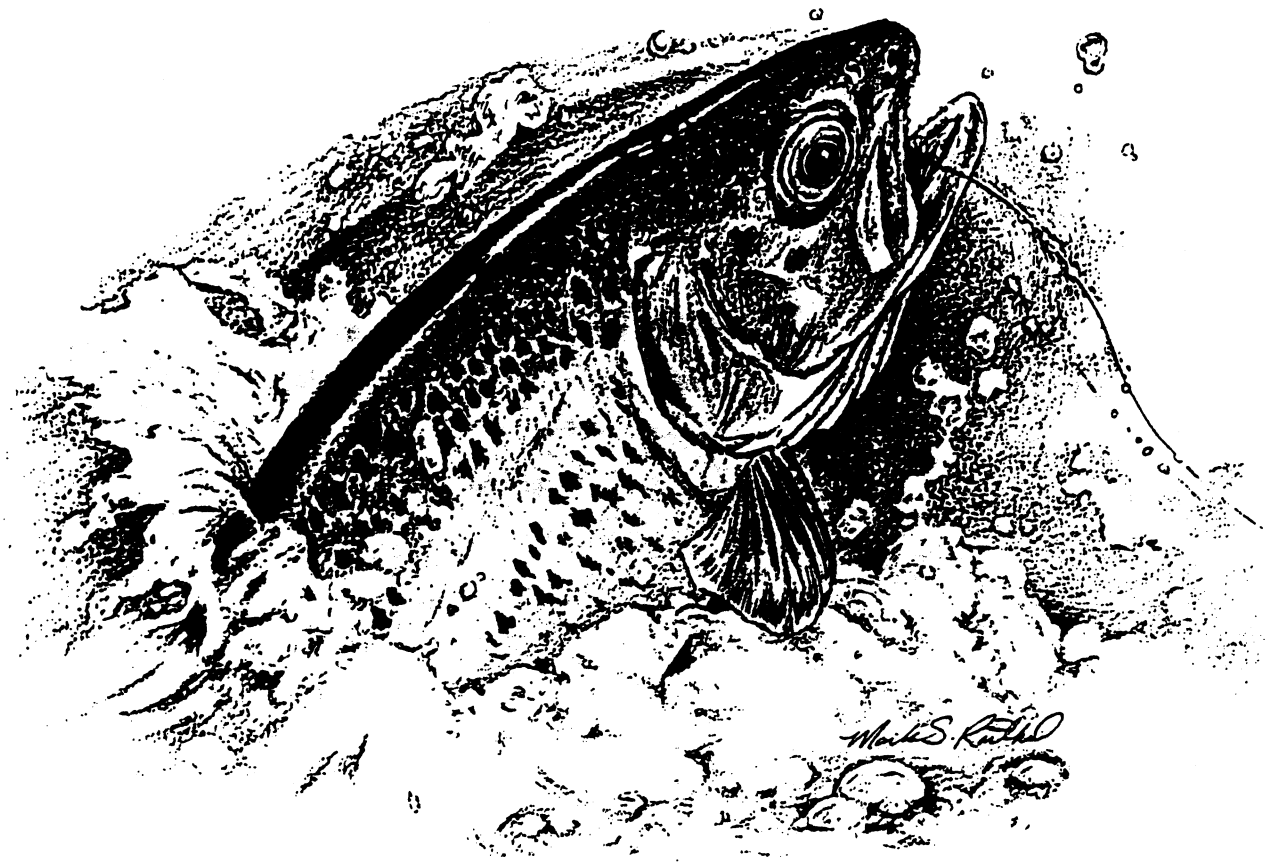
Management of Lake Taneycomo, Missouri
Job 1: Literature and Data Review



Mike Kruse
Fisheries Research Biologist
Missouri Department of Conservation

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Fish and Wildlife Research Center 1110
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FINAL REPORT

