SUPPLEMENTARY REPORT ON AQUATIC BIOLOGY

OF THE CLIMAX AREA

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ABSTRACT

Supplementary information is provided to the October, 1978, report on aquatic biology of the Climax area regarding the identification, feeding habits, reproduction, and general well-being of the cutthroat trout in Clinton Reservoir. Additional information basic to the development of a sound fisheries management program for the reservoir is included.

INTRODUCTION

The October, 1978, report detailed the occurrence of two subspecies of cutthroat trout in Clinton Reservoir. Detailed examination of all of the specimens has now been completed and information concerning precise identification, feeding, reproduction, and general biology is given to supplement the incomplete data of the October report.

A hypothetical population structure of Clinton Reservoir trout was developed (Fig. 1) to facilitate a discussion of future management options designed to maximize the fishery potential of this body of water. Action should be taken to preserve the purity of the rare Colorado River cutthroat trout and utilize it in management of the reservoir. Introduction of forage organisms may be necessary to increase the efficiency of energy pathways from primary production into trout production and to provide large forage species necessary to produce trophy size trout.

OBJECTIVES

To obtain information on taxonomic characters, feeding habits, possible ecological segregation between subspecies of cutthroat trout, major forage organisms present in reservoir, disease and parasite problems, sexual maturation and general well-being of the trout after two years of reservoir life from a critical examination of specimens.

To synthesize and evaluate pertinent research data on trout lakes and trout populations from my personal work and that of my graduate students in addition to a literature survey as a basis for developing a generalized future scenario of trout population dynamics in relation to a discussion on management options and recommendations and to recognize possible future problems in the fishery, their causes and treatment.

METHODS

Eight specimens of cutthroat trout (five Colorado River cutthroat and three Snake River cutthroat) taken in Clinton Creek and Clinton Reservoir in June and August, 1978, were examined in detail. Several taxonomic characters were recorded and compared to detect differences between the subspecies useful to assess the degree of hybridization between the two subspecies in future years. Stomach and intestine contents were examined microscopically to identify food organisms, type of feeding (bottom, pelagic [open water], or surface), and possible ecological segregation between subspecies. Gonads were examined to note prior spawning and to identify specimens that would have spawned in 1979. General health and condition was assessed from examination of internal organs, degree of fat deposition and observations of indication of parasites or pathogenic organisms.

Personal data and literature concerning cutthroat trout biology and populations in lakes were assessed to abstract pertinent information in relation to the future course of the cutthroat trout population in Clinton Reservoir, its management, manipulation, exploitation, potential problems and their suggested solutions.

IDENTIFICATION OF SUBSPECIES

Several characters were counted, measured, and compared between the five specimens of Colorado River cutthroat trout and the three specimens of Snake River cutthroat trout. Although the sample sizes are small, three characters (number of scales in the lateral series and above the lateral line, and number of basibranchial teeth) showed clear-cut differences and will be useful to evaluate the degree of hybridization occurring between the two subspecies in future generations. As discussed and illustrated in the October report, there is an obvious difference in the spotting pattern that allows ready separation of the two subspecies. To assess the degree of hybridization in future years (first or second generation hybrids, backcrosses to either parental subspecies, etc.), additional characters are necessary.

The characters possessed by the five specimens of Colorado River cutthroat trout convince me that they are a pure population which should be perpetuated. I expect pure populations of this subspecies to average at least 180 scales in the lateral series (counting the diagonal rows of scales in a horizontal series about two rows of scales above the lateral line) and at least 43 scales above the lateral line (made from the origin of the dorsal fin in a diagonal row to the lateral line). The five specimens of Colorado River cutthroat trout collected from Clinton Creek and reservoir in 1978 have 192, 201, 212, 216, 217 (208) scales in the lateral series. This is the highest scale count I have yet found in this subspecies. The scale counts above the lateral line are 46, 47, 48, 48, 49 (48). In comparison, the three specimens of Snake River cutthroat trout have 172, 174, 178 (175) scales in the lateral series and 41, 41, 44 (42) scales above the lateral line. The number of basibranchial teeth (minute teeth that lie on the floor of the pharynx between the gill arches) are 2-8 (4.2) in the Colorado River cutthroat trout specimens and 13-22 (19.7) in the Snake River cutthroat specimens. There is an indication that the two subspecies also differ in the number of gillbrakers (bony protuberances on the gill arch). I found 18-20 (18.6) gillbrakers in the Colorado River cutthroat specimens and 20-21 (20.3) in the Snake River cutthroat specimens.

