State of California
Natural Resources Agency
Department of Fish and Wildlife

Manzanita Lake fishery management plan

by

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EXECUTIVE SUMMARY

California Fish and Game Code (Chapter 7.2, Section 1726.4 (b)) states that it is the intent of the Legislature that "the department [specifically, the California Department of Fish and Wildlife (CDFW) Heritage and Wild Trout Program (HWTP)], in administering its existing [heritage and] wild trout program, shall maintain an inventory of all California trout streams and lakes to determine the most suitable angling regulations for each stream or lake. The department shall determine for each stream or lake whether it should be managed as a wild trout fishery, or whether its management should involve the temporary planting of native trout species to supplement wild trout populations that is consistent with this chapter." Section 1726.4 (b) additionally states that "biological and physical inventories prepared and maintained for each stream, stream system, or lake shall include an assessment of the resource status, threats to the continued well-being of the fishery resource, the potential for fishery resource development, and recommendations, including necessary changes in the allowed take of trout, for the development of each stream or lake to its full capacity as a fishery."

Furthermore, California Fish and Game Code (Chapter 7.2, Section 1727 (d)) requires that the CDFW "shall prepare and complete management plans for all wild trout waters not more than three years following their initial designation by the commission, and to update the management plan every five years following completion of the initial management plan." For clarification, wild trout waters, as stated above, represent waters that have been formally designated by the California Fish and Game Commission as Heritage and/or Wild Trout Waters. Wild Trout Waters are those that support self-sustaining trout populations, are aesthetically pleasing and environmentally productive, provide adequate catch rates in terms of numbers or size of trout, and are open to public angling. Wild Trout Waters may not be stocked with catchable-sized hatchery trout. Heritage Trout Waters are a sub-set of Wild Trout Waters and highlight wild populations of California's native trout that are found within their historic drainages.

In an effort to comply with existing policy and mandates, the HWTP, in coordination with Lassen Volcanic National Park (LVNP or Park), has prepared a fishery management plan (FMP) for Manzanita Lake. This FMP is intended to establish an adaptive framework for future management of Manzanita Lake and to communicate management direction to the public, other agencies, and trout angling organizations. This FMP has been developed to provide direction and identify actions necessary to sustain the recreational fishery for the benefit and enjoyment of the angling public. However, actions associated with this FMP are initiated independently; thus, any environmental review/permits needed to implement the actions specified herein are separate from the FMP itself.

INTRODUCTION

Manzanita Lake is a small lake, located in northern California (Shasta County), which offers anglers the opportunity to catch rainbow (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) in an aesthetically pleasing setting. This FMP summarizes data generated from studies and surveys conducted in Manzanita Lake, reviews past fisheries management activities, identifies stressors and provides a coordinated

fisheries management strategy designed to maintain a healthy and sustainable fishery from 2015-2020. It should be emphasized this FMP is meant to guide a joint management program between CDFW and the Park, but not limit flexibility that either or both parties may need to address unforeseen issues.

Under the Trout and Steelhead Conservation and Management Planning Act, established by the California Legislature in 1979, the California Department of Fish and Game (CDFG) (now CDFW) was mandated to annually recommend to the California Fish and Game Commission (CFGC) at least 25 miles of stream and one lake suitable for designation as a “catch and release” fishery. In 1986, with the concurrence of the Park, the CFGC designated Manzanita Lake a “Catch and Release” water. In 2007, the “Catch and Release” designation was removed and new requirements were established to instead designate Wild Trout Waters. Waters previously designated as Catch and Release fisheries were not automatically adopted into the Wild Trout Program and were to be re-evaluated to determine if they met the requirements for designation as Wild Trout Waters. In 2006, the CDFW and Park began collaborative efforts to assess the Manzanita Lake fishery and, in 2014, Manzanita Lake was formally designated by the CFGC as a Wild Trout Water. A memorandum of understanding (MOU) will be developed between the CDFW and Park to outline common goals and objectives related to the management of Manzanita Lake.

RESOURCE STATUS

Area Description

Manzanita Lake is situated in a shallow volcanic basin, at the base of Chaos Crags, on the northwest side of LVNP in Shasta County, California (Figure 1). The lake is located approximately 0.8 km (0.5 mi) southeast of the intersection of State routes 44 and 89 at an elevation of 1782 meters (5846 ft.).

Physical Characteristics

Manzanita Lake is a naturally formed lake. Pacific Gas and Electric Company, which owned the water rights to the lake in the early 1900's, dammed the outlet stream and increased the surface area to approximately 0.2 km^2 (53 acres). The lake outline is irregular, with two arms forming the western half of the lake and a single extension to the east (Figure 2). The lake measures 0.8 km (0.5 mi) long by 0.5 km (0.3 mi) wide at its widest point. The maximum depth is 9.7 m (32 ft.) but more than two-thirds of the lake is shallower than 4.6 m (15 ft.). The banks of the southern portion of the lake are gently sloped. The banks are steeper in the outlet stream arm where, at one point, the depth is 25 feet within 100 feet of the shore. The lake bottom consists of volcanic sand and cinder, mostly covered with a layer of silt and organic debris.

Manzanita Lake is fed by three streams: Manzanita Creek and an overflow channel from Reflection Lake (both of which flow year-round and enter along the northeast shoreline), as well as an intermittent unnamed tributary that enters on the south shore. Manzanita Creek is the largest of the three inlets, approximately 7.2 km (4.5 mi) in length from its origins at the base of Crescent Cliff to the lake. The creek is spring-fed and relatively cold, with temperatures averaging 5.5 to 8.9 ºC (42 to 48 ºF) throughout the year.

Area Maps

Figure 1. Location map of Manzanita Lake

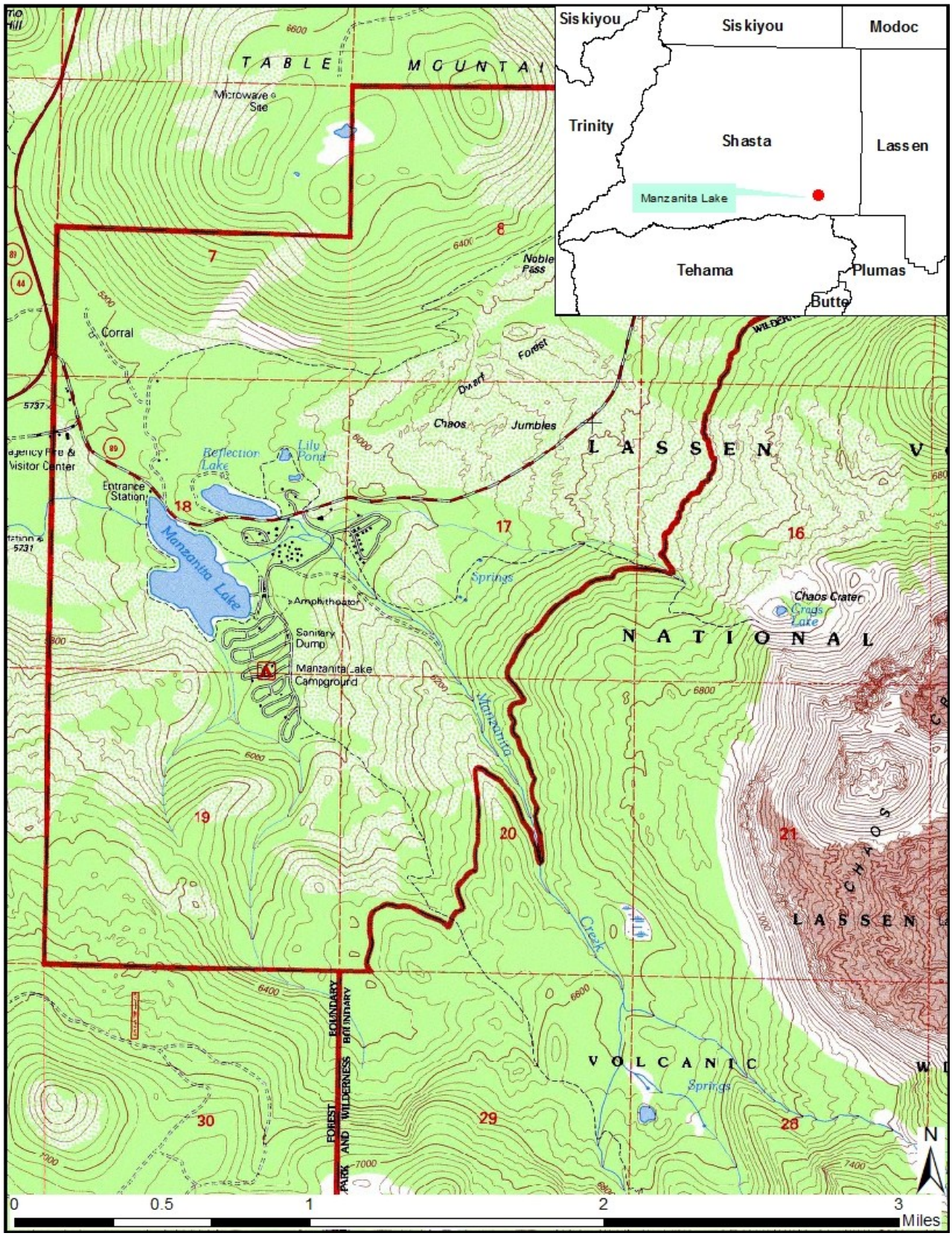
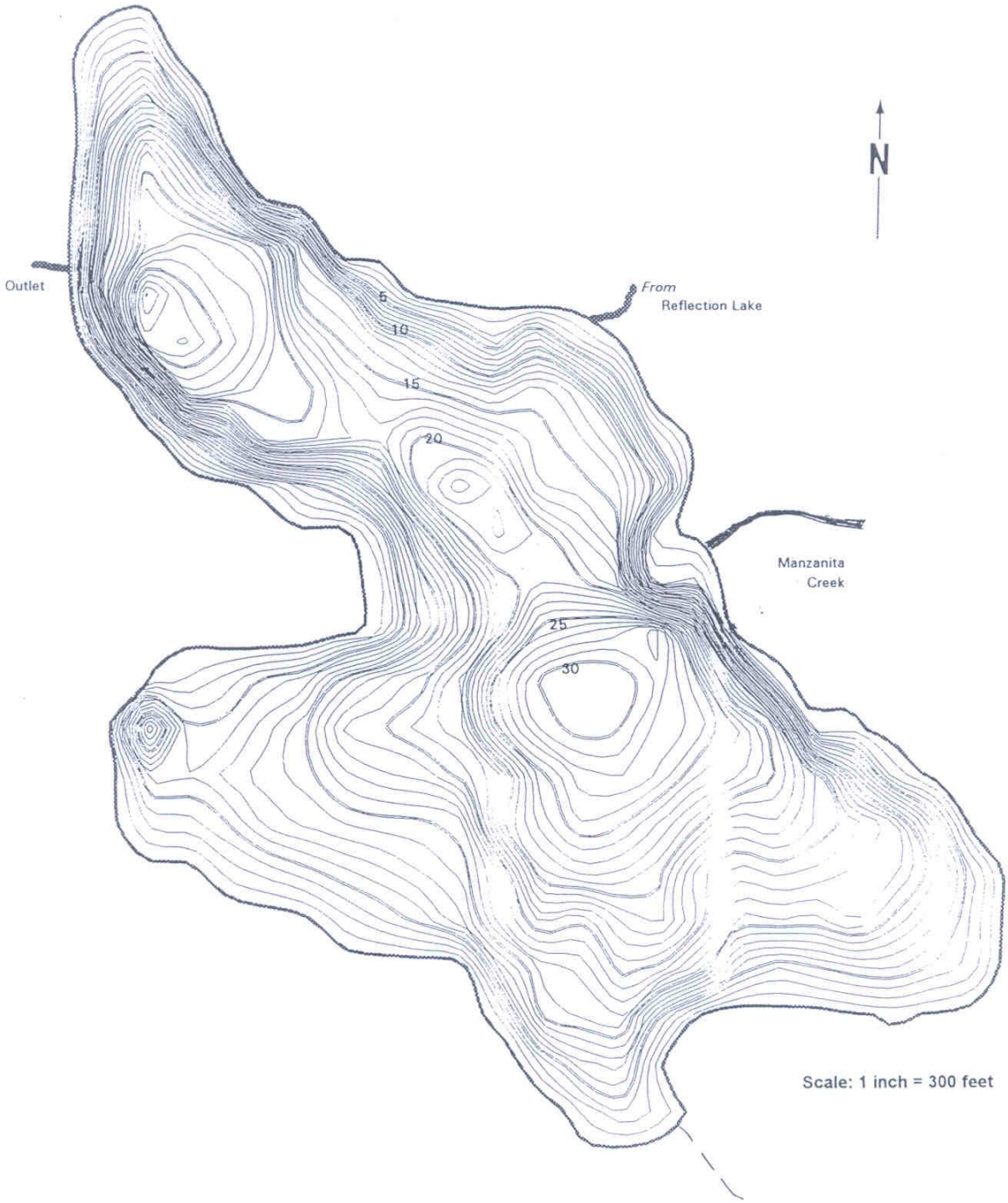


