State of California
The Resources Agency
Department of Fish and Game

THE TROUT FISHERY OF CROWLEY LAKE, MONO COUNTY, CALIFORNIA[1]

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SUMMARY

Crowley Lake is located in southern Mono County, California, at an elevation of 6,781 feet. It is an artificial impoundment approximately six miles long and three miles wide with a maximum surface acreage of 5,272. High total dissolved solids, combined with a relatively shallow mean depth, result in a high level of biological productivity.

Early management practices at Crowley Lake consisted primarily of planting fingerling brown and rainbow trout. As angling pressure increased, it became apparent that planting fingerling trout alone could not long maintain a satisfactory level of angling success. The value of planting larger trout was investigated and found feasible.

Present management practices are based around the annual planting of approximately 300,000 subcatchable rainbow trout averaging 10 per pound. Planting is usually done at, or near, the end of the Crowley Lake angling season on July 31.

Analysis of rainbow trout stomach contents revealed that the majority of their summertime food consisted of immature Tendipedidae and Cladocera. Later in the fall, rainbow trout consume chiefly small tui chubs (Siphateles sp.) and Cladocera.

The growth rates of Crowley Lake trout are exceptional. Rainbow trout planted in August at an average size of 10 per pound (about 5.8 inches, fork length) are taken by anglers at approximately one pound and 12 inches by the beginning of the following season about eight months later. This rapid growth continues into later years. Brown and cutthroat trout grow at a similar rate.

Crowley Lake rainbow trout were found to possess a higher mean condition factor than rainbow trout from nearby waters. However, condition factors for brown and cutthroat trout were only average.

The severity of winter conditions and the degree of reservoir fluctuation exert considerable influence on trout growth. Exceptional growth occurs during winters in which ice-cover is of short duration and the reservoir level is constant or rising.

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An intensive study of the Crowley Lake fishery during the 1958 angling season revealed that nearly 25 percent of the seasonal angling pressure and 35 percent of the seasonal catch occurxed on the opening weekend. Over 65 percent of the seasonal angling pressure and over 80 percent of the seasonal catch occurred during May. As the rainbow trout population was harvested, both [illegible]. It was estimated that 53 percent of [illegible] subcatchable rainbows planted in 1957 were eventually taken by anglers.

In several Mono County lakes stocked with catchable trout, the cost per pound of trout returned to the angler is about $0.90. The Crowley Lake management program produces a pound of trout in the angler's creel for approximately $0.15.

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INTRODUCTION

In May, 1947, the California Department of Fish and Game issued a news release indicating that on the opening weekend of the season at Crowley Lake 5,920 anglers caught nearly 9,000 trout weighing over 17,000 pounds. Fourteen years later, in May, 1961, the Department's release read as follows: "Opening weekend of trout season at Crowley Lake was another record breaker. The largest two-day crowd ever- nearly 19,000 anglers - took over 72,000 trout, a record number. The fish averaged one and one-eighths pounds. The total catch weighed 40 and one-half tons - another record. A check by Department of Fish and Game personnel showed that this year's (1961) opening weekend at Crowley drew nearly 5,000 more fishermen, over a thousand more boats, and almost 14,000 more trout were caught, weighing 11 and one-quarter more tons than on opening weekend last year."

It is difficult to believe, when observing the thousands of anglers at Crowley Lake on the opening of the season, that less than a century ago the Owens River drainage contained no game fish of any species and that less than a quarter of a century ago Crowley Lake itself did not exist.

This report tells the story of this remarkable reservoir and explains the fisheries management plan which provides a satisfactory level of angling success in the face of constantly increasing angling pressure.

DESCRIPTION OF CROWLEY LAKE

Crowley Lake is located on the eastern slope of the Sierra Nevada in southern Mono County, California, at an elevation of 6,781 feet. The lake was created in April, 1941, when the Long Valley Dam was placed in operation by the Department of Water and Power of the City of Los Angeles to impound the waters of the Owens River. Five years later, in the spring of 1946, the lake reached spillway level. At maximum storage, the lake is roughly six miles long and three miles wide. Maximum depth is 114,5 feet, and surface area is 5,272 acres. Volume at spill level is 183,743 acre-feet, and mean depth was calculated to be 34.85 feet (Pister, 1960). Fluctuations of the lake level are gradual; severe, short-term changes do not occur.

As the lake gradually filled, large areas of meadowland and sagebrush flats were inundated, and the resulting bottom material proved to be very productive of fish food organisms, chiefly midge larvae and pupae (Diptera, Tendipedidae). Pister (op. cit.), in a study of the lake's bottom fauna in 1953, found the mean standing crop to be 153 pounds per acre between May and August, with a total standing crop of over 400 tons.

Bottom types are chiefly mud and ooze, grading to gravel and sand in the shoal areas. The unusually high productivity of the lake has apparently become stabilized at a point somewhat lower than that which existed during the first few years after flooding, but is still probably above the "average" for lakes at this general elevation (Calhoun, 1944; Reimers, Maciolek and Pister, 1955). Although the bottom fauna productivity in Crowley Lake is not extraordinarily high per unit of area, so much of the lake is shallow that the overall food production in relation to the size of the trout population is quite substantial. Winter conditions in the Crowley Lake area are severe, and the lake almost invariably freezes over its entire surface. Ice-cover usually forms in late December and disappears in early April.

Crowley Lake is strongly bicarbonate in character, with relatively high concentrations of silica, sodium, chloride, and phosphate. Total dissolved solids (187 ppm. are quite high when compared with those of nearby lakes (Reimers, Maciolek and Pister, op. cit.). In addition, 83 percent of the total bottom area lies beneath less than 50 feet of water. These factors probably exert much influence dn creating a high level of biological productivity (Northcote and Larkin, 1956; Rawson, 1952, 1953a and 1953b).