Sport Fish Restoration Project F-1-R-45

Study I-35

MANAGEMENT OF LAKE TANEYCOMO, MISSOURI

JOB 1: LITERATURE AND DATA REVIEW

Missouri Department of Conservation

Jerry J. Presley, Director

Kenneth M. Babcock, Assistant Director

Alvin J. Brand, Federal Aid Coordinator

James P. Fry, Chief, Division of Fisheries

Prepared by: Mike S. Kruse — Fisheries Research Biologist — 7/25/96 Date

Approved by: Joel G. Dillard — Fisheries Research Supervisor — 7/26/96 Date

Approved by: Larry D. Flinger — Assistant Fisheries Division Chief - Research — 7/26/96 Date

ABSTRACT

Lake Taneycomo has been managed as a trout fishery since 1958, when discharges from the hypolimnion of Table Rock Lake began. Hatchery-reared rainbow trout, *Oncorhynchus mykiss,* have supported most of the angling effort since that time. Brown trout, *Salmo trutta,* were first stocked in 1980. Fishing regulations for rainbow trout have not changed since 1958 (5 fish daily, no length limit), although a voluntary 12- to 16-inch slot length limit was promoted in the early 1980s. Brown trout harvest has been restricted to one 20-inch or larger fish per angler per day since 1985. An excellent put-grow-and-take fishery for rainbow trout developed after the amphipod crustacean, *Gammarus,* became their dominant food item (87 % by volume in 1972) and accelerated trout growth rates to as much as 0.9 inches per month. Recently, electrofishing samples indicate that the number of large rainbow trout in the population has declined and that most trout over 16 inches are now brown trout. The causes for this decline are unknown, but may include a 90% reduction in *Gammarus* production; increased trout stocking to an average of over one million per year; increased population density of white suckers, *Catastomus commersoni,* which may provide interspecific competition with trout; increased angler harvest; or changes in aquatic habitat. Collectively, these changes may have degraded foraging conditions for rainbow trout. Fishery management options for restoring the putgrow-and-take rainbow trout fishery may include reducing trout densities, reducing white sucker densities or increasing the production of invertebrates while increasing rainbow trout residence times.

INTRODUCTION

Lake Taneycomo, impounded in 1913, was the first hydroelectric reservoir constructed in Missouri. It's original warmwater fishery was converted to a coldwater fishery in 1958 when Table Rock Lake was completed and began releasing cold, hypolimnetic water into upper Lake Taneycomo (Fry and Hanson 1968). Currently, the lake's 1,892 acres support Missouri's largest and most popular fishery for rainbow trout, *Oncorhynchus mykiss,* and brown trout, *Salmo trutta.*

The last data and literature review of the Lake Taneycomo trout fishery was conducted by Goddard, et. al in 1988. Additional changes have occurred and more information has become available in the intervening 5 years. This literature review will include all Missouri Department of Conservation efforts as well as information gathered by other agencies through 1992. This information forms the basis of new research on the lake's fishery that began in 1993 (Kruse, 1994).

Lake Taneycomo's trout fishery is influenced by a number of factors including those listed by Trial (1990). The relative importance of each of these factors is uncertain, and will likely remain so until additional data are collected. Potential problems can be identified by examining three important components of the fishery: predators (fish populations and the fisheries they sustain), prey, and aquatic habitat. The following review summarizes our understanding of each of these components.

FINDINGS

Predators

Trout Populations

Rainbow trout were first introduced into Lake Taneycomo in 1958. The original justification for stocking was to mitigate the loss of the popular warmwater fishery that declined soon after cold water releases from Table Rock Lake began. Rainbow trout stocking rates gradually increased from 700 rainbow trout in 1958 to a high of more than 1.6 million in 1984 (Table 1).

The first brown trout were introduced in 1980, and annual stockings have ranged up to 67,000 per year (Table 1). Recent stockings have averaged around 10,000 brown trout per year. In 1983, a 20-inch minimum length limit was enacted on brown trout. Although they comprise only a small percentage of the trout stocked in Lake Taneycomo, brown trout represent nearly all of the large trout currently in the lake. Lake Taneycomo contains many of the largest brown trout in Missouri and produced the current state record (24.95 pounds), in 1994.

A limited number of other salmonids have been released into Lake Taneycomo. Kokanee salmon, *Oncorhynchus nerka kennerlyi,* were stocked from1963 to 1968. However, survival and return to the creel were very poor. Steelhead trout (migratory strains of rainbow trout) from Michigan were released from 1971 to 1974. These stockings were discontinued because of the possibility of disease introductions.