SEXUAL MATURATION

One of the three Snake River cutthroat trout examined (a male of 12.6 in. [320 mm] total length) had well developed testes and undoubtedly would have participated in spawning in 1979. Another male of 10.8 in. (274 mm) had only rudimentary testes and would not have been sexually mature until 1980. The third specimen of Snake River cutthroat trout (12 in. [306 mm]) showed no gonadal development. This specimen is probably a female which would not have spawned until 1980 or 1981. The five specimens of Colorado River cutthroat trout had all spawned in 1978. They exhibited only slight gonadal development by August. No more than one or two would have spawned again in 1979. Biennial (every other year) spawning is typical of cutthroat trout living in lakes. Those fish which survive spawning, generally require two years to accumulate sufficient energy to mature sperm or eggs again.

Some males and probably a few of the females of the Snake River cutthroat population will sexually mature and attempt to spawn in Clinton Creek in 1979 and hybridization is expected to occur.

FEEDING

Except for one of the spawned-out fish taken in Clinton Creek in June, which contained only a few tiny beetle larvae, the other stomachs and intestines were glutted with food. Although the small sample size and timing of the collection does not allow for firm conclusions, the growth rate (3-4 in. per year) and the great amounts of fat (storage of surplus energy) deposited in the viscera, demonstrate that excellent feeding conditions have existed since the reservoir was created.

The forage organisms in all stomachs overwhelmingly (> 99%) consist of only a few species of two groups (orders) of insects. Larvae, pupae and adult "midges" ("black gnats") was the sole or dominant food in two of three Snake River cutthroat trout and in three of four Colorado River cutthroat trout (the "fifth" Colorado River cutthroat specimen taken in June from Clinton Creek had virtually no food in its stomach). One Snake River cutthroat trout and one Colorado River cutthroat trout had fed almost exclusively on pupae and adults of a single species of mayfly. A detailed comparison of the "midge" component in the diets, definitely indicates some ecological segregation is occurring in the feeding habits between the Snake River cutthroat trout and the Colorado River cutthroat. The Colorado River cutthroat trout had fed mainly on the larvae form of the midge (occurring on the bottom) and the Snake River cutthroat fed predominantly on pupae or adult midges (near or on the surface).

No crustaceans ("water fleas," "shrimp," etc.) were found in the food, which suggests the possibilities for introductions of additional forage organisms as part of a management program (discussed under recommendations).

GENERAL WELL-BEING

No indication of disease or unhealthy condition was found. The specimens appeared to be in excellent condition when captured. Roundworm parasites were found in stomachs containing mayflies but I believe they are parasites of the insect, not the trout.

Some disease organisms and parasites are associated with all fish populations but rarely create serious problems in wild populations. The most serious parasite problem in Colorado trout lakes occurs in the North Park region where the larval stage of the eye fluke causes impaired vision and blindness in trout. Trout serve as an intermediate host of the eye fluke. Snails are the primary host and fish-eating birds act as the final host.

