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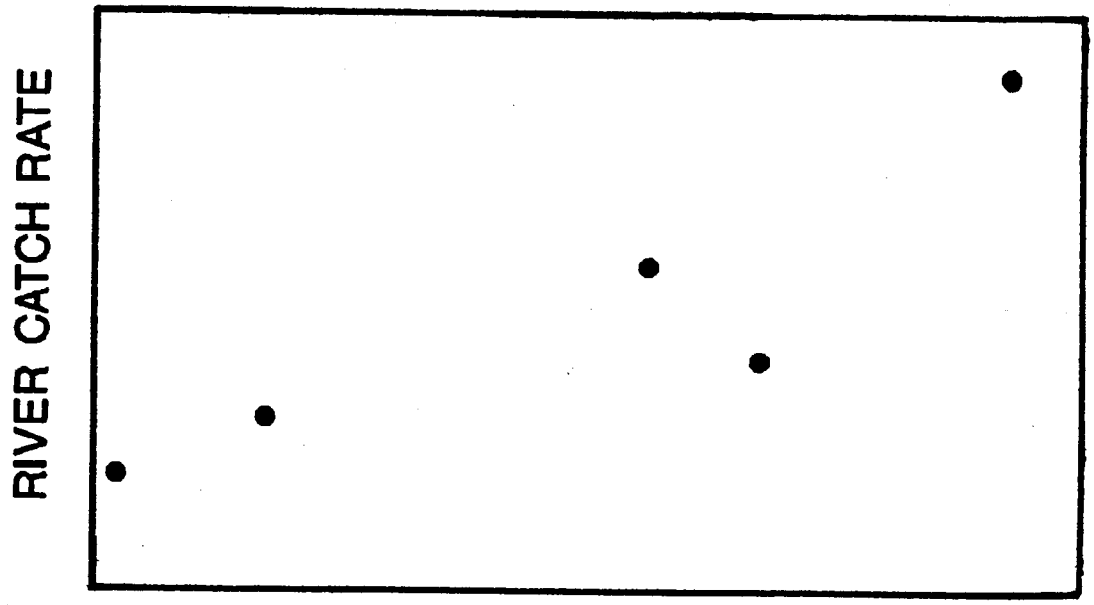
FISHERY RESEARCH

HATCHERY TROUT EVALUATIONS
American Falls Reservoir
Fishery Evaluations

Study Completion Report
Project F-71-R-13
Subproject V, Study II



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STUDY COMPLETION REPORT

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ABSTRACT

Angler effort and harvest on the Snake River below American Falls Reservoir is highest during the early part of the season. Thirty-two percent of the total effort and 26% of the total harvest occurs during the first two weeks of the season. Seventy-eight percent of the effort and 84% of the harvest occurs during the first eight weeks of the season. Carry-over hatchery rainbow trout form the basis for the fishery. Fifty-four percent of the estimated carry-over trout population in the river was harvested during the season, with half of that occurring during the first eight weeks. Of anglers responding in an angler preference survey, 61% indicated that they would accept a reduced bag limit and 73% indicated that they would accept a minimum size restriction. The most cost efficient stocking strategy for the reservoir and river fishery during normal water years is to stock catchable-size trout in the reservoir. However, during poor water years, stocking larger trout in the river should be more cost efficient. Yield of salmonids in American Falls Reservoir is comparable to similar reservoirs. Since 1979, opening day catch rates on the Snake River below the dam have declined, angler effort on the river has increased, number of fish stocked in the reservoir has declined, and the mean length of fish creeled has declined. A negative relationship between opening day river catch rate and angler pressure was found. There was a positive relationship between opening day river catch rate and the number of fish stocked in the reservoir the previous year. No relationship between river catch rate and reservoir storage levels, water releases from the dam, water temperature or dissolved oxygen concentrations in the river was found.

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INTRODUCTION

American Falls Reservoir is located on the Snake River in Bingham and Power counties. It has the uses of irrigation storage and flood control with hydropower production. The original dam was completed in 1927 and reconstructed in 1979. The dam and reservoir are managed by the U.S. Bureau of Reclamation and the powerhouse by Idaho Power Company.

At full capacity, the reservoir has a surface elevation of 1,327 m (mean sea level), covers 22,663 hectares, and contains 2,097 km^3 of water. Refill begins in October and continues through early spring. Irrigation use of the water begins in June, and drawdown starts as irrigation demand exceeds inflow. During years of below normal precipitation, as occurred from 1987 through 1990, reservoir drawdowns are more severe (95% total storage) than the long-term average (51% total storage) (Bureau of Reclamation 1990).

Hatchery rainbow trout emigrating from the reservoir to the Snake River downstream support the river fishery. Outmigration is believed to be triggered by reduced water quality in the reservoir during mid-summer (Heimer and Howser 1990). Historically, the reservoir has been managed with this outmigration in mind. The reservoir serves both as a fishery and a rearing pond for fish destined for the river fishery.

The passage of trout through American Falls Dam results in some mortality. As a result of apparent turbine marks on the fish and a perceived decrease in size and numbers of fish caught from the river, anglers believe the river fishery has declined since the early 1980s. Many anglers believe the apparent decline resulted from modification of the dam.

Catch rates in the river below the American Falls Dam are relatively high during the beginning of the season. However, these catch rates decline rapidly after opening weekend. Catch rates in the river remain low often until mid-summer. The decline in post-opening catch rates may result from heavy opening weekend fishing pressure (Heimer and Hauser 1990). An influx of trout from the American Falls Reservoir may boost fishing success later in the season.

High water temperatures and low dissolved oxygen in the reservoir during mid-summer may limit the traditional rainbow trout fishery. Preliminary research indicates that a game fish species tolerable of warm water temperatures and low dissolved oxygen concentrations may provide additional fishing opportunities. During the fall of 1989, 60,000 Lahontan cutthroat trout fingerlings were planted in the reservoir. The Lahontan cutthroat trout strain has **a** greater tolerance for warm water temperatures and low oxygen than the strain of rainbow trout presently being stocked. Managers hoped the Lahontans would remain in the reservoir longer and provide increased angling opportunity for large fish.

A general perception of American Falls Reservoir is that sport fish harvest in American Falls Reservoir is much lower than could be expected. Sport fish yields, however, have never been compared to other systems or to the predictions

of existing yield models. The limnological data used in several empirical yield models are available for the reservoir and can be used to index productivity or to estimate fishery potential.

OBJECTIVES

Project goals are to identify factors influencing the fishery in the American Falls Reservoir and Snake River below the reservoir and to provide recommendations that will guide management and research in the future.

Specific objectives were to:

1. Determine whether heavy exploitation depresses the fishery in the Snake River below American Falls Reservoir and whether the harvest can be managed to improve or more evenly distribute sport fish catch.

2. Determine the most cost efficient strategy for stocking hatchery rainbow trout in the reservoir and river.

3. Summarize information on reservoir productivity. Compare existing and potential sport fish yield predicted from established models and similar reservoir systems with that realized in American Falls.

4. Identify alternate sport fish species that may contribute to a fishery in American Falls Reservoir. Compare existing reservoir conditions with habitat, water temperature, dissolved oxygen, pH, turbidity, and available spawning and concealment cover requirements of alternate species for possible introduction into the reservoir.

5. Examine trends in the river fishery and determine whether factors other than early season exploitation are associated with the quality of the fishery.

6. Evaluate returns of Lahontan cutthroat trout to the creel.

METHODS

River Fishery

To determine the relative effect of exploitation, the temporal distribution of harvest, exploitation, and angler effort were evaluated by creel census. Only hatchery rainbow trout in the Snake River downstream from the American Falls Dam were considered because they form the basis of the fishery. An angler opinion survey was conducted to assess public support for potential special regulations.

Distribution of Angler Effort and Harvest

Following modification of the American Falls Dam in 1979, estimates of angler effort and harvest were made in 1981, 1982, and 1990. Partial estimates were conducted in 1988 and 1989 (IDFG Region 5 files). Data from the three complete estimates were compared graphically to assess annual trends in the distribution of angler effort and harvest in the river below the American Falls Dam.

Angler effort and harvest estimates for 1990 were obtained using an angler count and interview type creel census. Both roving and random access techniques were used. The fishing season was divided into eleven 2-week intervals beginning on opening day, May 25, 1990, and ending with the close of the season, October 31, 1990. Each 2-week interval was divided by day type, weekday, weekend day, and holiday. Four week days and two weekend days were randomly selected for creel census from each 2-week interval. Creel census was run on all holidays, with holidays being treated as weekend days during the analysis. Each creel census day was divided into four time intervals beginning at 0600 and proceeding in 4-hour increments until 2200. The time of the creel census was determined through random selection of the time interval, then selection of the hour within the time interval. Analysis of creel data was accomplished using a computer creel census program developed by the Idaho Department of Fish and Game (McArthur 1990).

Exploitation

The exploitation was evaluated for three fish stocks: 1. rainbow trout stocked in the reservoir the previous year and presumably carried over winter in the river; 2. rainbow trout stocked in the reservoir in the current year; and 3. rainbow trout stocked in the river in the current year.

Carry-Over Trout-A modified Petersen population estimate was conducted to determine carry-over hatchery rainbow trout numbers in the river below American Falls Reservoir (Ricker 1975). Fish were captured from the river between the American Falls Dam and Pipeline access using electrofishing equipment at night during late April and early May. Captured fish were marked with monel metal jaw tags. Prior to release, species, stock (as defined above), capture location, length, and tag number were recorded for each fish.

The population estimate for carry-over fish in the river was calculated based on the ratio of tagged fish versus the total number of carry-over fish observed during the opening day creel census. Unmarked carry-over fish were identified by length using data on length related to time at large from Heimer (1984). All fish larger than an estimated maximum length were assumed to be carry-over fish (Table 1).

Table 1. Maximum length of hatchery rainbow trout stocked in the reservoir during 1990 and creeled in the Snake River below the reservoir. From Reimer (1984).

Census interval	Estimated maximum length
1	320
2	320
3	340
4	340
5	360
6	360
7	360
8	370
9	370
10	370
11	380

AFTABLES

Exploitation of carry-over fish in the river was calculated by dividing the estimated harvest by the estimated population of carry-over fish in the river.

Reservoir-Stocked Trout-Exploitation of current year reservoir-stocked trout in the river was determined using the 1990 Creel Census and Department stocking records. Current year fish were identified in the creel by length (Table 1). Exploitation was calculated by dividing the estimated harvest by the total number of rainbow trout stocked in the reservoir in 1990.