Figure 2. Bathymetric contour map (in feet) of Manzanita Lake.



A 1.2 m (4 ft.) natural barrier blocks upstream fish migration approximately 1.1 km (0.7 mi) upstream of the lake. However, most of the trout spawning occurs much farther downstream. Manzanita Creek is the only stream entering the lake that provides trout spawning habitat.

The outlet of the lake is located at the dam in the northwest arm of the lake. As the water leaves the lake it flows through a collapsed wooden grizzly-type grate. Manzanita Creek, downstream of the dam, consists of approximately 0.3 km (300 yards) of short deep boulder and log plunge pools, short cascades, and occasional gravel riffles ending in a shallow pond on a permeable sand flat. Little water flows out of the pond, with surface flow extending for approximately 0.2 km (200 yards) before sinking entirely into porous soils. Habitat between the lake and pond is well suited for rearing and holding trout, but spawning gravel is limited to a few riffles. Trout leaving the lake to spawn downstream cannot return to the lake due to several downstream woody debris barriers and the collapsed grate at the dam.

Limnological Characteristics

Water temperatures vary little throughout Manzanita Lake. Summer surface temperatures ranged from 16.7 to 20 ºC (62 to 68 ºF), while temperatures at depth ranged from 13.3 to 15.6 ºC (56 to 60 ºF) and no thermocline was documented (Hubbell 1961). Temperature variation at depth was attributed to the varying inflows of cold, dense water from Manzanita Creek. The CDFG measured summer surface temperatures from 13.9 to 20 ºC (57 to 68 ºF), and deep water temperatures from 8.9 to 12.8 ºC (48 to 55 ºF). A slight thermocline was detected 0.9 to 1.8 m (3 to 6 ft) below the surface in July (CDFG 1990).

Dissolved oxygen has been documented to be well mixed throughout the water column, averaging 9-10 mg/L at all depths (CDFG 1990). The lowest dissolved oxygen reading during these surveys was 6 mg/L at a depth of 7.6 m (25 ft). Total alkalinity averaged between 25 to 30 mg/L. Hubbell (1968) found the lake surface pH increased from 6.8 in June to 8.6 in September. Surface pH ranged more narrowly between 8.9 and 9.4 from April through October, 1990 (CDFG 1990). The lake's water clarity, measured by Secchi disc, was 6.4 to 8.4 m (21 to 27.5 ft.) (Hubbell 1968).

Dense beds of rooted submerged aquatic plants cover 75 to 80% of the lake bottom (Hubbell 1968). Pink flowering *Polygonium* sp. cover large areas of the surface in shallow water in the southern portion of the lake. *Myriophyllum* sp. and *Potamogeton* sp. grow throughout the deeper parts of the lake.

Hubbell (1968) described the aquatic invertebrate community assemblage in Manzanita Lake and documented that the lake supports a diversity of taxa, many of which provide forage for trout. Multiple species from the Orders Coleoptera (beetles), Diptera (Chironomids and other flies), Ephemeroptera (mayflies), Hemiptera (true bugs), Odonata (dragonflies and damselflies), and Tricoptera (caddisflies) are found in large numbers. Leeches (Hirudinea), mollusks (aquatic snails and clams), amphipods (Amphipoda), and annelid worms (Annelida) are also present, contributing to an abundant aquatic food base.

Land ownership/administration

- ☐ United States Forest Service
- ☐ Bureau of Land Management
- ☐ State Parks
- ☒ National Parks
- ☐ Fish and Game
- ☐ Private
- ☐ Other

Public access

- ☒ Roadside
- ☐ Remote/hike-in
- ☒ Boat

Fishery Description

The earliest report of trout in Manzanita Lake credits Major P.B. Reading with stocking "the first fish that ever swam in the lake" in 1848. Reading supposedly brought trout in buckets of water to the lake from nearby Lost or Hat creeks. However, there is no reliable information about the biota in Manzanita Lake prior to the reported 1848 stocking and it is unknown whether rainbow trout are native to Manzanita Lake. Regardless, rainbow trout in Manzanita Lake apparently thrived after the planting. A newspaper account of a trip to Manzanita Lake in 1878 indicated the lake was filled with trout. Native Americans were taking trout with bow and arrow and spearing them by torchlight.

In 1880, Rudolph Klotz, a local sawmill owner, introduced "black cat fish" into Manzanita Lake and several other waters in the area. The fish were probably brown bullhead (*Ictalurus nebulosus*), which persisted in the lake well into the 1900's. In 1914, Mt. Lassen began a series of volcanic eruptions creating massive lahar mudflows. By 1915, the mudflows had entered Manzanita Lake and decimated all the trout in the lake. Bullheads were apparently the only fish that survived.

Early Stocking Programs

After the Mt. Lassen eruption, William Rice, an Anderson merchant and ardent fisherman, applied to the Mt. Shasta State Fish Hatchery (then known as the Sissons Hatchery) for 125,000 young rainbow trout for stocking in Manzanita Lake. The trout were shipped to Anderson via railway and, with 227 kg (500 lbs) of ice, trucked into the lake. Rice reported catching 1.1 kg (2.5 lb.) trout in the lake in 1922 (Robinson 1943).

In 1925, the Park made its first request for CDFG to stock trout in Manzanita Lake. Although no records exist to document what occurred between 1925 and 1931, it appears brown trout were introduced and produced a spawning run large enough to allow egg-taking operations in Manzanita Creek. Between 1931 and 1934, a combination of rainbow trout, brown trout, and a small number of brook trout were stocked in the lake. Over the next 19 years, the management program at the lake included annual plants of about 25,000 to 75,000 brown trout (Wallis 1955).

In 1953, the CDFG informed the Park that it was considering cessation of management in favor of the brown trout population in Manzanita Lake. At the time, the CDFG recommended chemically treating Manzanita and adjoining Reflection lakes to eradicate non-native brown trout and focus the fishery's management on rainbow trout. The CDFG further offered to provide the technical expertise, personnel and equipment needed for the treatment and the National Park Service (NPS) agreed to the proposal. Some public opposition existed to eliminating a trophy brown trout fishery (≥18 inches) and, as a result, the CDFG proposed to postpone the treatment until this controversy could be addressed. The NPS agreed to the postponement but determined that any changes to the Manzanita Lake stocking policy should focus on maintaining rainbow trout, rather than non-native brown trout (Wallis 1955).

Wallis' 1954 Assessment

Orthello Wallis, a well-known NPS biologist, was assigned to assess the existing fishery and recommend a future management program for Manzanita Lake. He spent portions of May and June, 1954, in the Park and identified several management options, including chemical treatment and restocking with rainbow trout, rainbow or brown trout fingerling stocking, or sustaining the fishery with catchable-size rainbow plants. Wallis concluded that a chemical treatment would not eradicate brown trout due to their presence in the stream. He also recognized that brown bullheads were very difficult to eliminate with chemical treatments and felt that rainbow trout could not sustain satisfactory "natural fishing," as brown trout had done, and could not be expected to attain large sizes. Wallis opposed a catchable trout program, in part, due to potential impacts from increased angling (damage to shoreline vegetation, litter, etc.). He noted that skilled anglers often did well at Manzanita Lake and, in contrast to most heavily-fished roadside waters, could catch trophy-size trout (Wallis 1955).

Wallis' management recommendations included retaining the brown trout fishery and, if possible, allowing natural reproduction to sustain the fishery. He concluded that two additional studies were urgently needed: catch and spawning surveys. He suggested that the latter study should be conducted in the spring and fall and may necessitate traps or weirs. In his estimation, a small rainbow trout population would continue to persist in Manzanita Lake, sustained by natural reproduction in Manzanita Creek, as well as recruitment from downstream migrants from Reflection Lake (Wallis 1955).

It is largely unknown what impact(s) Wallis' recommendations had on the management of Manzanita Lake over the next 22 years. The NPS did not allow Manzanita Lake to go the way of most heavily-fished roadside waters at the time and become a put-and-take catchable trout fishery. However, with the exception of a four year period (1968-1971) in which no trout were planted, and two years in which only rainbow trout were planted (1967 and 1976), the lake continued to be stocked with brown trout fingerlings from 1954-1976.

Hubbell's 1961 Study

Paul Hubbell, a student at Humboldt State University, studied the fisheries in Manzanita and Reflection lakes from June through September, 1961. His work included describing biological conditions, collecting basic limnological parameters, sampling and ageing the

brown and rainbow trout populations, and conducting a creel census (Hubbell 1968). Hubbell found Manzanita Lake had conditions suitable to support a small population of trout, many of which were relatively large fish. Brown trout were the dominant species with lesser numbers of rainbow trout, brook trout, and brown bullheads. Due to low density, bullheads did not compete with trout for available food. Results from his creel census showed the catch per unit effort (CPUE) for trout was low (0.20 fish/hr) and 70% of the 250 anglers surveyed caught nothing. Ninety percent of the reported catch was brown trout and the remaining 10% was rainbow trout. Trout greater than ≥356 mm (14 in) total length constituted 23% of the brown and 31% of the rainbow trout catch. No mention was made of anglers releasing any of their catch (Hubbell 1968).

