

THE MANAGEMENT OF CUTTHROAT TROUT IN YELLOWSTONE LAKE

YELLOWSTONE NATIONAL PARK, WYOMING

F. Phillip Sharpe
Bureau of Sport Fisheries and Wildlife
Fort Collins, Colorado
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INTRODUCTION AND HISTORY

"On the 28th of July we arrived at the lake and pitched our camp on the northwest shore in a beautiful grassy meadow or opening among the dense pines. The lake lay before us. A vast sheet of quiet water of a most delicate ultramarine hue was one of the most beautiful scenes I have ever beheld. The entire party was filled with enthusiasm. Although I searched with diligence and care in the neighboring streams and waters around Yellowstone Lake, I was unable to find any other species of fish except the salmon trout. Their numbers are almost inconceivable. The average weight, one pound and a half (Hayden, 1871)."

The item just quoted is both poetic and scientific. It is poetic in that it is the first written description of the white man's opinion of Yellowstone Lake. It is scientific in that it is the first investigation of any type regarding Yellowstone Lake and its fishes. Records are spotty from this time up through the year of 1901. In 1901, the Acting Superintendent of Yellowstone National Park requested the U.S. Bureau of Fisheries, Department of Commerce to set up a hatchery in Yellowstone and conduct investigations related to the fishery resources in the lake. At the time Robert McKinley was president of the United States.

Operations began when the first trout eggs were taken at West Thumb in May of 1901. The hatchery technicians were assisted by four soldiers from the U.S. Army which at that time was directing the operations of Yellowstone National Park. The first eggs were hatched in open troughs along the Yellowstone River and Thumb Creek. From this time on, there has been some type of fishery work conducted on Yellowstone Lake. In 1903 the Bureau of Fisheries constructed the first fish hatchery in Yellowstone Park. The actual operation of this hatchery continued until 1953 when investigators revealed that continuation of a hatchery in Yellowstone Park was not necessary.

Other interesting factors associated with the history of the Park can be listed which add significance to the background of fishery management on Yellowstone Lake. In 1931 Hazzard began a survey of all the Park waters in Yellowstone. This survey was never completed. Dr. John Scott, University of Wyoming, conducted extensive tapeworm studies in 1934. In 1939 the Public Works Administration built the first permanent fish traps on Yellowstone Lake tributaries. The last date of stocking of brook, brown, and rainbow trout was in 1939. Grayling were last stocked in large numbers in 1943. Until 1949 the fish limit on Yellowstone Lake was 10 fish, at which time it was reduced to five. In 1950 the Rocky Mountain Sport Fisheries Investigations began research on Yellowstone Lake. Their work continued until 1961 at which time management responsibility was delegated to the Division of Fishery Management Services, Bureau of Sport Fisheries and Wildlife.

Other interesting statistics associated with fisheries in Yellowstone Park are the tremendous numbers of eggs collected from this area. From 1933 to 1952, twenty nine million grayling eggs were distributed to 14 states and from 1929 until 1952, over three hundred and six million Yellowstone cutthroat trout eggs were distributed throughout 18 states and Canada. From 1925 through 1956, over 700 million cutthroat trout eggs were taken from Yellowstone Lake. During the same time period, approximately 7½ million rainbow trout eggs and 72 million grayling eggs were collected.

Further statistics associated with this fishery are the recorded catch which in 1925 was 75,000 fish while in 1965 it was 326,000 fish over a four-fold increase in the number of fish taken from Yellowstone Lake.

This short history show in some realm the course of management over many years in relation to a given fishery.

There are examples over the years in which exotic species were stocked in the many parks throughout the United States. Stocking in Yellowstone Park was controlled somewhat in the fact that of 18 species of fish located in Yellowstone Park, 13 are endemic to the area. Rainbow trout and silver salmon have been stocked in Yellowstone Lake. We have been fortunate that none of these species have survived.

Another consideration of the pure stock of cutthroat trout in Yellowstone Lake is it is a closed watershed. The Yellowstone River originates in the area of Two Ocean Pass near the same point as the headwaters of the Snake River, however, there is a definite distinction between Wyoming Snake River cutthroat trout and Yellowstone cutthroat trout. Twelve miles down the stream from Yellowstone Lake there is a high falls which is a natural barrier to movement of fish upstream. As a result, fish in Yellowstone Lake have remained more or less in their original condition with the exception of species that probably have been introduced by bait fishermen.

Yellowstone Lake contains five species of fish. These are: Yellowstone cutthroat trout (*Salmo clarki lewisi*), western longnose sucker (*Catostomus catostomus*), smallfin redbreast shiner (*Richardsonius balteatus hydrophlox*), longnose dace (*Rhinichthys cataractae occlla*), and the lake chub (*Hybopsis plumbea*). Of these five species cutthroat trout are by far the most abundant. Longnose sucker are prominent in certain areas of the lake and the redbreast shiner are present in very limited numbers. Dace are very seldom observed even in the tributary streams. The lake chub has been reported but not observed in recent years.

This paper attempts to deal directly with the fact that even though more fish have been taken from Yellowstone Lake, the relative size has maintained itself. Management considerations used to manipulate a fishery maintained on natural reproduction are limited and important. The first consideration is that Yellowstone Park is a Federal property and exclusive jurisdiction is by the United States Government. Fishery management recommendations are made in accordance with National Park Service policy, considering both national and local viewpoints. The criteria associated with Park Service policy, philosophy and goals is somewhat different than that associated with most other areas. The goal of the National Park Service is to maintain but not necessarily to promote fishing. The primary goal is to maintain the fishery in its native condition as near as possible.

As can be seen by the accompanying map, Yellowstone Lake encompasses an area of approximately 88,000 acres. It is 20 miles long, has an average depth of 139 feet, and is accessible by road for only 32 miles of its shoreline.

To summarize fishery management of cutthroat trout in Yellowstone Lake, one must review results of 11 years of research related to the fishery in the lake as well as management work for the past three years. The various facets of investigations presently being conducted on Yellowstone Lake are included in the following pages and detailed data supporting these findings are included in the appendices. Considerations of Yellowstone Lake fishery will be taken in order and a summary of the general method and results of present management will be explained.

Cutthroat Trout Management in Yellowstone Lake

Creel Census

Shoreline Fishery

During the fishing season 104 complete fishermen counts are made of the shoreline fishermen. These counts are made on 26 days over a period of approximately 85 days. The beginning point of each days count from the boat is reversed on the alternate days of count. Counts are made along a 32 mile section of shoreline from a point south of where the Cody highway leaves the lake to a point south of Grant Village Marina near West Thumb Figure 1. During the 104 counts in 1965, 18,049 fishermen were actually observed. This was a 9.3 percent increase over the number recorded in 1964.

