from 1993-1999 exhibited a continuation of this stability with ample numbers of mature, larger fish dominating populations and sufficient recruitment maintaining and abundant population. Oswald (1993) noted a reported decline in angling pressure on Hidden Lake in the 1989 and 1991 Pressure Estimates. This trend has continued over the 1993-1997 period with annual angling pressure averaging approximately 550 angler days per year over the period. The data strongly suggest that this decline in use is not associated with the abundance of the rainbow trout population but could be associated with the remote location of the lake and the limited angling season. Under current regulations, Hidden Lake is open to fishing from the third Saturday in June through November 30 while most lakes and reservoirs are open for angling the entire year The Hidden Lake decline in pressure is similar to that observed for nearby Elk Lake

The rainbow trout of Hidden Lake construct redds and actively spawn along shorelines and windswept shoreline points Spawning habitat in the small inlet stream from spring origins is extremely limited and few fish are observed using the stream for spawning The lake also does not have an outlet stream It therefore appears doubtful that the abundant rainbow trout population of Hidden Lake could originate from this limited stream spawning resource. The data and spawning observations suggest that the rainbow trout of Hidden Lake, and the Hidden Lake habitat represent unique resources which have resulted in a successful lacustrine rainbow trout population, that is, a population capable of spawning and reproducing in a lake. Additional research should be conducted to determine if the Hidden Lake rainbow trout do successfully spawn, incubate and hatch eggs in a lacustrine environment. This would elevate the status of the population as an important brood source for lakes with characteristics similar to Hidden Lake.

CULVER AND MCDONALD PONDS

Culver and McDonald Ponds, both located on the Red Rock Lakes National Wildlife Refuge, have been managed as trophy fisheries for brook and rainbow trout in the recent past. Oswald (1993) evaluated the effect of special regulations on both ponds and the effect of stock improvement via the introduction of Eagle Lake strain rainbow trout into McDonald Pond in 1988. Management strategies on McDonald Pond also called for removal of spawning barriers in Elk Springs Creek (Oswald 1986, 1989). Beginning in 1989, the ponds were subject to overwinter drawn downs to trigger trumpeter swan migration from traditional feeding sites. This program was intensified in 1992 and continued for several years thereafter. Peterson (1973) and Oswald (1993) related pond drawdowns to decreased carrying capacity and population abundance for the brook trout of Culver Pond and the rainbow trout of McDonald Pond. Declines in brook trout populations in Culver Pond and the virtual elimination of a rainbow trout sport fishery from McDonald Pond corroborate these findings

Recent U S Fish and Wildlife Service plans for the Refuge have included establishment of native species in at least two of the Ponds In 1999, Mc Donald Pond was drawn down to a minimum pool and gill nets and electrofishing methods were used to capture and remove nonnative species (Boltz 1999) Sampling of McDonald pond resulted in a total removal of 21 rainbow trout, 6 brook trout, and 1 cutthroat trout. Brook trout had not been encountered in Mc Donald Pond over the 21 year sampling period through 1997. Upon elimination of competing introduced species, USFWS plans to introduce native Red Rock Lake Arctic grayling into the pond via the placement of fertilized eggs into streamside incubators on Elk Springs Creek. Similar analysis for native species reintroduction is being conducted on Widgeon Pond.

It is doubtful that Culver Pond has any practical functionality for native species recovery in its current form. The pond is supplied with water from large springs located at its upper end and discharges from a man made dam. It lacks any form of inlet or outlet stream channel in which Arctic grayling or westslope cutthroat trout could spawn and successfully reproduce. The large nonnative brook trout of Culver Pond have been able to successfully spawn in the upwelling springs and maintain a self sustaining population in the available habitat. They are probably the best species for fisheries management in Culver Pond unless a substantial inlet stream can be artificially constructed and maintained.

TWIN LAKES

Twin Lakes has long been managed through the stocking of salmonid species due to its accessibility, developed campgrounds and boat ramps, and scenic alpine setting. Unsuccessful plants to establish Arctic grayling were attempted between 1928 and 1939. Single plants of cutthroat trout was made in 1934, 1994, and 1998 and rainbow trout were stocked annually from 1940 through 1963 with marginal success for either species. Despite this intensive management effort, Twin lakes remains sparsely populated with six species of fish, the least abundant of which are the rainbow and cutthroat trout. Oswald and Roberts (1998) noted limits in productivity based on very low dissolved chemical components and high elevation. The sport fishery is dominated by relatively low numbers of nonnative brook trout which pioneered the lake via Big Lake Creek. The native species composition includes lake trout, burbot, and longnose sucker. Oswald and Roberts (1998) suggested that the longnose sucker, primarily a fluvial species, occupied the lake during a short duration as part of a migration in Big Lake Creek and noted that the fish were large, mature individuals.

The lake trout of Twin Lakes have long been accepted as representing a native population Recent examination of the literature and genetic analysis lend credence to this assumption. Vincent (1963) cited naturalist's reports from the late 1800's which described visits to Twin Lakes and reference to native lake trout prior to 1890 when the species was first brought to the intermountain west for introduction. He concluded that the lake trout of Twin Lakes were a glacial relict population and native in origin. Khan and Quadri (1971) in a meristic and morphological examination of lake trout from across its range of distribution determined that the lake trout of Elk and Twin Lakes represented a glacial refuge population in the upper Missouri River drainage. Genetic examination of lake trout collected from Twin Lakes in 1994 led Wilson and Hebert (1998) to conclude that the fish were of a distinct haplotype represent a glacial relict native population. More recent genetic examination of 14 fish from Elk Lake and 14 fish from Twin Lakes led to agreement with Wilson and Hebert's findings and the conclusion that the lake trout populations of both lakes represent native populations of the same glacial origen (M. B. Curtis, USGS, Personal Communication 2000). Examinations of mitochondrial DNA by Curtis also suggest that low variation is associated with a genetic "bottleneck" caused and maintained by low populations of breeding individuals in both lakes. This is certainly substantiated by lake trout collection densities in Twin Lakes and also by age and size structure of the sample population. Sampling data collected over the 1964-1998 period are suggestive of extremely sporadic recruitment success and no typical lake trout spawning habitat in the form of large rock or rubble reefs can be readily observed in the lake. Length range, mean length, and length frequency distribution of lake trout in Twin Lakes are extremely variable when compared with the Elk Lake lake trout population. The data further suggest that lake trout sample density has been maximized when brook trout and burbot numbers were at their observed low sample densities. Limited lake productivity and short growing season length could enhance predatory affects in the Twin Lakes system This unique native population of lake trout has been managed under a restrictive two fish bag limit but data suggest a need for increased protection, most probably under immediate implementation of catch and release angling regulations. Additional management plans under consideration for the lake include construction of a low head dam between the two lake basins to increase storage capacity of the upper lake basin. This stored water would be used to augment late summer and early fall flows in the Big Hole River to improve Arctic grayling habitat during drought conditions. The affects of artificially raising and lowering the lake pool and of fragmenting the two lake basins on the native lake trout are currently unknown and merit intensive study. Additional study of the lake trout population should also include investigations on the feasibility of improving spawning and rearing habitat and the relationships with brook trout populations.

The native burbot of Twin Lakes have been collected at low sample densities when compared with Elk Lake but the population appears relatively stable over the sampling period. As is the case with the lake trout, no typical burbot spawning habitat can be readily observed in Twin Lakes but in contrast with the lake trout, length frequency analysis for the burbot is indicative of a normal age structure and regular recruitment. Burbot numbers have been maximized when lake trout numbers have been lowest over the sample period. As is the case in Elk Lake, limited productivity and elevation preclude sufficient ultimate size for the Twin Lakes burbot to be considered a viable component of the sport fishery.

The introduced brook trout was the dominant salmonid game fish in the Twin Lakes samples and provides the vast majority of sport fishing opportunity in the lake. Within the productive limits of Twin Lakes, the brook trout probably represents a significant portion of the lake's fish biomass and probably represents a significant predator and competitor within the system. Unlike the native lake trout, the brook trout can utilize spawning and rearing habitats in the inlet or outlet reaches of Big Lake Creek and the stream can act as a constant source to stock Twin Lakes with the species. Additional study should investigate the relationships between brook trout and native lake trout and burbot in the system.

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All Work Included in this Report in Conjunction with Federal Aid in Fish and Wildlife Restoration Acts:
Project Numbers: F-78-R-1; F-78-R-2; F-78-R-3; F-78-R-4; and F-78-R-5

Montana Fish, Wildlife & Parks Project Number 3304

APPENDIX OF FIGURES

Figure 1. End of irrigation season (fall) storage in Clark Canyon Reservoir, 1987 - 1999.

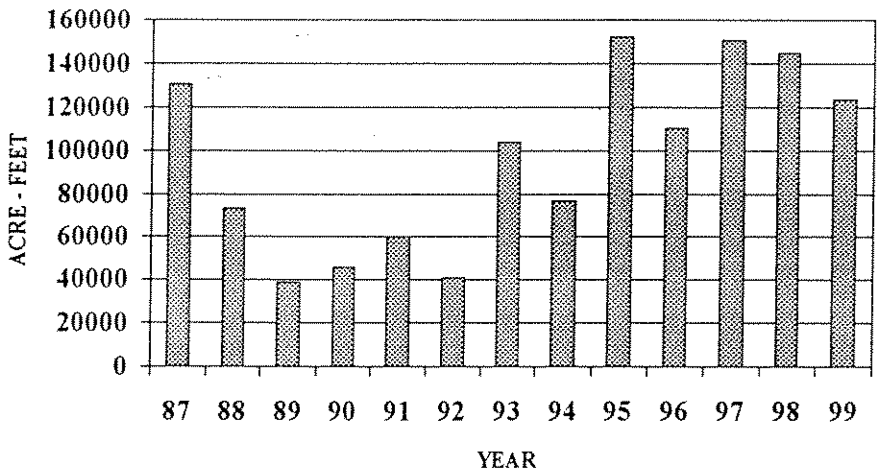

Figure 2. Mean number of rainbow trout collected per floating experimental gill net set overnight in Clark Canyon Reservoir, 1980 - 1999.

