REF 90374

SUMMER STEELHEAD (*SALMO GAIRDNERI*) IN THE MIDDLE FORK EEL RIVER AND THEIR RELATIONSHIP TO ENVIRONMENTAL CHANGES, 1966 THROUGH 1978[1/]

by

Weldon E. Jones
Region 3

ABSTRACT

Annual surveys were conducted from 1966 through 1978 in the Middle Fork Eel River to assess changes in habitat and adult summer steelhead numbers following the devastating December 1964 flood.

Steelhead counts increased from 198 in 1966 to 1,522 in 1974, then declined steadily to 377 in 1978. The summer holdover area, in the upper reaches of the Middle Fork between Bar and Uhl Creeks, is 42 km (26 miles) in length. Fish depended on deep pools for summer survival. Streamflows and surface water temperatures ranged from 0-0.55 m^3/s (0-20 cfs) and 17.2°-23.7°C (63°-75°F), respectively, during the surveys.

Recommemdations for managing and protecting this unique steelhead strain are included.

1/ Anadromous Fisheries Branch Administrative Report No. 80-2. Submitted October 1979.

INTRODUCTION

Summer, or spring-run[2/], steelhead provide a popular sport fishery and are intrinsically valuable because of their limited occurrence in California. Few populations of these fish exist in the State, and all are small, with perhaps as much as 50-80% of California's summer steelhead being found in the Middle Fork Eel River (Puckett 1975). This area was relatively remote and undeveloped until the late 1950's when timber harvesting and associated road building began.

The California Department of Fish and Game (CDFG) became concerned about summer steelhead following the devastating flood of December 1964, which filled in most of the cool deep pools upon which the steelhead depend during the summer. It also became apparent that increasing human activity in the Middle Fork drainage threatened to accelerate erosion and stream sedimentation in the area.

The abundance and distribution of adult summer steelhead in the Middle Fork Eel River from the Eel River Ranger Station to Robinson Creek (the study area), and certain aspects of their habitat including summer streamflow, water temperature and pool numbers and depths were studied from 1966 through 1978. This report presents and analyzes collected data and offers recommendations for managing and protecting this unique steelhead strain.

Future adverse environmental changes affecting the summer steelhead can be expected to occur in the absence of an effective watershed management plan involving Federal, State and private interests. This report outlines the need for the development of such a coordinated management plan and provides necessary basic fishery information.

MIDDLE FORK EEL RIVER WATERSHED

General Description

The Middle Fork Eel River drains about 1,950 km^2 (750 $miles^2$) of rugged, mountainous area in the northeastern portion of the California coastal range, about 130 km (80 miles) southeast of Eureka (Figure 1). The river originates in the Yolla Bolly Wilderness Area at an elevation of approximately 1,830 m (6,000 ft), flows generally southwesterly about 100 km (60 miles) and converges with the main stem Eel River at the town of Dos Rios.

The Middle Fork watershed is aligned along a northwest-northeast fault pattern (Brown and Ritter 1970). Its surface features, composed of metamorphosed sedimentary rock of the Franciscan group, are a highly folded, fractured and disoriented assemblage, extending over much of the Eel River drainage (Calif. Dep. of Water Resources 1964). Graywacke, a dark-gray sandstone, is prevalent in this group, along with some black shale, chert and serpentine.

2/ This strain migrates from the ocean into fresh water during the spring, holds over through the summer and fall, and spawns the following winter and spring.