Creel census is conducted through personal interviews at four areas along the 32 miles of shoreline simultaneously as counts are made from a boat. An effort is made to sample each area in proportion to the amount of fishing use being absorbed by the particular section. Only fishermen who have completed their fishing trip are interviewed. A total of 24 days of creel interviews occurs over the 85 day period. In 1965 creels of 1,608 fishermen were inspected and the fishermen interviewed. This is an increase of 16.1 percent over the number interviewed in 1964. Of the total number of anglers observed by shoreline counts from boats (18,049), 8.9 percent were subjected to personal interview.

The corrected number of fishermen (expanding empirical data to the entire 85 day sample period), revealed that 74,244 fishermen fished from the shoreline of Yellowstone Lake during the 1965 season. The method used to expand the total fishermen counted into the actual number of fishermen visiting the shoreline of the lake is explained in a correction formula in Appendix A. The total catch for the shoreline fishermen was 90,315 cutthroat trout. The average length of fishing trip in 1965 was 2.36 hours. The average catch per-hour effort was .51. The number of fishermen utilizing the lake shore and total catch was up slightly from previous years. Each fisherman caught an average of 1.2 fish each time he fished along the shoreline of Yellowstone Lake in 1965.

All shoreline fishermen interviewed were questioned as to the type of gear employed in obtaining their fish. It was found that 38.6 percent used bait, 52.2 percent used lures, and 9.2 were fly fishermen. It should be noted that the figures quoted on percent and type of gear do not include fishermen from the Yellowstone River and on the tributaries to Yellowstone Lake (Table 1).

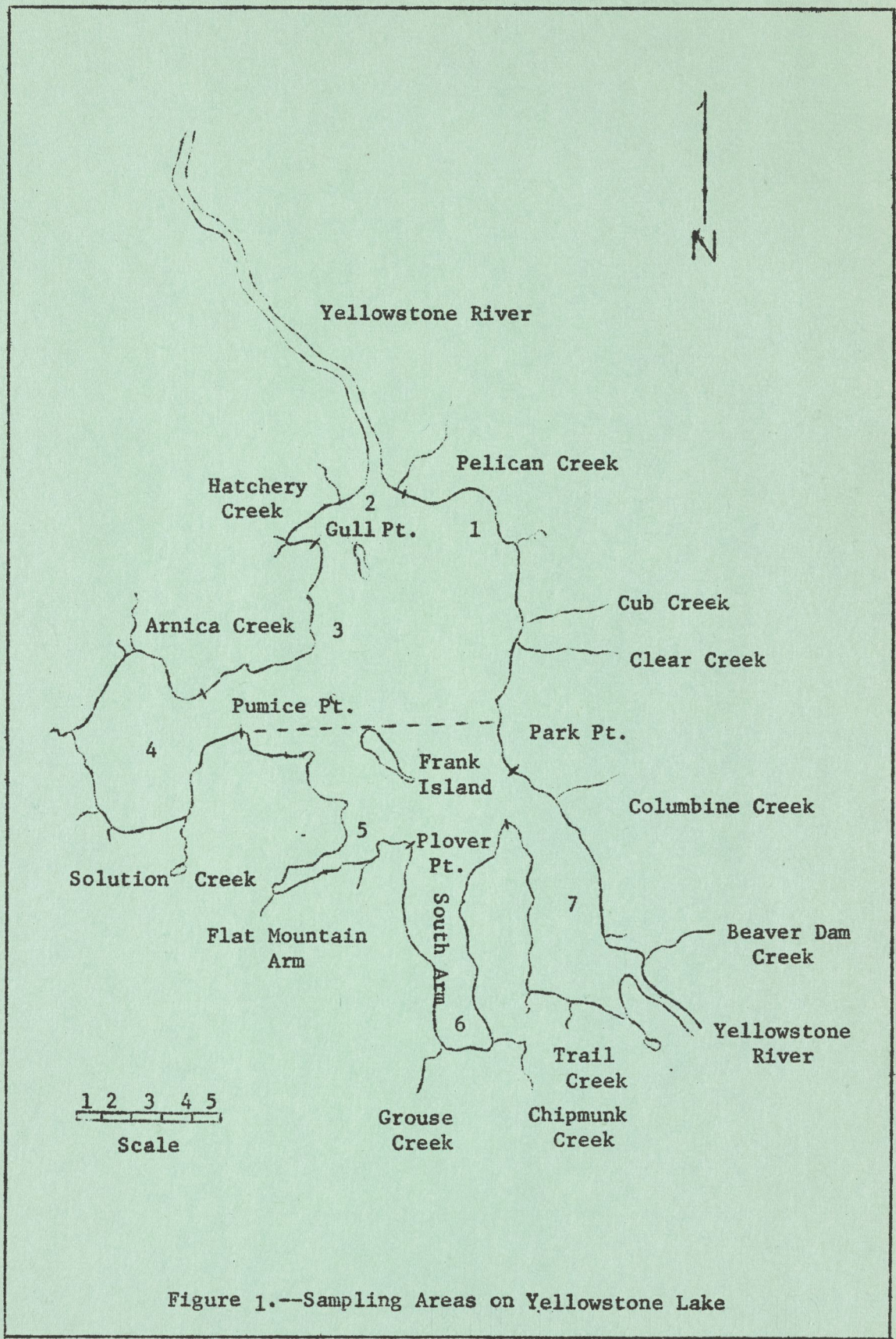


Figure 1.--Sampling Areas on Yellowstone Lake

Table 1.--The percent of bait, lure and fly fishermen in three phases of the fishery on Yellowstone Lake, 1965

Type of Fishery	<u>Method, Number and Percent</u>						Total
	Bait	Percent	Lure	Percent	Fly	Percent	
Shoreline	757	38.6	1,051	52.2	184	9.2	1,992
Guideboats	751	79.6	193	20.4	-	-	944
Cruisers	135	66.8	69	33.2	-	-	204
Total	1,643	52.3	1,313	41.8	184	5.9	3,140
Projected Total	109,267	-	87,330	-	12,327	-	208,924

Guide Boats

The total time of fishing for guideboat fishermen in 1965 was 31,010 hours. The total number of fishermen participating in this fishery was 19,503. The catch per-hour-effort was 1.79 and the catch per fisherman was 2.84.