FISHERY CONSIDERATIONS

Figure 1 represents an idealized size-age structure of the Clinton Reservoir trout population at some future time and illustrates an excellent fishery potential. The figure is based on the assumptions that spawning success is strictly limited, natural mortality rates are relatively low, growth rates are high, survival and growth are relatively high after first spawning (to produce trophy size fish), and anglers remove only "surplus production" (overexploitation doesn't occur). The total biomass represented by all age groups in figure 1 is about 5000 lbs. or 50 lbs./acre (46 kg/ha). Virtually all of this biomass consists of catchable size (8 in. and larger) trout. This representation is the way the population structure might appear in September of any year (toward end of growing season).

In reality, figure 1 is a great oversimplification of nature. The processes determining size-age and biomass structure of a population are highly dynamic and influenced by many factors. The blocks representing the age classes are stationary only at a given moment in time. A more realistic view is to view them as pistons in an engine, constantly moving up (increasing) or down (decreasing) during a year and between different years.

Although figure 1 may not approximate the Clinton Reservoir trout population it can serve as a useful reference to facilitate an understanding of a discussion of the reservoir fishery in relation to potential problems, management options and special angling regulations. Some of the potential problems which may appear in the future, diminishing the quality of the Clinton Reservoir fishery, can be summarized as follows.

<u>Problem</u>: Fish are small (average size 10 in. [254 mm] or less), growth is slow. Such a population, in reference to figure 1, would exhibit a great skewing to the left side of the figure with most of the fish and biomass tied up in small size groups. Slow growth results in fish of 8-10 in. (203-254 mm) at age 3-4 and very few fish in the population exceeding 12 in. (305 mm).

<u>Cause A</u>: Overpopulation resulting from too much natural reproduction which causes severe competition for food supply, high mortality, and slow growth (the fish are stunted). Figure 1 provides for 20,000 fry hatching each year in July which, in turn, suffer a 75% mortality by September leaving 5,000 fingerlings of the zero age group in the lake. The early life history stages of a fish are vulnerable to several environmental influences and high mortality is generally encountered, particularly in the first few weeks after hatching. In natural environments, year to year fluctuations in survival can be enormous.

Assuming that 20,000 fry (newly hatched) is the best approximation of the quantity necessary to "stock" the reservoir each year to avoid overpopulation and to maintain an abundant and stable population of trout exhibiting good growth, this number of fry would be expected to be produced from a spawning of about 40,000 eggs (assuming 50% mortality of eggs before hatching). About 40 to 50 lbs. of female trout will spawn 40,000 eggs. For an assessment of the spawning potential of the hypothetical population depicted in figure 1, it is assumed that about half of the population of age 3 and older are females. About half of the females spawn for the first time at age 3 but only every other year thereafter. Such a situation would result in a potential annual fecundity of about 500,000-750,000 eggs--a tremendous surplus.

Treatment: Limit spawning. All trout must spawn in Clinton Creek. Presently there are few areas suitable for successful reproduction due to lack of suitable spawning gravel in the stream. This natural limitation may serve to prevent the problem from developing. If suitable spawning areas are limited to 40-50 $yd.^2$ (or m^2), overreproduction should not be a problem.

Cause B: Food supply deficient in forage organisms of diverse size. Ideally, the forage base should favor feeding segregation between young, small trout (age 0 and 1) and older, larger trout (age 2 and older) and to maintain a sufficient abundance of large food items to produce trout of trophy size and favor survival and growth after first spawning.

Treatment: If adequate diversity of forage organisms are not present in reservoir, they can be introduced. The present indication is that crustaceans of a size suitable for trout forage are lacking. If pelagic and benthic crustaceans can be established, the channelization of energy through the food web from primary production (plant photosynthesis) into the trout population will become more efficient and more "trophy" (15-16 in. and larger) trout will be produced (see recommendations for specific types of organisms for introduction). If a diversity of forage organisms can be established, and both subspecies of cutthroat trout are maintained in the reservoir, segregation between the subspecies, resulting in greater total production, will also be favored.

Problem: Catch is mainly of young fish; reservoir exhibits indications of being "fished out."