River-Stocked Trout-Exploitation of river-stocked trout was determined using estimated harvest in 1990 and river stocking records. During 1990, we stocked 2,000 catchable rainbow trout in the river in May, June, and July (6,000 total). To evaluate harvest of river-stocked rainbow trout, 200 fish were tagged with monel metal jaw tags in the May release. Angler return of tags from the May release was too low for reliable calculation of harvest and exploitation. To achieve greater precision, we marked all rainbow trout stocked into the river during the June release. In June, 1,800 fish were marked with a caudal punch and 200 with a metal jaw tag. In July, 2,000 rainbow x cutthroat hybrids were stocked. Of these, we marked 200 with metal jaw tags; the remainder being identified in the creel by size and red jaw slashes. Exploitation of river-stocked fish was calculated by dividing the estimated harvest on river-stocked fish, identified by either jaw tag, caudal punch, length, or jaw slash, by the total number of trout stocked in the river.

Angler Opinion Survey

An angler opinion survey was conducted during normal angler interviews. Individual angler responses were pooled, and trends in angler opinions and support for management programs were evaluated.

The survey consisted of an informational questionnaire (Appendix A) which was explained by the interviewer. Anglers were asked to fill it out and return it to the interviewer. The survey explained the trend in reduced catch rates following opening weekend and proposed two possible regulation changes.

Anglers were asked two questions: 1. If it is possible to spread the harvest throughout the season (good fishing longer into the season) would you accept, (A) A reduced bag limit? (B) A minimum fish size?; 2. If it is possible to increase the average size of fish in the creel, would you accept a minimum fish size? Anglers were given four possible responses: accept, accept (but not favor), not accept, and need more information.

Stocking Strategy

To determine the most cost-efficient stocking strategy, we estimated the cost per pound of fish in the creel from reservoir and river stocking.

The calculations are detailed in Appendix B. The following variables were used in calculating the cost per pound of fish in the creel: number of fish stocked in the reservoir; number of fish stocked in the river; exploitation of reservoir-stocked fish in the reservoir; exploitation of reservoir-stocked fish in the river; exploitation of river-stocked fish; estimated reservoir mortality; estimated reservoir carry-over; estimated turbine survival; cost per pound of fish stocked in the reservoir; and, the cost per pound of fish stocked in the river. I calculated a best, worst, and most likely estimate for the cost per pound of fish in the angler creel. Estimates were made for fish stocked in the reservoir and returned in the reservoir, the river, or both, and for fish stocked in the river ant returned in the river. Values used in the calculations were selected from the range of available data to produce the best, worst and most likely estimate for each case. The most likely estimates represent point estimates or the midpoint of the observed range for available data (Table 2).

I assumed that to provide a fishery in the river comparable to that supported by fish emigrating from the reservoir, fish stocked in the river would have to be the same size as those emigrating from the reservoir (about 1 pound). Thus, I assumed the cost per pound of fish stocked in the river as $1.00 vs $0.33 for fish stocked in the reservoir (Heimer and Howser 1990).

Reservoir Yield and Productivity

Existing information on TDS and mean depth (Bushnell et al. 1969) was used to estimate a morphoedaphic index (MEI) (Ryder 1965) as an index of reservoir productivity. I calculated potential yield and compared that with actual yield. I also calculated a potential yield under the constraints of present reservoir stocking programs. Because much of the reservoir's production is harvested from the river below the reservoir, the harvest from both the river and the reservoir were combined to estimate the yield for the fishery. The potential sport fish yield was estimated after Jenkins (1982). The MEI was calculated by dividing the total dissolved solids value by the mean depth of the reservoir at full pool.

Due to drawdown and poor water quality, as much as 90% of the capacity of American Falls Reservoir may be unsuitable as rainbow trout habitat during mid-summer (Heimer and Howser 1990). As an alternative estimate of potential, I adjusted yield and productivity values for American Falls Reservoir for available habitat as defined by Heimer and Howser (1990). I consider a more realistic estimate of potential trout production then to be only 10% of the predicted potential for the entire reservoir.

Table 2. Values used for estimating the cost per pound of fish in the angler creel for fish stocked directly in the reservoir or the river. Values are from the range of available data and are selected to show the best, worst, and most likely cost for several stocking scenarios. Most likely estimates represent point estimates, or the midpoint of the observed range.

	Values used for cost		
	Best	Worst	Most likely
In Reservoir			
Annual exploitation[a,d]	0.23	0.0001	0.12
Annual conditional natural mortality[b]	0.10	0.30	0.20
Annual carryover[b]	0.12	0.11	0.10
In River			
Annual exploitation of reservoir stock[a]	0.17	0.01	0.08
Annual exploitation of river stock[a,d]	0.24	0.03	0.11
Cost per fish stocked in reservoir[c]	$0.33	$0.33	$0.33
Cost per fish stocked in river	$1.00	$1.00	$1.00
Survival in turbine passage	0.76	0.60	0.68

[a]Heimer (1984).
[b]Heimer and Hauser (1990) from Heimer (1984).
[c]Heimer and Hauser (1990).
[d]1990 Census (this report).

AFTABLES

The actual and estimated yields of American Falls Reservoir were also compared with the yields for comparable reservoirs with similar MEI values. Comparative data were obtained from Jenkins (1967), Schlesinger and McCombie (1983), and Heimer (1984).

Alternative Species

I reviewed characteristics of several sport fishes to identify species that might be better adapted to existing reservoir conditions and worthy of further consideration for possible introduction. Limnetic species better adapted to warm waters might provide a larger portion of potential reservoir yield than rainbow trout.

In evaluating sport fish species for possible introduction into the reservoir, I used the following criteria:

1. preferred water temperatures between 5°C to 24°C (Bushnell et al. 1969; Heimer and Howser 1990);

2. able to tolerate dissolved oxygen levels as low as 1.0 ppm (Bushnell et al. 1969; Heimer and Howser 1990);

3. able to tolerate pH of 8.3 (Bushnell et al. 1969);

4. able to tolerate moderate to very high turbidity (Bushnell et al. 1969);

5. due to limited availability of structure along the shoreline, habitat must be pelagic or not strictly limited to shoreline cover (Heimer and Howser 1990). Because fish populations could be maintained through stocking, the ability of a species to reproduce given the constraints of fluctuating reservoir water levels was not a criteria for selection, but was considered advantageous.

I did not consider risks of introduction from interaction with other desirable species either in American Falls or in contiguous waters. Those considerations will require a more detailed analysis than possible here.

Trends in the River Fishery

Relationships among the following variables were evaluated using correlation analysis: seasonal catch rates (Heimer 1984; 1990 creel census); opening day catch rates (Heimer 1984; Heimer 1985, 1986, 1987 unpublished data; creel census 1990); mean length of fish in creel (Heimer 1984; Heimer 1987 unpublished data; 1990 creel census); opening day angler pressure (opening day angler counts, Region 5, Idaho Department of Fish and Game); reservoir and river stocking rates (fish stocking records, Idaho Department of Fish and Game);

reservoir storage and outflow (records from U.S. Bureau of Reclamation, Burley, Idaho); water temperature and dissolved oxygen concentrations of releases below the dam (records from Idaho Power Company, Boise, Idaho).

The precision of past creel census data was evaluated to estimate detectable change for possible monitoring of the fishery. I used methods outlined by Parkinson et al. (1988), to estimate detectable differences or sample sizes.

Returns of Lahontan Cutthroat Trout

Creel census was used to document returns of Lahontan cutthroat trout to the creel in the river and reservoir during 1990. Creel census was conducted at the American Falls Reservoir sportsmens' access in conjunction with creel census on the Snake River below the reservoir. Reservoir creel census was discontinued in early July when water levels in the reservoir became too low to use boat launch facilities. Some Lahontan cutthroat trout were sampled in the river by electrofishing in late August 1990.

RESULTS

River Fishery

Distribution of Angler Effort and Harvest

Anglers fished 20,233 hours and harvested 1,763 carry-over rainbow trout, 568 rainbow trout stocked in the reservoir in 1990, and 1,365 rainbow trout stocked in the river in 1990 (Appendix C).

Angler effort and harvest was highest during the early part of the season, declined through the summer, and showed a slight increase during the fall. Thirty-three percent of the total estimated effort and 26% of the total combined harvest occurred during the first two weeks. Seventy-eight percent of the total effort and 84% of the total combined harvest was in the first eight weeks. Eighteen percent of the total effort and 11% of the harvest occurred during the second eight weeks. Four percent of the effort and 4% of the harvest took place during the last six weeks of the season (Figure 1).

A consistent year to year trend in the seasonal distribution was found for angler effort for 1981, 1982, and 1990. However, there is an inconsistent fluctuation in the harvest during the latter part of the season for these years (Figure 2).