The number of guide boats fishing in the remote areas of the lake during 1965 was recorded. It is of interest to note that 93.5 percent of all guide boat trips from the north end of the lake fished only in that area of the lake and 6.5 percent fished in the remote areas. From West Thumb 78.4 percent of the guide boats fished only in that area and 21.6 percent ventured onto the main body of the lake. The larger boats in the rental boat fishery and the cruiser type guide boats are beginning to alleviate the concentration of fishermen in the northern section of the lake. The number of these craft is not now a significant factor and this area of need is re-emphasized strongly in management recommendations. The condition of the fishery in the southern end of the lake is such that it could absorb all the guide boat and rental boat pressure that is presently being concentrated on the northern 42 percent of the lake.

In 1964 and 1965 detailed information was obtained from the guide boat fishery on the type of fishing equipment used by individual fishermen. Of 944 fishermen reporting, 751 used bait. Only 193 of the 944 reporting used artificial lures exclusively. This sample indicates that only 20 percent of the 19,503 anglers fishing from guide boats were fishing with purely artificial lures and 80 percent used bait.

Rental Boats

In 1965 a special voluntary creel census stand was employed for card returns. The stand includes an information sign, writing platform, blank card supply box and a completed card drop-box. Cards and pencils are available in the front portion of the creel census box. Instructions are given for filling out the cards and deposition in the creel census boxes. A general history of the significance of the information obtained is included. These stands are placed on the boat docks. Similar stands are used for private boats at each boat launching area along the lake-shore. They are placed in a position so that the fishermen returning to the dock stand or taking his boat from the water should observe them. The results from these signs have thus far been gratifying. In the past an average number of 359 cards, or 2.4 percent of the total fishermen were sampled. During the 1965 season a total of 1,759 cards were obtained, or a 12 percent sample of all rental boat fishermen. The accuracy of the sample increases proportionately, to a degree, in relation to the number of cards returned from fishermen. This assumes, of course, that successful and unsuccessful anglers fill out the creel census cards in equal proportions.

The use of rental boats from the three concession docks on Yellowstone Lake shows a continued shift to Bridge Bay Marina. In 1965, 56 percent of the boats were rented from Bridge Bay, 26 percent from West Thumb, and 18 percent from Fishing Bridge. Of the 56 percent rented from Bridge Bay Marina, 96.6 percent fished in the northern 42 percent of Yellowstone Lake. Of the 26 percent rented from West Thumb, 91.3 percent fished in 12 percent, or the West Thumb section of the lake. All of the boats rented from Fishing Bridge fished in the northern 42 percent. The restriction of rental boats under 16 feet within one-quarter mile from shore results in most of the rental boat fishing pressure being exerted on the northern 42 percent of the lake including the West Thumb area. During the past season the Yellowstone Park Company incorporated a few rental boats over 16 feet in length in their fleet. These boats account for the few incidences of fishing outside the northern half of the lake.

In 1965 a total of 44,071 anglers fished from rental boats -- an increase of 15 percent over the previous year. These fishermen caught 99,160 cutthroat trout. Total hours fished was 105,329 or 12 percent more than the previous year. The catch per-hour-effort was .94 in 1965. With more dispersion these boats could attribute significantly to shifting much of the fishing pressure to the southern half of Yellowstone Lake.

Fishing Bridge

The fishing season on Fishing Bridge did not open until July 15 in 1965. The opening day has been July 1. The recommendation for keeping the season closed on Fishing Bridge and the Yellowstone River for an additional 15 days was advanced to reduce the number of spawning fish that normally appear in the catch during the first two weeks of July. In past years samples from the creel and by electrofishing have indicated the percent of spawning fish from July 1-15 to be approximately 79 percent. Samples taken on July 14 and 16 in 1965 revealed the percent of spawning fish in the fish population in the upper Yellowstone River was approximately 33 percent. The delayed season opening resulted in a significant reduction in percent of spawners in the creel, but decreased the catch by only 7.8 percent.

Creel census is conducted on Fishing Bridge by counting the number of fish caught and the number of rods present on the Bridge at specified times throughout the entire sampling day. Sixteen days of actual fishermen counts were conducted during the 54 day sampling period from July 15 through September 6. During this time the total catch of fish from Fishing Bridge was 5,878, or 496 fish less than caught in 1964. The total hours of fishing on the Bridge was 41,387 hours. The catch per-unit-effort was .14.

The pressure exerted by Fishing Bridge fishermen on the entire fishery of Yellowstone Lake is relatively insignificant. It is definitely significant in relation to an index of the catch from the first four miles of the Yellowstone River. The reduction in the number of spawners in the catch, as compared to previous years, should attribute to the success or balance of the Fishing Bridge fishery in the future. Size classes of fish and age composition are discussed in detail under the length-frequency distributions. The catch per-unit-effort is relatively low as compared to other fishing areas. The status of having participated in fishing from the bridge is symbolic to a visit to Yellowstone National Park.

Private Boats

The creel census stands described in the rental boat fishery section were also used to census fishermen in the private trailer boat fishery. The addition of the creel census stand improved the total return of census cards by two percent over past years. In 1965, a 6.1 percent of the private boats were censused.

The number of private boats registered while entering Yellowstone National Park in 1965 increased one percent over the previous year. Total number of boats fishing on Yellowstone Lake was 2,868. The totals are based on the premise that 78 percent of all boats registered in the Park are used on Yellowstone Lake.

Total man hours fished in 1965 was 86,009 and the total catch was 60,622 cutthroat trout. Total man-days of fishing for private boat fishermen was 23,497. Catch per-hour was .72, the catch per-man-day was 2.58.

Private Cruisers

During fishermen counts in the regular creel census program, a count of the cruisers over 19 feet in length that are docked in the three marinas, as well as cruisers on the lake is obtained. An average of these figures is calculated and an accurate picture of the overall number of cruisers used during the summer is obtained. Individual census booklets are given to the owners of private cruisers. Returns from these booklets are used in the analysis of data.

During 1965 the number of anglers utilizing private cruisers was 6,222. Total catch was 15,351 fish and total man hours of fishing was 9,588. The catch per-unit-effort remained high, being 1.60 in 1965. The high catch per-unit-effort is directly related to the ability of cruisers to utilize the remote areas.

Miscellaneous Considerations for Creel Census on Yellowstone Lake

Marking spawning streams entering Yellowstone Lake with buoys and "closed to fishing" signs attributed to a marked decrease in the number of violations occurring in these areas. Decreasing the number of fishing violations on the spawning streams has directly decreased the number of spawning fish that enter the creel.