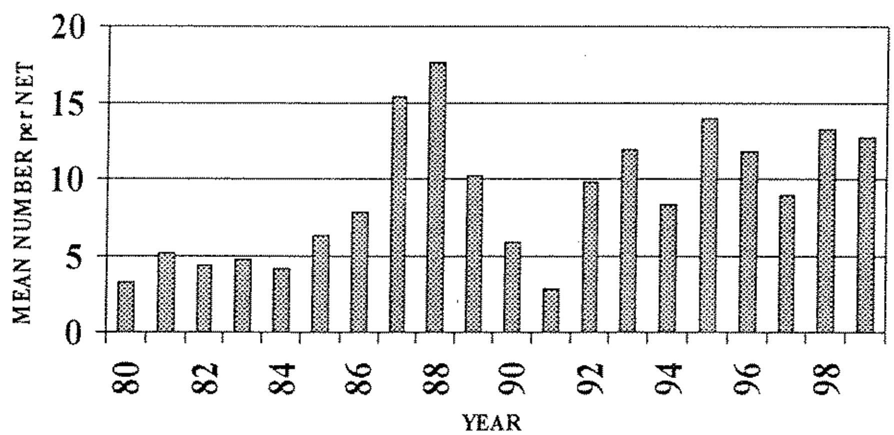

Figure 3. Mean number of Age I rainbow trout collected per floating experimental gill net set overnight in Clark Canyon Reservoir, 1980 - 1999.

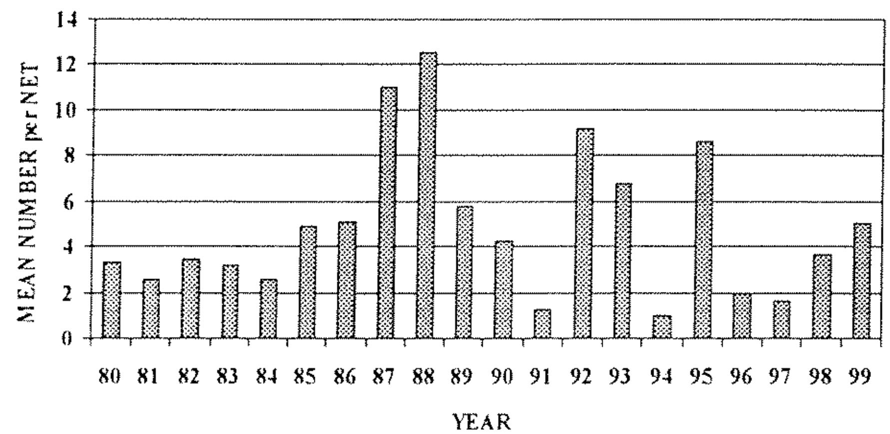

Figure 4. Mean numbers of spawning rainbow trout from Clark Canyon Reservoir captured per electrofishing run in the Roe Section of the Red Rock River, 1994 - 1999.

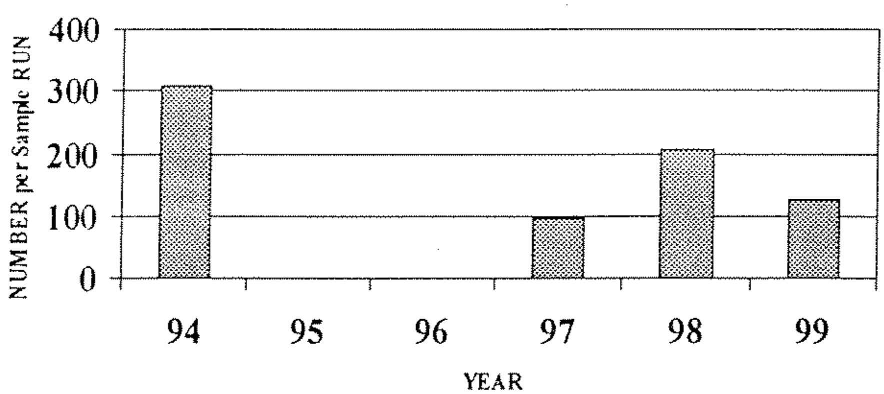

Figure 5. Daily capture rate of spawning rainbow trout from Clark Canyon Reservoir captured at the fish trap in the Roe Section of the Red Rock River, Mar. 22 - Apr. 17, 1995.

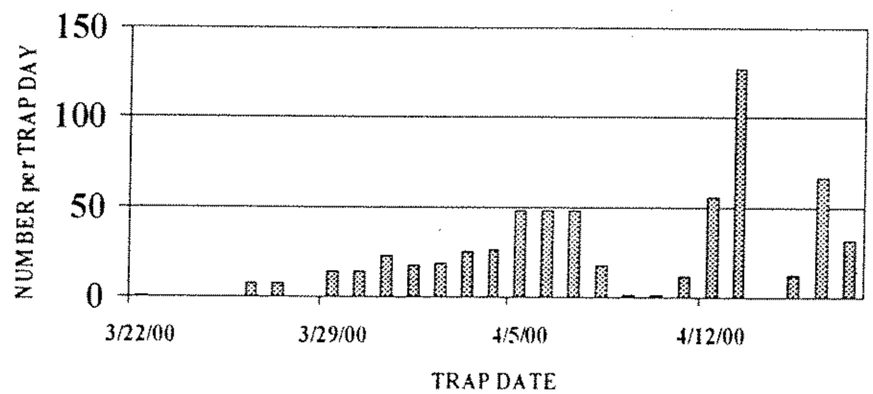

Figure 6. Mean rate of recapture (mark/capture) of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1994 - 1999.

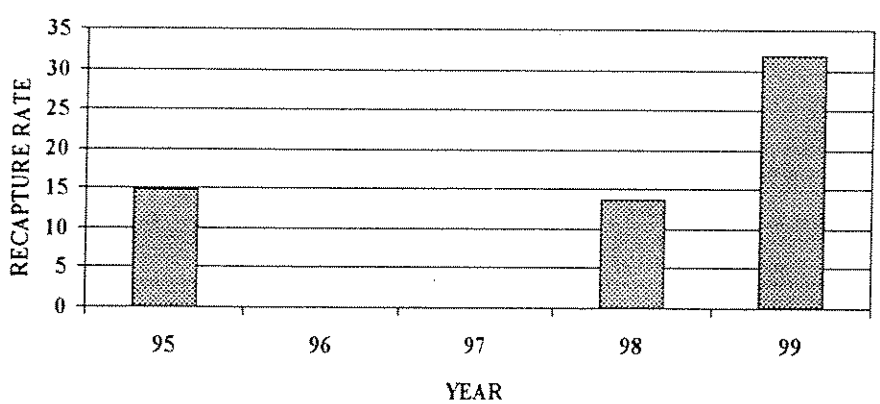

Figure 7. Length frequency distribution of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1994. (N=614)

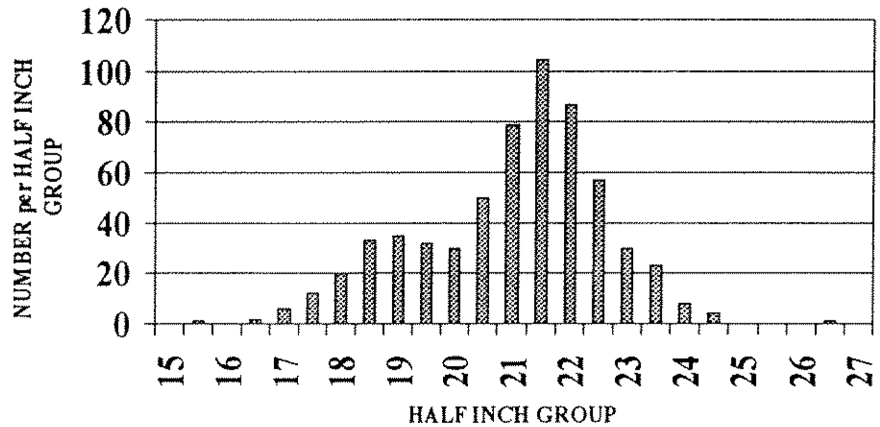

Figure 8. Length frequency distribution of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1995. (N=595)

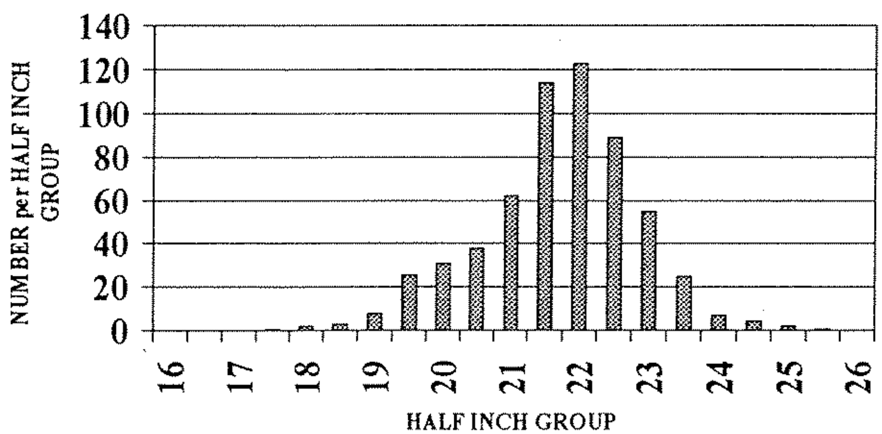

Figure 9. Length frequency distribution of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1997. (N=391)