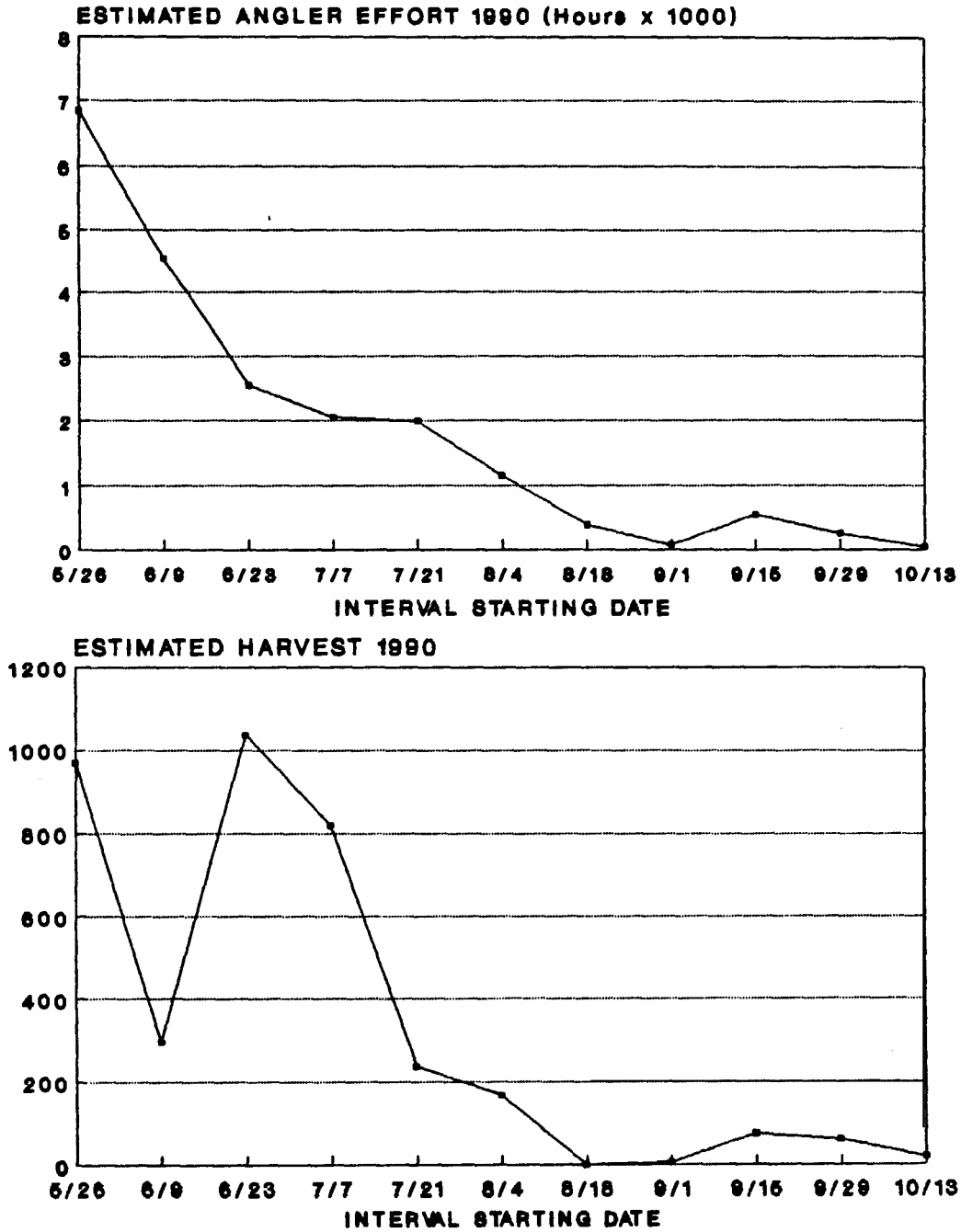

Figure 1. Estimated angler effort and trout harvest on the Snake River below American Falls Dam during 1990.

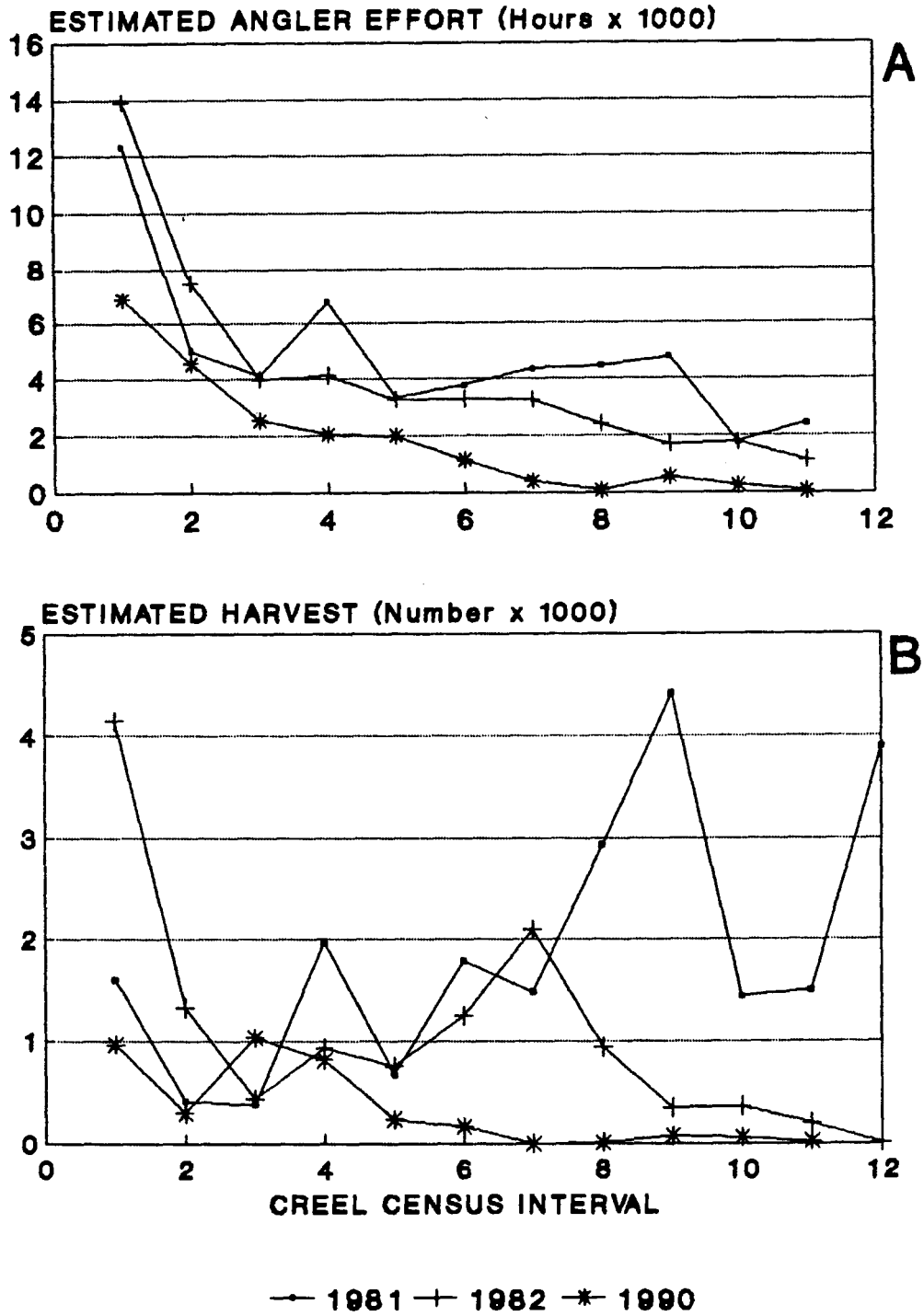

Figure 2. Estimated angler effort (A) and harvest of trout (B) on the Snake River during the 1981, 1982, and 1990 creel census.

Exploitation

Carry-Over Trout-Carry-over trout made up 48% of the total trout harvest for the season. Anglers took 93% of the carry-over trout harvested during the first eight weeks of the season (Figure 3).

An estimated 3,252 carry-over trout were in the river prior to opening day. Estimated exploitation was 54%. About half of the exploitation (26%) occurred on opening day.

Reservoir-Stocked Trout-Trout stocked in the reservoir in 1990 made up 15% of the total trout harvest for the season. Seventy-four percent of reservoir-stocked fish that were harvested were taken in the river during July and early August (Figure 3).

Trout released in the reservoir totaled 107,455 fish for 1990 (stocking records, Idaho Department of Fish and Game). Less than 1% of the rainbow trout stocked in the reservoir in 1990 were harvested in the river in 1990. We did not observe any rainbow trout creeled on the reservoir in 1990.

River-Stocked Trout-Trout stocked in the river during 1990 made up 37% of the total harvest for the season. Eighty-five percent of that harvest occurred during July (Figure 3).

Releases of rainbow and rainbow x cutthroat trout into the river totaled 6,000 fish in 1990. An estimated 23% of all river-stocked fish were harvested over the season.

Angler Opinion Survey

One hundred and fifty-four anglers responded to our survey regarding restriction of the fishery. Sixty-one percent indicated that they would accept a reduced bag limit, and 73% indicated they would accept a minimum size restriction if it would spread harvest later. Sixty-six percent said they would accept a minimum size restriction if it would produce larger trout. A complete summary of the survey is contained in Table 3.

Stocking Strategy

The prediction of cost per pound of fish creeled ranged from $0.49 to more than $100.00 (Table 4). The estimates depended on the site considered in the harvest and on the assumptions used in our estimator. When the total return was considered (i.e. fish caught either in the reservoir or the river), cost per

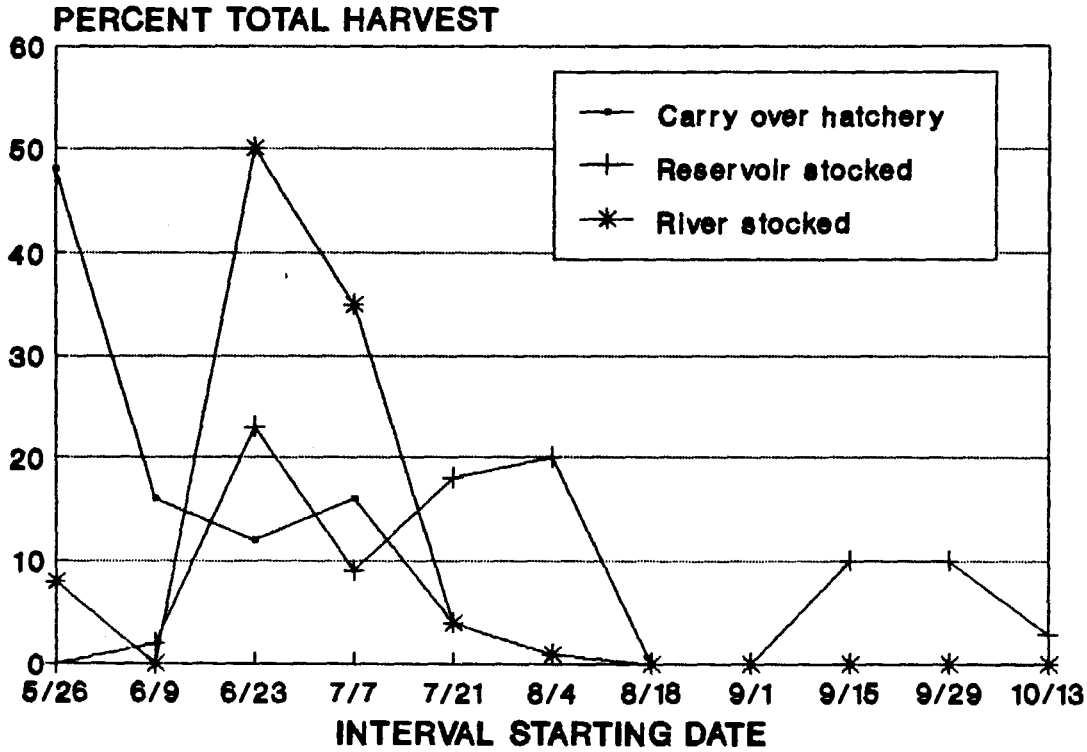

Figure 3. Estimated percent of total harvest for carry-over rainbow trout, reservoir-stocked trout, and river-stocked trout during 1990.

Table 3. Responses to the angler opinion survey conducted on the Snake River during the 1990 census.

If it is possible to spread the harvest throughout the season (good fishing longer into the season), would you accept a . . .