Length Frequency and Age Distribution

Spawning Streams

Beginning approximately May 20, fish traps on Pelican, Cub, and Clear creeks are in operation for a 70 day period. Extremely high water over an extended period complicated trapping on Pelican Creek in 1964 and 1965, and a total count of upstream migrants was not accomplished in this stream. A temporary trap was operated on Hatchery Creek and a suitable sample of migrants were captured.

The four weirs trapped a total of 50,155 trout in 1965. The Pelican Creek trap captured 3,228 fish, of which 1,799 were weighed, measured, and released upstream. Data were collected on 2,496, 3,973, and 125 individual trout trapped in Cub, Clear, and Hatchery creeks, respectively. Total numbers captured, including those processed for data, were 10,551 and 36,251 in Cub and Clear creeks. Data from 8,393 fish were collected at the four traps, a 16.7 percent sample of all spawners trapped and counted.

Scale samples were taken from all fish when small numbers were handled. Otherwise, a minimum 10 percent sample was taken. Approximately nine percent of the above scale samples were mounted on microscope slides and age and growth determinations made.

Average age of spawners was 3.58, 3.87, and 4.16 years, captured from Pelican, Cub and Clear creeks, respectively. It is noted that the average fish was in its fourth growing season, which corresponds closely to the first time spawning of four year old Yellowstone cutthroat trout (Table 2).

Average total lengths of spawners trapped from Clear, Cub, and Pelican, and Hatchery creeks were 378.5, 366.0, 348.5, and 330.9 millimeters, respectively (Table 3). Combined average length is 367.7 millimeters -- or a six millimeter decrease from the 1963-64 averages. Average mean length of Pelican Creek fish was 15.5 millimeters less than in 1964, a significant decrease believed related to the small sample obtained in 1965.

Total spawners trapped in Clear and Cub creeks in 1965 was the highest ever reported. This may be attributed to more efficient trapping rather than increase in numbers of migrants. Pelican Creek spawner census was incomplete (op. cit.).

Table 2.--Percentage of each age group in the catch from Fishing Bridge, West Thumb, and Bridge Bay Docks, 1956-1965. Mean length included

Year of Capture and Location	II	III	IV	V	VI	VII	Mean Age	Mean Length
1956								
Fishing Bridge	0.8	18.4	43.0	33.6	4.2	---	4.21	352.3
West Thumb	---	30.5	46.2	22.3	1.0	---	3.94	344.0
1957								
Fishing Bridge	1.4	12.3	53.5	30.8	2.0	---	4.20	353.2
West Thumb	0.7	13.5	47.4	36.3	2.1	---	4.26	353.3
1958								
Fishing Bridge	1.0	10.5	46.3	38.1	4.0	---	4.36	357.6
West Thumb	2.0	13.3	48.5	34.6	1.6	---	4.28	358.0
1959								
Fishing Bridge	8.1	20.0	54.4	17.4	0.1	---	3.81	355.5
West Thumb	1.3	20.2	68.0	10.4	0.1	---	3.88	353.2
1960								
Fishing Bridge	3.2	32.4	49.5	14.6	0.4	---	3.77	345.7
West Thumb	4.1	29.7	53.7	11.1	1.4	---	3.76	347.4
1961								
Fishing Bridge	0.9	26.8	60.8	11.5	---	---	3.82	340.5
West Thumb	1.7	27.1	59.2	11.9	0.1	---	3.82	345.4
1962								
Fishing Bridge	1.8	19.6	33.5	28.7	11.1	4.7	---	343.6
West Thumb	2.3	23.3	31.2	32.2	10.4	0.7	---	343.9
1963								
Fishing Bridge	1.0	9.0	36.0	44.0	10.0	---	4.53	344.0
West Thumb	10.	15.0	41.0	34.0	9.0	---	4.35	342.0
1964								
Fishing Bridge	10.	45.0	45.0	8.0	1.0	---	3.63	305.2
West Thumb	---	13.0	59.0	27.0	1.0	---	4.16	343.1
Bridge Bay	---	8.0	55.0	31.0	6.0	---	4.35	330.5
1965								
Fishing Bridge	3.3	46.0	47.4	3.3	---	---	3.50	327.3
West Thumb	4.0	36.9	55.0	4.1	---	---	3.59	336.9
Bridge Bay	0.7	32.9	58.3	8.1	---	---	3.73	340.6

Table 3.--Length in millimeters of Yellowstone cutthroat trout from four spawning streams, May 21 - August 10, 1963 - 1965

Year and Location	Sample Size	Average Length	Confidence Limits - 98%
Clear Creek			
1963	281	377.2	270--495*
1964	2,822	375.9	375--377
1965	3,973	378.5	377--380
Cub Creek			
1963	54	354.2	244--398*
1964	462	364.2	360--369
1965	2,496	366.0	365--367
Pelican Creek			
1963	-----	-----	-----
1964	62	364.0	355--373
1965	1,799	348.5	347--350
Hatchery Creek			
1963	-----	-----	-----
1964	84	331.8	325--373
1965	122	330.9	325--337
Total and Average			
1963	335	373.6	244--495*
1964	3,430	373.1	372--374
1965	8,390	367.7	-----

* Range

Creel Samples

Total lengths and scale samples were collected from 1,758 trout taken from six shoreline areas of Yellowstone Lake during 1965. Since these were in addition to boat dock samples, it broadens the scope and adds validity to this phase of the program (Table 4).

Creel samples showed an average fish size of 347.8 millimeters (TL) as compared to 348.3 in 1964 and 358.3 in 1963. Size differences are significant over the three years, but a comparatively small sample was obtained in 1963. Size of fish taken from the Yellowstone River outlet in Area 2 are well below the mean of the other five areas sampled, but the average is almost identical to 1964 and four millimeters less than 1963. Mean total lengths of sample fish taken in remote areas of the lake were greater than those from other areas, which reflects minimal fishing pressure in distant areas.

Boat Docks

Average total length of 912 trout measured at three docks in 1965 was 337.5 millimeters, or one millimeter less than the 1964 average (Table 5).

West Thumb mean fish length was 336.4 millimeters, identical to 1964 but 13 millimeters less than 1963. Fishing pressure remained constant in 1964 and 1965.

Bridge Bay trout averaged 343.1 millimeters (TL) which is comparable to 1964, the first year of operation of this marina.