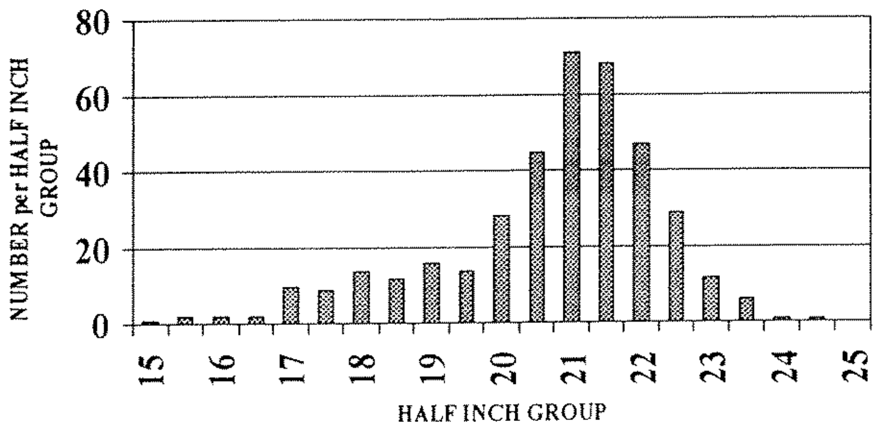

Figure 10. Length frequency distribution of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1998. (N=444)

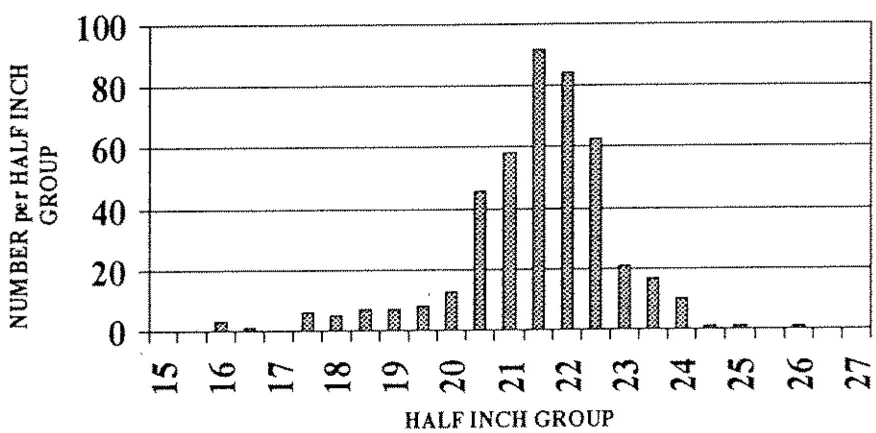

Figure 11. Length frequency distribution of spawning rainbow trout from Clark Canyon Reservoir captured in the Roe Section of the Red Rock River, 1999. (N=581)

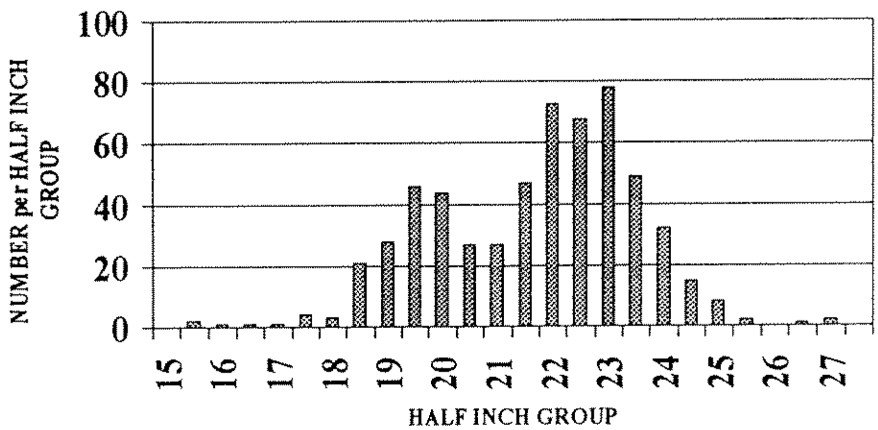

Figure 12. Weight distribution of 4.00 pound and larger spawning rainbow trout from Clark Canyon Reservoir collected in the Roe Section of the Red Rock River, 1994 - 1999.

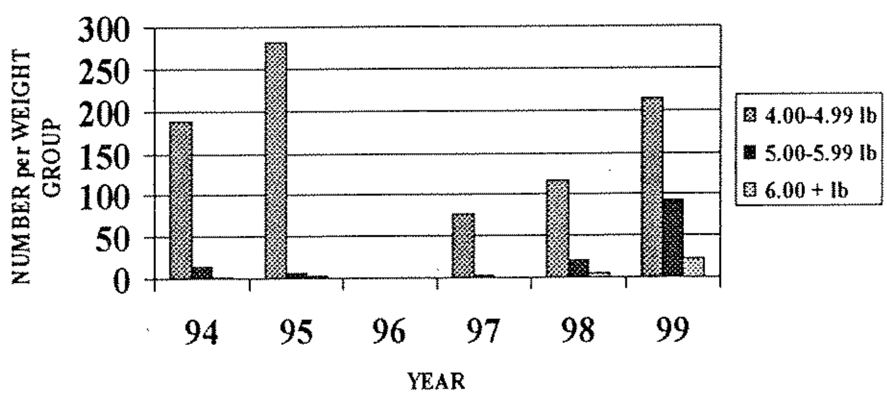

Figure 13. Mean number of brown trout collected per floating experimental gill net set overnight in Clark Canyon Reservoir, 1966 - 1999.

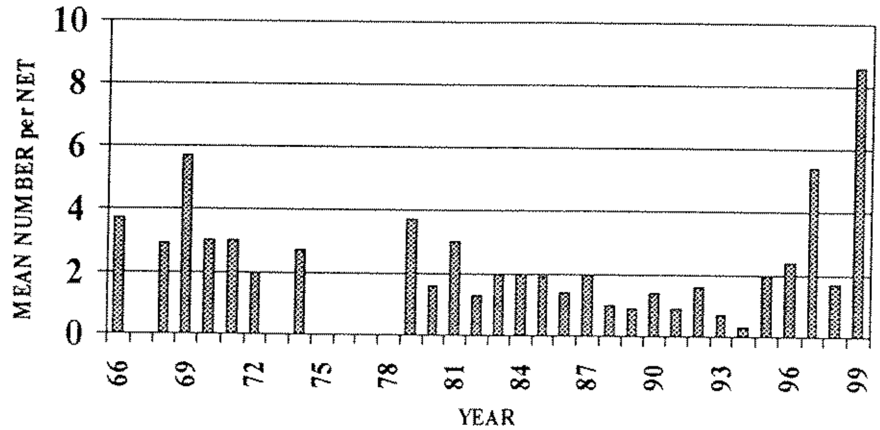

Figure 14. Estimated angling pressure (Angler - Days per Year) for Clark Canyon Reservoir 1983 - 1997.

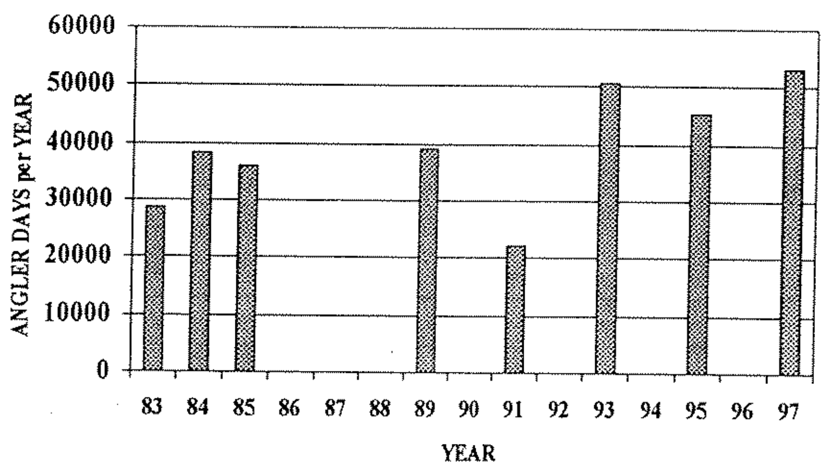

Figure 15. Estimated resident and nonresident angling pressure (Angler - Days per Year) for Clark Canyon Reservoir, 1983 - 1997.

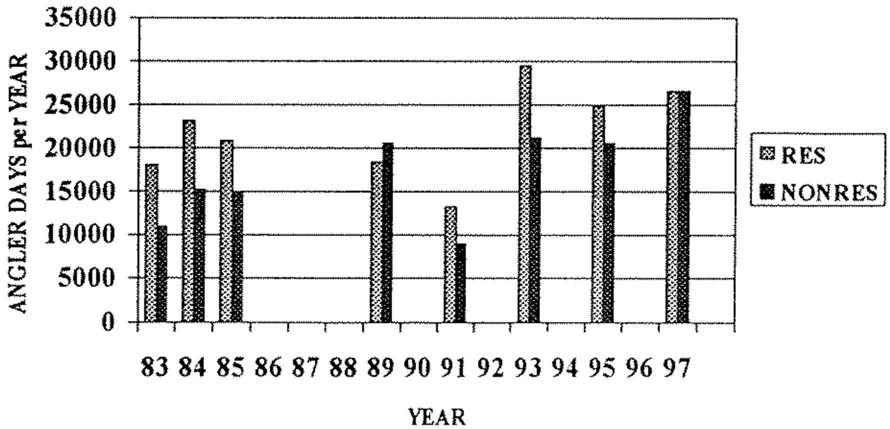

Figure 16. Winter creel catch rates for rainbow trout in Clark Canyon Reservoir, 1989 - 1999.