	Reduced bag limit?	Minimum fish size?
Accept	94 (63%)	50 (73%)
Accept (but not favor)	16 (11%)	6 (9%)
Not accept	16 (11%)	10 (15%)
Need more information	22 (15%)	2 (3%)

If it is possible to increase the average size of fish in the creel, would you accept a minimum fish size?

Accept	102 (65%)
Accept (but not favor)	16 (10%)
Not accept	14 (9%)
Need more information	26 (16%)

AFTABLES

Table 4. Estimated cost ($) per pound of fish creeled for fish stocked in the reservoir or in the river. Costs were estimated by incorporating estimates of growth, mortality, carry-over, and exploitation.

Return location	Stocking in Reservoir Assumptions			Stocking in River[a] Assumptions		
	Best	Most likely	Worst	Best	Most likely	Worst
Reservoir & river	0.49	0.99	19.68	-	-	-
River only	1.94	4.12	33.00	2.51	5.40	20.0
Reservoir only	1.43	2.75	7100.00	-	-	-

[a] Fish stocked in the river were returned only from the river.

AFTABLES

pound in the creel for fish stocked in the reservoir was about 20% of that for fish stocked in the river under the best and most likely cases. Under the worst cases, costs were similar. When I considered only the river fishery, the range of costs were similar under best and most likely cases, but about 50% higher for fish stocked in the reservoir under the worst case. The worst case scenarios for reservoir stocking were represented by 1990, an extreme low flow year, when a reservoir fishery was virtually nonexistent. The best case for stocked in the river was also represented by the same year, when fish seemed to be extremely vulnerable to anglers.

Reservoir Yield and Productivity

American Falls Reservoir has a mean depth of 15 m and an average TDS of 266 mg/l (Bushnell et al. 1969). The calculated MEI value is 17.7.

The estimated potential sport fish yield for the reservoir based on Jenkins (1982) is 18 kg/hectare, or 407,934 kg/year. By assuming that only 10% of the reservoir is normally suitable for salmonids during critical periods, I adjusted the expected yield. A more reasonable prediction of potential yield for trout might then be 40,800 kg.

A substantial part of the trout production in the reservoir apparently emigrates to the river. Harvest in the river, therefore, represents yield from the reservoir. Thirty-one to 36% of total yield for the reservoir and river comes from the river (Heimer 1984). If the reservoir and river are considered to be a single fishery, total sport fish yield was 45,932 kg in 1981, 20,026 kg in 1982, and 2,688 kg in 1990. Sport fish yields for comparable reservoir systems with MEI values similar to American Falls Reservoir are listed in Table 5.

Alternative Species

I briefly examined characteristics of sport fish species commonly used in warm reservoirs to identify candidates for possible introduction into American Falls Reservoir. I considered the following species: Largemouth bass *Micropterus salmoides*, smallmouth bass *Micropterus dolomieui*, white bass *Morone chrysops*, striped bass *Morone saxatilis*, bluegill *Lepomis macrochirus*, black crappie *Pomoxis nigromaculatus*, white crappie *Pomoxis annularis*, channel catfish *Ictalurus punctatus*, northern pike *Esox lucius*, and walleye *Stizostedion vitreum vitreum*.

White bass could be suitable for introduction into the reservoir if pelagic forage were available. White bass populations have been found in waters that were turbid or clear (Thompson 1951), deep or shallow, fluctuating or stable, and which ranged in size from 162 to 37,337 hectares (Tompkins and Peters 1951; Jenkins and Elkin 1957; McNaught and Hasler 1961; Webb and Moss 1968; Olmsted and Kilambi 1971; Priegle 1971; Ruelle 1971). White bass generally are

Table 5. Comparison of trout yields of reservoir systems with MEI values similar to MEI values calculated for American Falls Reservoir.

Reservoir/location	MEI	Yield (kq/hectare)
American Falls/Idaho	17.7	0.08-1.82
Four-Mile/Ontario, Canada	15.8	1.91
Kirkland/Ontario, Canada	16.7	0.78
Hebgen/Montana	17.5	1.12
Ft. Peck/Montana	19.5	1.12

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associated with the epipelagic zone of moderately large to large lakes; fisheries also occur in the tailwaters of some reservoirs (Chadwick et al. 1966; Walburg et al. 1971; Hamilton and Nelson 1984).

A dissolved oxygen level of 1 mg/l at 21°C to 24°C was lethal to white bass (Mount 1961). I assumed that 5 mg/l dissolved oxygen is the lower optimum limit, as recommended by the U.S. Environmental Protection Agency (1976). Because white bass prefer warm water (>20°C), oxygen should be adequate in American Falls. Upper and lower pH levels tolerated by white bass have not been investigated. The optimum pH range is assumed to be 6.5 to 9.0, based on recommendations by the U.S. Environmental Protection Agency (1976). Turbidity has no reported effect on white bass spawning success, larval survival, or growth (Jenkins and Elkin 1957; Jester 1971; Summerfelt 1971; Walburg 1976; Nelson 1980). However, white bass avoid areas of continuous turbidity and have become abundant in areas of decreased turbidity (Pflieger 1975). The periodic high turbidity in American Falls may limit success of an introduction. White bass are able to tolerate summer water temperatures of 19°C to 28°C (Gasaway 1970; Jester 1971; Nelson 1974; Kohler and Ney 1981), with optimum temperatures between 28.0°C and 29.5°C (Gammon 1973; Hamilton and Nelson 1984).

Although adult white bass are usually piscivorous, they will readily change to macroinvertebrates or even zooplankton when forage fish populations are depleted (Sigler 1949a; Forney and Taylor 1963; Olmsted and Kilambi 1971; Voigtlander and Wissing 1974). Extensive forage fish populations appear to be the key to a successful white bass population (Jenkins and Elkin 1957; Chadwick et al. 1966). Shad Dorosoma spp. are the preferred forage, particularly threadfin shad D. petenense because of its abundance, availability, and smaller size (Olmsted and Kilambi 1971). Gizzard shad D. cepedianum tolerate colder water temperatures and are more widespread, but either gizzard or threadfin shad are nearly always present where white bass are abundant (Hamilton and Nelson 1984). I found no information showing that white bass would use semi-pelagic cyprinids such as the Utah chubs in American Falls Reservoir. A more detailed review of foraging behavior and chub distribution would be useful in any further consideration.

Striped bass may be suitable for introduction into the reservoir again if a pelagic forage were available. Self-renewing inland stocks of striped bass generally require two major types of habitat: 1. riverine habitat for reproduction, and 2. lacustrine or estuarine habitat for foraging, growth, and development by the larvae, juveniles, and adults (Crance 1984).

Temperature has been reported as an important factor in habitat selection for juvenile and adult striped bass in some reservoirs (Coutant 1978, 1980; Schaich 1979; Waddel 1979; Coutant and Carroll 1980; Cheek 1982; Cheek et al. 1985; Moss 1985). Bailey (1975) reported that striped bass survived successfully after being stocked in reservoirs where the annual range of temperature was 0.0°C to 34°C, total hardness was 10 to 375 ppm, turbidity was 1.5 to 170 JTU, and the pH was 5.5 to 9.1 (Crance 1984).

Juvenile striped bass are opportunistic feeders (Merriman 1941; Morgan and Gerlatch 1950; Johnson and Calhoun 1952; Raney 1952; Heubach et al. 1963; Ware

1971; Manooch 1973; Boynton et al. 1981). Young-of-the-year striped bass feed mainly on invertebrates during the first winter and spring, changing to a diet of small fish the following summer (Stevens 1966). Morris and Follis (1978) reported that striped bass over one year old had reduced growth rates as forage fish (gizzard shad) populations declined (Crance 1984).

Adult striped bass also tend to be opportunistic feeders (Merriman 1941; deSylva 1973). Landlocked populations select for clupeids or soft-rayed fish over other available food items. Ware (1971) found that threadfin and gizzard shad was the dominant food item for striped bass >150 mm in Florida lakes. In the Illinois River, Oklahoma, stripped bass >5 kg fed heavily on rainbow trout for the first week after the trout were stocked, but that gizzard shad made up 75% of their diet thereafter (Deppert and Mense 1979). An abundance of small threadfin shad was considered critical for rapid growth of striped bass >110 mm in Lake Powell (Gustaveson et al. 1980; Crance 1984). Further consideration of possible striped bass-Utah chub interaction would be useful if introduction of alternative forage is not realistic.

Walleye could be suitable for introduction into the reservoir. Walleye are tolerant of a wide range of environmental conditions (Scott and Crossman 1973), but are generally most abundant in moderate to large lacustrine (> 100 ha) or riverine systems characterized by cool temperatures, shallow to moderate depths, extensive littoral areas, moderate turbidities, extensive areas of clean rocky substrate, and mesotrophic conditions (Kitchell et al. 1977; Leach et al. 1977; McMahon et al. 1984). Walleye may be more tolerant of the turbidity in American Falls than other potential predators.

Adult walleye generally are found under cover in moderately shallow (<15 m) waters during the day and move inshore at night to feed (Johnson and Hale 1977; Ryder 1977). They are found in lakes with a pH ranging from 6.0 to 9.0 and can tolerate dissolved oxygen levels of 2 mg/l for a short time (Scherer 1971); however, the greatest abundance of walleye occurs where minimum dissolved oxygen levels are greater than 3 to 5 mg/l (Dendy 1948). Optimum growth for adult walleye occurs between 20°C to 24°C (Dendy 1948; Ferguson 1958; Kelso 1972; Huh et al. 1976; McMahon et al. 1984).

Walleye survival, growth, and standing crop have been related to the abundance and availability of small forage fish (Jester 1971; Forney 1974; Swenson and Smith 1976; Momot et al. 1977; Groen and Schroeder 1978; McMahon et al. 1984). I do not know whether walleye will persist with Utah chub as a primary forage, and again, further consideration of forage limitations will be important.

Smallmouth bass and white crappie could be suitable for introduction into the reservoir, but populations would almost certainly be restricted to the limited shoreline concealment cover of broken rock outcroppings, aquatic vegetation, and woody debris. Fish would probably be aggregated in relatively small pockets of habitat that would be suitable throughout the year. Water level fluctuation in early spring would adversely affect reproductive success (Reininger 1984) and high turbidity may restrict growth.

Largemouth bass, bluegill, and northern pike probably would not do well following introduction into the reservoir due to low turbidity requirements and the limited availability of suitable shoreline concealment cover in the form of shoreline aquatic vegetation and woody debris (Reininger 1984).