Average total length of Fishing Bridge fish, taken from boats, was 329.0 millimeters, or 26 millimeters larger than in 1964. This may be attributed to the 15 day delay in opening the river to angling, resulting in less time for the angler to catch fish, and preventing a "normal" harvest of younger and smaller fish. Further discussion is given in the section entitled "Fishing Bridge Fishery."

Age group percentages of fish checked in the creel at three docks are presented in Table 2. These data shows the average fish age to be 3.50, 3.73, and 3.59 at Fishing Bridge, Bridge Bay and West Thumb, respectively. A significant shift toward younger age classes of fish were found at West Thumb and Bridge Bay.

Electrofishing

During 1964 and 1965, six areas were sampled with the electrofishing boat. Identical data as obtained by other sampling methods were taken.

Average total length of fish taken by electrofishing was 330.7 millimeters, compared to 333.7 in 1964. Samples taken from the southeast arm were biased, since a special effort was made to obtain small fish, resulting in a below average total length.

Table 4.--Length in millimeters of Yellowstone cutthroat trout from six areas of creel census, June 15 - September 11, 1963-1965

Year and Location	Sample Size	Average Length	Confidence Limits - 98%
Sedge Bay			
1963	-----	-----	-----
1964	74	332.9	320--346
1965	116	346.9	340--354
YSR Outlet			
1963	20	337.6	266--287*
1964	297	333.6	328--340
1965	462	333.5	-----
Sand Point			
1963	123	361.3	296--414*
1964	547	350.4	347--354
1965	995	351.6	349--354
West Thumb			
1963	28	324.7	242--399*
1964	241	349.0	344--354
1965	83	342.3	325--359
South Arm			
1963	49	378.5	336--437*
1964	130	351.4	323--377
1965	58	372.8	358--388
East Shore			
1963	----	-----	-----
1964	120	379.5	370--388
1965	44	391.0	380--402
Total and Average			
1963	220	358.3	242--414*
1964	1,409	348.3	-----
1965	1,758	347.8	-----

* Range

Table 5.--Length in millimeters of cutthroat trout from creel samples at Fishing Bridge, West Thumb and Bridge Bay Docks, June 15 - September 11, 1963-1965

Year and Location	Sample Size	Average Length	Confidence Limits - 98%
West Thumb			
1963	354	349.8	207--428*
1964	616	336.7	333--340
1965	390	336.4	332--341
Fishing Bridge			
1963	156	345.0	275--415*
1964	125	302.7	293--312
1965	182	329.0	323--335
Bridge Bay			
1963	-----	-----	-----
1964	619	343.3	340--347
1965	340	343.1	338--348
Total and Average			
1963	510	348.3	207--428*
1964	1,360	336.6	334--339
1965	912	337.5	-----

* Range

Fishing Bridge

The delay of the opening date was apparently accepted by anglers without adverse consequences. A significant reduction of gravid spawners occurred in the creel from this segment of the fishery in 1965. Total catch was higher than 1961-62 but slightly below the previous seven year average (Figure 2). Another result of the delayed season opening was the greater average total length of fish taken in this fishery. The trend is now apparently toward larger fish from this area, which was an objective in preventing fish stock depletion in this segment.

Summary of Samples

Length frequencies of 20,889 trout are summarized in Table 6. Unweighted mean total length is 358.7 millimeters for all trout sampled in 1965. Since a majority of measurements were taken from trapped spawners, results are slightly biased in that direction. Average total length is comparable to 1963-64.

Mean total lengths of sample fish taken from Fishing Bridge dock, creel census, and electrofishing in Area 2 are below the overall fishery average. This is further evidence of overfishing in the Fishing Bridge area.

Sampling by the above three methods at West Thumb produced similar results as at Fishing Bridge, with slightly higher average fish lengths.

Age Distribution

Age class distribution of trout from the three docks is shown in Table 2. This sample is a small percentage of the total and should not be confused with the overall average of total lengths. The table summarizes ten years age data at Fishing Bridge and West Thumb and two years at Bridge Bay. Fish scales were selected for aging on a stratified random sampling basis in an effort to reduce total numbers aged and still maintain validity of reading. A length frequency key constructed from empirical data collected for several years from Yellowstone Lake fish was applied to 1965 length and age data.

A decrease in average age is evident from all three boat docks. Percentage of fish in age group two decreased 6.7 percent at Fishing Bridge in 1965 which is directly related to the delayed fishing season opening in this area. Average age decrease of Fishing Bridge fish is attributed to a decline in numbers of five year olds appearing in the creel.