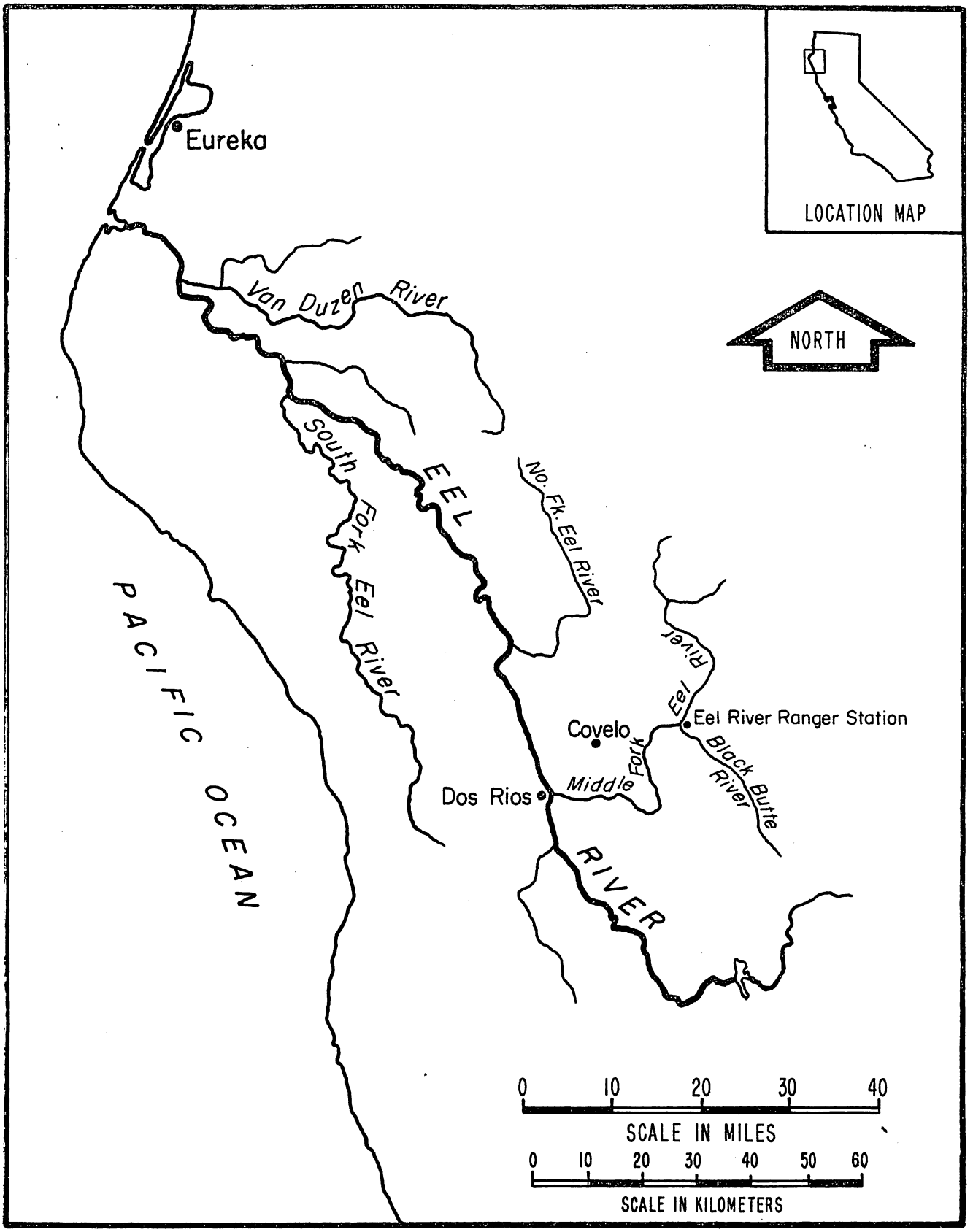

Figure 1. Eel River drainage.

Soils in the Middle Fork watershed have the same unstable properties as the parent rock (Brown and Ritter 1970). With chemical weathering and prolonged heavy rains, these soils become saturated and tend to move. As landslides and slumps encroach on the river, all but the heavy boulders are carried downstream. Consequently, in the study area where the topography is particularly steep and mountainous, the canyon floor is strewn in many places with boulders and rubble. Here the stream gradient averages 26.5 m/km (140 ft/mile).