Black crappie probably are not suitable for further introduction into the reservoir. Black crappie occur in American Falls Reservoir, but the population is very small and does not support an important or consistent fishery. Regular introductions to sustain a population might be possible (e.g. suggestion by Dick Scully, Idaho Department of Fish and Game Regional Manager). I do not believe, however, that an important fishery would result. The limited availability of suitable shoreline concealment cover in the form of shoreline aquatic vegetation and woody debris is probably important to the poor success of the existing population (Reininger 1984). High turbidity may also be restrictive, or at least more conducive to white rather than black crappie (Reininger 1984).

Channel catfish may not be suitable for introduction into the reservoir. Reininger (1984) suggests that high turbidity can strongly influence growth.

Trends in the River Fishery

I found the following correlations in fishery variables: 1. a significant decline ($r = -0.93$, $P < 0.01$) in the opening day catch rates in the Snake River below the dam with year since 1979 (Figure 4) ; 2. an increase ($r = 0.57$, $P < 0.10$) in opening day angling pressure on the Snake River below the dam with year since 1980 (Figure 5); 3. a negative correlation ($r = -0.79$, $P < 0.10$) between opening day catch rates and opening day car counts for the river below the dam since 1979 (Figure 6); 4. a negative correlation ($r = -0.87$, $P < 0.05$) between opening day catch rates and opening day boat counts for the river below the dam since 1979 (Figure 6); and, 5. a decline in stocking rates since 1980 correlated ($r = 0.89$, $P < 0.01$) with opening day catch rates in the river (Figure 7).

Complete length frequencies of the angler catch were available for 1982, 1987, and 1990. The modal and maximum size was not different among those years (Appendix D). There did appear to be a decline in relative numbers of large fish and an increase in smaller fish with time. The large contribution of small fish in 1990 was due in part to stocking of "catchable" trout directly in the river. Differences in mean length among years was not significant.

I found no significant ($P < 0.05$) correlation between catch rates in the river and: 1. reservoir storage levels, 2. water releases from the dam, 3. water temperature of releases from the dam, 4. dissolved oxygen content of releases from the dam, or 5. time of the season. Due to a small sample size (3), I was unable to evaluate associations with seasonal catch rate data.

I used estimates of the variability in the creel data to determine appropriate sample sizes and detectable differences in estimates of effort and fish per angler hour (Appendices E-H) for future monitoring. Results show that with the normal three or four angler counts made on opening day, we cannot expect

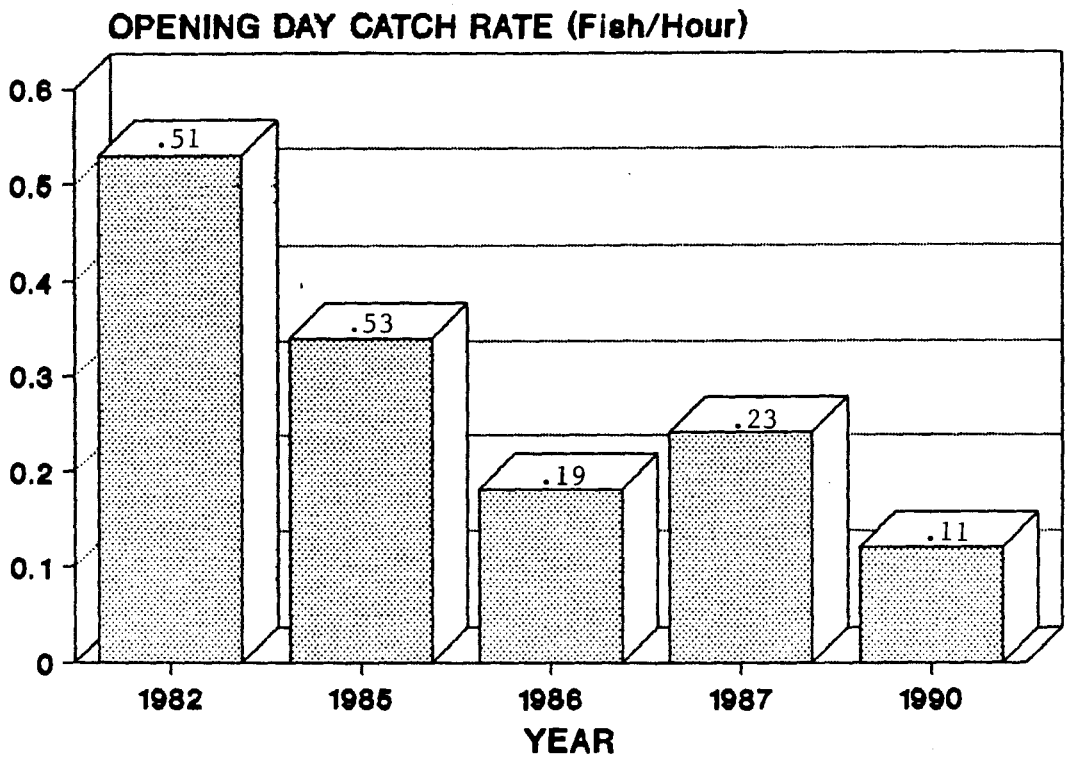


Figure 4. Opening day catch rate (fish/hour) on the Snake River below American Falls Reservoir by year.

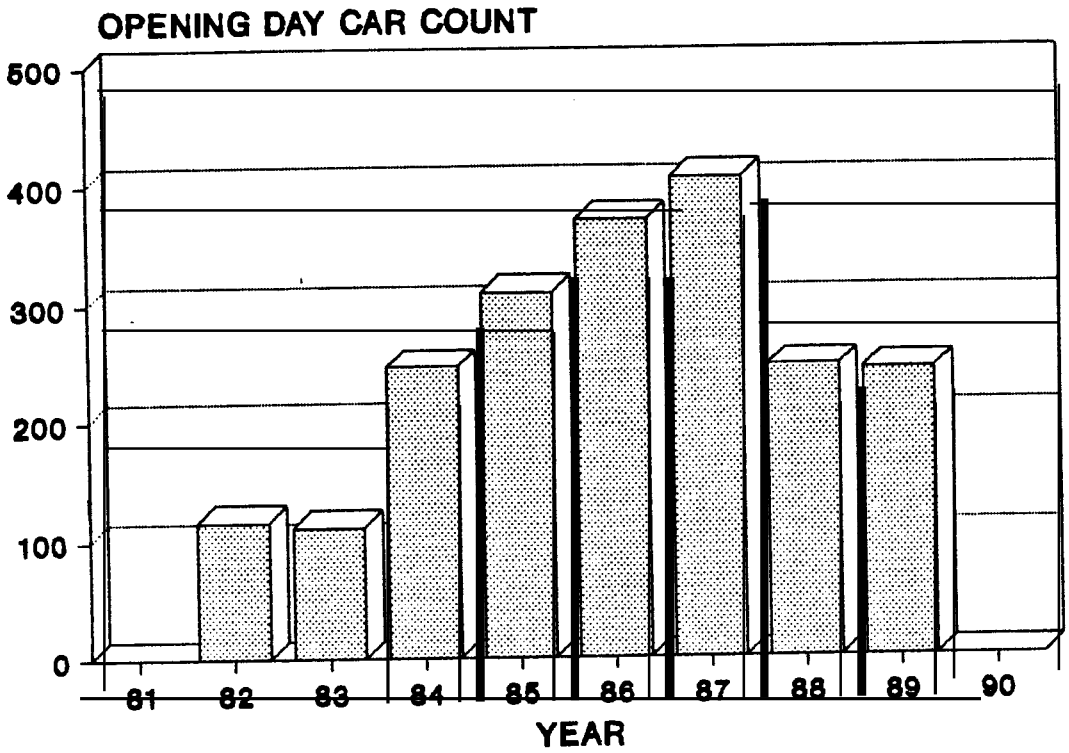
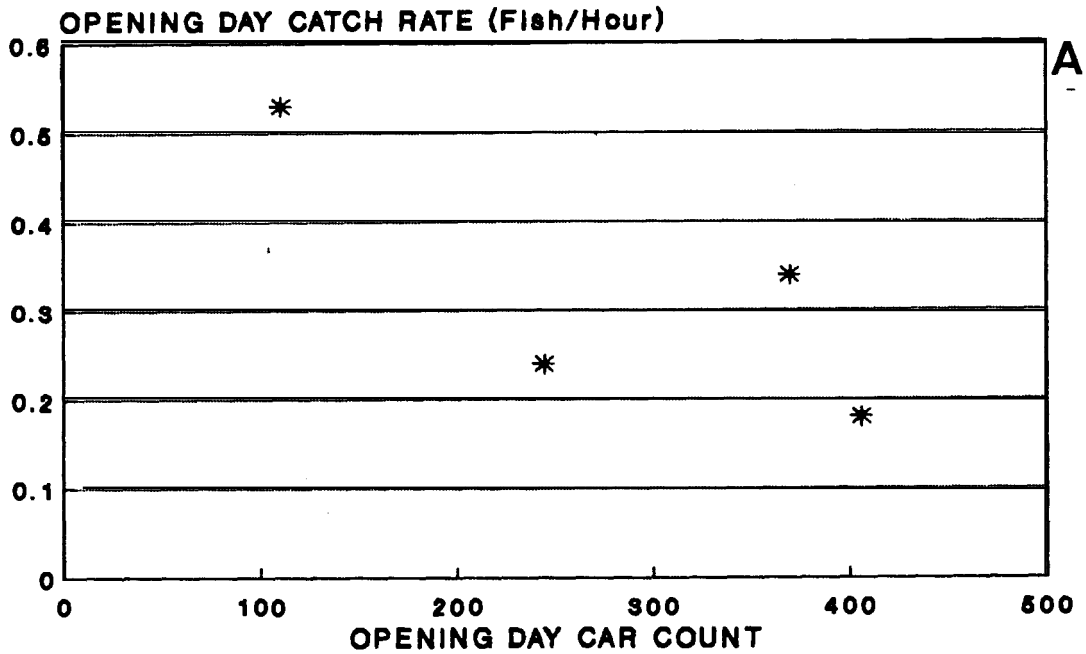


Figure 5. Opening day car count (by airplane) for the Snake River below American Falls Reservoir by year.