Historically, rainbow trout have provided an excellent put-grow-and-take trout fishery in Lake Taneycomo. Fry and Hanson (1968) determined that rainbow trout tagged and released at 10 inches total length were growing 0.4 inches per month, and those stocked at 6.0 inches grew about 0.6 inches per month. By 1969, after the introduced amphipod crustaceans had become abundant (see section on Prey, Page 5), tagged rainbow trout grew as much as 0.9 inches per month from an initial stocking size of about 10 inches (Vasey 1969). Later, Turner (1977) documented that rainbow trout stocked at less than 8 inches total length grew an average of 0.7 inches per month. By 1969, large rainbow trout (> 20 inches) were commonly caught by Lake Taneycomo trout anglers.

By the mid-1980s, the trophy rainbow trout fishery began to decline, prompting questions about feeding conditions for trout and the lake's carrying capacity (Goddard, et. al 1988). Recent food consumption estimates (Weiland 1992) indicated that rainbow trout were frequently feeding at levels below their maintenance ration. Such conditions suggest that growth of trout may be greatly reduced from historic levels. Preliminary application of simple bioenergetics models suggest that the number of

trout stocked in Lake Taneycomo may be greater than the current invertebrate production is able to sustain (Mike Kruse, Missouri Department of Conservation, unpublished data). Although recent estimates of trout growth are not available, size structure of the rainbow trout population has deteriorated. Most rainbow trout in recent electrofishing samples are less than 14 inches in total length, suggesting poor growth and/or high exploitation after stocking (Table 2).

Several studies of exploitation and residence times of rainbow trout have been conducted. Fry and Hanson (1968) found that 22 % of tags (no rewards offered) were returned from rainbow trout tagged at an average size of 10 inches, but only about 3 % were returned from 6-inch fish. Turner (1977) concluded that most rainbow trout had short residence times based on estimated harvest of trout stocked at 4, 6, 8 or 10 inches total length. Recent studies (Weiland 1992) indicated residence times (days until 1% of a cohort remained) ranged from 16 to 194 days. In an effort to increase residence times, the Missouri Department of Conservation actively promoted a voluntary 12- to 16-inch slot length limit on rainbow trout in the early 1980s. These efforts initially increased the percentage of rainbow trout that anglers released from 33 % in 1979 to 48 % in 1980. However, by 1984, anglers released only 37.3 % of the rainbow trout they caught (Goddard et. al 1988).

Fry and Hanson (1968) determined that most trout moved upstream after stocking, but a few fish had moved long distances down the length of Bull Shoals Lake. Observations were limited to fish released at two locations (immediately below Table Rock Dam and at Rockaway Beach) on one occasion.

Other Fish Populations

In the mid 1980s white suckers, *Catastomus commersoni*, became a major part of the fish community in upper Lake Taneycomo. They first appeared in large numbers during June 1985, after the discharge of large volumes of relatively warm water through the floodgates of Table Rock Dam attracted a variety of warmwater fish to the upper end of the lake. Recently, white suckers have

outnumbered trout in electrofishing samples. Despite their abundance, we lack basic information on their life history in Lake Taneycomo. However, preliminary studies suggest that they are efficient predators on the benthos, consuming large numbers of the same taxa utilized by trout (Hansen 1992, Goddard, et. al 1988). Such interspecific competition for food might reduce trout growth rates in Lake Taneycomo.

Angler Effort and Success

Angling effort has increased in Lake Taneycomo during the last 20 years, as documented by creel surveys (Figure 1). Such an increase in angling effort may be partially responsible for the decline in the numbers of large rainbow trout. Angler survey methods have changed over the years. In recent surveys (1975-1990), anglers were contacted at access points, while prior surveys (1951-1974) utilized roving methods of angler interview. Estimates obtained from the most recent methods suggest that Lake Taneycomo supports almost 400,000 fishing trips per year. Weithman and Hass (1984) estimated that the trout fishery was worth more than nine million dollars annually to the local economy. Spotts (1991) reported that the economic value of four similar tailwater trout fisheries in Arkansas was approximately 128 million dollars per year in 1988.