Curry (1976) states that a single regional zone of landslides extends from near the Eel River Ranger Station upstream to Hoxie Crossing; all within the study area (Figure 2). Within this zone are a series of eight major roughs where stream grade increases and large boulders up to 15 m (50 ft) in diameter litter the streambed. These eight roughs, the terminal ends of landslides and slumps, occupy 5.5 km (3.4 miles) of streambed.

Four of the roughs are considered impediments to upstream fish migration. These roughs, with streambed gradients of 8-12%, are located near Devils Den Creek, Maple Creek, Asa Bean Crossing and Hoxie Crossing. The respective lengths of the roughs are 1.9, 0.5, 0.3 and 1.0 km (1.2, 0.3, 0.2 and 0.6 miles). The other roughs, which are more easily negotiated, are located near Montague, Hammerhorn Creek, Rattlesnake Creek and Foster Glades. These range in grade from 4-5% and are 0.2, 0.6, 0.5 and 0.5 km (0.1, 0.4, 0.3 and 0.3 miles) in length, respectively.

As might be expected, the stream channel within the study area is generally broader at the lower elevations. Widths of 60 m (200 ft) are common near the Eel River Ranger Station, while widths average 12 m (40 ft) near Balm of Gilead Creek in the upper part of the drainage.

Long, narrow gravel berms deposited by the 1964 flood have persisted along protected portions of the channel. These berms approach heights of 9 m (30 ft) along some canyon walls.

Hydrology

Annual precipitation in the Middle Fork watershed averages 142 cm (56 in.), mostly as rainfall with some snow in higher elevations. Runoff averages 1.23 km^3 (one million-acre ft) yearly (Smith and Arend 1969), 90% occurring between December and May. For the period 1965 through 1973, highest mean monthly discharges generally occurred in December and averaged 32.2 m^3/s (1,138 cfs), at the Eel River Ranger Station (U. S. Geological Survey, Surface Water Records). Middle Fork flows decrease sharply in the spring from an average of 29.1 m^3/s (1,027 cfs) in April, to about 4.5 m^3/s (160 cfs) in June.

During the study, late summer discharges generally ranged from 0.03-0.08 m^3/s (1-3 cfs) near the confluence with the North Fork of the Middle Fork, increasing to approximately 0.28-0.57 m^3/s (10-20 cfs) near the Eel River Ranger Station. Surface flows in some of the tributaries and portions of the main stem were occasionally intermittent.

Goodson and Blake (1970) measured summer stream temperatures near Rattlesnake Creek in 1967 and 1968. Temperatures above 21.1°C (70°F) were recorded from June through September with a high of 24°C (75°F) recorded in August. Diurnal temperature fluctuations ranged up to 6°C (10°C).