Hubbell's management suggestions were similar to those made by Wallis. He recommended the lake be managed as a brown trout fishery and that stocked brown trout be marked to assess stocked versus wild fish. He recommended a creel survey to estimate trout harvest and angling pressure (Hubbell 1968).

Efforts were made to collect creel census data after Hubbell's study, but these programs did not involve an evaluation of marked trout and were not conducted over the entire fishing season. The stocking of primarily brown trout fingerlings continued but not necessarily annually, as in previous years. From 1977 through 1982, Manzanita Lake was not stocked with hatchery trout.

1983-1991 Rainbow Trout Fingerling Evaluation

In 1983, CDFG, in cooperation with the Park, undertook an evaluation of the contributions of wild and stocked trout to the Manzanita Lake fishery. Approximately 5,000 Eagle Lake rainbow trout fingerlings with an adipose fin clip were stocked each year in 1983 and 1984 (for a total of approximately 10,000 fish). An additional 5,000 (±) unmarked Eagle Lake rainbow trout fingerlings were stocked in 1985. During the study, special angling regulations were imposed on the lake: the limit was reduced to two trout, fish kept could not exceed 254 mm (10 in) in length, and fishing was restricted to the use of artificial lures and flies. The purpose of these regulations was to promote a self-sustaining trophy rainbow trout fishery and allow an evaluation of the comparative abundance between smaller-stocked trout and wild trout. Fish populations were sampled with a boat electrofishing unit each fall from 1983 through 1991 (CDFG 1990).

In the early phases of the study, marked Eagle Lake rainbow trout comprised about 50% of the rainbow trout catch. Toward the end of the study, the wild rainbow trout population was approximately equal to or greater than the brown trout population. In addition, the study revealed that marked Eagle Lake rainbow trout stocked as fingerlings survived in Manzanita Lake for six years or longer.

During the rainbow trout fingerling planting study, the NPS adopted a no-stocking policy in most of its waters. The fingerling study showed that, with a sharply reduced harvest rate, a sizeable rainbow trout population could be maintained in the lake. Further, it appeared this population had the potential to survive in numbers similar to the trophy-sized brown trout population. It is unknown, however, how much the fingerling stocking contributed to the rainbow trout population from 1989-1996, especially given that

fingerlings may have constituted part of the food base for larger, piscivorous brown trout.

1990 Creel Census Survey

At the start of the 1990 general fishing season, CDFG, in cooperation with the Park, initiated a study at Manzanita Lake to evaluate angling effort and catch rates throughout the fishing season, using both a creel census and voluntary angler-survey boxes. This study also included a monthly limnological survey, intended to provide an updated assessment of temperature, dissolved oxygen, and pH.

Angling effort from April 28 through October 31, 1990 totaled an estimated 16,060 hours. Anglers caught and released 6,066 trout (5,626 rainbow and 440 brown trout), with an average CPUE of 0.39 fish/hr. Angling effort increased from 1,513 hours in May to a peak of 5,389 hours in July and decreased to a low of 593 hours in October (Table 1- a, b, c). Catch rates ranged from 0.58 trout/hr in May to 0.31 trout/hr in September. Lure anglers caught an estimated 203 trout in 859 hours of fishing (0.24 fish/hr). Fly anglers fished 15,176 hours and caught 5,860 trout (0.39 trout/hr). Shore, boat, and float-tube anglers fished an estimated 3,800, 6,305, and 5,930 hours, respectively. Catch rates were similar for float-tube (0.41 trout/hr) and boat anglers (0.40 trout/hr), whereas anglers fishing from shore reported the lowest catch rates (0.29 trout/hour). Four percent of the rainbow trout released by anglers were reported to be less than 12 inches in total length, 28.5% were 12.0 to 15.9 inches, 61% were 16.0 to 19.9 inches, and 7% were equal to or greater than 20 inches in length (Figure 3). Brown trout less than 12 inches in total length accounted for 4% of the fish released for that species. Fish 12.0 to 15.9, 16.0 to 19.9, and equal to or greater than 20 inches comprised 17%, 45.5%, and 33.5% of the brown trout released, respectively. A comparison of the results from the creel-survey and angler survey-box forms showed close correlations in the lengths of trout that anglers reported releasing (Figure 4). Species composition of the catch, using these two data sets, was also similar. Mean catch rate from angler-survey boxes was higher than reported from the creel survey (0.74 vs 0.38 trout/hr).

At the start of the 1990 season, the NPS changed the 254 mm (10 inch) maximum size restriction to a zero-trout (catch and release only) regulation. The 1990 survey documented that rainbow trout were sustaining one of the best trophy-sized trout fisheries in the state, although it was recognized that Manzanita Lake was one of the more technically challenging fisheries in the Wild Trout Program. Manzanita Lake produced catch rates that were lower than most designated waters; however, the opportunity to catch large trout appeared to compensate for the angler's desire for a higher catch rate.

Contrary to earlier assessments, Manzanita Lake’s rainbow trout population appeared to provide a satisfactory "natural" fishery in 1990. Wild brown trout catch supplemented the trophy rainbow trout fishery, although catch rates appeared too low to sustain a viable fishery. The disparity in rainbow and brown trout catch rates may be attributed to species-specific differences in angling vulnerability, rather than a reflection of proportional abundance, although no surveys focused on species composition were performed. It worth noting that the stocking of approximately 15,000 Eagle Lake rainbow trout from 1983-1985 may have also skewed these results.

Table 1 - a) hours of fishing effort reported for the months of May through October, 1990; b) number of fish released for rainbow trout (RT) and brown trout (BN) during the months of May through October, 1990 and ; c) average catch rates for rainbow trout (RT) and brown trout (BN) at Manzanita Lake during the months of May through October, 1990 (from angler survey box data).

a)

	May	June	July	August	September	October	Total
Hours fished	1513	4378	5389	1991	2196	593	**16060**

b)

	May	June	July	August	September	October	Total
RT Released	792	1607	1786	592	646	203	**5626**
BN Released	87	151	100	48	42	12	**440**
Total	**879**	**1758**	**1886**	**640**	**688**	**215**	**6066**

c)

	May	June	July	August	September	October	Avg.
RT Catch/hr	0.52	0.37	0.33	0.3	0.29	0.34	**0.36**
BN Catch/hr	0.06	0.03	0.02	0.02	0.02	0.02	**0.03**
Total	**0.58**	**0.4**	**0.35**	**0.32**	**0.31**	**0.36**	**0.39**

Figure 3. Length of rainbow and brown trouts reported caught and released during the 1990 creel survey.

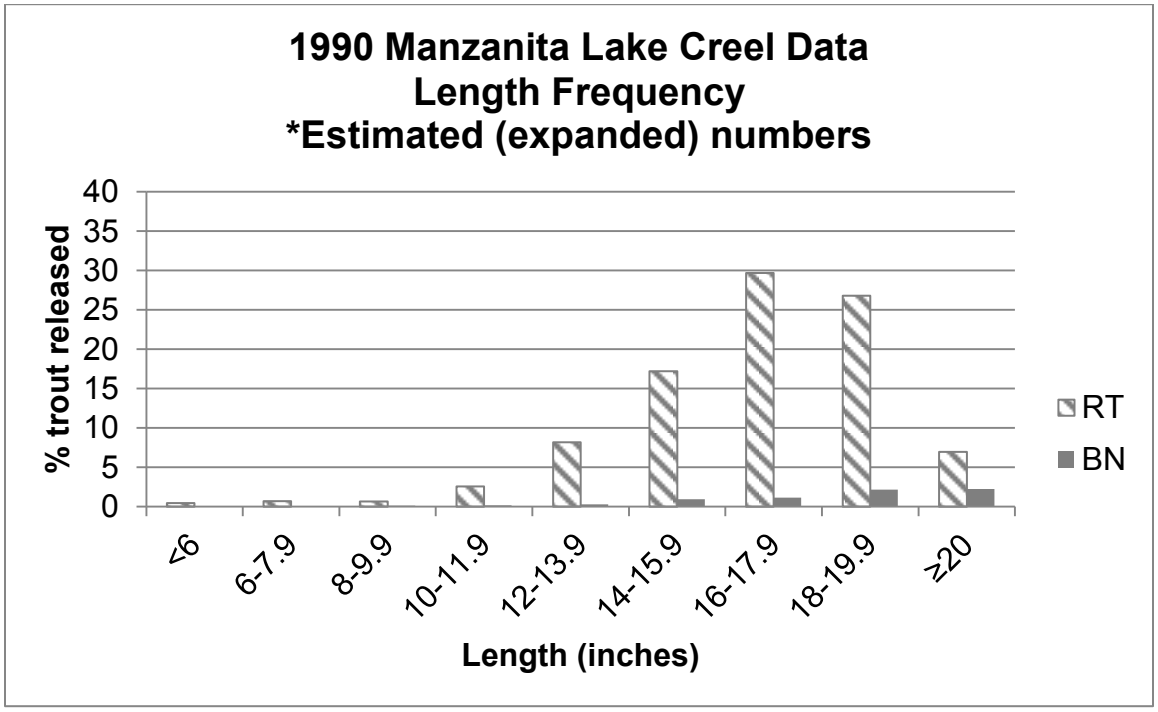
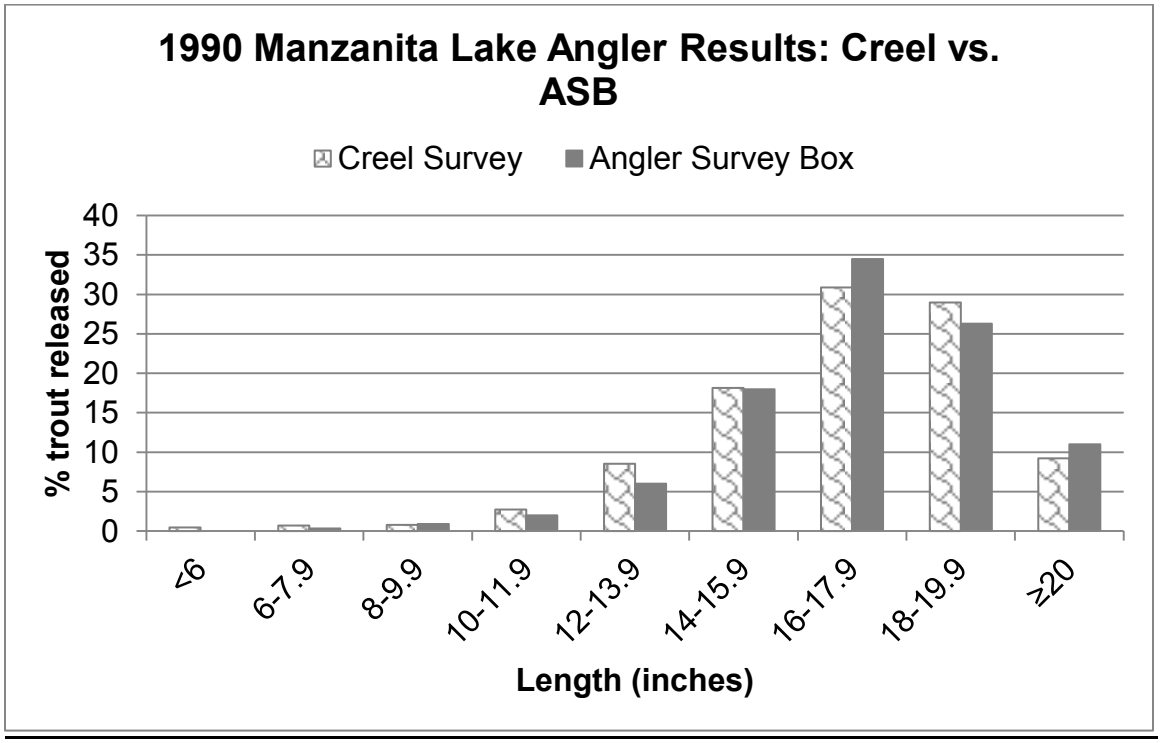


Figure 4. Comparison of reported fish length from creel census vs. angler survey box data (1990).