Past estimates of rainbow trout harvest are much lower than the numbers stocked, indicating either underestimated harvest with the past creel survey methods, or undocumented fishing mortality, natural mortality or emigration of large numbers of trout (Table 3).

Prey

In the early 1960s, Hanson (1960, 1963) determined that rainbow trout in Lake Taneycomo fed on a wide variety of invertebrates. Trout from upper Taneycomo were "fat and in excellent condition." The most common food item consumed at that time was Chrionomidae larvae and pupae. In 1963 and 1964, two amphipod crustaceans, *Gammarus pseudolimnaeus* and *Hyalella azteca,* were introduced into Lake Taneycomo from native populations in Maramec Spring Branch (Phelps Co.),

Rollins Spring (Boone Co.) and from the August. A. Busch Memorial Conservation Area (St. Charles Co.) (Hanson 1967). By the end of 1964, both species were well-established in the reservoir, *Gammarus* primarily in the gravelly substrate of upper Lake Taneycomo and *Hyalella* in the heavily vegetated lower portion of the lake. While amphipods were native to the Taneycomo watershed, only one was found in a rainbow trout stomach prior to 1963 (Hanson 1967).

When densities of *Gammarus* increased in upper Lake Taneycomo, this amphipod became the most important food item in the diet of rainbow trout -- 87 % by volume in 1972 (Pflieger 1977a). Pflieger (1977b) estimated *Gammarus* production to be 88 g/m^2 in the upper part of the lake. Under these conditions, tagged and recaptured rainbow trout were found to grow as much as 0.9 inches per month from an initial stocking size averaging about 10 inches. While *Hyalella* were abundant in the vegetation that once existed in lower Lake Taneycomo, they were never important in the diet of trout. And, in general, trout from lower Lake Taneycomo consumed less food than trout in the upper lake. Recent studies (Weiland 1992) suggest that chironomids have again become very important in the diet of both rainbow and brown trout except for large (> 12 inches) brown trout, which feed more heavily on fish (primarily *Cottus sp.* and *Dorosoma sp.).*

Invertebrate sampling conducted by Weithman (1981), Morris (1989), Trial (1990) and others suggests that densities of amphipods have declined in Lake Taneycomo (Table 4). Historically, most invertebrate production occurred in upper Lake Taneycomo, upstream from the mouth of Bee Creek. However, recent samples indicate a reduction in area inhabited by amphipods (Trial 1990).

Comparison of the invertebrate production estimates calculated by Pflieger (1977b) and preliminary estimates by Hansen (1992) indicate that invertebrate production has declined more than 90% from 1972 to 1992. Isopods and, more recently, chironomids have become important components of the benthic community. The reduction in amphipod densities is important because other taxa contain

less energy per gram and are therefore less nutritious prey for trout (Civiello 1989). A reduction in amphipods could theoretically reduce the number of trout that Lake Taneycomo can support.

The causes for the reduction in amphipod populations are unknown. However, predation from higher densities of trout and white suckers has been suggested. Other possible causes relate to changes in aquatic habitat (Trial 1990).

Aquatic Habitat

Aquatic habitat in Lake Taneycomo gradually changes from a riverine tailwater environment immediately below Table Rock Dam to lentic, reservoir conditions at Ozark Beach (Powersite Dam; Figure 2). Habitat quality for trout in the lower, lentic, portion of Lake Taneycomo fluctuates seasonally. In this area, water temperature stratification can occur in the summer during periods of minimum water releases from Table Rock Dam (Knowlton and Jones 1990). Under such conditions, trout habitat in lower Lake Taneycomo is restricted to the deeper, cooler waters.

Seasonally-low dissolved oxygen levels in Lake Taneycomo have been a problem since the construction of Table Rock Dam. Concentrations less than 6 mg/liter have been documented in upper Lake Taneycomo since July of 1959. However, the problem became acute during and after 1968 when concentrations of 2-4 mg/liter were measured (Weithman and Haas 1980). Such conditions are common in most cold tailwater fisheries (Hill 1978). Low dissolved oxygen levels in upper Lake Taneycomo may also be stressful to invertebrates. Pflieger (1977b) recommended that these effects be studied.