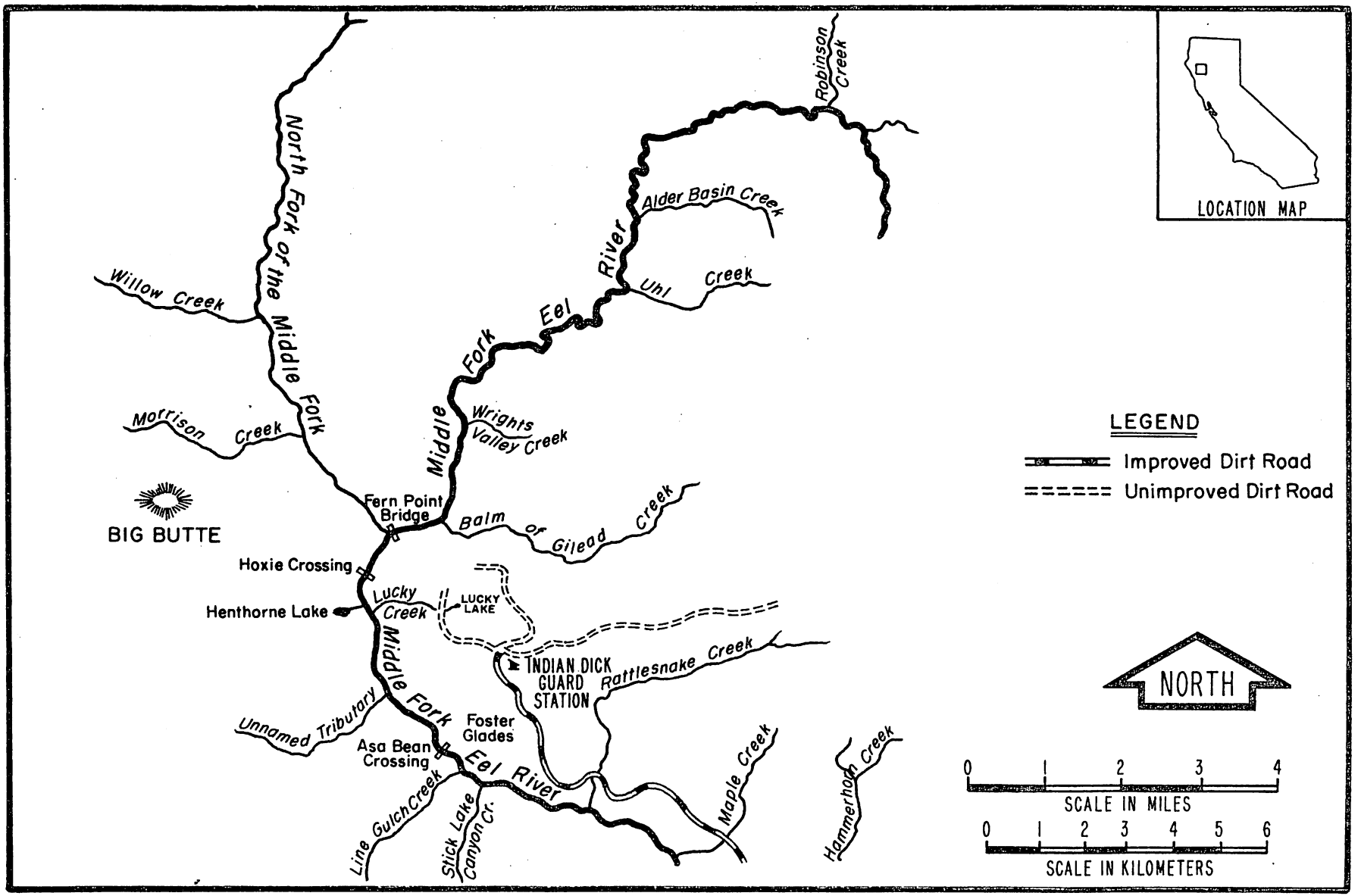
Robinson Creek
Alder Basin Creek
Eel River
Uhl Creek
Willow Creek
North Fork of the Middle Fork
Middle Fork Eel River
Morrison Creek
Wrights Valley Creek
Fern Point Bridge
BIG BUTTE
Balm of Gilead Creek
Hoxie Crossing
Lucky Creek
LUCKY LAKE
Henthorne Lake
INDIAN DICK GUARD STATION
Rattlesnake Creek
Middle Fork Eel River
Unnamed Tributary
Foster Glades
Asa Bean Crossing
Maple Creek
Hammerhorn Creek
Line Gulch Creek
Stick Lake Canyon Cr.
LOCATION MAP
LEGEND
Improved Dirt Road
Unimproved Dirt Road
NORTH
0 1 2 3 4
SCALE IN MILES
0 1 2 3 4 5 6
SCALE IN KILOMETERS

Figure 2.