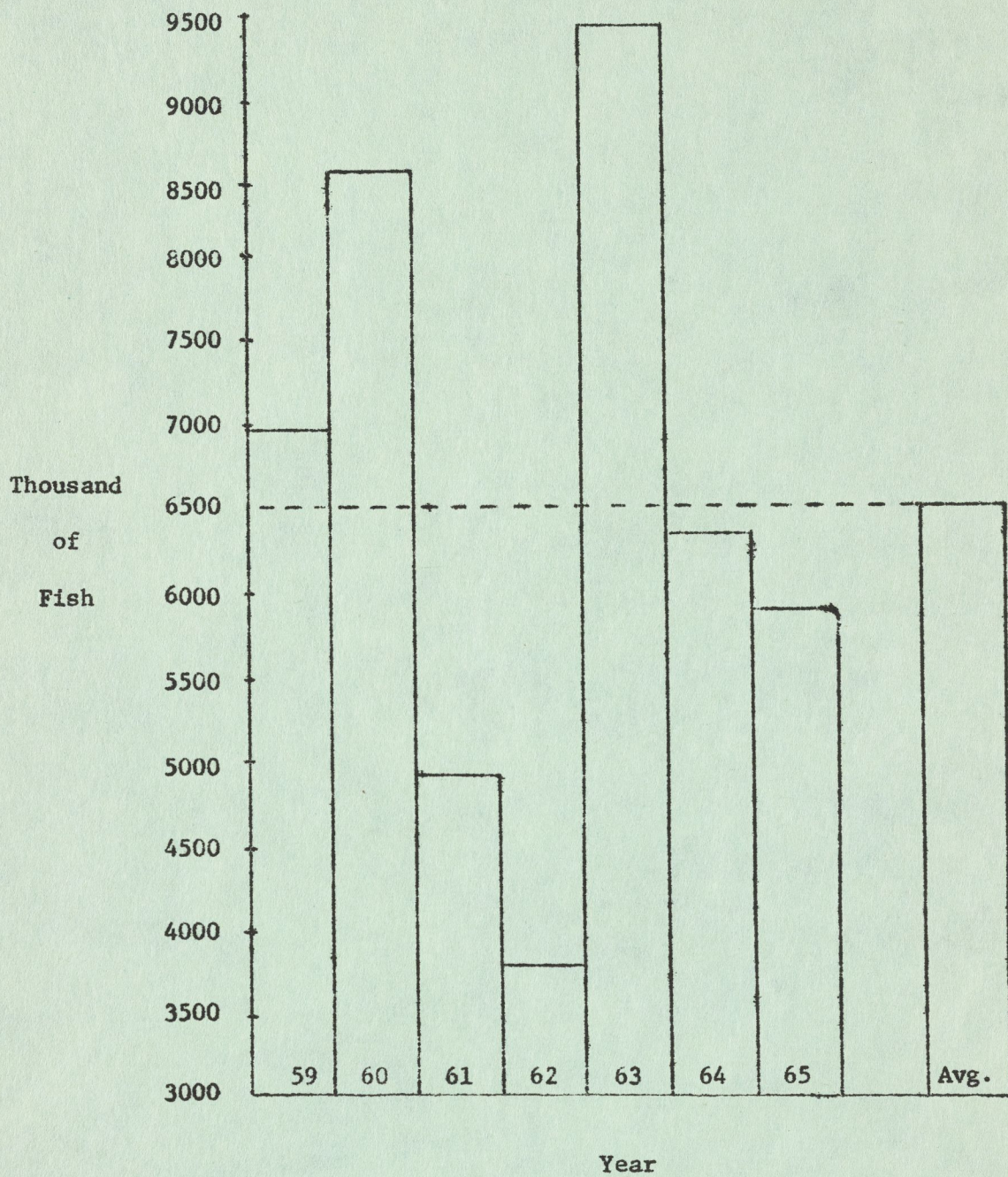


Figure 2.--Total catch of cutthroat trout from Fishing Bridge, Yellowstone National Park, Wyoming. 1959-1965

Table 6 .--Summary of length in millimeters of Yellowstone cutthroat trout sampled from Yellowstone Lake, June 1 - September 15, 1963-1965

Year and Location	Sample Size	Average Length	Confidence Limits - 95%
Spawning Streams			
1963	335	373.6	244--495
1964	3,430	373.1	372--374
1965	8,390	367.7	-----
Boat Docks			
1963	510	348.3	207--428
1964	1,360	336.6	334--339
1965	912	337.5	-----
Creel Census			
1963	220	358.3	242--414
1964	1,409	348.3	-----
1965	1,758	347.8	-----
Electrofishing			
1963	-----	-----	-----
1964	1,273	333.7	330--338
1965	1,292	330.7	-----
Total and Average			
1963	1,065	358.3	207--496
1964	7,472	355.1	354--356
1965	12,352	358.7	-----

Decline of the average age of West Thumb trout is interpreted differently: percentage of five year old fish creeled decreased, while three year old percentage increased. This trend toward a younger age class may suggest stabilization of catch on year class strength of the fish population. Average age of West Thumb fish taken in 1965 was much lower than 1963 but comparable to the 1959-61 catches.

Mean age of Bridge Bay fish sampled decreased considerably -- from a high percentage of five year olds to a predominance of age group three. This is believed related to recent construction of the marina in a relatively unfished area, resulting in older fish being cropped off first. Stabilization of the catch at present age class percentages may occur unless angling pressure increases to the degree that annual available four year old fish are over cropped.

Age distribution and mean age of Clear, Pelican and Cub creek fish was as expected. Highest to lowest percentages occurred in four, five and three year olds, respectively. Average age composition of trapped fish was 4.16, 3.58, and 3.87 for Clear, Pelican and Cub creeks, respectively.¹

Discussion

Creel Census

In 1965 the total catch of cutthroat trout in Yellowstone Lake was 326,714, up 1.6 per cent, or 5,281 more fish than 1964 (Table 7). This figure is just above the upper range of the maximum equilibrium game fish yield that can be taken annually from the northern end of Yellowstone Lake (Benson, 1963). Anglers decreased 0.9 per cent to 208,924, and they fished 446,742 hours. Average catch was 1.6 fish per angler day. Catch per-unit-effort was 0.73, compared to .66 in 1964 and a 16 year average of 0.67. Increased angler success per unit effort is proportional to increased angling in remote areas of the lake. Rental boat anglers increased while guide boats anglers decreased, but catch per-unit-effort increased significantly in both segments from 0.94 in 1964 to 1.14 in 1965.

Fishing pressure and catch has increased annually at an average rate of 2.1 and 2.4 per cent, respectively, the past 16 years. Optimum catch is predicted in a few years, with a subsequent decline in catch per-unit-effort, under present management policies.

Based on present increase rates, a catch of 404,000 fish with 540,000 angler hours expended is predicted on Yellowstone Lake by 1976. Average equilibrium yield is reported to be approximately 325,000 fish in the northern lake area (op. cit.). Catch and angling effort rates will continue to increase until the equilibrium yield is reached, at which time catch per-unit-effort will decline. This assumes that catch and effort rates continues to follow a predictable pattern.

1 For example, Cub Creek fish averaged 3.87 years old or in their fourth year of life

Table 7.--Total catch and catch by segments from six types of use of the fishery (1950-1965) from Yellowstone Lake, Yellowstone National Park, Wyoming

Year	Segments of the fishery						Total Catch
	Shoreline Anglers	Rental Boats	Guide Boats	Private Trailer Boats	Private Cruisers	Fishing Bridge	
1950	55,370	55,123	28,228	50,377	4,500	6,417	200,015
1951	48,966	60,993	29,449	54,857	5,052	8,938	208,255
1952	53,423	74,761	27,449	75,457	9,322	4,865	245,277
1953	64,116	38,772	23,592	20,118	13,887	5,338	195,873
1954	71,919	39,969	32,400	51,222	13,351	7,072	215,933
1955	97,831	47,986	41,484	80,270	12,320	6,165	286,056
1956	65,383	47,765	46,550	110,937	15,462	4,124	290,221
1957	63,286	61,350	43,436	115,141	13,806	4,136	301,155
1958	81,210	56,552	36,802	149,667	14,800	9,996	349,027
1959	140,102	66,281	38,996	124,421	16,696	6,971	393,467
1960	65,539	41,266	34,854	126,109	18,513	8,617	294,898
1961	98,954	53,362	46,433	93,632	15,794	4,419	312,594
1962	62,985	71,128	48,104	64,980	13,500	3,760	264,457
1963	84,456	66,548	53,271	89,696	18,054	9,498	321,523
1964	89,213	68,006	66,077	70,157	21,606	6,374	321,433
1965	90,315	99,160	55,388	60,622	15,351	5,878	326,714

Concentrated angling pressure in a given area would tend to shift local fish populations toward predominantly younger year classes. This could upset the fish population equilibrium in the northern lake area, resulting in a deterioration of the fishery.