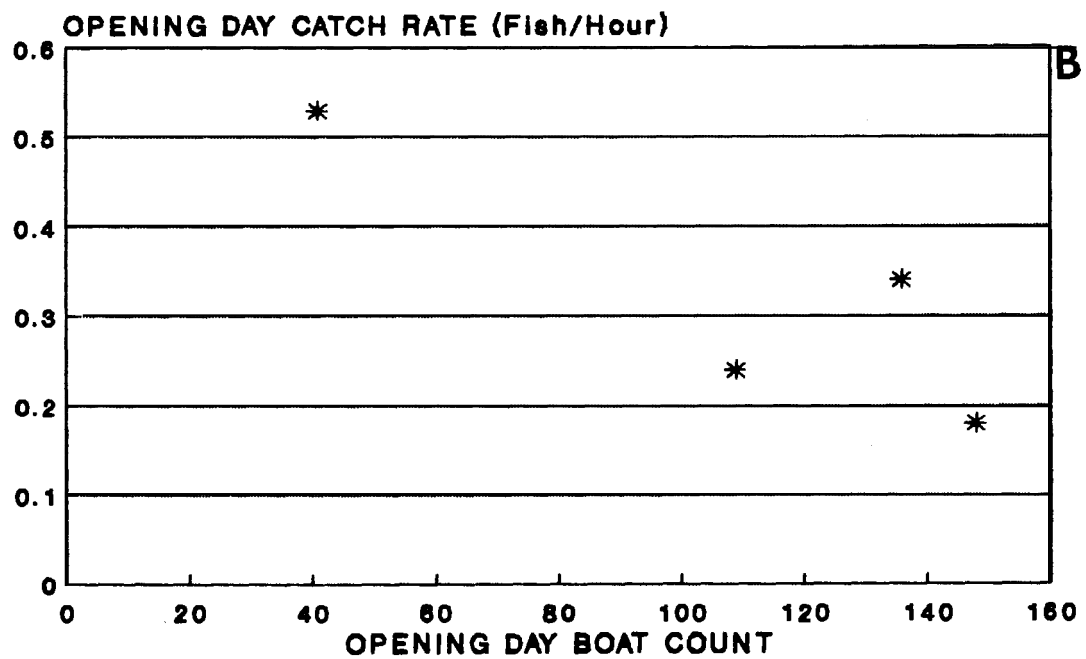


Figure 6. Relationship of opening day catch rate with opening day car count (A) and boat count (B) on the Snake River below American Falls Reservoir.

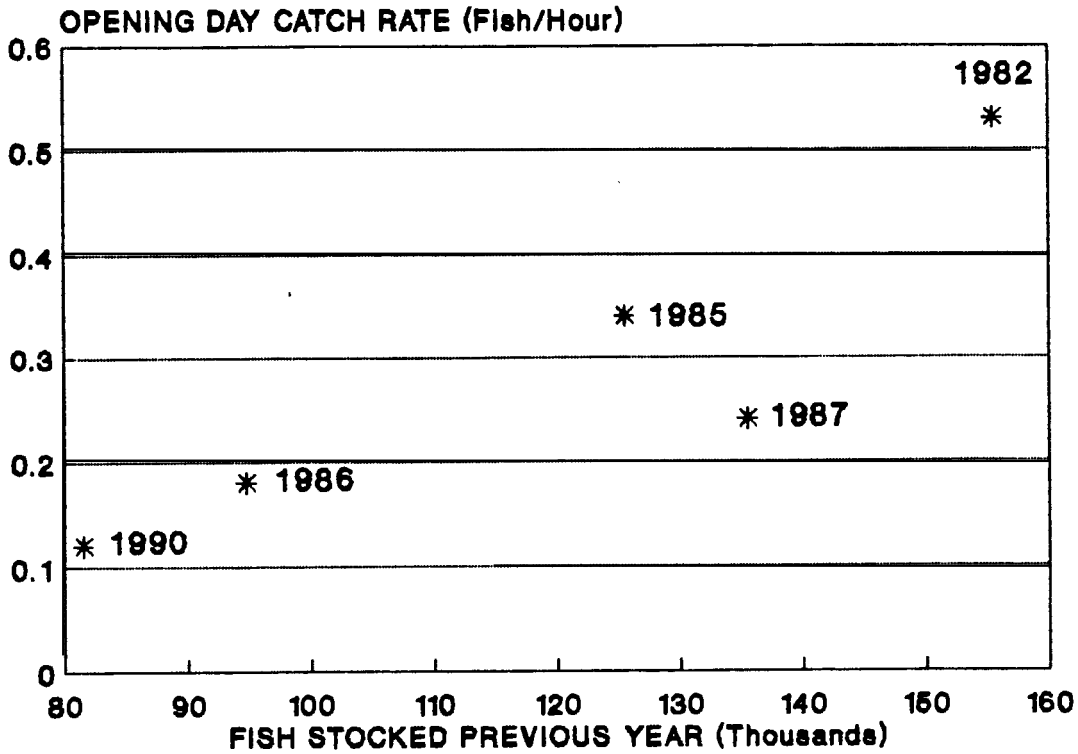


Figure 7. Relationship of number of trout stocked in American Falls Reservoir and opening day catch rate in the river below the reservoir the following year.

to detect differences in overall fishing pressure of less than about 75% to 100% between years (Appendix E). Opening day trend information might be improved by counting anglers at a standard time (e.g. 1200) each year. We have no way of estimating the relative precision because the counts are not repeatable in any year. However, midday period counts during the first census interval ranged from 32 to 117 anglers ($\bar{x}$ = 82.6, S = 44.79, n = 3) in 1990. The coefficient of variation (S.E./x) for weekend midday counts in interval 1 was 0.31 compared to 0.39 for all counts in the first interval. Sampling at a set time may not substantially improve data for trend comparisons.

Opening day angler checks normally produce 100 to 150 interviews. That sampling effort should be adequate to detect differences of less than 50% in opening day fish per angler (Appendix F).

Estimates of catch rate (fish per angler hour) for the entire season will probably require more than 100 to 200 interviews to detect differences of less than 75% to 100% (Appendix G).

Returns of Lahontan Cutthroat Trout

No Lahontan cutthroat trout were observed in the creel on the reservoir or river during the 1990 creel census. Due to low water conditions in the reservoir, angler effort on the reservoir was low. We interviewed 54 anglers that fished a total of 143 hours on the reservoir. No fish of any species were observed creeled from the reservoir during the 1990 census.

Six Lahontan cutthroat trout were captured while electrofishing the Snake River below the dam in late August. The mean length of captured Lahontan cutthroat trout was 227 mm and ranged from 210 to 240 mm. Three of the captured fish were in good condition. Two of the three had turbine marks. The remaining three fish were in relatively poor condition and showed no turbine marks.

DISCUSSION

River Fishery Management

The temporal distribution of angler effort on the river is consistent season to season and is typified by high early spring effort and harvest followed by. a sharp decline during early summer. Effort tends to increase again toward the end of the season.

The seasonal trend in harvest shows some inconsistency from year to year during the later part of the season. The reasons for these fluctuations during the fall are not known, but may be related to problems with creel census accuracy and/or variation in fish emigration patterns from the reservoir. During the fall, virtually all the angler effort that occurs on week days occurs in the

evenings after 1700. During the last eight weeks of the 1990 creel census, all of the angler counts for weekdays, as well as weekend days, were conducted before 1700. This resulted in angler effort and harvest estimates that could be 20% to 40% too low. The creel census design used for the 1990 census is the same design used since 1979. Similar stratification problems may exist in creel data from earlier years. Unfortunately we do not have sufficient information about previous work to evaluate that problem.

Heimer and Howser (1990) indicate that reduced reservoir habitat suitable for trout may result in movement of large numbers of rainbow trout out of the reservoir and into the river. They attribute increasing river catch rates during mid-summer and fall to this immigration. They suggest the number of fish emigrating from the reservoir may be related to the extent of reservoir drawdown. Variation in reservoir storage levels during mid-summer and the corresponding variation in movement of fish out of the reservoir may explain the year to year fluctuation in fall catch rates as well as estimated harvest.

Correlation analysis indicates that there is no relationship between reservoir storage levels and estimated harvest or catch rate on the river. It may be that a relation exists, but we simply have too little data to see it. Resolution of this question may provide useful insight into the fishery and a means of predicting future fisheries. If this relation does exist, managers can expect to see changes in the fishery resulting from severe reservoir drawdowns during the last several years. Continued monitoring of the reservoir and river fisheries during "good" and "poor" water years should be useful.

Most of the angler effort and harvest on the river occurs during the first eight weeks of the fishing season. Effort declines with declining catch rates. As catch rates decline in the river, anglers look for other more productive fisheries. By improving catch rates in the river through the summer, it may be possible to increase angler use of the fishery and reduce angler pressure on other waters.

Carry-over trout provide the basis for the river fishery. Not only do the carry-over rainbow trout provide the large fish that anglers expect, but they also make up a substantial portion of the total overall creel. Angler satisfaction could be increased by providing anglers with the opportunity to harvest a limited number of carry-over rainbow trout longer into the season.

Exploitation of carry-over hatchery rainbow trout in the river is very high opening day and during the first eight weeks of the season. Heavy exploitation early in the season results in reduced angler opportunity until large numbers of fish begin to immigrate from the reservoir. **A** reduction in early season harvest may result in increased angler opportunity through the season.

River-stocked hatchery rainbow trout provide increased angling opportunity in the river during the mid-summer period. Although a source of angler success, stocked fish size was also a source of angler dissatisfaction. Anglers indicated that they could catch small fish in greater numbers elsewhere.

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Anglers were favorable towards minimum size restrictions and reduced bag limits. Anglers indicated that if it was possible to spread the harvest or increase fish size throughout the season, they would be willing to accept a reduced bag limit and/or a minimum fish size restriction. Special regulations and/or bag limits appear to be a management alternative that is viable with the public.

The effectiveness of regulating the river fishery is uncertain. A lower bag limit might reduce harvest, but probably would have a relatively minor effect after the first two weeks. Successful anglers (those with any fish) averaged three fish per creel during the first two weeks of the season. However, the average angler is harvesting less than one fish per fishing trip throughout the season. A lower bag limit (one fish) might reduce harvest by as much as 60% early on and could prolong fishing on carry-over fish by a similar magnitude of time.

A slot limit with anglers only keeping fish above 406 mm (16 inches) and below 355 mm (14 inches) would reduce the harvest during the first two weeks of the season by about 50% based on length of fish returned to creel during 1990 creel census. Use of this size slot limit would allow all fish in the river to be subject to harvest at some time during the season based on observed growth. This regulation should spread the harvest of fish throughout the season more effectively than a bag limit and should provide increased opportunity to harvest larger fish.

A minimum size regulation (355 mm) would reduce the harvest during the first two weeks of the season by 21% based on length of fish returned to creel during the 1990 creel census. This regulation may spread the harvest of larger fish throughout the season, but would also reduce the overall harvest by 31% based on length of fish creeled during the 1990 creel census. Overall benefits of completely eliminating that portion of the catch would depend on survival over winter in the river. Although we know that carry-over fish support the early season harvest and produce the largest fish in the catch, we do not know what overwinter survival is. Estimates of that survival would allow a comparison of benefits for regulations that spread the harvest through the season (bag; slot limit) versus a minimum size that would exclude some fish until the following year.