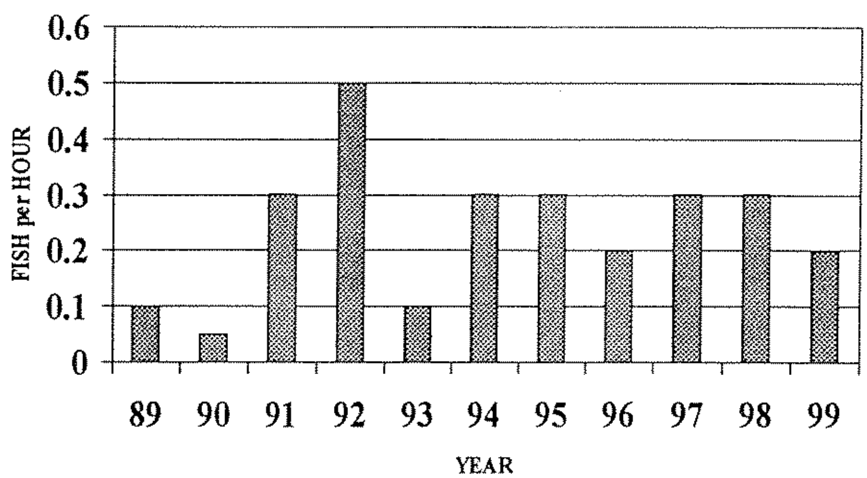

Figure 17. Winter creel catch rates for brown trout in Clark Canyon Reservoir, 1989 - 1999.

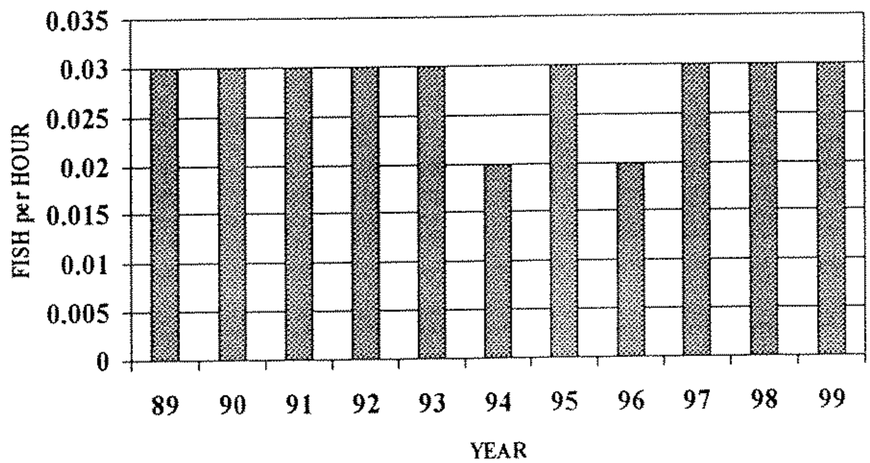

Figure 18. End of irrigation season (fall) storage in Ruby Reservoir, 1986 - 1999.

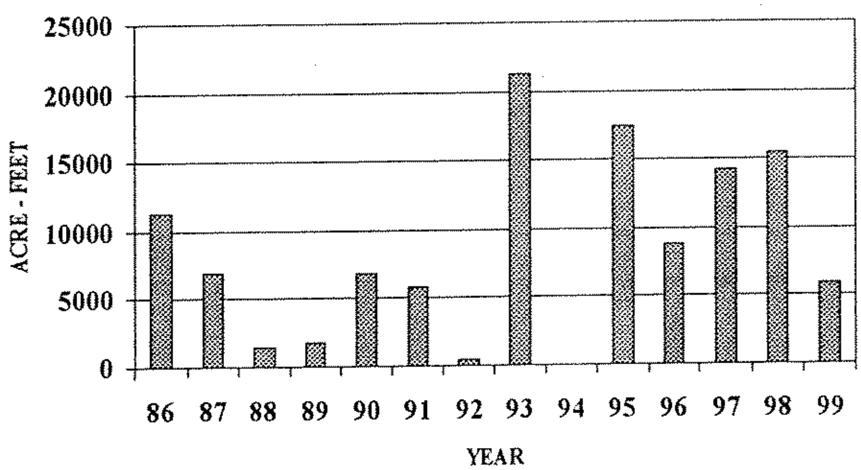

Figure 19. Mean number of rainbow trout collected per floating experimental gill net set overnight in Ruby Reservoir, 1979 - 1999.

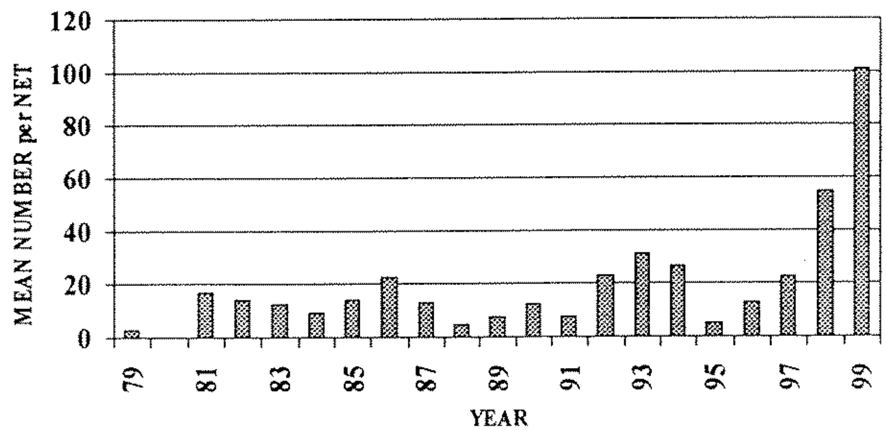

Figure 20. Length range and mean length of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1990 - 1999.

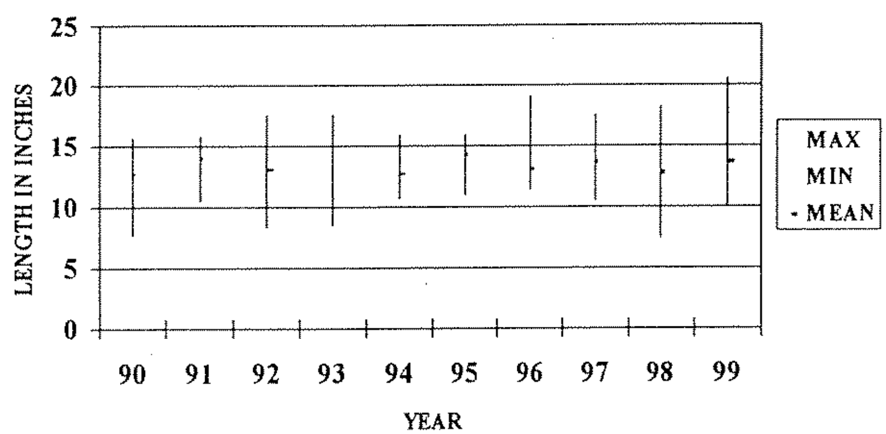

Figure 21. Length frequency distribution of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1994. (N=131)

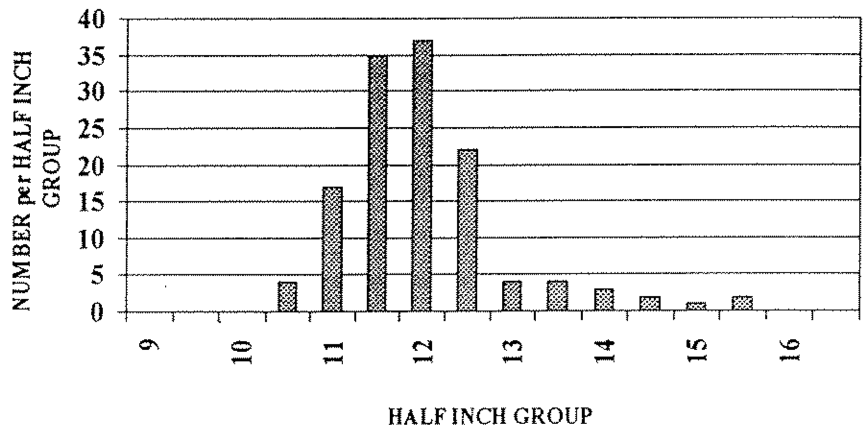

Figure 22. Length frequency distribution of rainbow trout collected in experimental floating gill nets set overnight in Ruby Reservoir, 1995. (N=27)

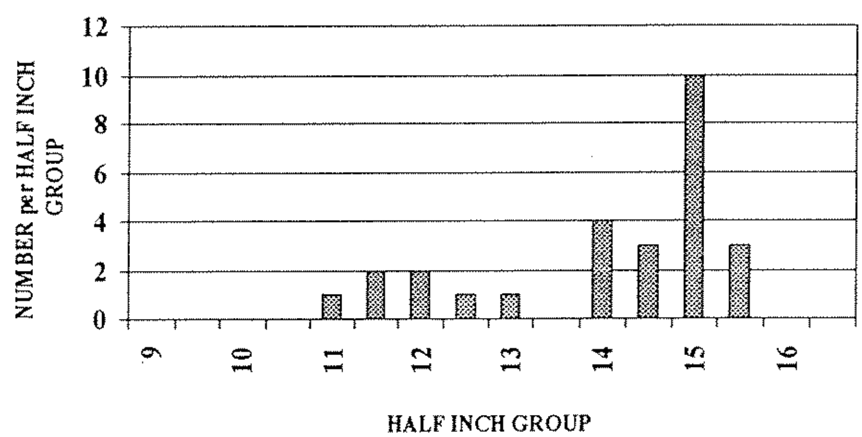

Figure 23. Length frequency distribution of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1996. (N=64)

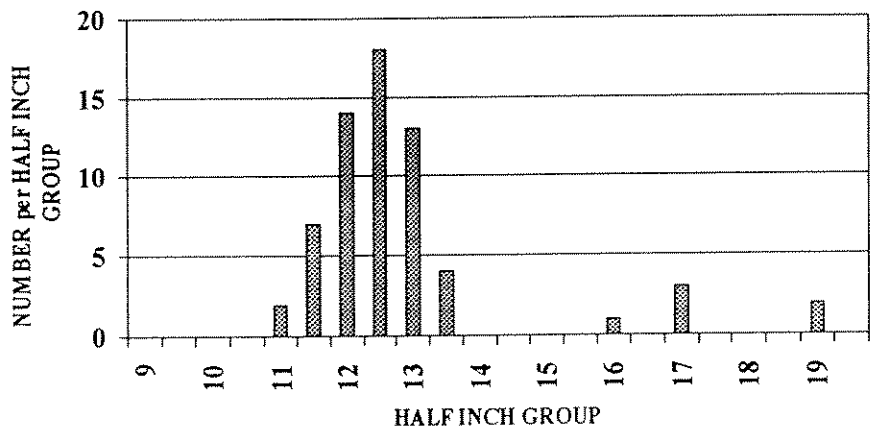

Figure 24. Length frequency distribution of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1997. (N=110)