Recommendations

1. Initiate steps to begin phasing-out the Fishing-For-Fun program on Yellowstone Lake. Section (5) of the Yellowstone fishing regulations should be modified to read as follows: "A fisherman must cease fishing immediately upon filling his catch or possession limit, as hereinafter specified in subdivisions (i) and (ii) of this sub-paragraph."

Several factors associated with increased fishing pressure and optimum yield of the northern area should be considered. Significant numbers of fish are being returned to the lake annually as a result of the Fishing-For-Fun program. Recent studies show that approximately 60,000 trout were returned alive to Yellowstone Lake annually for the past three years (Marnell, 1965, Table 8). Mortality of these returns averaged 18 per cent or an annual survival of some 49,000 cutthroat trout. The mortality figures obtained by Marnell in 1964-65 closely approximate those observed by Benson, 1963.

Using these figures, it is apparent that an adjusted yield figure is necessary. Actually only 277,000 trout were harvested in 1965 from Yellowstone Lake, although 326,000 were caught.

Average annual equilibrium yield of the northern lake area is reportedly 325,000 fish (op. cit.), without consideration for the approximate 50,000 live fish returns annually. Since data collections indicate a relatively stable fishery, with slight fluctuations and overfishing in local areas, it is logical to conclude that the average optimum yield should be adjusted to 277,000 trout annually in the northern lake area. This number, with minor fluctuations, may be harvested annually without damage to the fishery.

Further justification for the adjusted equilibrium yield of 277,000 fish is the decrease in size and average age of fish taken in recent years from specific areas of the Yellowstone River outlet and at West Thumb. The same trend is appearing at Bridge Bay. These patterns began appearing in the Fishing Bridge and West Thumb fisheries within the past two-three years and became a firm pattern in 1965. Mean total lengths of fish sampled from remote areas of the lake has remained relatively constant and consistently greater than fish from northern areas of the lake. Electrofishing and trapping data further substantiates creel census implications that smaller and younger fish populations inhabit the northern and more heavily fished areas.

Until now, the catch and release program appeared worthwhile. With annual harvests approaching optimum yield, the Fishing-For-Fun program begins to be hazardous to the lake fishery. Without this program, it is possible the fish returned to the lake would never have appeared in the creel.

Table 8.--A projection of the number of fish returned to Yellowstone Lake in relation to the "Fishing-For-Fun" program, 1963-1965

Area		Catch	Kept	Percent Returned	Total Catch	Total Returned
Shoreline	1963	2,163	1,829	15.4	84,456	13,006
	1964	1,660	1,489	10.3	89,213	9,189
	1965	1,954	1,697	13.2	90,315	11,922
Guide Boats	1963	8,932	7,882	11.8	53,271	6,286
	1964	8,459	7,387	12.7	66,077	8,391
	1965	10,669	8,903	16.6	55,388	9,194
Private Boats	1963	4,880	3,095	36.6	89,696	32,829
	1964	2,385	1,241	48.0	70,157	33,675
	1965	3,921	2,667	32.0	60,622	19,399
Cruisers	1965	1,506	1,296	13.9	15,351	2,134
Total	1963	15,975	12,806	19.8	227,423	45,030
	1964	12,504	10,117	19.1	225,447	43,060
	1965	18,050	14,563	19.3	221,676	42,649
Projected	1963	--	--	19.8	321,523	63,662
	1964	--	--	19.1	321,433	61,394
	1965	--	--	19.3	326,714	63,056

2. As the rental boat fleet is depreciated annually it should be encouraged that a portion of the boats under 16 feet in length be replaced with boats measuring over 16 feet and be equipped with 18 horsepower motors.

Another method of reducing annual harvests from the northern lake area is to incorporate more large boats, 16 feet or longer, into the rental boat fleets. This would allow longer trips into remote lake areas and better distribute angling pressure.

3. Reconstruct the boating regulations (Sec.(10)(vii)(c) to allow boats of class I and II to fish within one-quarter mile of the shoreline section in the zoned areas of Yellowstone Lake. This should apply only to areas zoned for five mile per-hour speed limit in Flat Mountain, South, and Southeast arms of the lake.

A major objection, as expressed by numerous boat anglers, has been the one-fourth mile restriction that prevents trolling along shoreline areas where trout tend to concentrate.

Yellowstone Lake trout inhabit the shoreline during spawning migrations and late seasons, but are found in deeper water in mid-season. Migrations generally parallel aquatic food production, which moves further from shore as water warms up. There is no evidence that wilderness areas would be disturbed by allowing fishermen to troll closer than one-fourth mile from shore.

It is reiterated that the basic concept of equilibrium yield remains unchanged even though total catch may be reduced by deletion of the Fishing-For-Fun program. The estimated annual optimum yield of 325,000 fish from the northern lake area does not consider numbers of live fish returned from the Fishing-For-Fun program. The Fishing-For-Fun program was in operation at the time optimum yield was calculated. Subsequent analyses of the Fishing-For-Fun program has determined actual fish returns and survival, causing a readjustment of annual equilibrium yield of the northern lake area from 325,000 to 277,000 fish.

4. Encourage all guide boats to fish south of a point beginning at Breeze Point across the west tip of Frank Island to the Park Point patrol cabin. This area is about six miles from West Thumb and eight miles from Bridge Bay and Fishing Bridge. This restriction could decrease the average annual catch from the northern lake area by about 50,000 trout.

APPENDIX A

Because of certain limitations in sampling design and some inherent bias in the computational scheme, it has been necessary to redesign the Yellowstone creel census for the shoreline fishery. The nature of this fishery and monetary and manpower limitations required an incomplete census. Scheduling requirements for other aspects of the Yellowstone study project require non-random allocation of census effort.

The shoreline fishery extends from approximately Cub Creek to Grant's Village, a distance of 32 miles. Portions of this shore are inaccessible to vehicles and a boat-based counting system is much more accurate. The general census design involves four counting trips per census day over the entire 32 miles of shoreline. Each trip requires two hours. These are spaced at reasonably equal intervals throughout the census day. The direction of trips is reversed as frequently as possible to avoid introduction of bias due to systematic differences in the distribution of effort and catch with respect to shoreline location or time of day. In any one day, consecutive trips reverse direction, thus providing two trips down the Lake and two trips up the Lake.