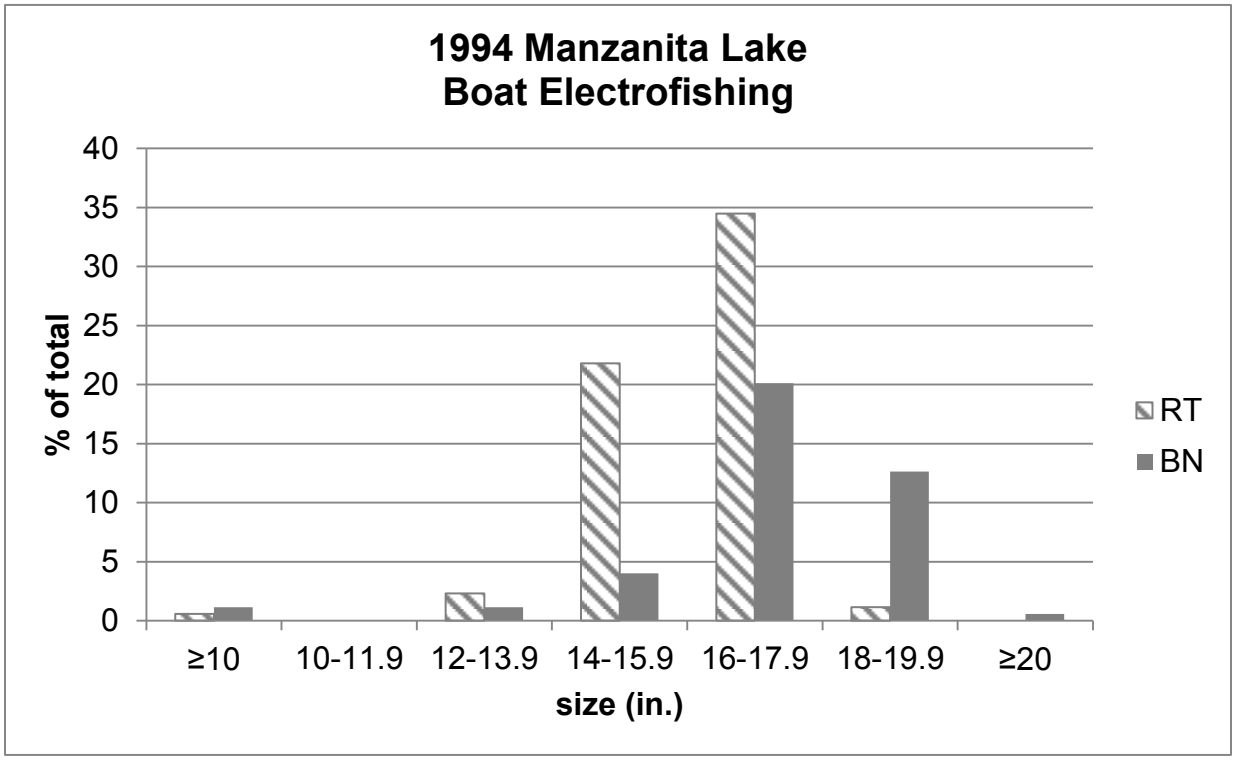


1994 CDFG Boat Electrofishing Surveys

In November, 1994, a single boat electrofishing survey was conducted in order to: 1) determine the presence/absence of stocked Eagle Lake rainbow trout; 2) compare trends in the ratio of rainbow to brown trout, and; 3) evaluate size class structure of rainbow and brown trout.

One pass around the entire perimeter of the lake was performed, with a total of 174 trout captured. Of those, 105 were rainbow (60%) and 69 were brown trout (40%) (Deinstadt et al.1995). Zero rainbow trout captured were from the fingerling stocking study performed from 1983-1985. Results indicated that the rainbow trout population was sustained by natural recruitment from Manzanita Creek. The length frequency data showed that 93% of the rainbow trout captured were between 14 and 17.9 inches and that 91% of the brown trout captured were between 15 and 19.9 inches (Figure 5; Deinstadt et al. 1995); however, electrofishing is inherently biased toward capture of larger fish, due to their larger body surface area and increased susceptibility to the electric field. It is likely smaller fish evaded capture and are underrepresented in the length frequency analysis.

Figure 5. Length frequency of trout collected during November, 1994 boat electrofishing survey.



1995-1996 Pipal Thesis

Kerrie Pipal, a student at Humboldt State University, studied the spawning habitat characteristics of Manzanita Creek and recruitment from fall, 1995, through summer, 1996. The primary objectives of this study were to: 1) document spawning location and timing for both rainbow and brown trout in Manzanita Creek; 2) determine downstream migration patterns for juvenile trout; 3) characterize spawning gravel conditions; 4) locate potential barriers to upstream migration of adult trout; and 5) locate juvenile trout rearing habitat in Manzanita Lake.

Pipal (2003) documented brown trout spawning from late October through early December and rainbow trout spawning from the beginning of April through the end of June. It was noted that 75% of both species spawned within 100 meters of the lower footbridge, which is approximately 150 meters (500 ft.) upstream from the mouth. During the study, 193 spawning adult brown trout (fall) and 758 spawning adult rainbow trout (spring) were observed via direct observation (shoreline counts). Habitat preference within Manzanita Lake was also evaluated. Juvenile rainbow and brown trouts (<10 cm FL) mainly utilized shallow lake margins and willow clumps as cover in the lake, while larger fish (11-30 cm) used medium to larger-sized pieces of woody debris as cover. The study also documented relative abundance and timing of juvenile emigration, as well as residence time, in Manzanita Creek.

Pipal (2003) also noted potential stressors and made management recommendations to the Park and CDFG. The central recommendation was that Manzanita Lake should continue to be managed as a wild trophy-trout, catch and release fishery, with emphasis on maintaining a viable rainbow trout population. In addition, the following recommendations were made:

- Conduct annual spawning surveys, juvenile emigration surveys, spawning habitat assessments, spawning gravel surveys and redd counts over the next three to four years.

- Document habitat types in Manzanita Creek.

- Maintain suitable flows in Manzanita Creek by clearing unnatural debris build-up from the creek channel and maintain a deep channel in lower Manzanita Creek to allow adult trout migration during spawning and juvenile trout emigration.

- Examine all non-natural barriers in Manzanita Creek and evaluate fish passage options.

- Examine natural barriers (fallen trees, woody debris build-ups) due to large storm or flood events and provide fish passage to provide access for spawning and rearing.

- Limit or restrict visitor access to Manzanita Lake during trout spawning and fry emergence.

- Increase visibility of the angler survey boxes.

- Increase visitor awareness about the life history of brown and rainbow trout.

- Consider placing fish habitat structures (small trees and brush) in the lake to increase habitat and cover for juvenile trout.

2008 and 2010 Boat Electrofishing Surveys

In 2008 and 2010, CDFG, in cooperation with the Park, collected updated information on the fishery, with specific objectives to document species composition, fish condition, size-class structure, and age and growth.

In 2008, Manzanita Lake was boat electrofished on three occasions during the summer-fall period. Overall, brown trout comprised the majority of trout captured. Of the 550 trout collected, 342 (62%) were brown trout and 208 (38%) were rainbow trout (CDFG 2008). No brook trout were captured in 2008. Fish condition increased over the course of the sampling effort for both rainbow and brown trout, with the highest condition factor observed in the fall. This is likely attributed to natural seasonal changes related to water temperature and diet. The average condition (all three surveys combined) for rainbow trout was 1.04 and, for brown trout, was 1.03 (CDFG 2008). A condition factor of 1.0 is considered average for inland (non-anadromous) trout. Of the 550 trout captured, zero were trophy trout (≥ 18 inches; Figure 6). For comparison, approximately 14% of the trout captured were of trophy size during the 1994 boat electrofishing survey.

Manzanita Lake was again boat electrofished in 2010, with the same objectives developed for the 2008 surveys. However, due to staff limitations, only a single survey was conducted during October. A total of 199 trout were captured during the survey, of which 165 (83%) were brown trout and 33 (17%) were rainbow trout (CDFG 2010). One brook trout was captured. The average condition for rainbow trout was 1.07 and, for brown trout 1.05, a slight increase from 2008. Of the 199 trout captured, three brown trout (1.5%) were trophy-sized (Figure 7).

In 2008 and 2010, efforts were made to utilize the same electrofishing protocols employed in the 1980-1990's, including surveying the entire perimeter of the lake. However, during the 2008 and 2010 surveys, crews were unable to electrofish the entire perimeter of the lake due to the abundance of trout captured and the inability to hold and process large numbers of fish. Approximately 1/3 of the perimeter of Manzanita Lake was electrofished each time during the 2008 and 2010 surveys. Although a limited portion of the lake perimeter was surveyed, trout numbers exceeded all other historical surveys in which the entire perimeter of Manzanita Lake was surveyed. The average number of trout collected, while completing the entire perimeter of the lake from 1987-1990, was 99. Although these data cannot provide an accurate population estimate and have limited comparability with data collected in previous studies, the findings suggest that trout density has increased in recent years, with higher numbers of smaller fish.

Figure 6. Length frequency of trout captured during 2008 boat electrofishing surveys.