Efforts to increase dissolved oxygen content in water discharged through Table Rock Dam may contribute to periodic supersaturation of gas levels in upper Lake Taneycomo. Total gas and nitrogen gas concentrations have exceeded 110% during power generation at Table Rock dam and 120% when floodgates were employed (Camenisch 1992). The frequency and magnitude of gas supersaturation and its effects on aquatic life have not been studied in upper Lake Taneycomo. However, Nebeker and

Brett (1976) determined that the 96-hour LC50 for total gas concentration in steelhead smolts was 116%.

Studies by Weithman (1981) indicated that shallow water with a gravel substrate is essential to invertebrate production in Lake Taneycomo. However, the most desirable substrate particle size for invertebrate production has not been identified. Average particle sizes can be altered by sedimentation, bed scouring during high flows, and commercial gravel dredging. Since 1977, commercial gravel dredging has been prohibited in upper Lake Taneycomo (upstream of the U.S. Highway 65 bridge).

Particle sizes in the substrate of Lake Taneycomo could also be altered by sedimentation. An increase in land disturbances in the lake's watershed suggests that erosion and sedimenation may have increased. Morris (1989) reported that few crustaceans were found in sedimented parts of the lake. Sediment may reduce invertebrate habitat by occluding interstitial spaces in the substrate. Sediment may also be toxic to invertebrates. In a study of chironomids collected from Lake Taneycomo in 1986, Trial (1993) detected morphological anomalies in five percent of the chironomids that were examined. Warwick (1988) associated some types of water pollution with morphological anomalies in the head capsules of chironomid larvae.

While Lake Taneycomo may be receiving more sediment from land disturbances in the watershed, much of the existing sediment was apparently deposited before construction of Table Rock Dam in 1958 (Berkas 1989). Now, sediment transport from 92 % of Lake Taneycomo's watershed is blocked by Table Rock Dam. Berkas (1989) concluded that "the upper two-thirds of the lake seems to have been scoured after Table Rock Dam greatly decreased sediment load to the lake." He further stated that "Estimated velocities and particle-size data of bed material indicate that scouring of the upstream reaches of the lake are possible."

The quantity and quality of invertebrate habitat may also be influenced by the flow regime from Table Rock Lake (minimum flow, maximum flow, ramping rates, duration of various flows, etc.) and changes in this regime could influence invertebrate habitat, particularly in upper Lake Taneycomo.

Removal of suspended solids from Shepherd of the Hills hatchery effluent beginning in 1979 has been offered as an explanation for reduced productivity of the invertebrate community (Trial 1990). In contrast, increasing populations of both humans and livestock in the White River watershed may have increased nutrient concentrations in water entering Lake Taneycomo. These changes in nutrient concentrations, and any effects they may have had on aquatic habitat (particularly in upper Lake Taneycomo), are virtually unstudied. However, Camenisch (1971) determined that hatchery effluent had little effect on Lake Taneycomo's biological oxygen demand at the hatchery loading rates that existed in 1971. While there is little information on the effects of changing nutrient densities in Lake Taneycomo, studies in the Au Sable River of Michgan showed reduced trout growth after removal of sewage discharges (Merron 1982). Growth reductions were attributed to lower abundance of *Gammarus fasciatus* and *Asellus militaris* after sewage removal.

SUMMARY

Many changes have occurred in Lake Taneycomo since the construction of Table Rock Dam in 1958. The most obvious change has been a decline in the size structure of the rainbow trout population and the development of a put-grow-and-take fishery for brown trout.

Fishing pressure has always been high at Lake Taneycomo, and most trout have traditionally been caught soon after stocking (Hanson 1977, Turner 1977, Weithman and Haas 1984). However, through the 1970s some rainbow trout were able to avoid immediate capture, feed on *Gammarus* and grow to large sizes. An excellent put-grow-and-take fishery developed and trout over 20 inches long were common. A gradual decline in the numbers of large rainbow trout began in the early 1980s. By

this time, fishing pressure had nearly doubled, and trout stocking rates were increased to a million or more rainbow trout per year to accommodate angler demand. A voluntary 12- to 16-inch slot length limit failed to restore large rainbow trout to the fishery. Recently, the size structure of the rainbow trout population has deteriorated.