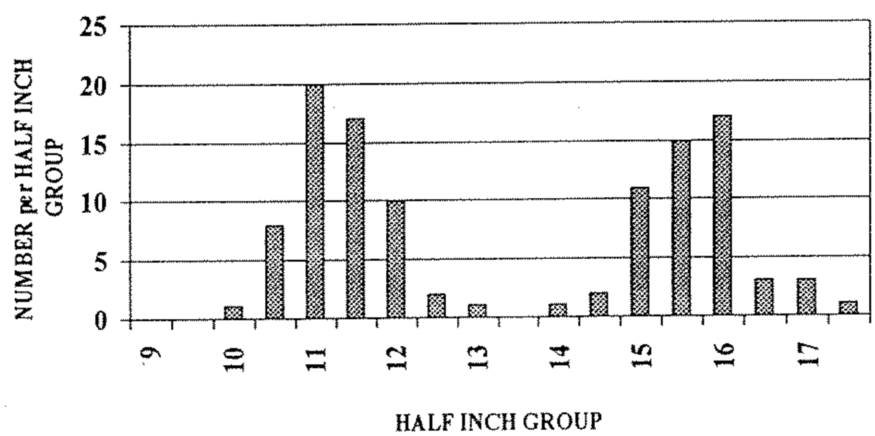

Figure 25. Length frequency distribution of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir 1998. (N=275)

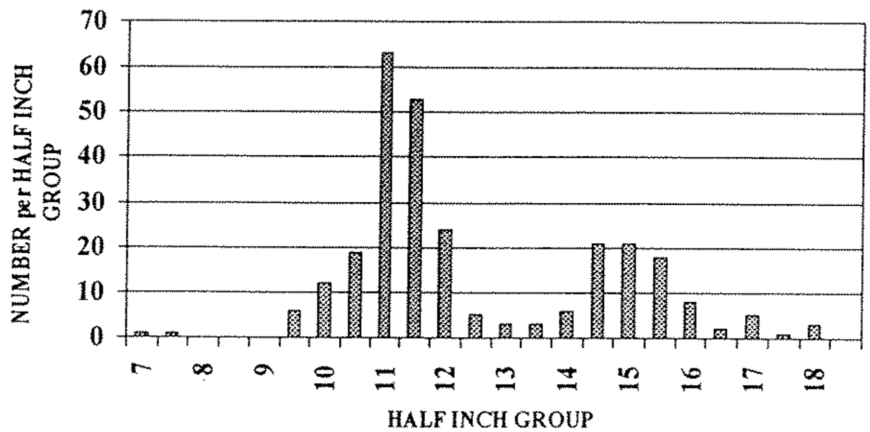

Figure 26. Length frequency distribution (fall sample) of rainbow trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1999. (N=304)

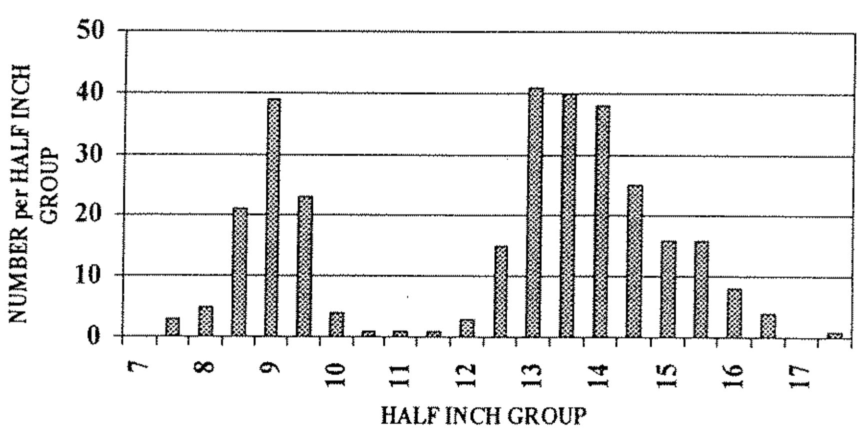

Figure 27. Mean number of brown trout collected per floating experimental gill net set overnight in Ruby Reservoir, 1979 - 1999.

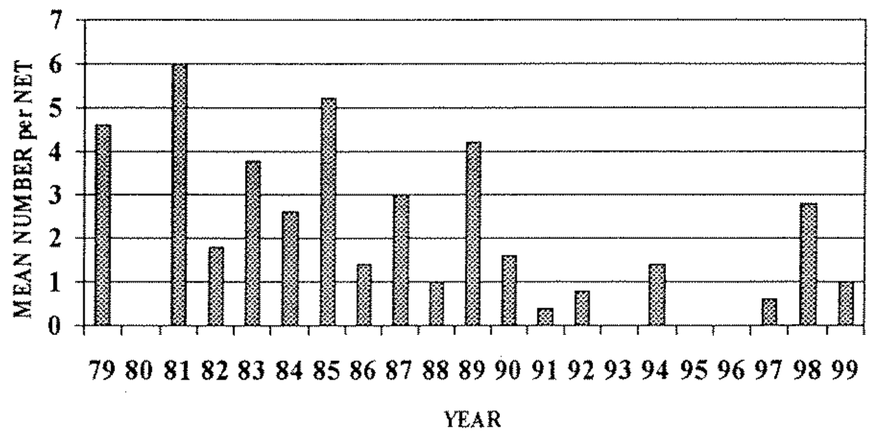

Figure 28. Length range and mean length of brown trout collected in floating experimental gill nets set overnight in Ruby Reservoir, 1979 - 1999.

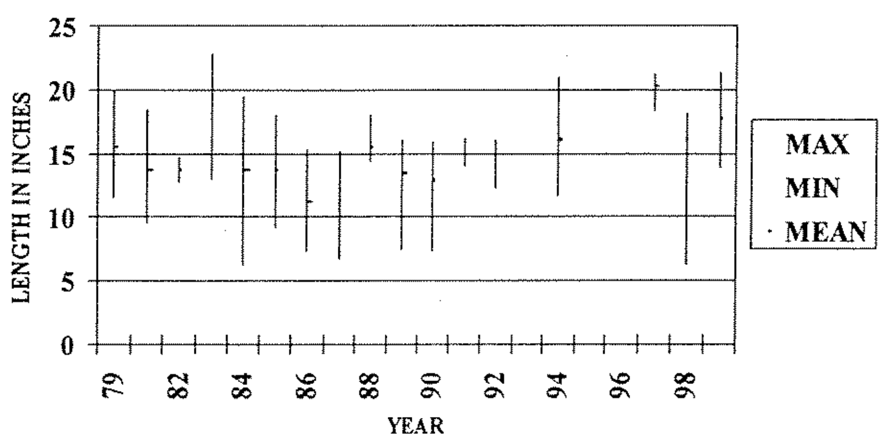

Figure 29. Estimated angling pressure (Angler - Days per Year) for Ruby Reservoir, 1984 - 1997.

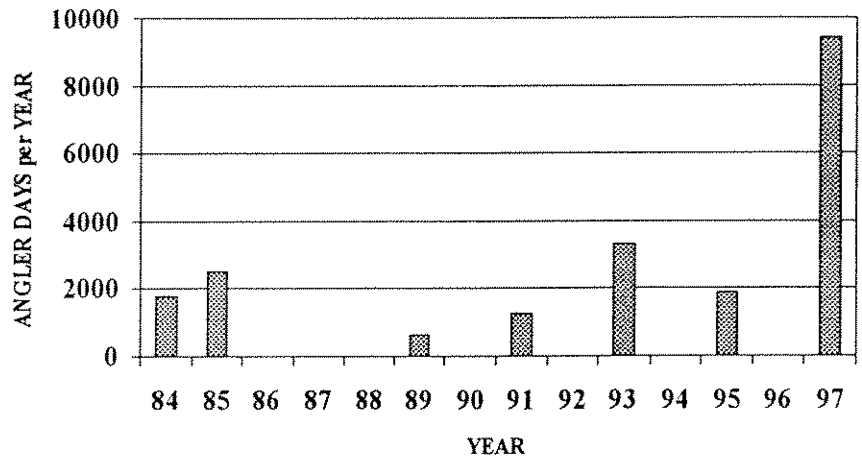

Figure 30. Winter creel catch rates for rainbow trout in Ruby Reservoir, 1997 - 2000.

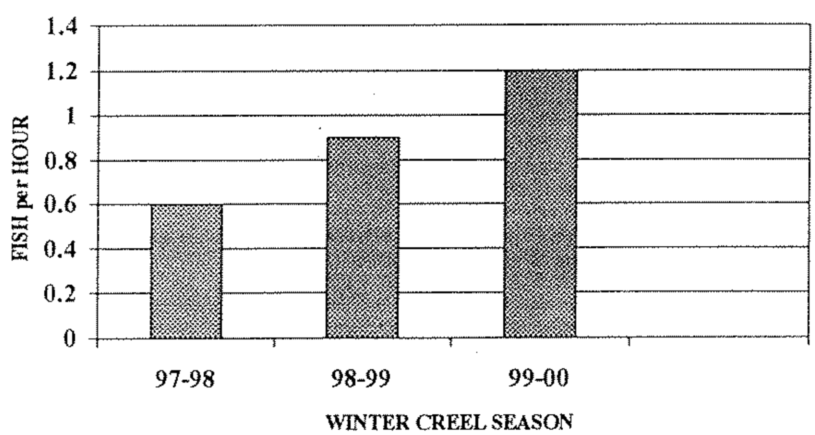

Figure 31. Mean number of McBride Yellowstone cutthroat trout collected per floating experimental gill net set overnight in Elk Lake, 1981 - 1999.