Cause: Overexploitation by anglers. Overexploitation occurs when anglers kill more fish than would have died from natural causes during the year if there was no angling mortality so that fewer fish are alive the following year than there would have been without angling mortality. In general, mortality factors in fish populations are largely compensatory. That is, the more fish killed by anglers, the fewer die from natural causes and vice versa. The hypothetical population illustrated in figure 1 shows a natural annual mortality (or surplus production) of 2500 catchable size (8 in. and more) trout. Under ideal conditions, anglers might account for 80% (2000 trout) of the total mortality without increasing the total mortality. Thus, the population in figure 1 might sustain an annual kill of 2000 trout before overexploitation occurs.

It must be recognized, however, that the most significant values associated with a wild cutthroat trout fishery in a mountain lake are not measured by the numbers and pounds of trout killed, but rather by the recreational experience and the quality of the fishery expressed in catch-per-man-hours (CPMH) and average size of the fish. As discussed in the October report, cutthroat trout are the most vulnerable trout species to angler overexploitation, but they are also the best species for special regulation fisheries because they are susceptible to being caught and released several times (they can maintain a high CPMH on a limited stock of fish). Thus, even though half or more of the cutthroat trout caught and released in any year may die of natural causes before the next year, they are maintained in the current fishery and contribute to a high CPMH by being caught again before their death.

As discussed in the October report, I believe that even light (20-40 hrs./acre) angling pressure under current Colorado Division of Wildlife regulations will result in overexploitation and "overfishing." Because of the accessibility of Clinton Reservoir, angling pressure may well exceed 100 hrs./acre/year. West Lake, one of the Red Feather Lakes, about 50 mi. (80 km) northwest of Fort Collins, received more than 2000 hrs./acre angling pressure in 1974, the last year of complete creel census on the lake. This extremely high angler use is maintained and encouraged by the stocking of catchable size rainbow trout. In 1973, as part of an experiment designed for learning more about the role of the Snake River cutthroat trout in fishery management, I stocked 1900 Snake River cutthroat trout fingerlings (about 2 in. in length and weighing 950/lb.) into West Lake. Survival and growth of this plant was excellent. In 1974, creel census data revealed that 847 of the 1900 (45%) introduced cutthroat trout were harvested by anglers. Strictly from a cost-benefit point of view, the 1900 fingerling cutthroat trout stocked in 1973 provided an excellent return in 1974 (2 lbs. stocked, about 350 lbs.

caught), but under the intense angling pressure, there were virtually no cutthroat trout which escaped angling mortality to become trophy size fish in 1975-76. On the other hand, brown trout fingerlings stocked into West Lake, remain in substantial numbers for two and three years in the fishery because the brown trout is much more resistant to catch (and overexploitation) than is the cutthroat trout.

Trappers Lake, Colorado, is a body of water of 280 surface acres (116 ha) in size with a maximum depth of 175 ft. (53 m). Cutthroat trout is the only fish in Trappers Lake. From 1960 to 1968 Colorado Division of Wildlife personnel collected much data on the cutthroat trout and its fishery in Trappers Lake. Angling pressure averaged about 11,000 hrs./yr. (or about 40 hrs./acre) and the catch ranged from 2172 to 7401 trout per year, averaging about 4500. Regulations regarding size and bag limits had no detectable effects on the Trappers Lake cutthroat trout population. That is, the angler's catch did not overexploit this population (they were removing only surplus production). This is due mainly to the size-age structure of the population, but may also be influenced by the large area of deep water where the trout may retreat and not be available to the fisherman. The Trappers Lake cutthroat grows reasonably well, reaching 11.1 in. (279 mm) to 14 in. (356 mm) at three to four years of age. However, due to a lack of large forage organisms, survival is poor and growth is very slow after first spawning. Of a total of 10,688 fish examined from spawning runs from 1960 to 1968, only 18 (1 of 600 or .2%) of the adult fish were 18 in. (456 mm) or larger. The largest specimen of the 10,688 trout examined was 20 in. (508 mm). Thus, under such a growth regime, it would be fruitless to attempt to create a trophy fishery in Trappers Lake by protecting younger, smaller trout in expectation that a significant number would reach "trophy" size.