In addition to the increased angling effort and harvest, other changes in Lake Taneycomo may also be responsible for a decline in the number of large rainbow trout in the lake. An increase in the number of trout stocked, the addition of white suckers to the fish community and a dramatic decline in the density, distribution and production of amphipods may have collectively degraded foraging conditions for trout. Dense populations of amphipods present from the late 1960s through the early 1980s apparently accelerated trout growth rates. However, records also show that trout grew well before amphipods were abundant, although stocking rates were much lower at that time.

This literature review suggests that options available for restoring the put-grow-and-take rainbow trout fishery include reducing trout densities, reducing white sucker densities, or increasing the production of invertebrates while increasing rainbow trout residence times.

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Table 1. Number of rainbow trout and brown trout stocked in Lake Taneycomo, 1958-1993.

Year	Rainbow Trout	Brown Trout
1958	700	0
1959	194,600	0
1960	233,800	0
1961	356,400	0
1962	178,700	0
1963	663,800	0
1964	542,300	0
1965	419,000	0
1966	490,159	0
1967	442,261	0
1968	573,048	0
1969	1,063,491	0
1970	698,968	0
1971	626,606	0
1972	708,501	0
1973	372,068	0
1974	870,449	0
1975	936,231	0
1976	1,042,353	0
1977	408,949	0
1978	774,568	0
1979	922,935	0
1980	1,159, 909	19,819
1981	1,062,095	63,636
1982	1,137,213	67,333

Table 1. (Cont.) Number of rainbow trout and brown trout stocked in Lake Taneycomo, 1958-1993.

Year	Rainbow Trout	Brown Trout
1983	1,423,893	61,077
1984	1,685,066	34,027
1985	1,591,749	39,237
1986	1,204,236	46,419
1987	890,688	10,259
1988	1,020,994	14,695
1989	969,955	9,982
1990	1,033,355	10,892
1991	1,057,633	14,325
1992	714,164	10,000
1993	776,900	10,000

Table 2. Abundance and size structure of rainbow trout and brown trout in August electrofishing samples, upper Lake Taneycomo, 1979-1993.

Year	Rainbow Trout				Brown Trout			
	No./Hr.	RSD-13	RSD-16	RSD-20	No./Hr.	RSD-13	RSD-16	RSD-20
1979	256	14	3	1	2	60	40	40
1980	140	24	4	1	10	60	7	0
1981	85	19	6	1	51	40	11	1
1982	95	7	1	<1	132	10	4	1
1983	165	47	9	2	225	38	10	<1
1984	191	8	<1	0	160	33	8	1
1985	103	13	5	0	188	14	6	<1
1986	135	5	0	0	273	24	2	<1
1987	76	19	1	0	134	60	14	0
1988	-	-	-		-	-	-	-
1989	74	10	1	0	76	37	17	2
1990	73	19	0	0	204	40	13	2
1991	68	<1	0	0	62	44	16	2
1992	43	8	0	0	71	45	11	1
1993	99	33	2	0	133	57	15	3

Table 3. Comparison of the number of rainbow trout stocked and harvested, Lake Taneycomo, 1958-1993.

Year	Number Stocked	Estimated Number Harvested
1958	700	
1959	194,600	28,900
1960	233,800	49,700
1961	356,400	133,400
1962	178,700	117,100
1963	663,800	139,000
1964	542,300	296,541
1965	419,000	281,843
1966	490,159	297,429
1967	442,261	214,196
1968	573,048	296,570
1969	1,063,491	-
1970	698,968	346,581
1971	626,606	376,452
1972	708,501	265,568
1973	372,068	294,498
1974	870,449	519,961
1975	936,231	-
1976	1,042,353	-
1977	408,949	-
1978	774,568	-
1979	922,935	467,966

Table 3. (Cont.) Comparison of the number of rainbow trout stocked and harvested, Lake Taneycomo, 1958-1993.