Midsummer surface temperatures reach the low 70's. During this time, blooms of both zooplankton (Cladocera) and phytoplankton (Volvox and Gloeotrichia) are commor This plankton material, chiefly Cladocera, is an important food source for rainbow trout. The heavy algae bloom, combined with extensive growths of rooted aquatic plants of various species in the shoal areas, creates a depreciation of the oxygen supply and other unstable biological conditions, especially at night, occasionally resulting in the mortality of considerable numbers of nongame fish and an occasiona trout. Nonegame fish generally inhabit the shoal areas, while trout occupy the deeper, cooler portions of the lake and are therefore not greatly affected by these adverse conditions.

FISH FAUNA OF CROWLEY LAKE

Trout are not native to the Owens River drainage. Native fishes in the upper portion of the drainage are reported as sucker, Catostomus sp.; chub, Siphateles sp.; and dace, Rhinichthys sp. (Hubbs and Miller, 1948; Kimsey and Fisk, 1960). Only suckers and chubs have been collected recently from Crowley Lake. Collecting operations, however, have not been extensive.

Prior to the creation of Crowley Lake, rainbow trout, Salmo gairdnerii; brown trout Salmo trutta; Lahontan cutthroat trout, Salmo clarkii henshawi; golden trout, Salmo agu onita; and eastern brook trout, Salvelinus fontinalis had been introduced into the Owens River drainage above the present location of Crowley Lake. However, only rainbow and brown trout were present in the lake area in significant numbers.

GAME FISH-NONGAME FISH RELATIONSHIPS

The role of nongame fish in the ecology of Crowley Lake is not thoroughly understood. It is known that significant populations of suckers and chubs exist, apparently without detriment to the trout population. Food habit studies reveal that the young of these species are consumed in large numbers by trout, particularly during the late fall when aquatic insect populations reach a low level. The overwinter growth of trout is unusually good, and it seems probable that this may be due in large measure to the easy availability of these small fish.

Nongame fish control measures do not appear warranted at this time. As long as the trout growth rate in Crowley Lake approximates the growth rate attained in a good fish hatchery, any changes in the existing situation should be carefully considered.

EARLY MANAGEMENT PRACTICES

In the early 1940 s, as Crowley Lake began to fill, fish planting consisted primarily of fingerling brown and rainbow trout supplemented by relatively small numbers of yearling rainbows (Table 1). The high initial productivity of the lake and small population of large, predatory fish permitted good growth and survival. Under light, wartime angling pressure, a good catch rate of large fish was maintained. However, as the lake became more popular and angling pressure increased, the planting of fingerling trout could not maintain a satisfactory level of angling success.

TABLE

Crowley Lake Fish Plantings

Year	Subcatchables	Fingerlings					
	Rainbow	Rainbow	Kamloops rainbow	Brown	Cutthroat	Eastern brook	Total
1941	1,000			95,890			96,890
1942	21,905			124,426			146,331
1943	82,979				8,298 1/		91,277
1944	125	210,538					210,663
1945	182,417	7,904					190,321
1946	13,510	185,600			718,782		917,892
1947	35,088	122,000					157,088
1948	28,340	54,793					83,133
1949	21,923	54,400			190,800		267,123
1950		128,800					128,800
1951	161,240						161,240
1952	156,890				100,000		256,890
1953	224,409			176,400	161,476		562,285
1954	175,224			114,895	194,035		484,154
1955	207,616		30,000 1/		100,000		337,616
1956	238,690				158,400		397,090
1957	235,943				173,728		409,671
1958	212,183	135,390	182,080		226,725		756,378
1959	315,265		245,430		229,890	100,000	890,585
1960	295,860	14,500			183,760	66,000	560,120
1961	436,982	52,640	110,310		100,000		699,932
1962	298,350	111,740	104,000		122,128		636,218
Total	3,345,939	1,078,305	671,820	511,611	2,668,022	166,000	8,441,697

1/ Indicates fish planted at yearling size.

Management measures in the 1940's were carried out on an experimental basis in an effort to arrive at a satisfactory overall plan. The planting of larger numbers of subcatchable rainbow trout (averaging 10 per pound) was successful, and the problem then became one of producing adequate numbers of trout of this size to carry on a sustained planting program. The opening of Fish Springs Hatchery in 1952 made this possible. Since that date, Crowley Lake has been planted on an annual basis with large numbers of subcatchable rainbows.

PRESENT MANAGEMENT PRACTICES

The primary reason for Crowley Lake's popularity is that people are able to catch big fish. The average trout taken weighs a pound or more, whereas at other roadside waters anglers must generally be satisfied with planted rainbow trout weighing three or four ounces.

Crowley Lake is managed as a trophy fishery. To make this possible, special angling regulations have been placed in effect. The season opens with the surrounding area on the Saturday nearest May 1. It closes on July 31, three months earlier than the general area closure.

Shortly after the close of the season, approximately 300,000 subcatchable rainbow trout of the Hot Creek fall spawning strain are planted. With the advantage of the long growing season and abundant food supply these fish grow rapidly. Subcatchables planted in August at an average size of 10 per pound (about 5.8 inches, fork length) are taken by anglers at approximately one pound and 12 inches by the beginning of the following season about eight months later. Although fingerling trout of various species are planted regularly in Crowley Lake, the management plan is based upon the subcatchable program.