Treatment: Institute special regulations regarding size, bag, and gear restrictions on the Clinton Reservoir fishery. In the October report I suggested a 14 in. (356 mm) size limit and a bag limit of two trout per day and also suggested a season on the fishery, opening July 1, with angling restricted to artificial flies and lures.

All angling regulations on waters open to public fishing must be approved by the Colorado Division of Wildlife, and I would urge the adoption of my suggested regulations. In the future, as indicated by the response of the Clinton Reservoir trout population, the regulations can be modified to adjust to existing situations.

The restriction of angling to artificial flies and lures is necessary for any fishery where large numbers of fish are returned to the water with an expectation that they will survive and be caught again. Bait caught trout (worms, salmon eggs, etc.) typically suffer 30% to 50% mortality based on numerous studies. This is due to the tendency for the trout to swallow the bait and be hooked deeply and fatally. Depending on temperature, fly and lure caught trout, typically suffer 2% to 10% mortality. There is little consistent difference in mortality between trout caught on flies (single hook) or lures (treble hook) or between barbed and barbless hooks. In a test conducted in a hatchery raceway in Colorado with catchable size rainbow trout (8.2-11.9 in. [209-303 mm], 3 of 233 trout caught on a single hook lure and 4 of 224 trout caught on a treble hook lure in April, died after being released. The mortality difference (1.3% and 1.7%) was not significant in April. The same test conducted in July, in warmer waters, resulted in a mortality of 28 of the 272 trout caught and released on the single hook lure (10.3%) and a mortality of 13 of 271 (4.8%) caught on a treble hook. The July test did show significant statistical differences in mortality--a higher proportion of the trout were killed by the single hook (because it was more likely to be taken into the mouth and fatally rupture the gills).

In Yellowstone Lake, bait caught cutthroat trout suffered a 40% mortality while only 3% of the cutthroat trout caught on barbless flies and 4% caught on barbed flies died after release (the difference between barbed and barbless hooks was not statistically significant).

Thus, any regulations regarding minimum size must also restrict angling gear to artificial lures or flies if it is to be effective.

RECOMMENDATIONS

1. Preserve the pure population of Colorado River cutthroat trout in Clinton Reservoir by artificial propagation and establishment of a brood stock. This recommendation is given in more detail in the October report. I have examined hundreds of specimens of Colorado River cutthroat trout from many sites and have never been as confident of the purity of the stock as I am with the Clinton Reservoir population. Populations of this trout uncontaminated by hybridization with rainbow trout or other subspecies of cutthroat trout are extremely rare--to the point of virtual extinction. Colorado Division of Wildlife should be willing to cooperate in taking eggs from the spawning run in Clinton Creek for propagation. Hybridization between the Colorado River cutthroat trout and the

Snake River cutthroat will begin in Clinton Creek in 1979. Year classes of Colorado River cutthroat trout born prior to 1979 are pure and they will continue to spawn into the 1980s (probably to 1984-85), but each generation produced from 1979 on will likely become increasingly hybridized. Eggs and sperm from pure Colorado River cutthroat trout can probably be taken until about 1984-85, but the largest numbers of pure Colorado River cutthroat trout should appear in the spawning runs from 1979 to 1982 (from those born from 1976 to 1978). The practical value of maintaining a source of the Colorado River cutthroat for propagation is that they can be stocked as fingerlings into the lake each year to maintain two groups of cutthroat trout (the native Colorado River cutthroat and the hybrid which will probably become dominated by its Snake River cutthroat ancestry) and create ecological segregation resulting in a more productive and higher quality fishery.