The major problem in this census is to provide some means of compensating or correcting for those anglers who are missed during a complete two-hour passage.

The rationale which is most defensible involves the use of a correction factor to expand observed counts in a proportion which approximates, as closely as possible, the proportion of anglers missed.

Geometrically, the problem may be expressed in terms of a uniform rate of travel between two points, expressed as the diagonal of a square (Figure 1).

In the Figure 1 diagram, the Y-axis is the time axis and the X-axis represents distance traveled. A square is used, rather than a rectangle to facilitate calculation of the needed correction factor. As the observer traverses a path from A to C, he will intersect fishing trips, which can be conveniently represented as vertical time lines within the square. In terms of the time parameter, the observer can be best thought of as traversing the center of a path whose width on the vertical axis is the average length of fishing trip (Figure 2). As long as the average length of fishing trip is less than four hours, some anglers will be missed in the count which is made. This bias will occur because these anglers stop fishing before the observer passes or begin fishing after he has gone by.

The general geometry is symmetrical, and the best correction factor which can be calculated is that proportion of the area of the total square which lies outside the band representing the average length of trip. On the average, such a correction factor will correct only when one-half the average length of trip is less than the vertical time axis (in this case, 2 hours). Thus, any trip originating at a point in time such that its center lies within the

shaded zone representing the average length of trip in Figure 2 will, on the average, be counted. Trips originating at any other point in time will, on the average, not be counted.

The correction factor itself is, simply:
$$\frac{\text{area abc and area def}}{\text{area ABCD}}$$

The corrected count will be obtained as: Total Count + Total Count x correction factor.

This method required information on the average length of trip. Computations of catch require, additionally, information on the catch per unit effort. Therefore, the census design requires that a sample of anglers be contacted to determine these estimates. It is best to contact anglers at the completion of their fishing trip, since most anglers who do not catch limits will fish for a varying period of time after they stoping catching fish. The general effect of contacting anglers during their trip is to inflate the catch per unit effort. In the present census these estimates are derived from complete census of all anglers fishing four points spaced reasonably equally in any two-week period. The information which is available consists of good estimates of the average length of trip and catch-per-unit-effort for each two-week period of the fishing season, and a total of sixteen angler counts along the 32 miles of shoreline in any two-week period.

The method of using these data to arrive at an estimate of catch and effort for this fishery is best illustrated by a sample work sheet for the 1965 season (Appendix A, Table 1).

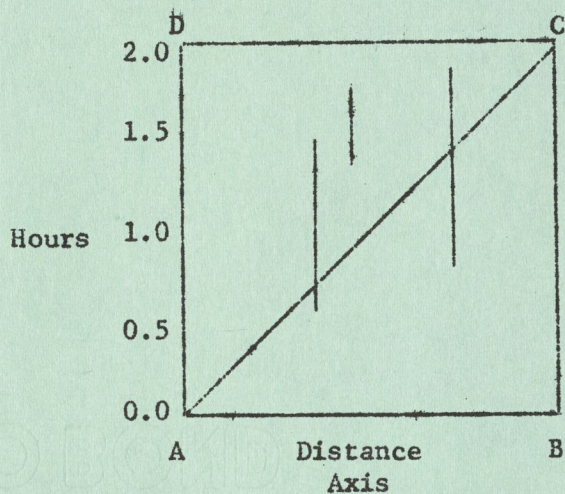


Figure 1.--Geometrical illustration of the census problem

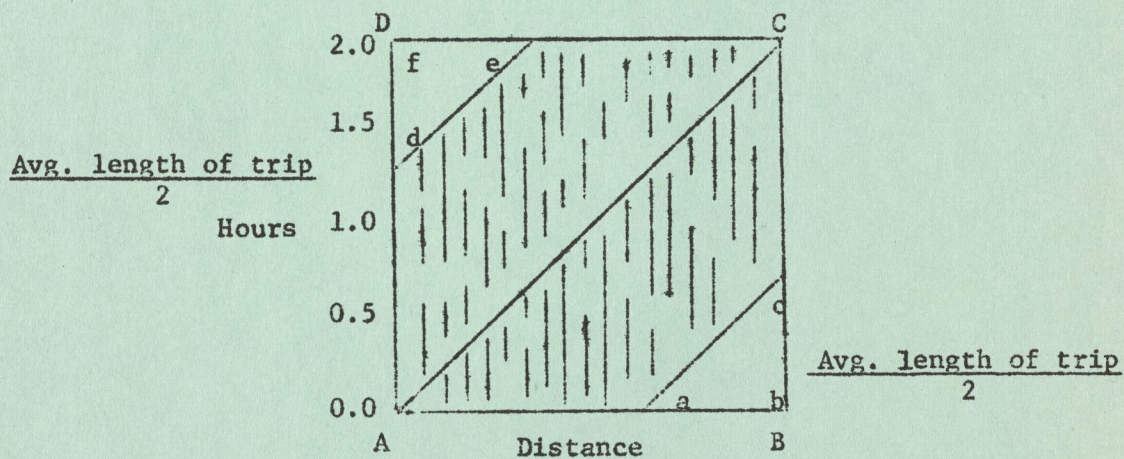


Figure 2.--Geometrical representation of proportion of time-distance block which has been counted

Appendix A, Table 1. --Creel census worksheet for catch-effort computation for the shoreline fishery, Yellowstone Lake, 1965

Period	Avg. Length of Trip	Total Count	2 $\frac{(1)}{2}$	(3) ²	$\frac{(4)}{4}$	Corrected Total Ct. (2)+(5)(2)	Trips $\frac{(6) \times 14}{4}$	Hours (1)(7)	CPMH	Catch (8)(9)
1	2.20	2,874	0.90	0.810	.203	3,457	12,099	26,618	.71	18,899
2	2.12	6,296	0.94	0.884	.221	7,687	26,904	57,037	.47	26,807
3	2.53	3,634	0.74	0.548	.137	4,132	14,462	36,589	.57	20,856
4	2.54	2,955	0.73	0.533	.133	3,348	11,718	29,764	.61	18,156
5	2.86	1,598	0.57	0.325	.081	1,727	6,044	17,286	.26	4,494
6	<u>2.03</u>	<u>692</u>	0.99	0.980	.245	<u>862</u>	<u>3,017</u>	<u>6,125</u>	<u>.18</u>	<u>1,103</u>
Totals and Averages	2.36	18,049				21,213	74,244	173,419	.51	90,315

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