The time at which Crowley Lake is planted exerts considerable influence on the size of fish taken during the following season. Marking experiments carried on in 1960-61 show this difference (Table 2). Because of crowded hatchery conditions resulting from the 1960 drought, it became necessary to plant a portion of the regular yearly allotment in mid-June rather than after the close of the season. The remainder of the allotment was planted on August 29. In order to provide comparative information concerning growth and survival of the two plants, 10,000 of each group were fin-clipped and lengths and weights of the marked fish were recorded as they entered the catch during the 1961 season.

The growth rate of the marked fish is especially noteworthy. The additional two and one-half months of growing time in Crowley Lake permitted the June plant to *surpass* the August plant, even though the June-planted fish were significantly smaller when stocked. In addition, a higher survival rate of the June plant is indicated. It is possible that the August plant may have been affected by toxic shoal-area water conditions which are at a maximum in late August. Another theory is that, since the plants were made from different hatcheries, preplanting conditions may have exerted some influence.

On the basis of the 1960-61 study it would appear advantageous to plant Crowley Lake as early as mid-June. However, anglers are quick to learn of the easy availability of newly planted fish. More recently, when early planting has been necessary, these small fish have constituted a significant portion of the late season catch. Since the premature harvest of subcatchables in Crowley Lake violates the current management principle which allows newly planted fish to attain substantial growth before being subjected to angling, every effort is now

TABLE 2

Growth and Return of Marked Subcatchable Rainbow Trout
Planted in June and August, 1960

	June 15 plant	August 2,, plant
Hatchery	Fish Springs	Hot Creek
Strain of rainbow trout	Hot Creek fall spawning	Hot Creek fall spawning
Time in lake prior to following season	10.5 months	8 months
Number of marked trout planted	10,000	10,000
Mean fork length at planting (inches)	5.03	5.82
Mean fork length on April 29-30, 1961 (inches)	12.97	11.89
Mean length gain (inches)	7.94	6.07
Mean weight at planting (ounces)	1.23	1.54
Mean weight on April 29-30 (ounces)	18.73	14.82
Mean weight gain (ounces)	17.50	13.28
Number of marked fish returned on April 29-30, 1961 1/	203	129
Total number of marked fish returned through July 31, 1961 1/	239	180
Total trout planted in 1960	183,402	112,458

1/ Indicates number of marked fish seen during creel censuses carried on during weekends.

being made to plant the lake as close to the end of the season as possible. Because the principal angling methods in use at Crowley Lake involve the use of bait, it is felt that an attempt to minimize the taking of newly planted fish by means of a size limit would result in a high degree of mortality among the fish returned to the water and would defeat the intended purpose.

During the winter of 1960-61, precipitation in the Sierra Nevada was only a fraction of normal, and hatchery water supplies were seriously depleted. Consequently, it became necessary to plant the majority of the 1961 subcatchable allotment in early May. These fish grew rapidly and large numbers were taken prior to the close of the 1961 season and therefore did not enter the catch in 1962.

The lack of precipitation during the 1960-61 winter had an indirect effect on trout survival. The area and volume of the lake was reduced to approximately 50 percent of maximum by November, 1961. Predation on the newly planted fish by the population of large brown trout was probably greater than usual. The smaller available population of rainbow trout at the beginning of the 1962 season is clearly indicated by early season catch data (Table 3).

When normal planting procedures were followed (planting of subcatchables during the latter portion of the season or post-season), a close correlation between the magnitude of the previous year's plant and opening weekend angling success was noted. Using data for seven years between 1953 and 1961 (census data are not available for 1955 and 1957), a correlation coefficient of 0.92 was calculated for the relationship between numbers of rainbow trout subcatchables planted during the previous year and mean catch per angler hour over the opening weekend of the following season (Figure 1). A similar relationship was noted for mean catch per angler hour for the entire season.

Hot Creek fall spawning strain rainbow trout have been the predominant plants in Crowley Lake and its tributaries. Generally, the females retain their fall spawning characteristic, while the males quickly revert to spring spawning under natural conditions. Consequently, natural spawning by rainbow trout in recent years has not been extensive.

Beginning in 1958, both fingerling and subcatchable rainbows of the Mt. Whitney spring spawning strain were planted in increasing numbers as part of the overall allotment for Crowley Lake. Since that time, considerable spawning activity by these fish has been noted in the tributary streams, normally beginning in March and continuing into May. We may therefore expect more natural recruitment of rainbow trout than has been experienced in past years. This was indicated early in the 1963 season, when naturally produced fish about nine inches long were observed in the catch.

Fingerling trout of various species have also been planted regularly. Brown trout fingerlings were planted intermittently until 1954, when it became apparent that natural reproduction in the tributary streams was adequate to maintain an excellent population. Since that time, brown trout have entered the catch at approximately the same rate as during the period in which they wereplanted.