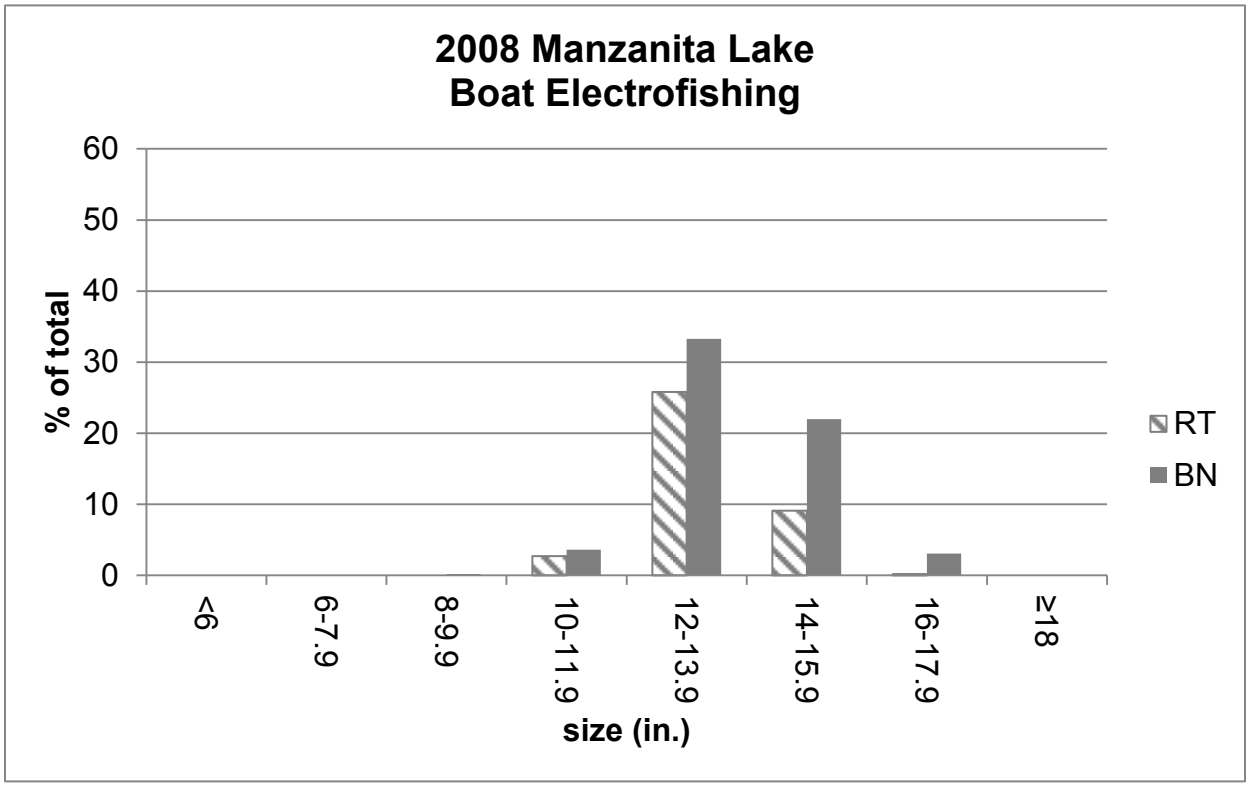
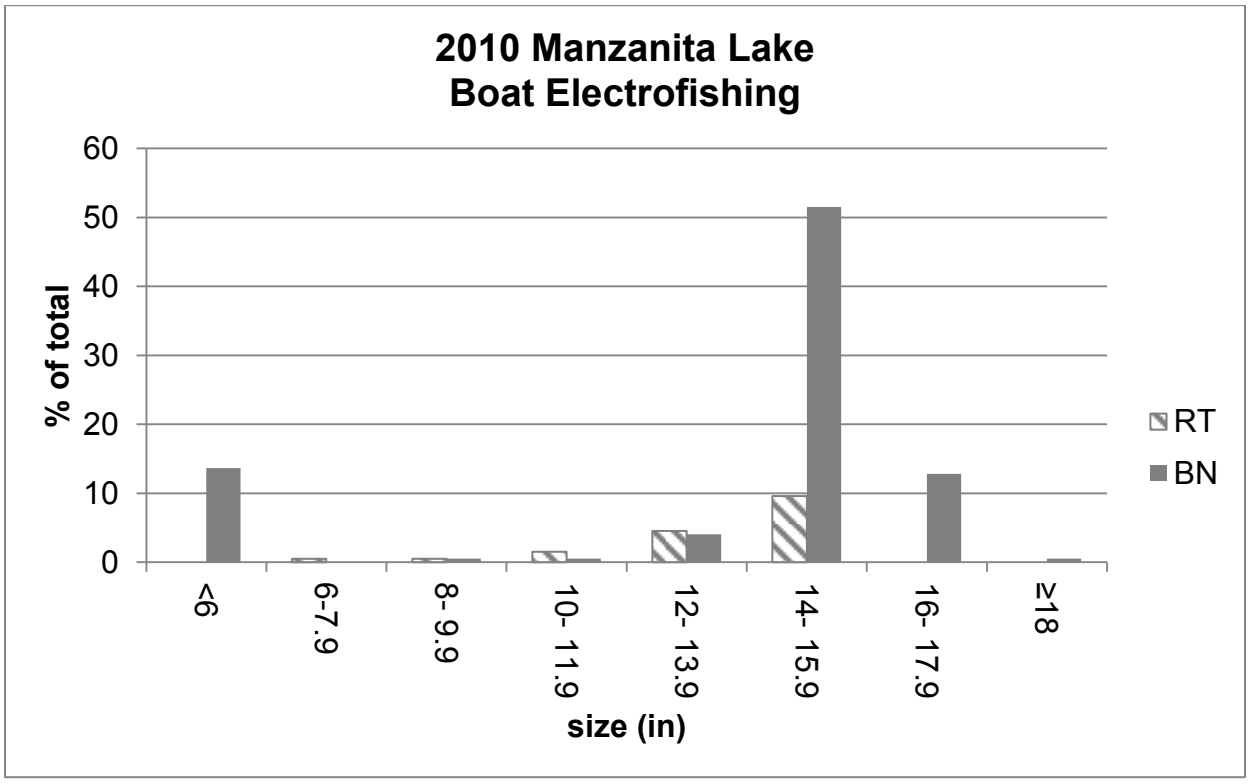


Figure 7. Length frequency of trout captured during 2010 boat electrofishing survey.



Angler Survey Box Monitoring Program

After the 1990 "season-long" angler survey, CDFG and the Park continued to monitor the Manzanita Lake fishery through the use of angler-survey boxes in order to assess trends in catch rate, size, species composition, angler effort and satisfaction. Angler Survey Boxes are an easy and inexpensive way to remotely monitor a fishery. Completion of the forms is voluntary and may be prone to survey bias (it is assumed that successful anglers are more likely to complete a form than unsuccessful ones); however, the data gathered can be used to evaluate long-term angling effort and catch trends.

The ASB catch data indicate the ratio of rainbow to brown trout fluctuates in Manzanita Lake. During the early years of the ASB monitoring program, rainbow trout were the dominant species reported caught. This may have been an artifact of the approximately 15,000 Eagle Lake rainbow trout fingerlings stocked from 1983-1985. However, from 1999-2011, brown trout accounted for at least 31% of the catch and, in three of those years (2000, 2006 and 2010), they were the dominant species reported caught (54%, 53% and 58%, respectively). Angler catch may or may not be representative of the overall population composition, so it is important to compare these data with results from other survey techniques (e.g. boat electrofishing) to better understand population structure. Manzanita Lake has always been a destination for fly fishing anglers. Since 1992, 90% of the anglers used fly gear versus other methods (artificial lures, bait, or a combination of terminal tackle). Although use of bait was prohibited at Manzanita Lake starting in 1990, anglers still reported using bait on survey forms after this restriction was imposed.

On average, CPUE remained fairly consistent from 1990-2011, with the exception of three years in which CPUE was higher than normal (2005-2007). Average CPUE from 1990-2011 was 0.76 fish/hr (standard deviation of 0.26). The minimum and maximum during this time period was 0.43 (1992) and 1.35 fish/hr (2006), respectively. From 1992-2011, on average, ASB data showed approximately 21% of trout caught were over 18 inches; however, the percentage of trophy-sized fish in the reported catch has fluctuated over time. From 1992-2002, trout larger than 18 inches represented 32% of the catch whereas, from 2003-2011, they comprised 7.6%. This disparity may be due to the cessation of trout stocking, changes in species composition, density-dependent factors, or other unknown variables. In general, trophy trout waters are not fast-action fisheries (>2 fish/hr) and tend to have lower catch rates. Manzanita Lake ASB analysis shows a negative correlation between catch rates and size; when CPUE increases, the percentage of trout greater than or equal to 18 inches reported caught decreases. The Pearson correlation for this data range is significant (-0.65) (Appendix).

From 1990-2011, during years when brown trout abundance increased relative to rainbow trout, catch per hour increased but percentage of trophy trout (rainbow and brown ≥ 18 inches) reported caught decreased (Appendix 2B and 2C). In contrast, during this same period, in years where rainbow trout abundance increased relative to brown trout, catch per hour decreased but the percentage of trophy trout reported caught increased (Appendix 2B and 3C). The ASB data suggest that, although proliferations of brown trout support increased catch rates, they also diminish the trophy trout potential of the Manzanita Lake fishery.

Age and Growth

Hubbel (1968) collected and analyzed scale samples from rainbow and brown trout during his study in 1961. He found that brown trout age I through VI averaged 5.8, 9.5, 13.5, 16.9, 19.8 and 22.9 inches fork length at time of capture. Rainbow trout age I through V, captured during the same time period, averaged 5.9, 10.9, 12.0, 16.2 and 22.4 inches fork length at time of capture (Table 2; Figure 8-9). The growth rates Hubbell documented were higher than typical growth rates for trout, indicating Manzanita Lake supported a robust forage base and/or population dynamics were such that competition was minimal.

In 1990, CDFG again analyzed scale samples for age and growth and found that brown trout age I through VII averaged 4.6, 8.0, 12.0, 14.9, 16.0, 18.0 and 19.2 inches fork length at time of capture. Rainbow trout age I through VIII captured during this same time period averaged 3.7, 6.5, 9.4, 12.1, 14.2, 15.9, 16.8 and 17.3 inches fork length at time of capture (Table 2; Figure 8-9). The growth rates identified in the 1990 CDFG study were slower than those from the Hubbel study but were slightly above average.

In 2010, CDFG repeated age and growth studies and found that brown trout age I through VII averaged 2.3, 4.7, 7.7, 10.9, 12.7, 14.0 and 15.0 inches fork length at time of capture. Rainbow trout age I through V captured during the same time period averaged 2.4, 5.8, 9.6, 11.5 and 13.4 inches fork length at time of capture (Table 2; Figure 8-9). The growth rates from the CDFG 2010 study are well below average trout growth rates and both species were notably smaller at a given age than in previous studies.

Comparing these trends in growth rates over a 50 year span illustrates that rainbow and brown trout have not been growing as fast or as large in the recent past as they had in the 1960s. It is unknown what factor(s) have negatively affected trout growth rates in Manzanita Lake but it is likely that, over time, biotic and/or abiotic conditions in either the lake or creek (or both) have changed to the detriment of trout growth potential. The most probable cause is increased trout density leading to increased competition for resources, particularly forage base. This is underscored by the fact that brown trout can become piscivorous at larger sizes and can, thus, switch their forage base from invertebrates, terrestrial insects, annelids, or other sources to smaller fish. Rainbow trout generally do not become piscivorous and are, therefore, reliant on non-fish food sources. Given the abundance of smaller brown trout in recent years that are directly competing with rainbow trout for food, it is possible that the mechanisms for trophy growth potential have been compromised.