2. Introduction of forage organisms. As discussed, I found no evidence of crustaceans suitable as trout food in Clinton Reservoir in 1978. Crustaceans can make effective use of the pelagic (open water) and benthic (bottom) resources and supply a dependable source of food and also effect feeding segregation (avoidance of competition) between young, small trout and older, larger trout and feeding segregation between subspecies of cutthroat trout. I would break down the crustacea considered for introduction into three categories based on their sizes: Small (1-3 mm) species represented by copepods and cladocerans (water fleas) which are pelagic and are typically the "bread and butter" of young trout in most mountain

lakes. Trout can grow rapidly to a size of about 12 in. (305 mm) on these small organisms alone if they are abundant, but grow slowly beyond that size because of the energy expenditure required to capture sufficient quantities of such small organisms. Trappers Lake is an example of the basic food supply consisting of small crustaceans. Few trout exceed 14 in. (356 mm) in Trappers Lake, but there is an abundance of smaller trout.

Medium size species (3-15 mm) represented by freshwater "shrimp" or scuds and aquatic "sow bugs." The trout from lakes with an abundant "shrimp" population are characterized by rapid growth, excellent condition ("plumpness"), and red flesh color. "Shrimp" occur in many, but not all, mountain lakes in Colorado. Sometimes introductions of shrimp into waters where they did not previously occur are successful, sometimes not. The aquatic "sow bug," where it occurs, typically becomes abundant in fall and winter months, when it makes significant contributions to the trout's diet. They inhabit mud bottom areas and are abundant in Dillon Reservoir.

Large size (20 mm and larger) crustacean are largely restricted to crawfish and "possum shrimp" in Colorado lakes. The "possum shrimp" has been introduced into several Colorado lakes and is abundant in Twin Lakes. Since the establishment of "possum shrimp" in Twin Lakes, the small crustaceans (water fleas), once the most abundant trout food, has disappeared. This "trade-off" may not be beneficial to the trout population.

Crawfish are a prime food for large trout. In waters where crawfish are abundant (and of a species available to trout), trout growth curves show an interesting phenomenon. A size of about 14 in. (356 mm) is attained primarily on a diet of small crustaceans and insects in perhaps two to four years, then the trout start to feed almost exclusively on crawfish and their growth spurts rapidly. I have two small ponds (.5 acre) on my property in Fort Collins in which I raise Snake River cutthroat trout. After reaching a size of 13-15 in. (330-382 mm), the cutthroat trout start to feed intensively on the abundant crawfish population and the following year are 18-21 in. (457-533 mm) in length and weigh three to four pounds and more.

I have observed this same growth pattern in the Snake River cutthroat trout introduced into Towave Reservoir on the Uinta Indian Reservation, Utah, after crawfish became established in the reservoir. I do not know of any crawfish population existing at 11,000 ft. (3333 m), the elevation of Clinton Reservoir, and their successful introduction is doubtful, but as with the freshwater "shrimp," it is a "try it and see" situation.