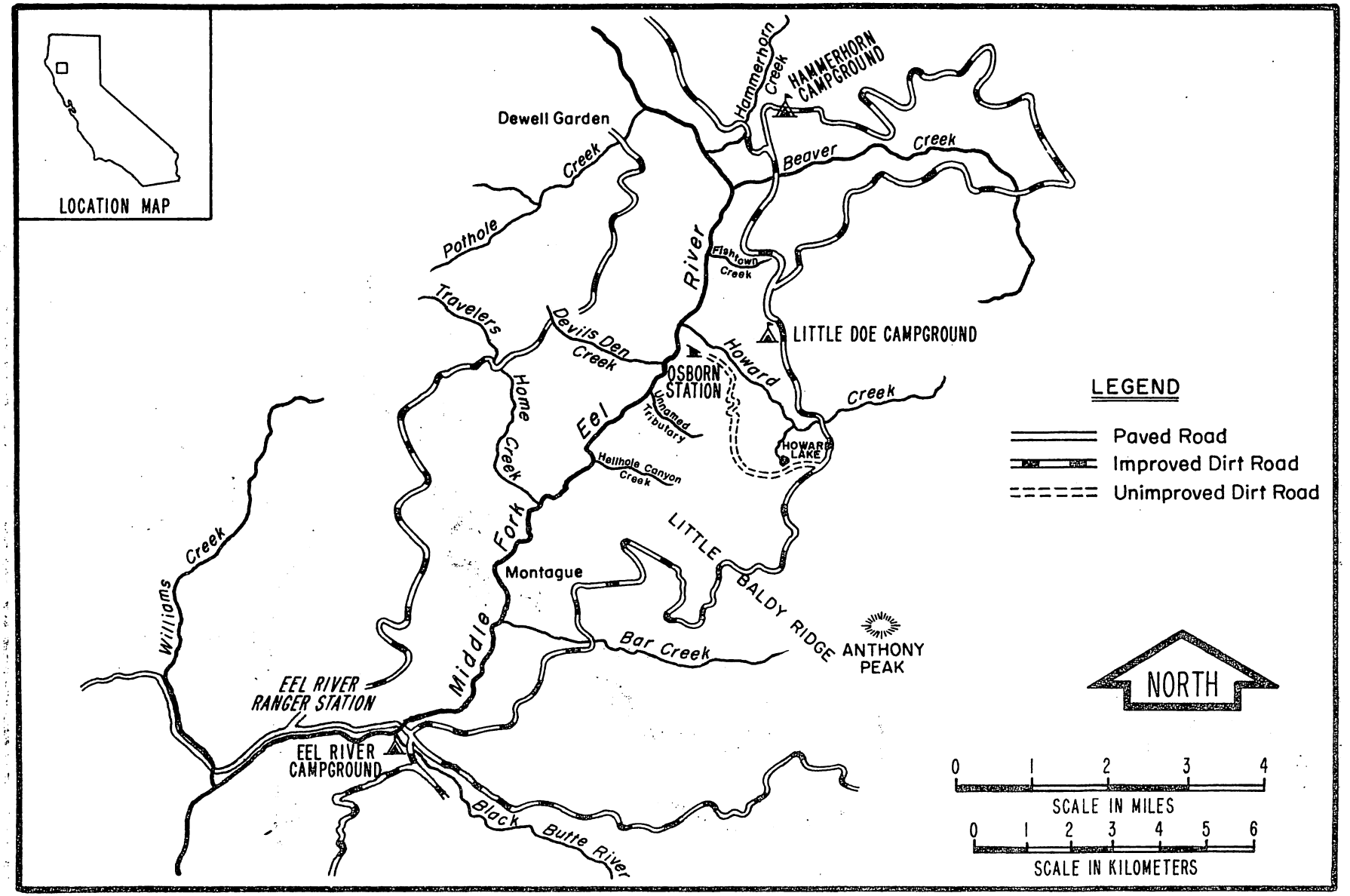

Figure 2. Middle Fork Eel River drainage.

In the Eel River system, a large amount of loose material erodes to the river and is removed by flushing. According to Brown and Ritter (1970) the system is the most rapidly eroding river basin in North America, annually moving an average of 9.7×10^4 kg of material per km^2 (277 tons/$mile^2$) of drainage.