Table 2. Results of rainbow and brown trout length at age scale sample analyses.

	Hubbell 1961		CDFG 1990		CDFG 2010	
Age	**RT (in.)**	**BN (in.)**	**RT (in.)**	**BN (in.)**	**RT (in.)**	**BN (in.)**
1	5.9	5.8	3.7	4.6	2.4	2.3
2	10.9	9.5	6.5	8	5.8	4.7
3	12	13.5	9.4	12	9.6	7.7
4	16.2	16.9	12.1	14.9	11.5	10.9
5	22.4	19.8	14.2	16	13.4	12.7
6	n/a	22.9	15.9	18	n/a	14
7	n/a	n/a	16.8	19.2	n/a	15
8	n/a	n/a	17.3	n/a	n/a	n/a

Figure 8. Rainbow trout growth rates recorded from three different studies.

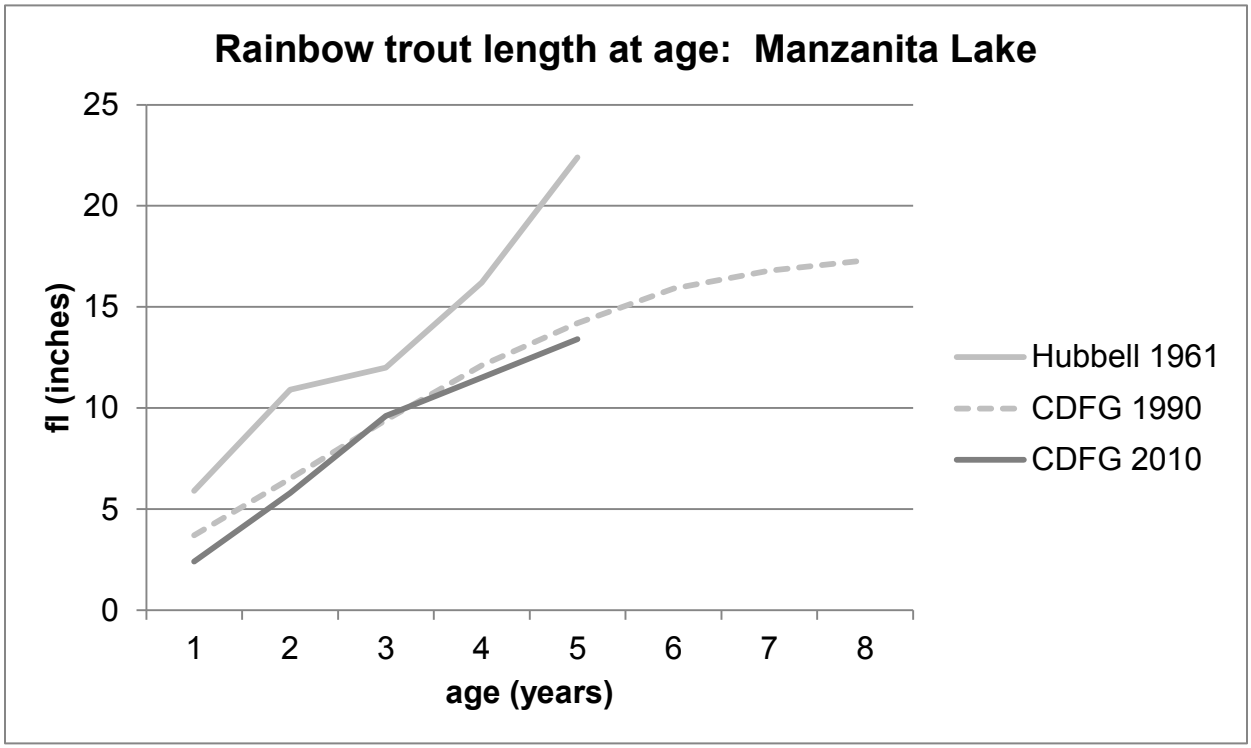
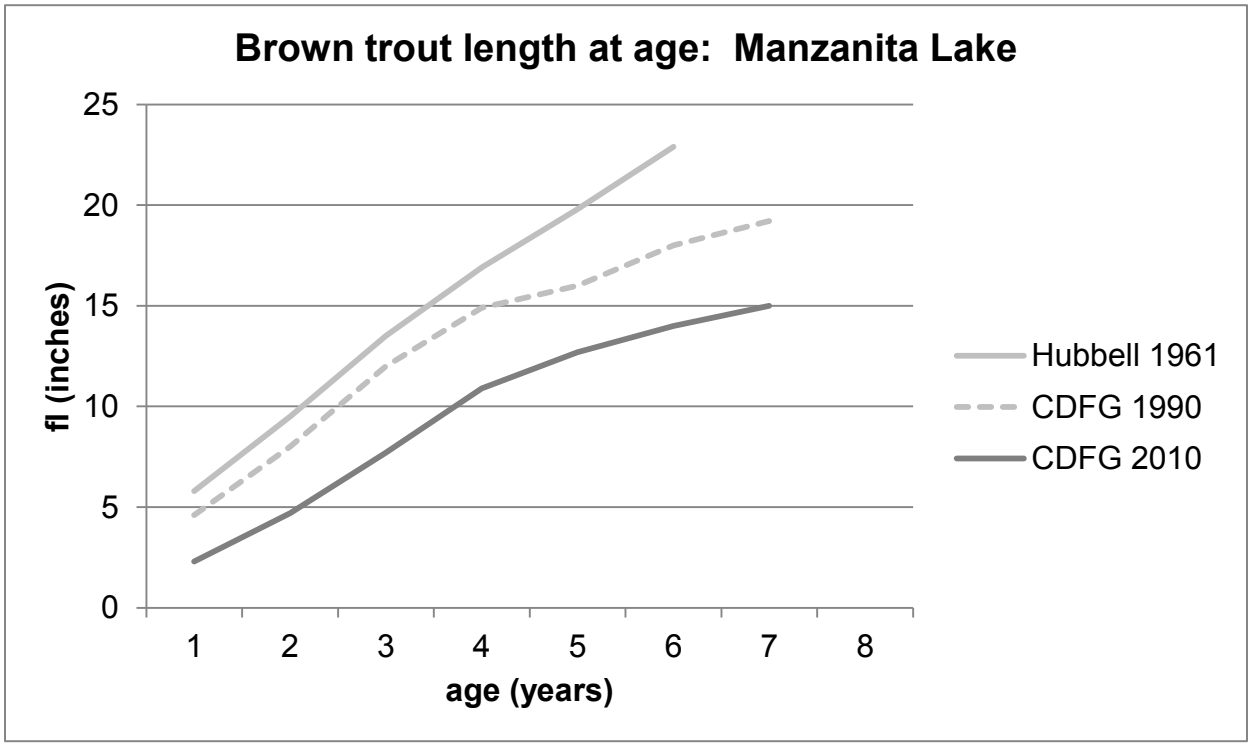


Figure 9. Brown trout growth rates recorded from three different studies.



Summary of Manzanita Lake Studies and Management Strategies

Manzanita Lake has been an intensely studied fishery for the last 60 years (Table 3). In the past, researchers believed Manzanita Lake could not be sustained by natural recruitment. During this time, Manzanita Lake was heavily stocked with mainly brown trout, some rainbows and few brook trout (Table 4). In 1954, Wallis began studying the system and concluded the fishery could, in fact, be sustained with natural recruitment.

Since Wallis's studies, several different management strategies have been implemented, based upon the prevailing resource management practices at a given time, and past strategies may have been heavily influenced by favorable attitudes toward stocking. Even after Wallis' recommendations to cease stocking and experiment with natural recruitment to sustain the fishery, stocking continued until 1976 and, again, from 1983-1985.

In the years following the last stocking event, rainbow trout were the dominant species but this may have been a result of the 15,000 fingerling Eagle Lake rainbow trout stocked from 1983-1985. Recent boat electrofishing surveys indicate that brown trout now dominate the system. Current management strategies for Manzanita Lake are based upon the most recent available science and, because fish stocking has not occurred for over 30 years and is not planned for the future, stocking will not factor into current or future management decisions.

Table 3. History of research, surveys, results and management recommendations for Manzanita Lake (1954-2010).

Year	Researcher	Dominant Species	Contributions/ Results	Management Recommendation
1954	Wallis	BN	Came up with 7 solutions to the management problems	Retain BN and RT fishery through natural reproduction
1961	Hubbell	BN	Described limnological and biological conditions	Manage Manzanita Lake for brown trout
1983-1991	CDFG	BN→RT	Wild vs. stocked fish study	With special regulations, natural recruitment will sustain the RT fishery
1990	CDFG/LVNP	RT	Creel census study	Catch and release will retain trophy RT trout fishery, supplemented by BN.
1994	CDFG	RT	RT still dominate species composition	Natural recruitment is sustaining a healthy fishery
1996	Pipal	RT	Studied spawning habitat characteristics of Manzanita Creek	Maintain catch and release; manage for trophy trout, maintain a viable RT population
2008/2010	CDFG	BN	Smaller and more fish than historic surveys; Slower growth rates.	Manage for self-sustaining, wild trophy rainbow trout.

Table 4. Manzanita Lake stocking history (1848 to present).

Year	Species	Number Stocked
1848	RT	n/a
1880	bullhead	n/a
1922	RT	125,000
1931-1934	RT, BN, BK	n/a
1934-1953	BN	25,000-75,000/ year
1954-1961	BN	n/a
1962	BN	5,000
1963	BN	4,550
1964	BN	10,010
1965	BN; RT	9,600; 5,184
1966	BN	10,000
1967	RT	5,000
1972	BN; RT	5,200; 200
1973	BN	4,416
1974	BN	5,040
1976	RT	5,018
1977-1982	n/a	not stocked
1983-1985	RT	5,000/ year
1986-current	n/a	not stocked

National Park Service Fisheries Management Policy

In 1968, the Director of the NPS issued a policy to discontinue the artificial stocking of non-native fish in park aquatic ecosystems. The policy also prohibited the stocking of both native and non-native fish in naturally fishless waters. That decision was, in part, based on a report to Secretary of Interior, Stewart Udall, from a group of scientists headed by A. Starker Leopold (University of California) on Wildlife Management in the National Parks.

The report recommended an ecosystem approach to the management of wild populations inhabiting the nation's parks. Implementation of the policy began in 1968, via a fish stocking phase-out. By 1975, stocking of all lakes and streams in LVNP was reduced to only four lakes (Butte, Crystal, Manzanita and Summit) and two streams (Kings and Hot Springs creeks). The no-stocking policy was generally supported by the public but some individuals and groups desired continuation of stocking.