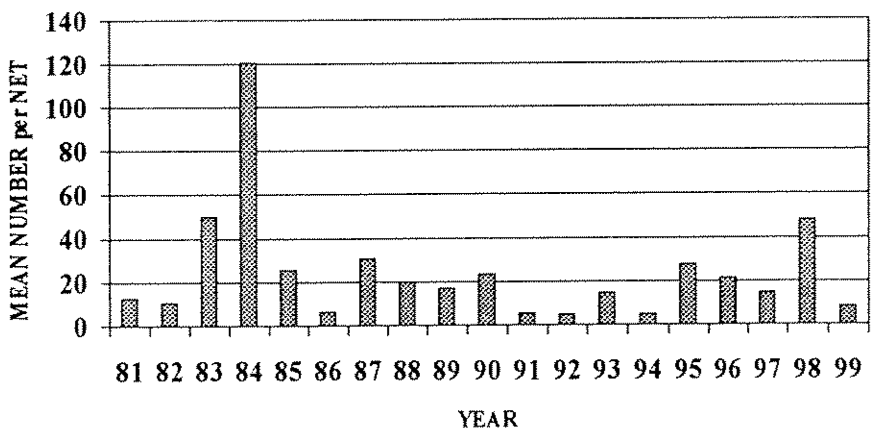

Figure 32. Age distribution of McBride Yellowstone cutthroat trout collected in floating experimental gill nets set overnight in Elk Lake, 1981 - 1999.

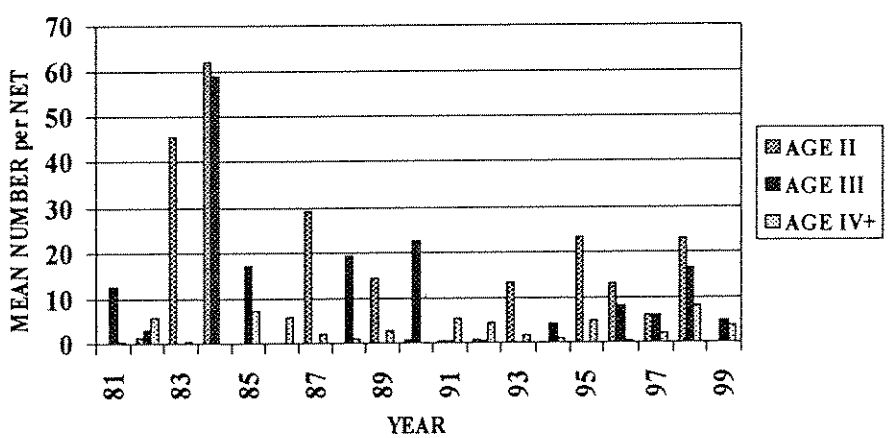

Figure 33. Mean number of arctic grayling collected per floating experimental gill net set overnight in Elk Lake 1981 - 1999.

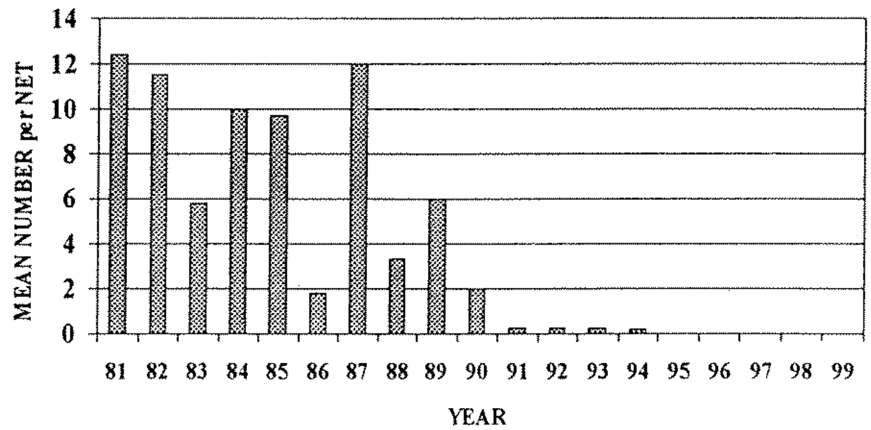

Figure 34. Mean number of lake trout collected per floating and sinking experimental gill net set overnight in Elk Lake 1981 - 1999.

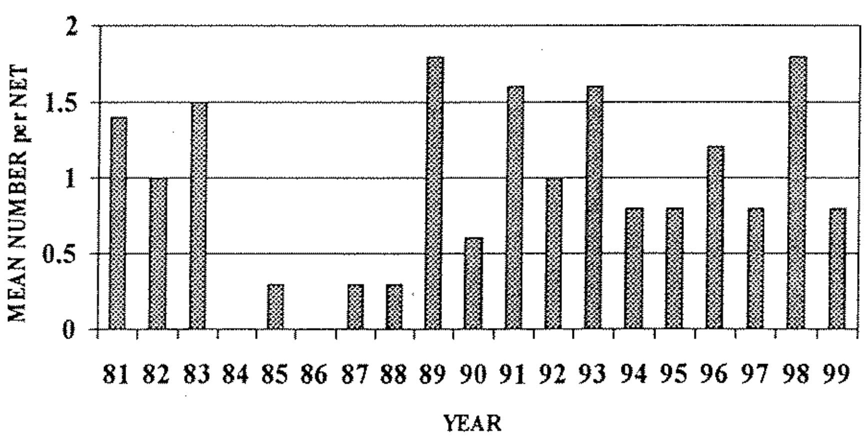

Figure 35. Length range and mean length of lake trout collected in floating and sinking experimental gill nets set overnight in Elk Lake 1991 - 1999.

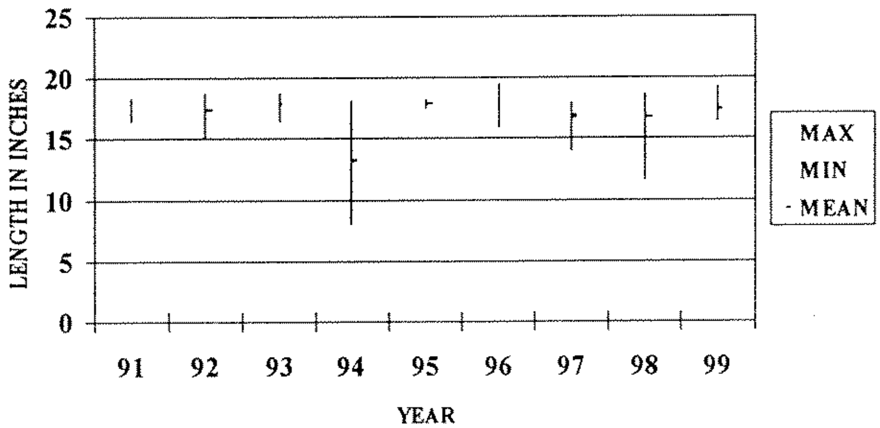

Figure 36. Composite length frequency distribution of lake trout collected in floating and sinking experimental gill nets set in Elk Lake 1993 - 1999. (N=66)

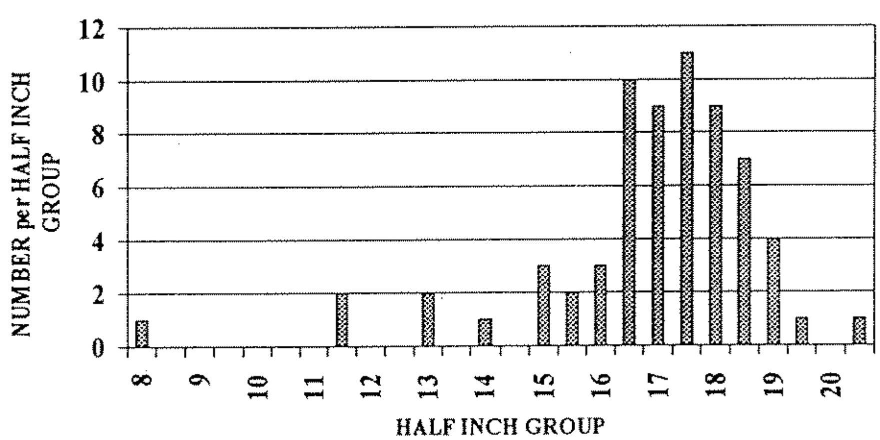

Figure 37. Mean number of burbot collected per sinking experimental gill net set overnight in Elk Lake, 1991 - 1999.

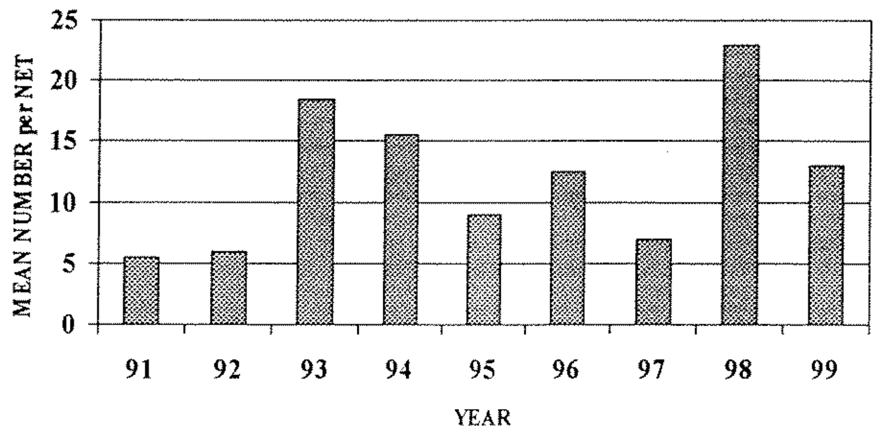

Figure 38. Length range and mean length of burbot collected in sinking experimental gill nets set overnight in Elk Lake, 1991 - 1999.