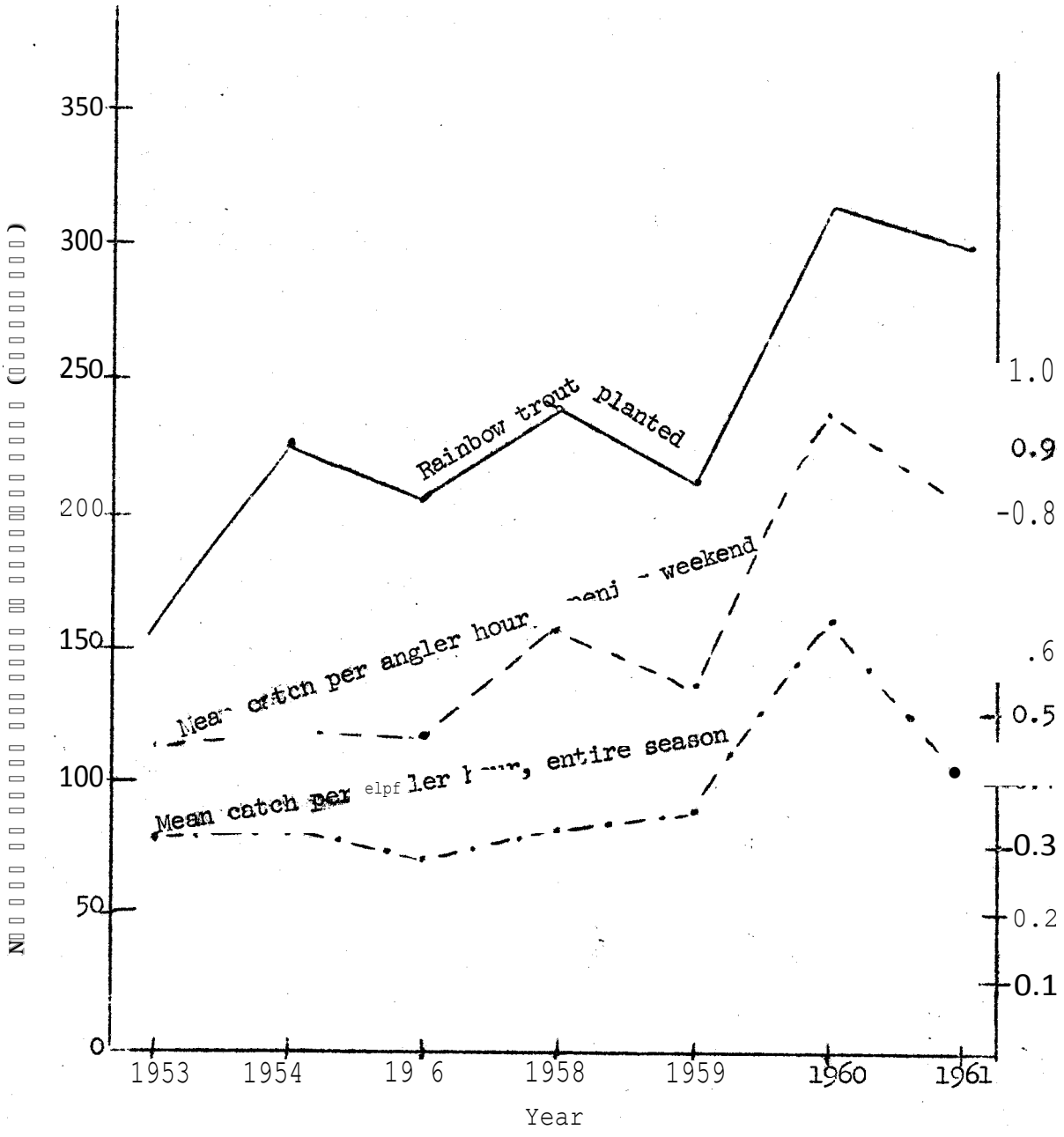
Several experimental plants of Kamloops rainbow trout have been made in Crowley Lake. This strain survives well when reared to yearling size and is very popular among anglers. In 1955, 30,000 yearling Kamloops were stocked and contributed significantly to the fishery during the next three years. Those fish remaining into the 1958 season exhibited strong migratory tendencies. Some were observed spawning in upper McGee Creek over five miles and 1,200 feet above Crowley Lake.

TABLE 3

Creel Census Data For Eight Angling Seasons at Crowley Lake[1]

	1953	1951.	1956	1958	1959	1960	1961	1962
Mean catch per angler hour, opening weekend	0.46	0.56	0.52	0.70	0.57	0.94	0.85	0.39
Mean catch per angler hour, remainder of May	0.30	0.41	0.43	0.45	0.28	0.57	0.31	0.34
Mean catch per angler hour, June	0.23	1/	0.18	0.22	0.24	0.19	0.18	0.12
Mean catch per angler hour, July	0.20	0.19	0.11	0.22	0.28	0.19	0.19	0.17
Mean catch per angler hour, season	0.33	0.37	0.29	0.38	0.39	0.66	0.45	0.26
Mean catch per angler hour, opening weekend, rainbow trout	0.44	0.47	0.46	0.63	0.54	0.94	0.82	0.36
Mean catch per angler hour for season, rainbow trout	0.31	0.33	0.27	0.33	0.36	0.64	0.42	0.23
Percent rainbow trout in catch, May	94.86	87.00	90.85	90.82	92.02	98.34	95.02	90.03
Percent rainbow trout in catch, June	93.81	/	86.59	76.38	82.09	87.57	75.23	81.36
Percent rainbow trout in catch, July	89.92	93.42	56.95	71.88	92.96	94.12	88.40	83.65
Percent rainbow trout in catch, season	94.11	88.26	87.97	87.97	90.69	97.77	92.92	88.30
Percent brown trout in catch, May	4.23	10.25	4.50	5.92	4.80	1.37	2.94	8.66
percent brown trout in catch, June	5.56	1/	5.32	18.50	15.25	10.54	22.48	16.59
Percent brown trout in catch, July	9.45	5.00	28.70	15.34	5.98	5.63	9.51	15.04
Percent brown trout in catch, season	5.05	9.19	6.07	7.91	6.28	1.89	5.01	10.30
Percent cutthroat trout in catch, May	0.91	2.75	4.65	3.26	3.18	0.29	2.04	1.23
Percent cutthroat trout in catch, June	0.63	1/	8.09	5.12	2.66	1.89	2.29	2.05
Percent cutthroat trout in catch, July	0.63	1.58	14.35	12.78	1.06	0.25	2.09	0.38
Percent cutthroat trout in catch, season	0.84	2.55	5.96	4.11	3.03	0.35	2.07	1.24
Number of censuses conducted during season	15	11	17	56	15	15	16	15
Number of anglers interviewed during season	4,389	1,012	2,406	9,768	3,195	4,563	5,071	4,044

1/ Creel censuses were not conducted in 1955, 1957, and June, 1954.