As a result, the NPS Director authorized parks in the Sierra Nevada Mountains to continue planting fish on a limited basis during a field investigation and reevaluation of NPS Policy. In 1976, the NPS, in cooperation with CDFG, began a study to determine the biological, economical, and recreational effects of a no-stocking policy. Field investigations were completed and policy was reevaluated prior to the last revision of NPS Management Policies in December, 1988. Under the revised policies, fish stocking, which was allowed during the interim study and review period, was discontinued in all park waters in 1990.

NPS Policies were again revised in 2006. Under the current policy, Section 4.4.3 Harvest of Plants and Animals by the Public states:

> "The Service (NPS) manages harvest to allow for self-sustaining populations of harvested species and does not engage in the stocking of plants and animals to increase harvest…"
>
> "The Service will not stock waters that are naturally barren of harvested aquatic species."

Per this Policy, no stocking of native or non-native fish will occur in Manzanita Lake.

Designations

☒ Wild Trout Water ☐ Heritage Trout Water

☐ Federal Wild and Scenic River ☐ Wilderness

☐ Other

Water source(s)

☒ Spring ☒ Rain ☒ Snow ☐ Tailwater

Gradient

☐ Low (< 2%) ☐ Medium (2-4%) ☐ High (>4%) ☒ N/A

Table 5. Fish species documented in Manzanita Lake.

Common name	Scientific name	Native (Y/N)	Listing status
Rainbow trout	*Oncorhynchus mykiss*	?*	None
Brown trout	*Salmo trutta*	N	None
Brook trout	*Salvelinus fontinalis*	N	None
Golden shiner	*Notemigonus crysoleucas*	N	None
Brown bullhead	*Ameiurus nebulosus*	N	None

*Unknown if rainbow trout naturally existed in Manzanita Lake prior to stocking in 1848

Table 6. Other aquatic species.

Common name	Scientific name	Native (Y/N)	Listing status
Aquatic beetles	*Coleoptera* (Order)	Y	None
Mayflies	*Ephemeroptera* (Order)	Y	None
Caddisflies	*Tricoptera* (Order)	Y	None
Dragonflies	*Odonata* (Order)	Y	None
Midges/ gnats	*Diptera* (Order)	Y	None
Leeches	*Hirudinea* (sub class)	Y	None

Common name	Scientific name	Native (Y/N)	Listing status
Aquatic snails/clams	*Mollusca* (Phylum)	U	None
Worms	*Annelida* (Phylum)	Y	None
Crustaceans	*Amphipoda* (Order)	U	None

Table 7. Fisheries Assessments.

Water	Date	Survey type	Reference data/summary report
Manzanita Lake	1954	Fisheries Assessment	Wallis 1954
Manzanita Lake	1961	RT and BN aging Creel Census Survey	Hubbel 1961
Manzanita Lake	1983-1985	RT fingerling study program	CDFW Northern Region Files
Manzanita Lake	1983-1991, 1994, 2008, 2010	Boat Electrofishing	CDFW Northern Region Files
Manzanita Lake	1990	Creel Census Survey	CDFW Northern Region Files
Manzanita Lake	1990-Present	Angler Survey Box	CDFW Northern Region Files

Water	Date	Survey type	Reference data/summary report
Manzanita Creek	1995-1996	Spawning Surveys	Pipal 2003
Manzanita Creek	2002-present	Spawning Surveys	LVNP Files

Angling Regulations

The California Fish and Game Commission is responsible for adopting sport fishing regulations in California, although federal parks have the ability to set more stringent regulations if desired. Since 1990, LVNP has set special angling regulations for Manzanita Lake. The lake is currently open to fishing year-round with a zero bag limit and gear restricted to artificial lures with single barbless hooks.

Known Stressors/Issues

Illegal Angling/Poaching

Illegal angling at Manzanita Lake falls largely into three categories: i) anglers who would not normally violate the law, but are unaware of the special angling regulations; ii) anglers who know the regulations but, for a variety of reasons, openly choose to ignore them and, iii) anglers that seek to harvest trophy-size trout from the lake, in spite of the zero bag limit. While park rangers regularly patrol the lake, the presence of law abiding anglers who understand and support the catch and release program is recognized as the best means of controlling most illegal fishing (self-policing).

Manzanita Creek

Manzanita Creek is the only tributary suitable for trout spawning and sustains the Manzanita Lake fishery. Because of its importance, Pipal (2003) noted that visitor access to the creek should continue to be restricted to minimize disturbance to spawning fish and emerging fry. In addition, Pipal (2003) suggested that barriers to upstream movement of spawning fish may negatively affect recruitment to the fishery. In addition, the mouth of Manzanita Creek has moved and become braided in the past. If this occurs again in the future, spawning success may be limited.

Manzanita Lake Outlet Structure

The Manzanita Lake outlet structure was documented to allow passage of trout up to 20-30 cm (7.9-11.8 inches) fork length to escape the lake (Pipal 2003). Trout that leave Manzanita Lake through the outlet structure are unlikely to be able to return to the lake and become lost to the lake's fishery.

Guiding Services/ Angler Outfitters

Manzanita Lake is a very popular destination for fly-fishing anglers. In recent years, the Park has received interest from fly fishing outfitters seeking permits enabling them to guide clients on the lake. Without careful management and limitations on the numbers of guides and guided days, licensed outfitters could potentially lead to increased angling pressure.

MANAGEMENT

Management Goals and Objectives

- ☐ Fast action (catch rates > 2 fish/hour)
- ☒ Trophy (trout > 18 inches)
- ☐ Heritage trout
- ☐ Other

In the past, Manzanita Lake has supported a trophy trout fishery (>18 inches). Although the average catch size had decreased over time, anglers have the opportunity to catch large quality rainbow and brown trouts. The overarching Manzanita Lake fishery management goal is:

> Maintain and enhance the self-sustaining wild rainbow trout population to a level that provides for satisfactory fishing, in terms of size or numbers (catch rate) of fish, with the opportunity to catch trophy trout >18 inches.

The CDFW and Park will collaborate to meet management objectives, which includes evaluating options for increasing the number of trophy trout in the system, as well as methods to alter population dynamics to favor rainbow over brown trout.
The proposed methods to achieve these management objectives are:

> Reduce brown trout recruitment/numbers by blocking access to spawning locations. This will be achieved by installing a seasonal weir on the only spawning tributary to the lake.
> Modifying angling regulations to allow the harvest of brown trout. This will be accomplished at the federal and/or state level.

If the objectives are implemented, we expect changes to the fishery to be apparent within several years and achievement of the management goal within 6-8 years. Although the objectives specifically address reducing the number of brown trout in the lake, with their reduction, we expect a positive shift in both the quantity and quality of rainbow trout in Manzanita Lake.

Table 8. Manzanita Lake and Manzanita Creek monitoring schedule.

Water	Date range (month/year)	Survey type	Survey interval
Manzanita Lake	April-November	Angler Survey Box	Annual
Manzanita Lake	April-November	Creel Census Survey	5 years or as necessary
Manzanita Lake	July-October	Boat Electrofishing	5 years or as necessary
Manzanita Lake	July-October	Direct Observation	5 years or as necessary
Manzanita Creek	Spring/Fall	Spawning/Redd surveys	Annual

Angling Regulations

Prior to 1983, no special fishing regulations were in place for Manzanita Lake. In 1983, a two trout bag limit with a ten inch maximum for both species was adopted. In 1990, due to concerns regarding Manzanita Lake's capacity to sustain a naturally reproducing fishery, angling regulations were changed to a zero bag limit with artificial lures and single barbless hooks. However, since the 1990 regulation change, the trophy trout potential of Manzanita Lake has declined. Data suggest that trout density has increased while individual size has decreased.

The CDFW and the Park intend to manage Manzanita Lake as trophy trout water with emphasis on maintaining a viable, self-sustaining rainbow trout fishery. The Park and CDFW will monitor the fishery, along with angler satisfaction, to guide and direct any future regulatory changes as warranted. Regulations will be used in an adaptive manner to optimize angler opportunities, while adhering to the management goals and objectives outlined in this FMP.

Addressing Stressors

<u>Illegal Angling/Poaching</u>

The CDFW should increase public outreach through social media, news articles, talks, and other avenues to educate the public about regulations, management of the fishery and appropriate actions to take when violations are observed. The Park and CDFW will post angling regulations at informational kiosks and high use access areas around the

lake. The Park will continue to enforce angling regulations.

Manzanita Creek

Manzanita Creek is the only spawning tributary for Manzanita Lake and active management and protection are required to maintain a naturally spawning fishery in the lake. In the early 1990's, special regulations were implemented for Manzanita Creek and its mouth at Manzanita Lake. The regulation currently states "Manzanita Creek (above Manzanita Lake) permanently closed to fishing. Manzanita Creek and Lake nesting and wetland at the confluence of Manzanita Creek inlet and Manzanita Lake and immediate surrounding area is closed" to the public. This closure was implemented to protect fragile plant communities and native bird nesting areas from recreational impacts associated with concentrated shore angling in this area. However, the closure also provided benefits to trout populations, as this part of the creek is utilized by spawning adults and rearing/emigrating juveniles (Pipal 2003).

The Park has completed spawner and redd surveys intermittently since 2002 and these monitoring efforts should continue, in concert with monitoring of Manzanita Lake. All non-natural fish barriers in Manzanita Creek should be evaluated for fish passage. Non-natural barrier removal could increase spawning habitat for fish, increase their chances of successful spawning and provide steady recruitment to the fishery. In addition, natural fish barriers should also be evaluated for fish passage.

Maintaining a single deep channel at the mouth of Manzanita Creek is imperative to provide access to suitable spawning habitat and the Park, in collaboration with CDFW, will monitor this portion of the creek and develop restoration or improvement plans as necessary.

Manzanita Lake Outlet Structure

The grizzly-type outlet structure grate should be replaced with a smaller screen size that will not allow downstream passage of trout, in particular young-of-year. In its current state, the outlet structure has the potential to negatively affect recruitment by allowing fish to leave the lake via the outlet stream and become isolated from the lake population.

Guiding Services/ Angler Outfitters

The Park allows an unlimited number of permits on an annual basis for licensed guides, enabling them to guide clients on Manzanita Lake. To date, only a few guides each year have acquired a permit and this activity does not appear to be limiting the fishery. The Park and CDFW will continue to monitor the number of guide permits issued each year in relation to angling pressure and success. If the Park and CDFW determine that the number of guide permits issued (and, particularly, number of guide days on the water) is potentially contributing to reduced catch rates for the non-guided public, this issue will be further evaluated and thresholds will be developed to limit the number of guide permits issued as necessary.

Adaptive Strategies

This FMP provides guidance and management direction for wild trout resources in Manzanita Lake. These management recommendations are based on achieving self-sustaining and healthy wild trout populations and should be implemented in accordance with updated information over time. Long-term monitoring of the fishery and associated angler success and satisfaction will play a central role in future management recommendations. Any changes to the prescribed management goals/objectives should be based on updated quantifiable data, stakeholder input, HWTP Policy, NPS Policy, the CDFW Strategic Trout Plan, and collaborative CDFW/Park review.