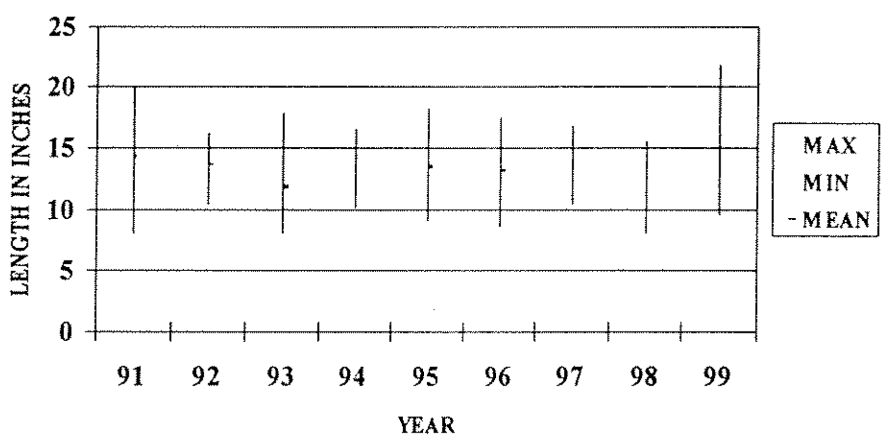

Figure 39. Composite length frequency distribution of burbot collected in sinking experimental gill nets set overnight in Elk Lake, 1991 - 1999. (N=391)

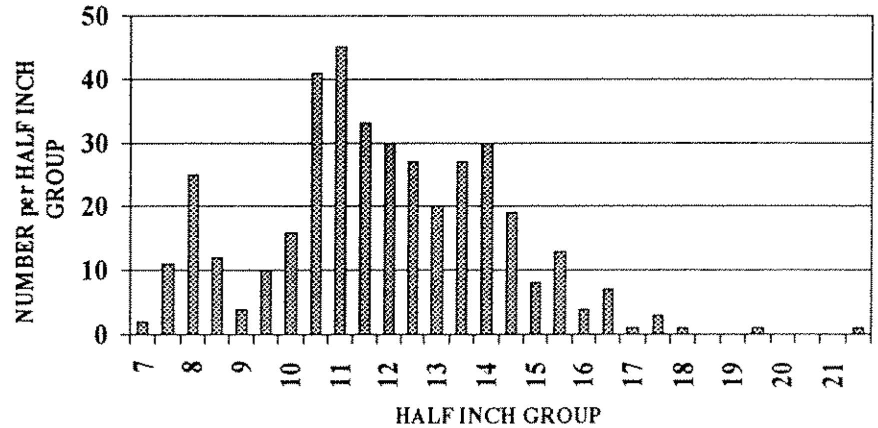

Figure 40. Mean number of rainbow trout collected per sinking experimental gill net set overnight in Hidden Lake, 1985 - 1999.

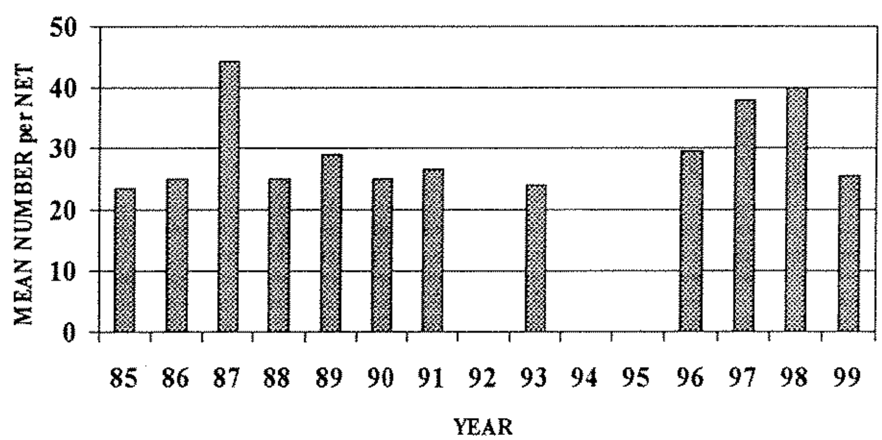

Figure 41. Length range and mean length of rainbow trout collected in sinking experimental gill nets set overnight in Hidden Lake, 1985 -1999.

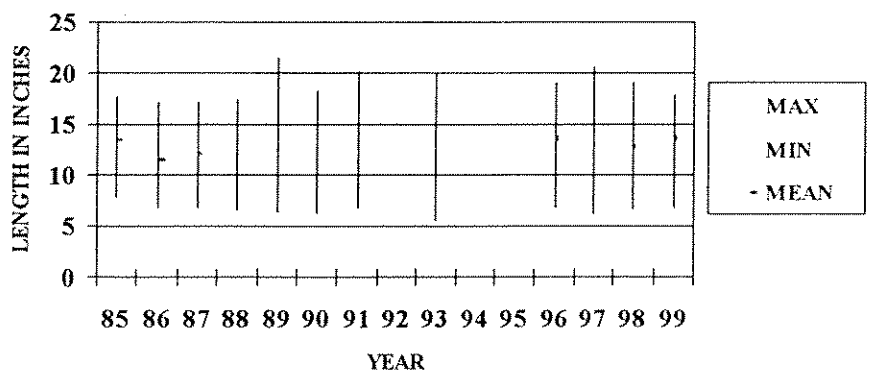

Figure 42. Composite length frequency distribution of rainbow trout collected in sinking experimental gill nets set overnight in Hidden Lake, 1993 - 1999. (N=310)

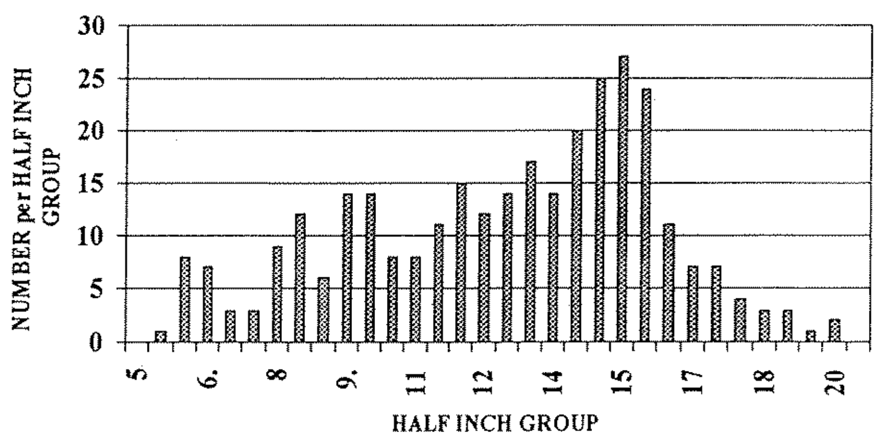

Figure 43. Mean number of brook trout collected per floating experimental gill net overnight in Culver Pond, 1979 - 1997.

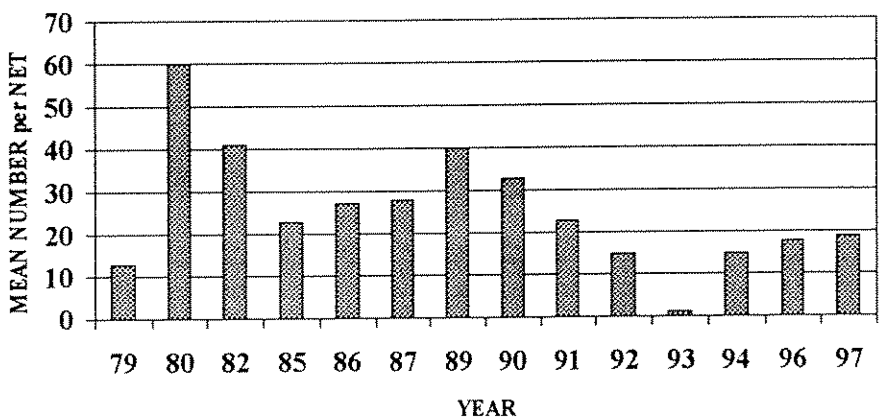

Figure 44. Mean number of rainbow trout collected per floating experimental gill net set overnight in McDonald Pond, 1979 - 1997.

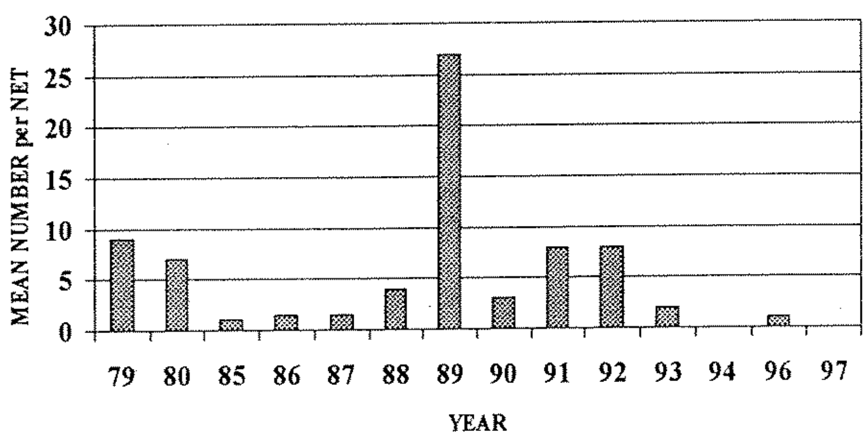

Figure 45. Percent composition, by species, of fish collected in Twin Lakes experimental gill net samples, July - October 1998.