In December 1964, a storm with rainfall exceeding 0.5 m (20 inches) in 48 hours produced record flooding in the Eel River system (Brown and Ritter 1970). An instantaneous crest of approximately 2,950 m^3/s (104,000 cfs) passed the Eel River Ranger Station on December 22. High water levels were 1.5-4.5 m (5-15 ft) above all previous records.

The impact of the heavy rains in the upper Middle Fork was intensified by sedimentation. Bank slumps, gully enlargement and landslides were widespread and added a record 2.3 million metric tons (2.5 million tons) of sediments to the runoff (Brown and Ritter 1970). Deposition of sediments in the vicinity of the Eel River Ranger Station raised the streambed 1.8-2.4 m (6-8 ft) (Hickey 1968). The river appeared to be one long channel of rubble and gravel. In the study area, aggradation raised the channel floor as much as 9 m (30 ft). The depth of this deposition was irregular, being most extensive below the Devils Den, Maple Creek and Asa Bean roughs. Near Travelers Home Creek and above Balm of Gilead Creek, sedimentation increased streambed elevations approximately 3 m (10 ft).

After the December 1964 flood, summer streamflows in many reaches of the study area were subsurface. Distances between pools often exceed 183 m (200 yd). Most of the main stem of the river was devoid of riparian vegetation.

Resource Development

Most of the Middle Fork drainage upstream of the Eel River Ranger Station is in public ownership. The largest portion, approximately 470 km^2 (180 $miles^2$), is managed by the U. S. Forest Service (USFS). About 44 km^2 (17 $miles^2$), located to the west of the river, are managed by the U. S. Bureau of Land Management (BLM). The remainder, about 14 km^2 (6 $miles^2$), is in private ownership.

Road construction in the basin above the Eel River Ranger Station began in the late 1950's. USFS logging of the mixed pine and fir forests in the area started in 1958 near Howard Lake. By 1962 logging roads had extended to Indian Dick Guard Station, permitting vehicle access to almost the entire length of the summer steelhead holdover area. In 1973, road development was begun on the west side of the river. These roads, with laterals for timber harvest purposes, now extend from the Eel River Ranger Station to Dewell Garden. Skyline and helicopter logging were first used in 1974 and 1976, respectively.

USFS timber harvest has decreased from an annual average of more than 25 million board ft (MBF) during 1961-65 to about 12 MBF in 1970-75. Future harvests are expected to average 8-10 MBF annually (Thomas Mower, USFS, pers. comm.). BLM timber operations started in 1971 with the Ham Pass Sale of more than 3 MBF and now total more than 7 MBF, with future sales of 10.5 MBF proposed (Robert Barnes, BLM, pers. comm.). The extent of timber harvest on private lands is unknown. However, logging is currently underway on 6 km^2 (1,500 acres) in the Hoxie Crossing area.

Other activities in the drainage include cattle grazing, mining and camping. Grazing appears to be increasing slowly after a long period of low activity (Appendix 1). A small scale jade mining operation occurs in the Pothole Creek area on the main stem. Lastly, there are three campgrounds, Eel River, Little Doe and Hammerhorn, with 46 units. In 1976, the Forest Service recorded 5,800 visitor days in the area, many of which occurred at unimproved campsites.

FISHERY RESOURCES

Fishes Present

Resident fish species present in the Middle Fork Eel River include Western sucker (Catostomus occidentalis), California roach (Hesperoleucas symmetricus), three-spined stickleback (Gasterosteus aculeatus), and rainbow trout (Salmo gairdneri). The suckers, roach and stikleback are present only in the main river below the Devils Den roughs. Resident rainbow trout are believed present throughout most of the system.

Anadromous fishes observed in the Middle Fork Eel River are the Pacific lamprey (Entosphenus tridentatus), fall- and spring-run chinook salmon (Oncorhynchus tshawytscha), and winter-run and summer steelhead. Lamprey were observed in small numbers throughout the Middle Fork study area during the summer surveys. Smith and Elwell (1959) reported fall-run chinook salmon in the Middle Fork up to Devils Den roughs. Two spring-run chinook salmon were observed in the Montague area in the August 1975 survey, and one again in 1977. Winter-run steelhead have been observed as far upstream as the Asa Bean crossing (Smith and Elwell 1959); however, the extent of their range has not been determined.