Year	Number Stocked	Estimated Number Harvested
1980	1,159,909	423,073
1981	1,062,095	367,621
1982	1,137,213	415,853
1983	1,423,893	590,768
1984	1,685,066	499,138
1985	1,591,749	399,327
1986	1,204,236	427,398
1987	890,688	290,838
1988	1,020,994	480,610
1989	969,955	366,203
1990	1,033,355	292,842
1991	1,057,633	-
1992	714,164	-
1993	776,900	-

Table 4. Number of amphipods collected at seven sites in Lake Taneycomo, 1980-1991.

	Year				
Site	1980	1987	1989	1990	1991
1	4,194	2,660	186	1,081	58
2	2,961	1,626	*127*	*575*	*222*
3	4,967	4,388	266	731	87
5	1,032	2,375	307	115	64
6	737	1,553	206	230	183
7	1,033	298	66	399	1
19	4,221	40	54	168	7
Totals	19,145	12,940	1,212	3,299	622

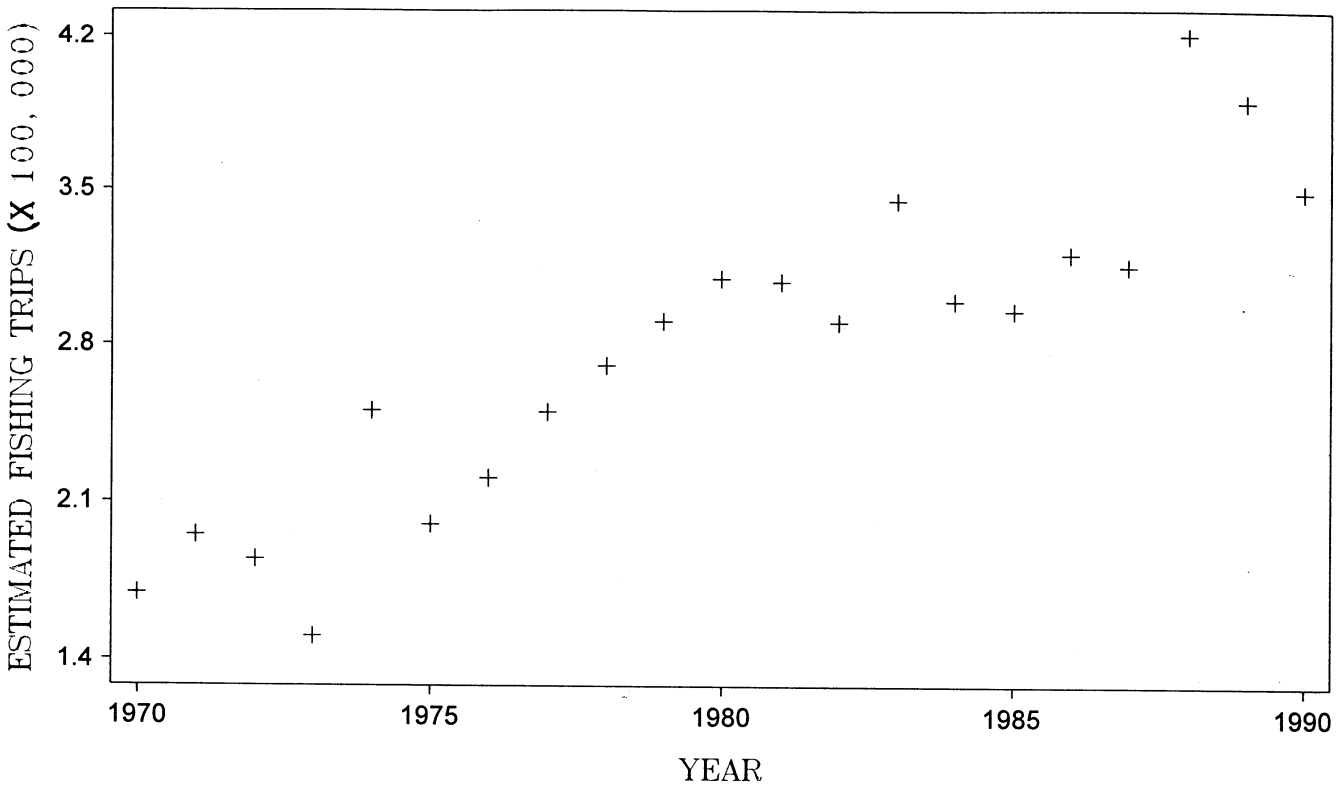
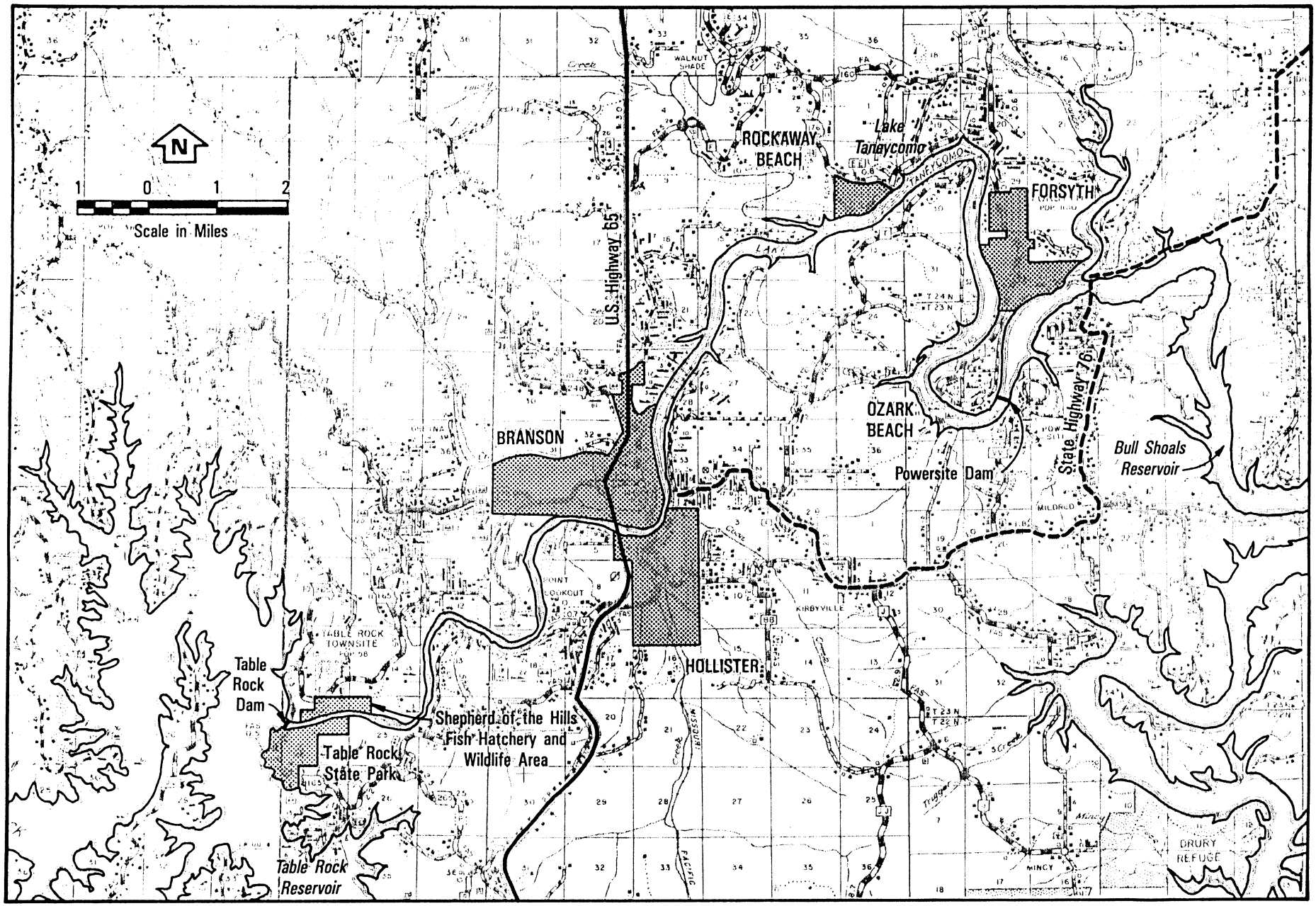


Figure 1. Estimated number of fishing trips at Lake Taneycomo, 1970-1990.



Source: Missouri Highway and Transportation Department

Figure 2. Lake Taneycomo, Missouri.