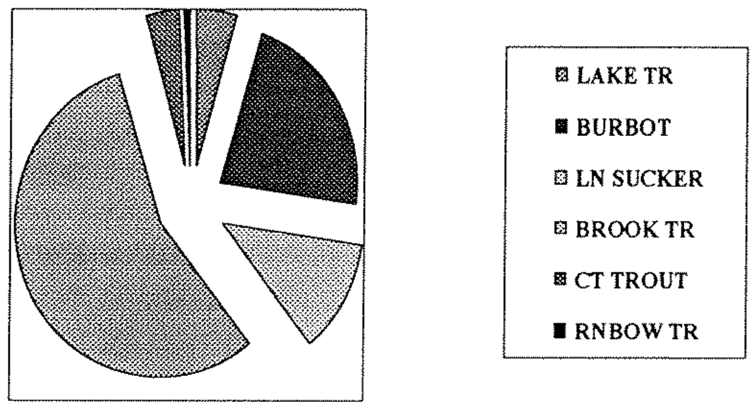

Figure 46. Collection rate for six species of fish collected in sinking experimental gill nets set overnight in Twin Lakes, July - October 1998.

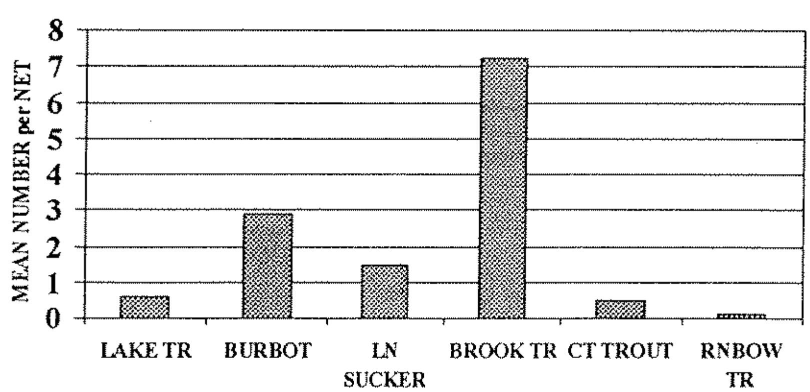

Figure 47. Mean number of lake trout collected per sinking experimental gill net set overnight in Twin Lakes 1964 - 1998.

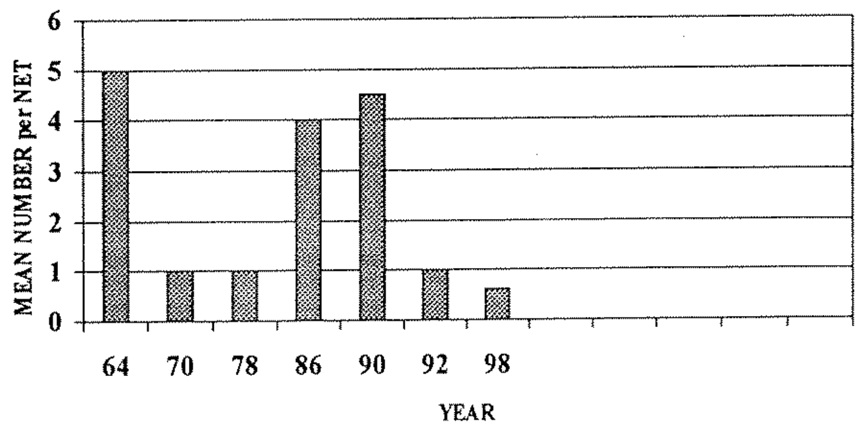

Figure 48. Length frequency distribution of lake trout collected in sinking experimental gill nets set overnight in Twin Lakes, July - October 1998. (N=12)

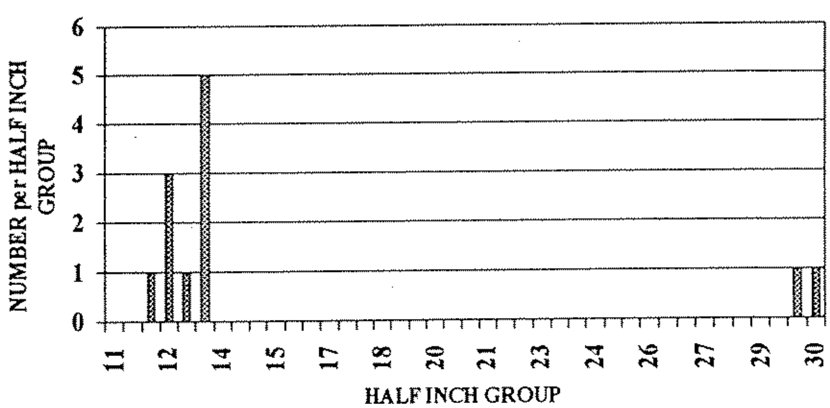

Figure 49. Mean number of burbot collected per sinking experimental gill net set overnight in Twin Lakes, 1964 - 1998.

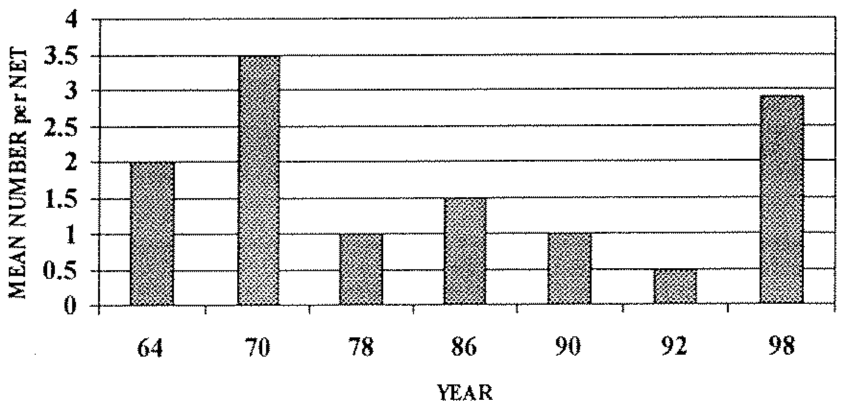

Figure 50. Length frequency distribution of burbot collected in sinking experimental gill nets set overnight in Twin Lakes, July - October 1998.

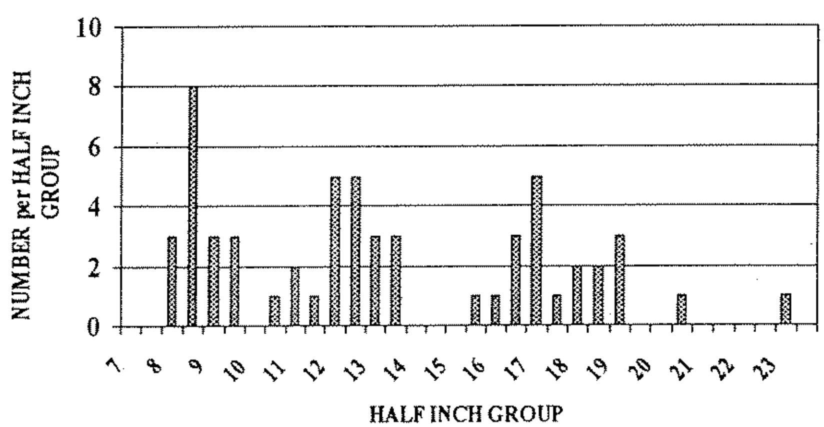

Figure 51. Mean number of brook trout collected per sinking experimental gill net set overnight in Twin Lakes, 1964 - 1998.

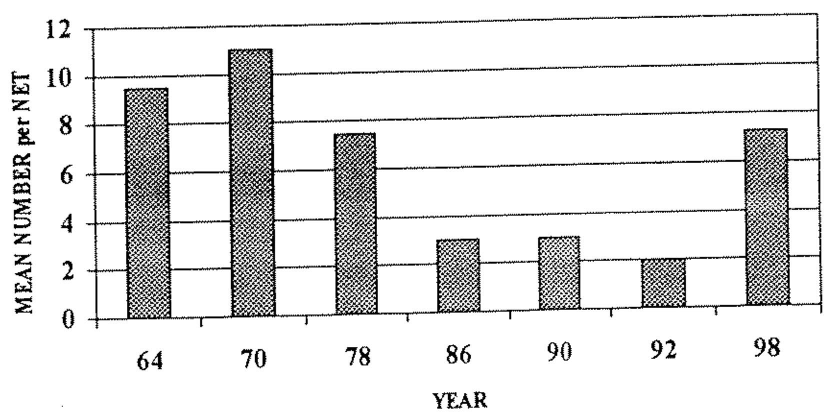

Figure 52. Length frequency distribution of brook trout collected in sinking experimental gill nets set overnight in Twin Lakes, July - October 1998. (N=145)

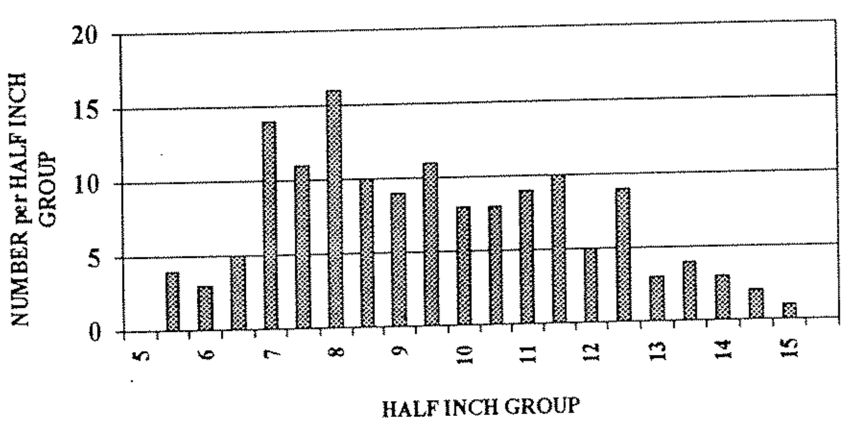

Figure 53. Mean number of rainbow and cutthroat trout collected per sinking experimental gill net set overnight in Twin Lakes, 1964 - 1998.