FICURE 1. Relationship of numbers of **subcatchable** rainbow trout planted in **previous** year to angler success.

At this time they had attained lengths of approximately 20 inches. Probably because of the heavy angling pressure at Crowley Lake, and consequent rapid rate of harvest, Kamloops rainbow are seldom taken in excess of three pounds in weight. Fingerling plants of Kamloops rainbow to date have not been particularly successful, and this is also generally true of Lahontan cutthroat. Plants of eastern brook trout fingerlings have been totally unsuccessful.

The only fish taken at trophy size are brown trout. The Crowley Lake record for this species is 19 pounds 10 ounces. Brown trout in the 8 to 10-pound range are taken rather frequently.

An additional management measure in effect at Crowley Lake is a reduced limit. Only seven trout maybe taken at Crowley. This tends to reduce the tremendous early season catch and provides better angling for fishermen visiting the lake later in the season.

FUTURE NANAGEMENT PLANS

The present management procedures in effect at Crowley Lake may be deemed satisfactory, but the question naturally arises as to what changes must be made to meet the greatly increased angling pressures expected in future years.

It is reasonable to assume that greater numbers of subcatchable rainbow trout will be planted, especially if additional rearing facilities become available. Since catch data make it apparent that an increase in planting would result in an even higher degree of early season angling success, with little benefit to the fishery in June and July, it will probably become necessary in future years to initiate a lower bag limit.

The exceptional fishery at Crowley Lake will in all likelihood result in an increase in angling pressure even greater than that anticipated for the remainder of the area. Consequently, additional means of providing a satisfactory fishery for as long a period during the season as possible will be investigated. Two possibilities would be opening the lake to fishing only on alternate weeks during the season, and restricting the methods of angling. An experiment was carried on during the fall of 1963 and 1964, when a portion of the shoreline was opened to angling with barbless flies only, with a minimum size limit of 12 inches. Although the angling pressure during these special seasons was comparatively light and the catch rate was low, some beautiful fish were taken, and anglers indicated a high degree of satisfaction.

Experimental management procedures will be continued. The planting of yearling Kamloops rainbow and cutthroat trout is planned.

METHODS OF EVALUATING THE FISHERY

With the exception of the 1958 season, when a more intensified study was made, the evaluation of management procedures in effect at Crowley Lake has been accomplished by means of a creel census program conducted primarily on weekends throughout the angling season. Anglers are inverviewed at random. It has been possible to contact as high as 65 percent of those on the lake on a given day. During the opening weekend of the angling season, when over 10,000 anglers are on the lake each day, a crew of 10 census clerks generally contacts about 15 percent of the anglers present. Only completed fishing efforts are recorded.

Total angler use has been calculated by boat counts at the lake and multiplying by the mean number of anglers per boat (ordiaarily slightly in excess of 3). Boat counts on the opening weekend have been conducted by the Department of Fish and Game and later in the season by the Los Angeles Department of Recreation and Parks.

Eech year, during a 48-hour period immediately preceding the opening of the angling season, the California Division of Highways conducts a count of vehicles and boats passing north through Bishop on Highway 395 on their way to the many waters of Mono County. It has been noted that a close correlation exists between the number of boats counted by the Division of Highways and the number of boats on Crowley Lake on the opening day. This ratio has ranged from 1:1.11 to 1:1.16, with a mean of 1:1.14. Likewise, counts of boats on the lake during the opening weekend have shown that boat use on Sunday has been a relatively constant percentage of that on Saturday. These figures have ranged from 87 to 88 percent, with a mean of 87.5.

This information will be used in estimating future opening weekend angler use and catch, with occasional counts being made to check the accuracy of the relationships. Use of these data greatly simplifies evaluation of the opening weekend fishery. After the opening weekend, angler use drops to a level where counting boats is a relatively simple matter.

The evaluation of established and experimental management procedures will be continued through the use of the creel census program.

THE FISHERY DURING THE 1958 SEASON

Creel censuses were conducted at Crowley Lake on 56 days of the 90-day 1958 season. With this level of sampling it was possible to estimate the magnitude of the catch with a reasonable degree of confidence.

Crowley Lake creel census data since 1953 (Table 3) reveals that catch data are quite similar from year to year and that the fishery during the 1958 season was typical of the usual pattern under the present management plan.

Observations over a period of years have indicated that shore anglers take relatively few fish. Consequently, only anglers were censused during the 1958 study. To minimize bias, all boat landing areas were censused, with major activity being devoted to the main boat launching area at the South Landing. Because all boats at Crowley Lake must dock in the immediate vicinity of the South Landing, it was possible to interview as high as 65 percent of the anglers on the lake during a given day.