The success of any regulation depends on the following assumptions: 1. fish in the river must not be subject to high natural mortality; 2. fish must not emigrate down river; and 3. post-release mortality must not be excessive (i.e. deep hooking mortality resulting from use of bait).

The estimated number of carry-over rainbow trout in the river prior to opening weekend 1990 was low relative to the number stocked. All fish that immigrate from the reservoir may not remain in the upper river and may either move downstream towards Lake Walcott or suffer high mortality in the river. In that case, regulations to reduce harvest would provide little benefit.

Accurate assessment of fish mortality and movement in the river may be unfeasible due to logistics, manpower, and/or budget constraints. The most cost effective method of evaluating the success of these regulations may be to implement and monitor them on a temporary basis.

Stocking Strategy

During "normal" water years, the most cost efficient stocking strategy for the reservoir and river fisheries should be to stock catchable-size rainbow trout in the reservoir. Emigration of fish from the reservoir provides recruitment for the river. This strategy will take advantage of the potential growth rates provided by the reservoir and provide angling opportunities in the reservoir as well as the river.

During "poor" water years (i.e. 1990), there may be no reservoir fishery. The most efficient strategy then would be to stock fish directly in the river. During 1990, recruitment of reservoir-stocked fish to the creel was poor (<0.001%), while returns of river-stocked fish were much better (22.75%). However, the size of river-stocked fish was a source of angler dissatisfaction. If fish are to be stocked directly into the river, a minimum size of 320 mm should be the goal. We do not know if fish stocked directly in the river will overwinter. Fish stocked directly in the river may not compensate for the early season carry-over fishery. Monitoring of the 1991 carry-over fishery should document the fate of fish stocked in a poor water year (1990).

The use of fingerling stocks in supplementing the reservoir and river fishery has not been formally evaluated. However, regular stocking of fingerlings has been curtailed since 1979, and the fishery has apparently declined since then. The use of fingerling stocks needs to be addressed in future investigations.

Reservoir Yield and Productivity

The sport fish yield of American Falls Reservoir is similar to other comparable reservoir systems based on minimum available trout habitat. Comparison of the American Falls Reservoir system with other northern reservoir systems with similar MEI values indicates that the trout yields in good years are not unusually low (Table 3). The total sport fish yield for the reservoir during 1981, 1982, and 1990 was 1% to 11% of the predicted potential yield. However, when I considered yield on the basis of available habitat for trout, observed yields ranged from 7% to 115% of "adjusted" potential.

Substantially better yields in American Falls Reservoir probably cannot be obtained through enhancement of the trout fishery. Some benefit might be realized in the reservoir itself if a trout strain tolerant of warm water performed well and did not emigrate. That enhanced production in the reservoir,

however, would come at the expense of the fishery in the river. Much greater benefits might be possible with species that are tolerant of the relatively high temperatures and variable dissolved oxygen which predominate in American Falls Reservoir.

Alternative Species

The introduction of alternate sport fish species in the American Falls Reservoir should be undertaken with extreme caution. Introduction of new species carries significant risks to existing fisheries both in American Falls and in contiguous waters. A thorough knowledge of the ecological and biological characteristics of any predator or prey species considered for introduction or expansion into new waters would reduce the risks associated with new species introduction and increase the potential for enhancing fisheries (Reininger 1984). My evaluations were meant to serve only as a starting point for more indepth evaluation of species that may be considered for introduction in American Falls Reservoir.

Although striped and white bass seem to be possibilities for introduction into the reservoir, other attributes of the two species may make them unsuitable for introduction. A suitable forage base for adult stripped and white bass may not exist in the reservoir. Both species prefer pelagic, schooling prey. Utah chubs, which are abundant in American Falls, might fill that requirement. We found no information, however, on associations of white or striped bass and Utah chubs. Prior to introduction of these species, it will be necessary to establish a forage fish population in the reservoir or perform introductions only on an experimental basis.

Walleye might also work in the reservoir, but the effects of introduction of this predator species on existing trout populations in the Snake River above and below the reservoir are a concern. Walleye could use chubs effectively, but again suitability as forage over the long-term is uncertain.

Introduction of smallmouth bass and white crappie into the reservoir would probably result in small localized populations in areas of suitable habitat in the form of broken rock outcroppings and shoreline woody debris. These species might become established and could provide a limited fishery associated with the relatively small amount of suitable habitat. Since smallmouth bass have been introduced into the Snake River and Ririe Reservoir above American Falls Reservoir, they may establish themselves over time.

Trends in the River Fishery

An apparent decline in the river fishery below American Falls Dam is associated with increased angler effort and reduced stocking rates in the reservoir. Other factors that may contribute to a decline include discontinuation of the fingerling stocking program or effects that we simply

could not address through our data. Fluctuation in the river fishery does not appear to be related to the observed range of reservoir storage level, volume, temperature, or dissolved oxygen content of water released from the dam.

There has been a modest decline in the mean length of fish creeled since 1979. The decline may be related to increased angler effort and corresponding increased harvest of fish or poor growth rates resulting from relatively poor water years. Size frequency data are limited, so it was impossible to correlate fish lengths with any other effect.

Fish released in American Falls Reservoir contribute to two fisheries over two years. To effectively monitor the fishery and evaluate any single release, it will be necessary to do census work simultaneously on both the river and reservoir during two consecutive years. Because the creel data are relatively imprecise, sampling over a longer term or even continuous monitoring will be important to identify trends in the fishery or to evaluate management changes.

Our established techniques for either monitoring trends in opening day effort and success are not very powerful. Differences in opening day statistics must approach 2-fold to be significant. Managers should be cautious in the interpretation of opening day information. Long-term trends should be more meaningful than year to year variation. Full season census accuracy might also be improved by increasing sampling effort, or by pooling data over longer intervals or more appropriate strata. Before another full census is conducted, we should do a more careful sampling design and allocation. Data generated in 1990 could be used to determine the best allocation and precision possible with normal or expanded sampling effort.

Returns of Lahontan Cutthroat Trout

Our study year (1990) was a record low water year and the reservoir was drawn down as far as possible. We observed no trout harvest. Evaluation of the Lahontan cutthroat stocking was not a good test of their ability to survive or produce a fishery.

SUMMARY AND CONCLUSIONS

Changing the river fishery to more evenly distribute sport fish harvest should be possible with restrictive regulations. A bag limit may extend the early season fishery by several weeks. A slot limit should spread harvest of large fish through the season and may produce more larger fish in the catch. A minimum size limit might provide similar benefits, but could be offset by overwinter mortality or emigration from the river. Mortality during carry-over time for fish in the river should be determined before implementation of a minimum size limit.

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During good water years with a reservoir fishery, the most cost effective use of hatchery fish is to stock in the reservoir. Growth and movement into the river offset losses to natural or turbine mortality. During poor water years without a significant reservoir fishery, the most cost effective stocking method should be to stock large fish (>300 mm) directly in the river.

The historic trout yields in American Falls is comparable to similar reservoir systems based on usable trout habitat. The actual observed sport fish yields of the reservoir were much less than the estimated potential sport fish yield. However, given the habitat constraints for rainbow trout, the yields we are obtaining may not be unreasonable. To realize the full sport fish potential of the reservoir, it will be necessary to introduce a fish species better suited to existing reservoir habitat and conditions or maintain a constant pool elevation.

Based on the conditions in the reservoir, white bass and stripped bass might be, and walleye probably could be, successfully introduced. Introduction of the first two species in the reservoir might also require introduction of a forage species. Such introductions would represent risks in contiguous waters. Additional evaluation addressing effects on existing fish and fisheries will be needed prior to any introduction.

Smallmouth bass and white crappie probably could be successfully introduced into the reservoir, but populations would be small and localized.

Estimated catch rates in the river fishery have declined over recent years. That trend is associated with increased angler pressure and reduced stocking rates. Other factors may be contributing to a decline, but there is insufficient data to evaluate those.

Catch rates in the river were not found to be associated with water levels in the reservoir, releases from the dam, and the temperature and dissolved oxygen content of water released from the dam for the range of values sampled. Assumptions that catch rate in the river is influenced by increased movement of fish from the reservoir cannot be statistically evaluated at this time due to insufficient data. However, the assumption that river catch rates increase with movement of fish out of the reservoir appears to be the best working hypothesis.

The mean length of fish creeled in the river fishery has declined slightly since 1979. We cannot explain the decline, but it may be associated with increased angling pressure.

A creel census monitoring both the reservoir and river simultaneously during a minimum of two consecutive years will give managers data that can be used in managing and following trends in the fishery. Census data have relatively poor precision, but could be improved with more effort or better stratification.

Evaluation of the Lahontan cutthroat trout fingerling stocks was not possible due to conditions in the reservoir.

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RECOMMENDATIONS

1. Consider (in the Snake River) spreading harvest of carry-over trout more evenly through the season. Both a restricted bag (1 fish) or a slot limit should provide some benefit and should be acceptable to the anglers. If a minimum size limit is desirable, additional data on natural mortality and emigration should be collected to evaluate potential benefits.

2. During normal or high water years, most hatchery catchables should be stocked in American Falls Reservoir to support fisheries there and in the river below. In extreme low water years, stocking in the reservoir could be curtailed with production shifted to the river. Fish stocked directly in the river should be reared to a larger size (>300 mm), if possible, to compensate for normal reservoir growth.

   The 1991 fishery should be monitored to determine the relative contribution of fish stocked in 1990. River-stocked fish should be recognized by tags and fin clips. Reservoir-stocked fish should be evident by size. If the carry-over fishery is important, reservoir stocking should not be eliminated, even in poor water years, unless river stocking fish carry-over as well.

3. To achieve more of the potential yield in the reservoir, consider introduction of other species or strains better suited to environmental conditions. Note that use of salmonid strains better suited to the reservoir and more likely to carry-over would necessarily reduce production available in the river. Repeat the introduction of Lahontan cutthroat when a better water year is expected.

4. Implement and evaluate the performance and yield for fingerling versus catchables stocked in the reservoir to historic levels. This may reestablish the declining fishery (catch rate) in the river.

5. Continue monitoring of the opening day fishery. To track effort, either use a standardized count during a set time (e.g. 10:00 am), or expand census counts to six to eight over the day. Creel data should include at least 50, and preferably more, interviews for any period to be represented in a census. Use caution in the interpretation of variation in year to year creel data. Differences on the order of 50% to 100% may be due to chance. Long-term trend data should be used rather than year to year changes to interpret or evaluate management changes.