Summer Steelhead

Life History

The physical appearance of an adult summer steelhead is similar to that of the winter-run strain. Body color grades from silver-white on the ventral surface to silver on the sides and blue-green on the back. Dark spots are clearly visible on the dorsal surface. A pale red lateral band is present on some of the adults during the summer. Fish lengths recorded in separate studies show males averaging 66 cm (26 inches) and females, 61.5 cm (24.2 inches)[3/]. The males ranged in weight from 1.5-5.5 kg (3.1-12.1 lb); females, from 1.2-5.0 kg (2.6-11.0 lb).

Normally, summer steelhead migrate into the upper Middle Fork from mid-April through June, occasionally into July (Smith and Elwell 1959), which coincides with a period of decreasing streamflows and increasing water temperature. Puckett (1975) found that the age composition of adult summer steelhead at time of upstream migration was 2-year-olds, 1%; 3-year-olds, 46%; 4-year-olds, 44%; and 5-year-olds, 9%. About 6% of the fish had spawned at least once previously. The steelhead hold over in deep pools between Bar and Uhl Creeks during the summer and fall.

3/ From 11 males and 8 females captured at McCann on the Eel River from April 12-June 15, 1969 (Gerald Bedell, CDFG, Memo. 1969), and 46 males and 43 females observed in the 1974 Middle Fork fishery (Puckett 1975).

Although actual spawning locations are not accurately known, the accessible spawning habitat includes portions of 50 km (31 miles) of the Middle Fork above Bar Creek and 26 km (16 miles) of tributaries. The best spawning gravel observed during the study occurred in Balm of Gilead Creek, the North Fork of the Middle Fork and in the Middle Fork from Hoxie Crossing to the North Fork (Figure 2). Remains of spawning redds have occasionally been observed in the Middle Fork about 0.5 km (0.3 mile) below the North Fork; however, the use of this site by winter-run steelhead cannot be ruled out. A redd found near Howard Creek on December 30, 1976[4/] was probably constructed by a summer steelhead since low flows during the 1976-77 drought prevented winter-run steelhead from reaching this area. This may not be a usual summer steelhead spawning site since the low flows may also have prevented migration to their traditional spawning areas.

Limited observations indicate summer steelhead in the Middle Fork may spawn from late December through April. The earliest indication of spawning was that of December 30, as discussed above. On January 25, 1977, 11 fish collected near Pothole Creek showed signs of impending spawning, probably within two months[5/]. Five Middle Fork summer steelhead were artificially spawned at Trinity Hatchery on March 27 and April 8, 1969 (Gerald Bedell, CDFG, pers. comm.) which also suggests an early spring spawning period.

We have not determined if summer steelhead use different rearing areas from winter-run fish. During midsummer surveys juvenile steelhead were found throughout most of the study area above Bar Creek. The largest numbers were found above Devils Den roughs and declined rapidly downstream from that point.

Puckett (1975) reported that juvenile summer steelhead smolt at an age of one to three years. Four percent migrate to sea after one year in fresh water, 79% after two years, and 17% after three years. The bulk of the spring downstream migration occurs before the end of May (Smith and Elwell 1959) after which it decreases rapidly as temperatures increase. Downstream movements resume following the first fall rains.

4/ The redd was located in about 0.5 m (1.5 ft) of water. It was estimated to be 2 by 3 m (6 by 10 ft) in size. Particle size of the gravel ranged from 2.5-9 cm (1-3.5 inches) in diameter. Flow at the site was visually estimated at 0.15 m^3/s (5 cfs).