The opening weekend of the angling season at Crowley Lake has gained fame throughout the west. Angler use and success are high during this period and throughout most of May (Tables 4 and 5). In 1958, nearly 25 percent of the seasonal angling pressure and nearly 35 percent of the seasonal catch occurred on the opening weekend. Over 65 percent of the seasonal angling pressure and over 80 percent of the seasonal catch occurred during May. Mean catch per angler hour for May was 0.70 on the opening weekend and 0.50 during the remainder of the month, with a monthly mean of 0.53. By far the greatest percentage of trout in the catch were rainbows planted at the close of the previous season. During the last two months of the season, as the more easily caught rainbows were removed from the fishery, brown and cutthroat trout constituted a much great percentage of the species composition. During May, the total catch was comprised of over 90 percent rainbow trout. During June, this figure was dropped to 76 percent and dropped again in

TABLE

Crowley Lake Angler Use Data, 1958 Season

	Angler da s	Percent of seasonal total
Opening weekend use	12,243	23.89
May use exclusive of opening weekend	21,204	41.38
Total May use, including opening weekend	33,447	65.27
Total June use	11,109	21.68
Total July use	6,690	13.05
Total seasonal use	51,246	100.00

TABLE 5

Crowley Lake Catch Data, 1958

Opening weekend[1]			
Rainbow trout		43,810	
Brown trout		3,723	
Cutthroat trout		1,397	
Total opening weekend catch		48,930	
	$\bar{X}$ - (t.058x)	$\bar{X}$	$\bar{X}$ + (t.058x)
opening			
Rainbow trout	56,754	62,613	68,472
Brown trout	2,430	3,213	3,996
Cutthroat trout	1,890	2,430	2,970
Total	61,074	68,256	75,438
Total estimated catch[2]			
Rainbow trout		106,423	
Brown trout		6,936	
Cutthroat trout		3,827	
Total		117,186	
June			
Rainbow trout	10,200	11,640	13,080
Brown trout	2,490	2,820	3,150
Cutthroat trout	630	780	930
Total	13,320	15,240	17,160
July			
Rainbow trout	5,456	6,975	8,494
Brown trout	899	1,488	2,077
Cutthroat trout	961	1,240	1,519
Total	7,316	9,703	12,090
Total estimated seasonal catch[3]			
Rainbow trout		125,038	
Brown trout		11,244	
Cutthroat trout		5,847	
Total		142,129	

Because of extremely heavy use and exceptionally high level of angler success on the opening weekend, catch data for these two days were calculated separately and are absolute figures. Catch data for the remainder of the season were calculated to the 95 percent confidence interval.

2/ Total May catch figures equal sums of opening weekend catches and mean May catches.

3/ Total seasonal catch figures equal sums of opening weekend catches and means of May, June, and July catches.

July to 71 percent. For the season as a whole, the catch was comprised of approximately 88 percent rainbow, 8 percent brown, and 4 percent cutthroat.

While the catch per angler hour for rainbow trout dropped from a mean of 0.63 during the opening weekend to 0.15 during July, the mean catch per hour for brown and cutthroat trout remained relatively constant during the entire season. This indicates that the rainbow trout, being more easily caught, are quickly harvested, while the populations of brown and cutthroat trout remain relatively constant. This theory is given further substantiation through gill net sampling operations, which reveal that brown trout comprise nearly 35 percent of the trout population of Crowley Lake, even after heavy stocking of rainbows. It is obvious that the average Crowley Lake angler finds it most difficult to catch brown trout.

Studies of returns of marked rainbow subcatchables planted in 1957 revealed that natural recruitment of this species had been negligible. Five percent of the 1957 plant was marked by removal of the left ventral fin, and an identical percentage of the rainbow trout taken in 1958 bore this mark. An attempt to provide for natural recruitment is being made through the planting of the spring spawning Mt. Whitney strain.

It was estimated that 53 percent of the subcatchable rainbows planted in 1957 eventually entered anglers' catches. However, the 1958 study included only boat anglers. Since shore anglers are known to take predominantly rainbow trout, we must consider the 53 percent figure to be minimal.

COST OF MANAGING CROWLEY LAKE

Nearly 90 percent of the 1958 catch at Crowley were rainbow trout planted in 1957. These fish, reared at the Fish Springs, Hot Creek and Mt. Whitney-Black Rock installations, weighed 26,943 pounds at planting time and cost $19,297 based on average production costs during the fiscal years 1955-56 to 1957-58 and prorated according to the poundages planted from each installation (Macklin and Cordone, 1956, [illegible] Macklin and Tharratt, 1957 and 1958). Mean weight of rainbow trout taken in 1958 was approximately one pound. The season's take of rainbow trout, 125,038, therefore totaled approximately 125,000 pounds. Dividing this figure into the total cost figure of $19,297, we find that the average cost per pound of rainbow trout returned to the angler during the 1958 season was slightly over $0.15.

During the same years, production costs of catchable-sized rainbow trout, which provide the main form of management for roadside waters in the Inyo-Mono area, averaged $0.76 per pound for the three installations mentioned above. Assuming an average recovery rate of 85 percent ([illegible] Geldern, 1960, and Pister, 1961), the cost per pound of catchable trout returned to the creel in 1958 was $0.90. Despite the efficiency of the I[illegible]-M[illegible] catchable program, it is possible to provide six pounds of trout to the creel at Crowley Lake for the same cost as each pound returned to the creel by the catchable program. Angler satisfaction is, needless to say, much higher at Crowley because of the larger fish.

With the exception of brown trout, it is impossible to estimate the management cost of the other species of trout planted in Crowley Lake in terms of pounds returned to the creel, since it is not known what percentage of the catch is supplied by naturally produced fish. Brown trout, however, are [illegible] longer stocked in Crowley, so it is safe to assume that the entire catch is provided through natural reproduction.