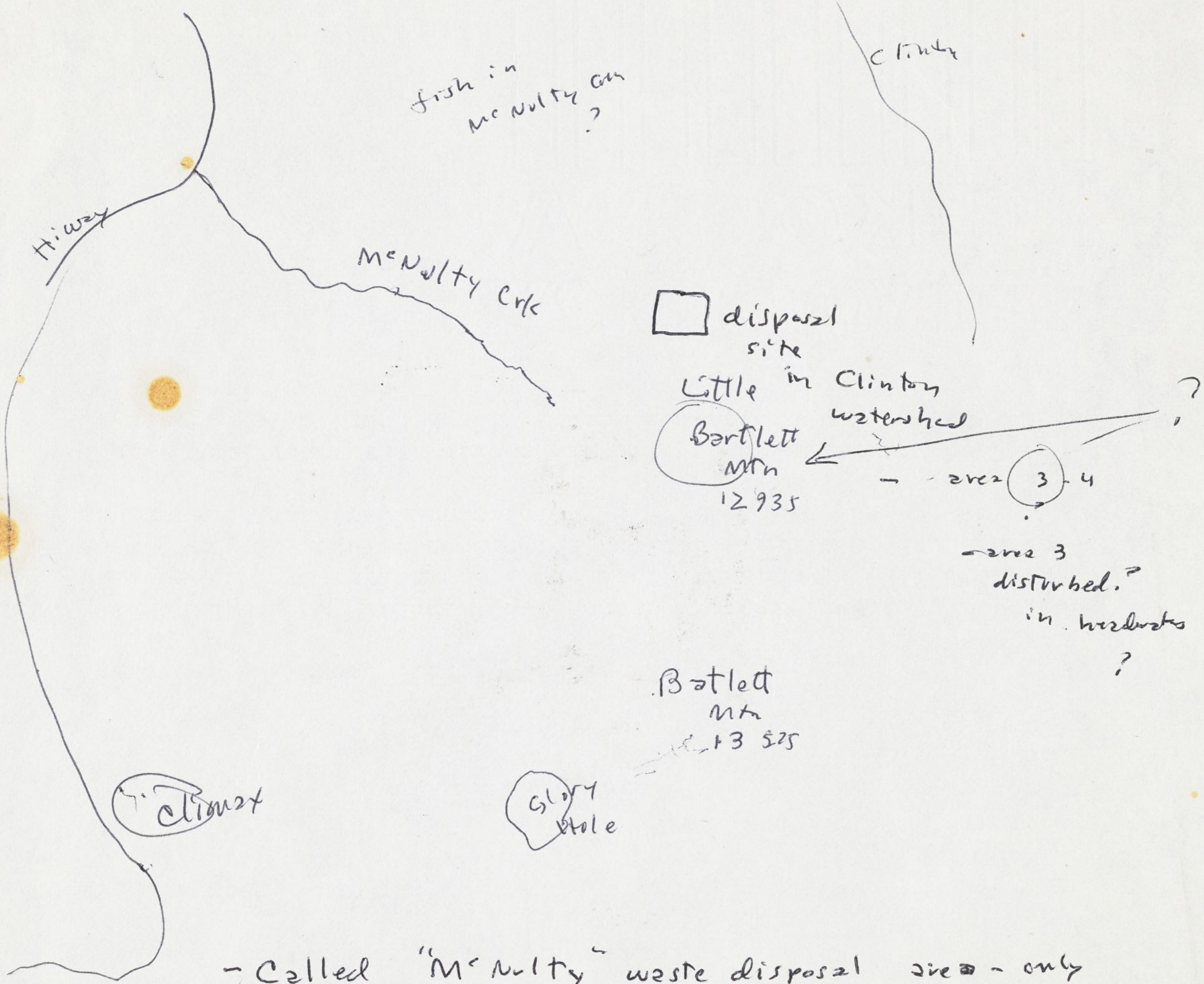
3. Plan future management and monitoring of Clinton Reservoir trout population and fishery. Much useful information can be obtained from relatively little effort such as sampling of spawning runs, sampling anglers catch for size, age, growth rate, feeding habits, etc., but if detailed data regarding population dynamics, recruitment, catch, feeding, etc., are desired, an intensive research plan must be adopted. The most cost effective method to conduct intensive research would be the employment of a graduate student or students who would collect and analyze the data for thesis studies.

Figure 1. Hypothetical and idealized size and age structure of Clinton Reservoir trout population in September of some future year. Assumptions for this model are that natural mortality rates are relatively low, growth and production remain good to excellent, natural reproduction is limited to no more than about 10% of the potential fecundity of the population (to prevent overpopulation, slow growth and stunting), and anglers remove only surplus production (overexploitation does not occur).

The standing crop (total biomass) is about 5000 lbs. or 50 lbs./acre. There are 5775 trout of catchable size (ca. 8 in. or more); of these, 2500 will die within a year (surplus production).