6. Evaluate and redesign the stratification and sampling effort used in any full census for the river or reservoir.

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ACKNOWLEDGEMENTS

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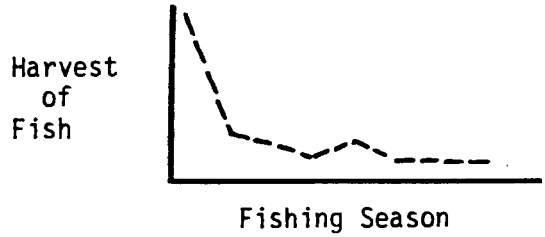
A P P E N D I C E S

Appendix A. Form used during 1990 Creel Census Angler Opinion Survey.

CENSUS QUESTIONS - SNAKE RIVER MANAGEMENT



Typically, the catch of fish in the river drops rapidly after opening day. It appears that we are "fishing out" the population with heavy angling pressure in the first few days of the season. If you are disappointed with how quickly the fishery drops off, and it is possible to spread the harvest out (good fishing longer into the season) by giving up some of your early harvest, would you favor more restrictive regulations? Examples of changes might include reducing the bag limit, meaning you would keep fewer fish (2 or 3 rather than 6), or size restrictions meaning you would have to release all fish under a size around 14 or 15 inches.

Would you accept such a change in regulations to spread out the harvest during the season?

	Reduced Bag Limit	Minimum Size
Accept	☐	☐
Accept, but not favor	☐	☐
Not accept	☐	☐
Need more information	☐	☐

If it is possible to increase average size of fish in the creel, by releasing smaller ones, would you favor that change? An example of a possible regulation change would be not keeping any fish below 14 to 16 inches.

Accept	☐
Accept, but not favor	☐
Not accept	☐
Need more information	☐

What is your ZIP CODE ?

How many times did you fish this area last year?

Appendix B. Equations, parameters, and variable definitions used in the stocking model.

Equation No.	Equation
(1)	REST X REEX = RTRE
(2)	REST - RTRE - (REST X REMT) - (REST X RECT) = REEM
(3)	REEM X TUSL = RIIM
(4)	RIEX1 X REST = RTRI1
(5)	RIST X REX2 = RTRI2
(6)	REST X RCOST1 = STCOST1
(7)	STCOST1 / (RTRE + RTRI1) = CPFC1
(8)	RIST X RCOST2 = STCOST2
(9)	STCOST2 / RTREI2 = CPFC2
(10)	STCOST1 / RTRI1 = CPFC1A
(11)	(RTRE + RTRI1) X 1.66 = LBRE
(12)	RTRI2 X 1.66 = LBRI
(13)	STCOST1 / LBRE = CPPRE
(14)	STCOST2 / LBRI = CPPRI

Variable	Variable Definitions
REST	The number of fish stocked in the reservoir.
REEX	The rate of exploitation in the reservoir.
REMT	The rate of conditional natural mortality.
RECO	The rate of reservoir carry-over.
TUSL	The rate of turbine survival.
RIEX1	The rate of exploitation in the river for reservoir-stocked fish.
RIST	The number of fish stocked in the river.
RIEX2	The rate of exploitation of river-stocked fish.
RCOST1	The per fish cost of stocking the reservoir.
RCOST2	The per fish cost of stocking the river.
RTRE	The amount of reservoir-stocked fish returned to the creel.
REEM	The number of fish emigrating to the river.
RIIM	The number of successful immigrants to the river.
RTRI1	The returns from reservoir-stocked fish.
RTRI2	The returns from river-stocked fish.
STCOST1	The total cost of stocking in the reservoir.
STCOST2	The total cost of stocking in the river.
CPFC1	The cost per reservoir-stocked fish creeled.
CPFC2	The cost per river-stocked fish creeled.
CPFC1A	The cost per reservoir-stocked fish creeled in the river.
LBRE	The total pounds return of reservoir-stocked fish.
LBRI	The total pounds return of river-stocked fish.
CPPRE	The cost per pound of reservoir-stocked fish.
CPPRI	The cost per pound of river-stocked fish.

AFAPPENB

Appendix C. Estimated angler effort and harvest of trout from the Snake River below American Falls Dam during 1990.

Interval number	Starting date	Hours fished	Reservoir stocked rainbow	River stocked rainbow	Holdover rainbow	Wild rainbow	Cutthroat	Brown	Total trout caught	Rainbow yield (kg)
1	5/26	6,857	0	118	856	167	10	20	1,171	738
2	6/9	4,560	13	0	284	13	0	0	310	225
3	6/23	2,326	132	68	197	57	63	9	526	789
4	7/7	2,060	45	489	292	35	0	0	861	623
5	7/21	1,933	102	57	78	55	0	0	292	160
6	8/4	1,152	121	29	25	34	5	0	214	127
7	8/18	400	0	0	0	0	0	0	0	0
8	9/1	80	1	1	3	0	0	0	5	5
9	9/15	549	59	4	15	0	5	2	85	58
10	9/29	253	57	0	5	0	0	0	62	47
11	10/13	63	23	0	4	0	2	0	29	15
Total		20,233	553	766	1,759	361	85	31	3,555	2,787
+95% CI		3,581	183	395	515	165	49	20	827	

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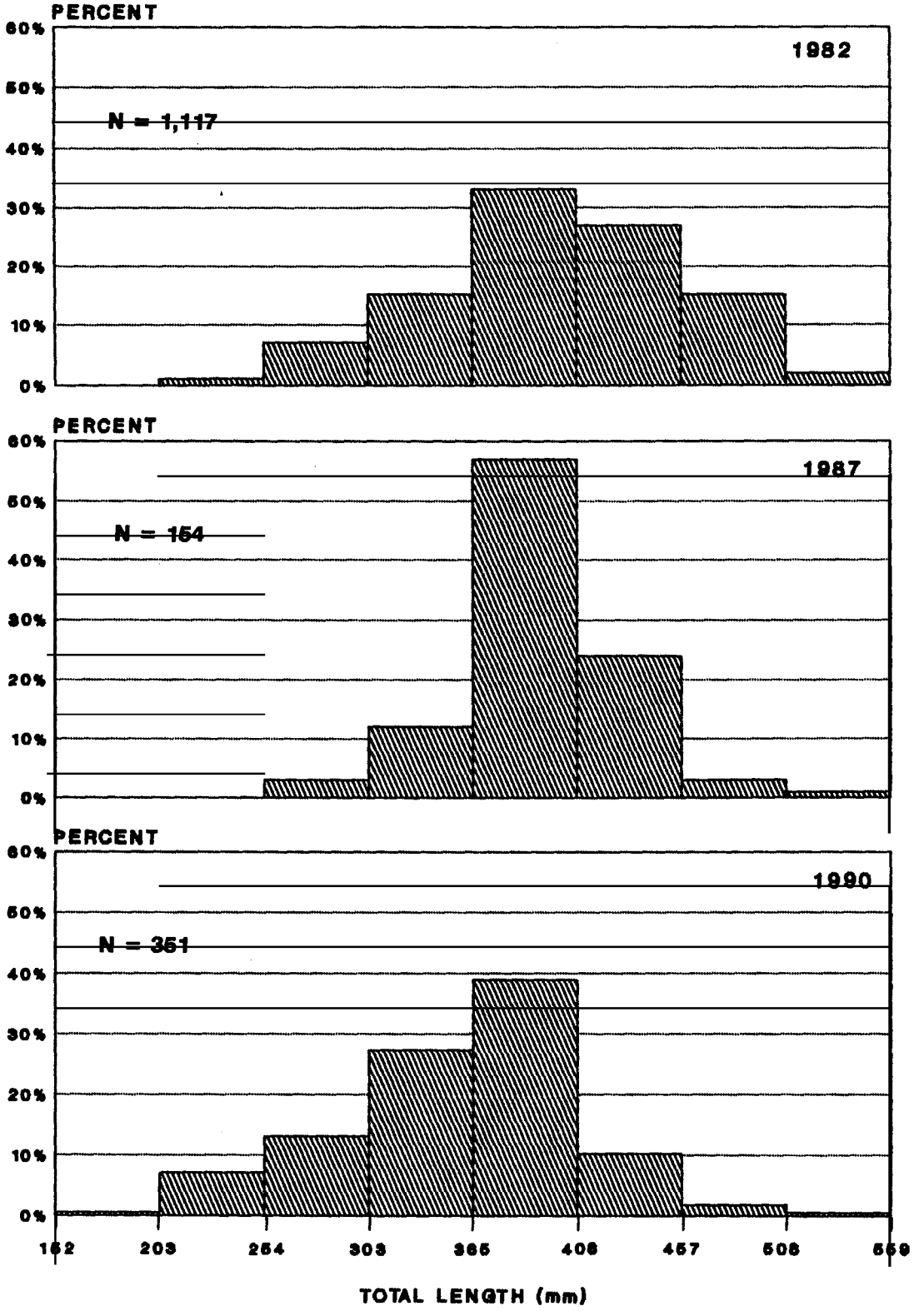

Appendix D. Length frequencies of rainbow trout creeled during 1982, 1987, and 1990.

Appendix E. Relative power of opening day angler counts on the Snake River below American Falls Dam. Calculations are for select values of a and B and are based on 1990 creel data[a]. Calculations are after Parkinson et al. (1988).

Detectable change ± % of mean		Sample size		
	α =	0.05	0.05	0.20
	B =	0.05	0.10	0.20
25		150	121	53
50		38	30	13
75		16	13	6
100		9	8	3
150		4	3	2
200		2	2	1

[a]S = 92.63, `x = 154.5, n = 4.

Appendix F. Relative power of opening day catch rate estimates (fish/angler hour) on the Snake River below American Falls Dam. Calculations are for selected values of a and B and are based on 1990 creel data[a]. Calculations are after Parkinson et al. (1988).

Detectable change ± % of mean		Sample size		
	α =	0.05	0.05	0.20
	B =	0.05	0.10	0.20
25		724	585	251
50		181	146	63
75		80	65	28
100		45	37	16
150		20	16	7
200		11	9	4

[a]S = 1.28, **X** = 0.97, n = 158.

Appendix G. Relative power of season long catch rate estimates (fish/angler hour) on the Snake River below American Falls Dam. Calculations are for selected values of a and B and are based on 1990 creel data[a]. Calculatiions are after Parkinson et al. (1988).

Detectable change ± % of mean		Sample size		
	α =	0.05	0.05	0.20
	B =	0.05	0.10	0.20
25		1,774	1,435	615
50		443	359	154
75		197	159	68
100		111	90	38
150		50	40	17
200		28	22	10

[a]S = 0.316, **x** = 0.153, n = 915.

Submitted by:

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