FOOD AND FEEDING HABITS OF TROUT

The great abundance of midges (Tendipedidae) in Crowley Lake is especially significant when one considers the value of these organisms as a food for trout, and the degree to which trout feed upon them. All of the rainbow trout stomachs examined contained tendipedids, with pupae comprising 89 percent of the total volume (Table 6).

Tendipedid larvae generally remain in or near the bottom of lakes and do not become readily available for consumption by trout until their journey to the surface as pupae to emerge as adult insects. This emergence occurs principally in the early morning hours, during one of the most active periods of trout feeding, and thus probably explains the large numbers of pupal and emerging forms found in the stomachs of the fish. Concerning the value of tendipedids (Tendipedidae-Chironomidae) as trout food, Johannsen (1937) states the following: "The ability of the chironomids to live on foodstuff that has a general distribution, their ability to build their own shelter and their consequent adaptability to a variety of conditions, their great reproductive capacity, and their brief life cycle, combine to make these insects so important a forage organism for fish."

Next in importance to tendipedid pupae was zooplankton. Cladocera made up over 10 percent of the total volume of organisms consumed and were present in 33 percent of the stomachs examined. Tendipedid larvae were taken only rarely, presumably because of their bottom dwelling habit. In addition to insects and plankton, small nongame fish, chiefly Siphateles sp., are consumed in large numbers by rainbow trout during the fall months. During this period the young Siphateles sp. are about two inches in length.

Insufficient numbers of brown and cutthroat trout stomachs were available to obtain a valid picture of the feeding habits. of these species. Nine brown trout stomachs examined in 1958 contained approximately equal volumes of ramshorn snail (Helisoma sp.) and chironomid pupae.

GROWTH AND CONDITION

Growth

The growth of subcatchable rainbows in Crowley Lake has, through the years, followed a regular pattern. Fish planted in August at a mean fork length of 5.8 inches and 1.6 ounces (10 per pound) attain a mean fork length of approximately 10 inches and a weight of 9 ounces before ice-cover forms in December. By the beginning of the angling season near the first of May (about five months later), these fish reach a mean fork length of nearly 12 inches and a weight of about one pound. Since ice and snow generally cover the lake from late December through late March or early April, winter growth maybe considered exceptionally good.

Growth continues at a good rate during the season and, by mid-June, the mean sizes are nearly 13 inches and 20 ounces. By the end of the season in late July, fish are approximately 14 inches in length and 26 ounces in weight.

Rainbow trout which go through their first angling season without being caught enter the catch as 2+ fish at the beginning of the following season when about 17 inches long and 37 ounces in weight. The few which remain into July are taken at a mean fork length of approximately 18 inches and a weight of approximately 46 ounces.

TABLE 6

Foods Consumed by Crowley Lake Rainbow Trout, 1953

Organism	Stomachs containing organism		Number organisms	Volume	Percent total volume
	Number	Percent			
Tendipedidae pupae	18	100.0	9,763	113.5	89.3
Tendipedidae larvae	1	5.6	4	0.1	
Cladocera	6	33.3	Not counted	13.2	
Copepoda	1	5.6	Not counted	0.3	0.2

Dates of collection: May 9, 16; June 5, 21, 23; July 5.

Size rangeof fish (pounds): 1.0 to 3.5

Number of stomachs examined: 18

Number of empty stomachs: 0

Survival into the third year by Crowley Lake rainbow trout is negligible, but an occasional fish of the 3+ age class is taken at about 20 inches and 4 pounds.

The season's catch of rainbow trout at Crowley Lake is comprised of approximately 95 percent 1+ and 5 percent 2+.

The virtual absence of 3+ and 4+ rainbow trout in the catch is difficult to explain. It is surmised that this is attributable to heavy angling pressure and harvest, an extraordinarily rapid growth rate, and the genetic characteristic of the strain itself.

- Although the growth rates of cutthroat and brown trout have not been thoroughly investigated, examination of scales from these species indicates that their growth is also very rapid.

The rapid growth rate of Crowley Lake rainbow trout is particularly impressive when compared with growth rates of the same species from nearby lakes. In a study of the growth rates of rainbow trout in Convict Lake, located about five miles west of Crowley Lake, Reimers, Maciolek and Pister (op. cit.) reported [illegible] total lengths at formation of the first, second and third annuli of 3.8, 6.4 and 11.1 inches. Slower growth rates were exhibited by rainbow trout from lakes [illegible] at higher elevations in the same drainage (Table 7). Measurements of Crowley Lake rainbow trout taken during late fall gill net sampling reveal mean total lengths of 10.1, 15.8 and 19.9 inches at the end of the first, second and third years of life. It is difficult to make direct comparisons of growth because rainbows planted in Crowley Lake are held for nearly nine months in hatcheries prior to planting. However, the exceptional growth of fish in Crowley Lake is obvious.

Condition

The condition factor Kwas calculated for 138 Crowley Lake trout collected during the 1958 season (Table 8). This factor, which is in general use to indicate plumpness in relation to length, was calculated according to the fornula:

$$K = \frac{\text{Weight in grams}}{\text{Total length in millimeters}^3} \times 100\,000$$

Rainbow trout collected during the early portion of the angling season had a mean condition factor of 1.30, whereas mean condition factors for brown and cutthroat trout were calculated to be 1.06 and 0.94, respectively. Reimers, Maciolek and Pister (op. cit.) reported average condition factors ranging between 0.88 and 1.15 for rainbow trout in three lakes of the Convict Creek Basin and an average condition factor of 1.05 for brown trout in Convict Lake.