Good growth and survival into the older age classes to produce "trophy" size trout is dependent on an abundance of relatively large forage organisms.

Overexploitation by anglers will occur if the number of trout removed by anglers equals or exceeds the numbers in the surplus production. Restrictive regulations aimed at creating a high catch-per-hour (bulk of trout caught and released) may be necessary if angling pressure approaches 50 hrs./acre/year.



- Called "McNulty" waste disposal area — only rock ... toxic ? — drain to Clinton — erosion — roads.

— roads ..

S. Fk.
— Ten Mile Crk — polluted — no fish

1860's — Clinton ? ... cutthroat ?

should I mention
— Rep. — Apr. 5 meet. — discuss cutts ? ?

COLLEGE OF FORESTRY AND NATURAL RESOURCES

MEMORANDUM

March 27, 1979

TO: Faculty and Staff
College of Forestry and Natural Resources

FROM: Jay M. Hughes

FORESTRY FORUM

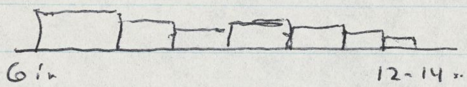
WHEN: Monday, April 2, 1979 - 11:45 a.m.

WHERE: Cherokee Park Room, Student Center, C.S.U.

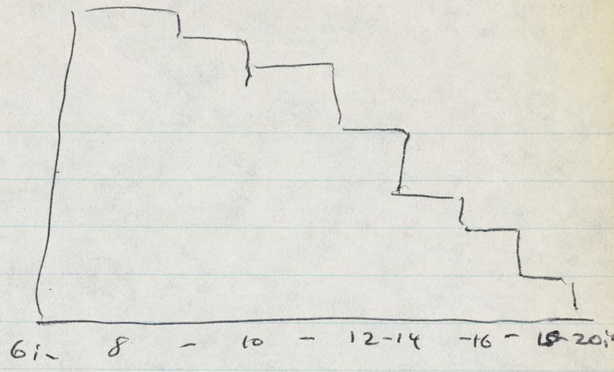
PROGRAM: Mel Schamberger, National Coordinator Project Impact Evaluation, will be giving a briefing on the activities of the PIE group, including the involvement in the Habitat Evaluation Procedures and impact assessment methodology.

Please make your reservations with the secretaries in the Dean's Office, 6675, by noon Friday, March 30, in order for them to notify Food Services.

Cutthroat Trout
Kelly Crk.
Idaho
catchable size trout (>6 in)



normal angling exploitation

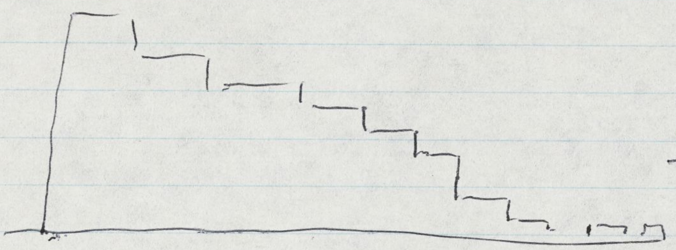


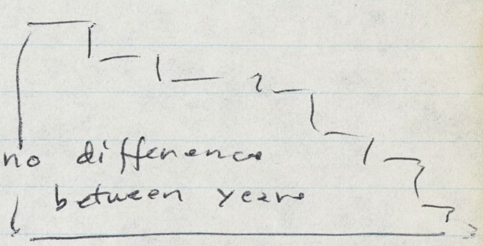
13 fold greater

catch-and-release

angling pressure (ca. 20 hrs./acre)
(exploitation rates 75-90%)
[nat. mortality ca. 35%)

(also rainbow trout)
Brown trout
Poudre R.
Colo.





769 hrs./acre

normal regulations
angling mortality 35% (max.)
natural (40-50%)

- artificial lures -