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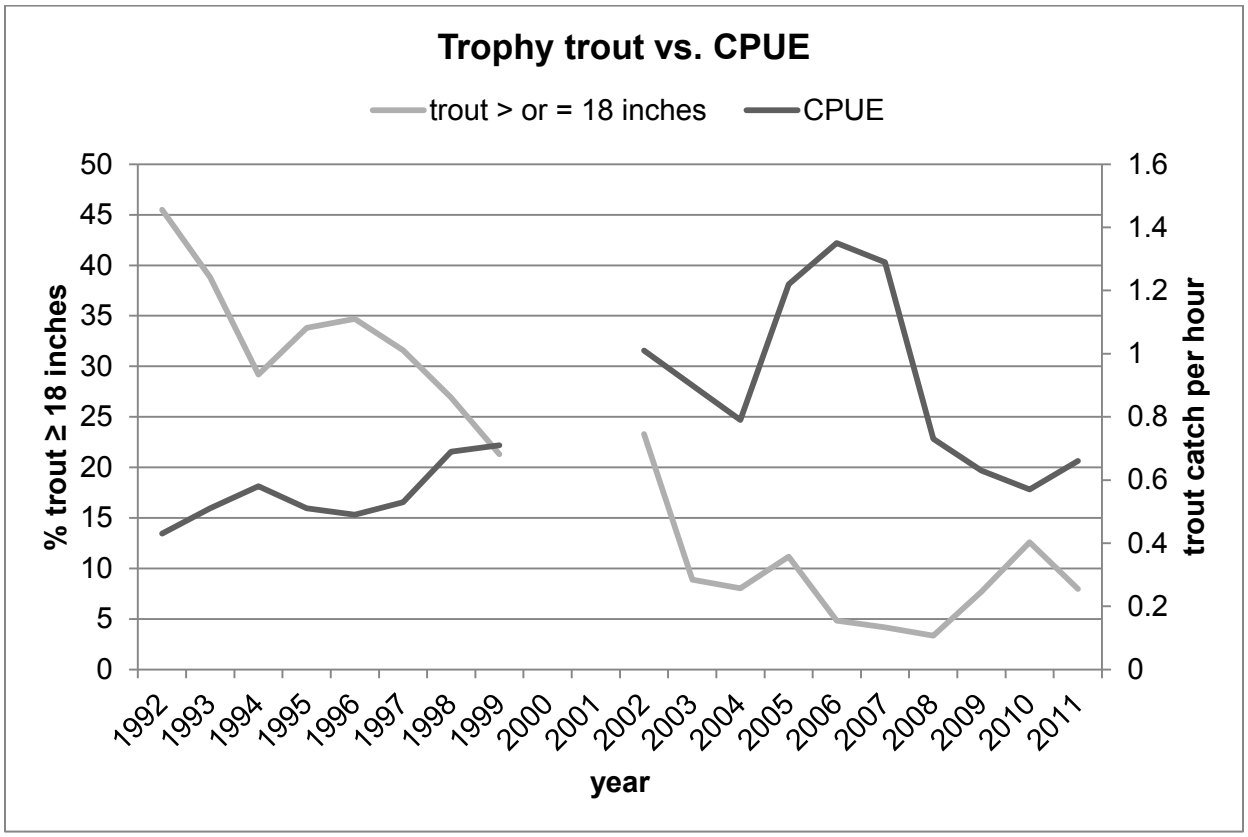
APPENDIX

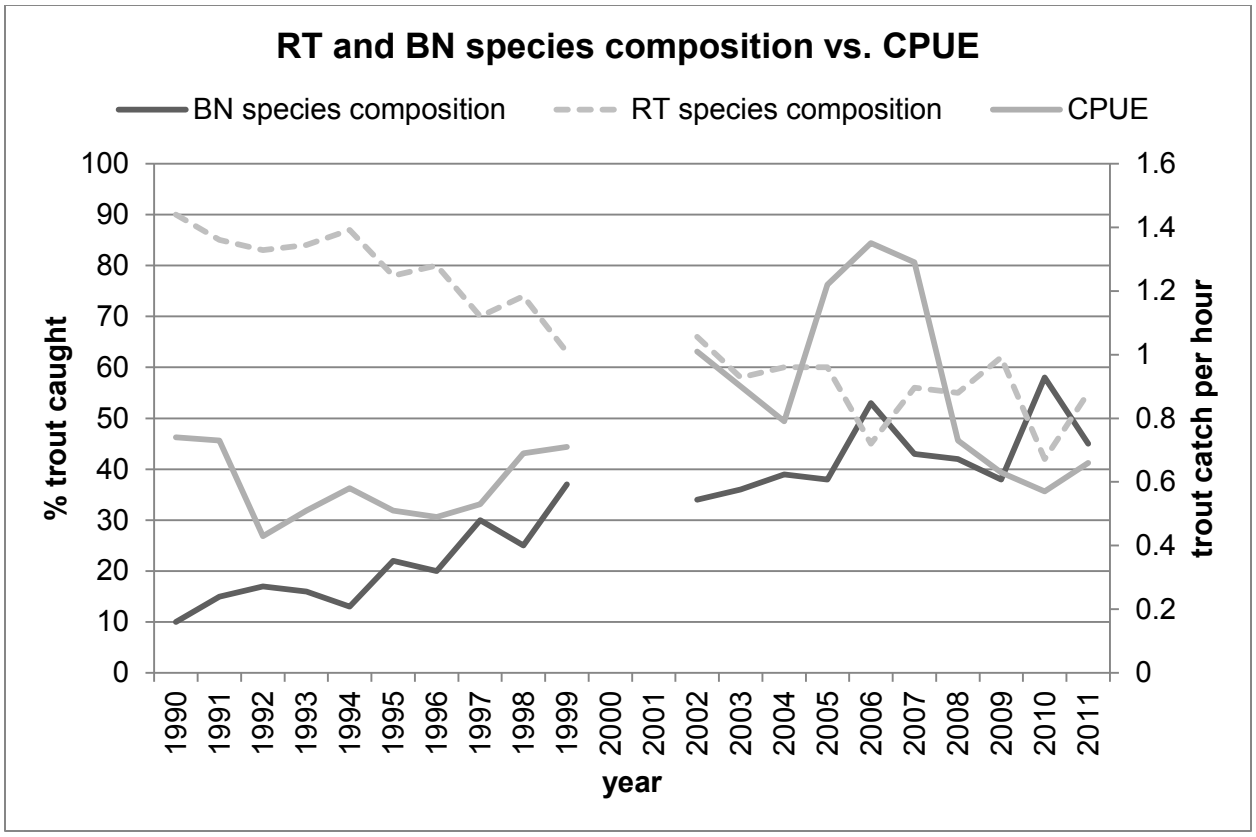
1. Summary of ASB data analyses for Manzanita Lake (date ranges vary slightly, but generally covering 1990=2011)

1a. ASB data comparing size of trout with catch rate (1992-2011*); trophy trout are ≥ 18 inches; CPUE = catch per hour; Pearson Correlation is -0.65.



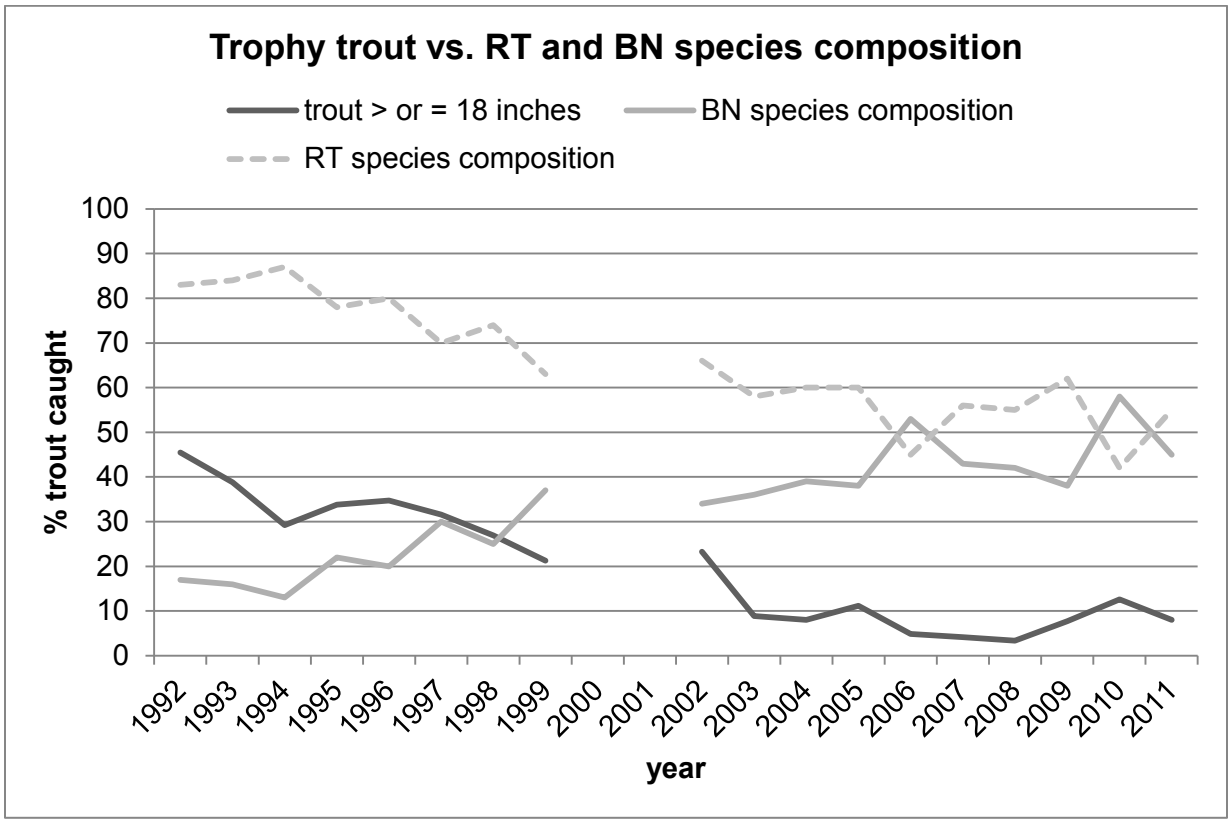
*Years 2000 and 2001 were removed from the data set due to small sample sizes (n=9 and 17, respectively).

1b. ASB data summarizing catch by species in Manzanita Lake (1992-2011*); CPUE = catch per hour; data for CPUE and RT species composition had a Pearson Correlation of -0.51; data for CPUE and BN species composition had a Pearson Correlation of 0.49.



*Years 2000 and 2001 were removed from the data set due to small sample sizes (n=9 and 17, respectively).

1c. ASB data summarizing size of fish caught by species in Manzanita Lake (1992-2011*); trophy trout are ≥ 18 inches; data for trophy trout and RT species composition had a Pearson Correlation of 0.87; data for trophy trout and BN species composition had a Pearson Correlation of -0.84.



*Years 2000 and 2001 were removed from the data set due to small sample sizes (n=9 and 17, respectively).