Although the average condition factor for rainbow trout was significantly higher for Crowley Lake, the brown trout condition factors were nearly identical. This may be explained at least partially by the spawning habits of the species involved. Rainbow trout of the Hot Creek fall spawning strain have not been observed to spawn extensively under natural conditions and therefore do not undergo the rigors of the spawning process and the accompanying lossof body weight which ordinarily accompanies spawning. Brown trout, however, do not finish their spawning activities until early winter and apparently are unable to regain their normal condition during the period of ice-cover preceding the angling season. Cutthroat trout generally are in the midst of their spawning activities at the onset of the angling

TABLE 7

Trout Growth and Condition in Crowley Lake and Nearby Waters[1/]

Lake and species of trout	Year of life			KTL
	1	2	3	
Crowley, rainbow	10.1	15.8	19.9	1.30
Convict, rainbow	3.8	6.4	11.1	1.02
Mildred, rainbow	3.6	5.7	7.7	1.15
Dorothy, rainbow	3.4	5.8	8.2	0.88
Crowley, brown	9.4	14.6	18.7	1.06
Convict, brown	3.9	8.5	12.5	1.05

1/ Average calculated lengths in inches at annuli formation for trout in various lakes of the Convict Creek Basin, Mono County (Reimers, Maciolek and Pister, 1955). Figures for Crowley Lake are mean actual lengths at the end of each year of life. Condition factors (KTL) were calculated from total lengths in millimeters.

TABLE 8

Average Coefficients of Condition (KTL) for Crowley Lake Trout

Species	Number of fish	Size range total length inches)	Size range total length (mm.)	K total length mm.)
Rainbow	50	11.3 to 18.7	287 to 475	1.30
Cutthroat	61	12.0 to 25.6	305 to 650	0.94
Brown	27	13.3 to 22.4	338 to 569	1.06

season, and their relatively poor condition is probably attributable to this factor. All trout species collected towerd the end of July appear to be in better condition than in early May.

EFFECT OF RESERVOIR FLUCTUATIONS AND WINTER CONDITIONS ON TROUT GROWTH

The size of Crowley Lake may vary considerably from year to year, depending upon the amount of precipitation received in the drainage area. However, the lake has never been drawn down to a level where a reduction in food organisms has seriously reduced trout growth.

Ordinarily, Crowley Lake gradually decreases in surface acreage during the fall and winter months, reaches a low point in late winter or early spring, and then approaches its maximum acreage for the year during midsummer as runoff is stored. Under present management practices, the production of food organisms has been sufficient to maintain excellent trout growth.

Occasionally an unusually good growth year occurs. While the mean weight of rainbow trout taken during the opening weekend of the angling season is usually about one pound, instances have occurred in which the mean is considerably higher. This is well illustrated by growth data gathered from the groups of fish planted in 1959 and 1962 (Table 9). Although the growth rates of these two groups of fish were similar between August and November, the fish planted in 1962 grew much more rapidly in the period between November and the following May, reaching a mean weight of 18.9 ounces as compared to 15.3 ounces for the 1959 plant.

The most obvious explanation lies in the differences in the periods of ice-cover and the operation of the reservoir, which determines the amount of productive shoal area, during the two overwinter periods involved. During the winter of 1959-60, the lake had an ice-cover for 13 weeks, extending from December 15 through March 17, while the surface area decreased from 4,300 acres on November 1 to 3,600 acres on May 1. During the winter of 1962-63, conditions were very different. Ice was present for only seven weeks, extending from December 13 through February 2, and for only a short period was the lake completely covered. Surface acreage increased in this season from 3,950 on November 1 to 4,450 on May 1. It is reasonable to assume, therefore, that shoal area food production and conditions for trout growth were much better during the early portion of 1963 than during the same period in 1960.

FISH PRODUCTION OF CROWLEY LAKE

During the 1958 season a mean total catch of 142,149 trout was calculated. The mean weight of rainbow trout taken in 1958 was slightly over one pound each, whereas brown trout and cutthroat trout averaged approximately two pounds. The total estimated weight of trout taken in 1958 was 160,000 pounds. During the period August 1957, through July, 1958, the mean surface area of Crowley Lake was approximately 4,800 acres. Deducting the weight of trout planted during the previous season (26,943 pounds) from the total weight taken, we find that the lake yielded a net weight of 27.7 pounds per acre to the fishery.

Despite the fact that ever-increasing numbers of fish are planted in Crowley Lake, the point has not yet been reached where a decrease in the growth rate has occurred. In addition, the production of unharvested brown trout is difficult to estimate. Consequently, it is impossible at this time to calculate the maximum productive capacity of the lake. It may be in the neighborhood of 50 pounds per acre.

TABLE 9

Comparison of Growth Rates of Rainbow Trout Planted in 1959 and 1962

Date	August 3	August 1
Mean weight at planting (ounces)	2.6	2.7
Mean weight in early November (ounces)	9.0	8.5
Mean weight gain since planting (ounces)	6.4	5.8
Mean weight at opening of following season (early May) (ounces)	15.3	18.9
Mean weight gain since early November (ounces)	6.3	10.4
Mean fork length at planting (inches)	7.0	7.0
Mean fork length in early November (inches)	9.8	9.9
Mean length gain since planting (inches)	2.8	2.9
Mean length at opening of following season early May) (inches)	12.2	12.8
Mean length gain since early November (inches)	2.4	2.9
Mean monthly weight gain, August to November (ounces)	2.1	1.9
Mean monthly weight gain, December to May (ounces)	1.1	1.7
Mean monthly length gain, August to November (inches)	0.9	1.0
Mean monthly length gain, December to May (inches)	0.4	0.5

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