5/ Of the 11 fish (3 males and 8 females) examined, 10 appeared to be approaching sexual maturity. Milt could be stripped from all but one of the males. One female was killed and gonadal examination revealed the fish would have spawned in about 2 months. The ovaries contained 9,516 eggs (610 ml), determined volumetrically. The fish was 78 cm (30-3/4 inches) FL, weighed 4.4 kg (9-3/4 lb) and had a girth of 38.6 cm (15-3/16 inches). Examination of its scales showed an age formula of 2/1.1S.1 (after Shapavalov and Taft 1954), suggesting the fish spent 2 summers in fresh water, 1 winter in the ocean, 1 year in fresh water during which spawning occurred, 1 year again in the ocean, and the return to fresh water for the second spawning.

Both animals and man prey upon summer steelhead in the holdover area. Otter scats containing fish bones have been found throughout most of the area and on one occasion an otter was observed eating a summer steelhead. Bear are present in the drainage; however, there is no evidence that they capture steelhead. Evidence of poaching has increased since 1966, and is most noticeable near major trail crossings. In recent years, the bulk of the poaching equipment, such as spears, nets and fishing tackle, has been found between Hoxie Crossing and the North Fork of the Middle Fork.

Fishery

Prior to the end of World War II, the presence of summer steelhead in the Middle Fork Eel River was relatively unknown. Vehicle access to the main stem of the Middle Fork was restricted to a few bridge crossings with the remote holdover area reachable only on foot or by packtrain. During the early 1950's the presence of summer steelhead became more widely recognized, and a popular spring fishery developed near the Eel River Ranger Station. A summer fishery also developed in the canyon above. Access into the canyon, however, remained limited to hikers and packers.

At the present time the fishery on the adult steelhead is limited to the spring fishery near the ranger station. This fishery, on upstream migrating fish, is restricted by law to the area below Bar Creek.

Little information is available on this fishery. Eugene German (CDFG, Memo., Region 3 files 6/5/57) determined that 109 anglers caught 54 fish on opening day in 1956, and 54 anglers caught 16 fish opening day in 1957. Puckett (1975) estimated that anglers expended approximately 5,000 angler hours from April through June in each of two years, 1973 and 1974, for 394 and 328 fish, respectively.

Management

The Department of Fish and Game's management program for Middle Fork summer steelhead is directed toward the preservation of this unique fish within its native habitat. A series of protective regulations has been imposed to meet changing conditions.

In December 1955, the largest flood ever recorded at that time deposited large quantities of sediment in the upper Eel River system, reducing fish numbers and damaging summer holdover habitat. In response to public concern, the Fish and Game Commission in 1956 established the first fishing closure on the Middle Fork, prohibiting fishing in the lower 25 km (15.5 miles) above Bar Creek, about 60% of the summer holdover area, from July 11 through October 31. From 1962 through 1969, the reach between the mouth and Bar Creek was closed from September 16 to October 31.

The record flood of December 1964 further damaged habitat and reduced fish numbers. In 1966, in an effort to protect the remaining resource, the Commission closed an additional 7.2 km (4.5 miles) of summer holdover area, from the previous upper closure boundary upstream to the Fern Point Bridge and made the closure year-round.

In 1970, regulations were eased to permit fishing year-round in the Middle Fork below Bar Creek, with a ten-fish limit during the summer and three fish in the winter. When Fern Point Bridge was removed in 1971, the confluence of the North Fork of the Middle Fork with the Middle Fork was designated as the upper boundary of the closure. Present regulations, enacted in 1977, also prohibit the take of steelhead trout greater than 38.1 cm (15 inches) TL in the Middle Fork tributaries above Bar Creek.

Other management activities include the annual summer surveys reported here, and the periodic removal of impediments to fish migration. Five rock barriers have been modified since 1964.

The USFS has designated the summer steelhead in the Middle Fork as a "sensitive" species, indicating that the fish and its habitat is to be managed in such a manner as to prevent the fish "from declining to the point that listing them as endangered or threatened [under the Federal Endangered Species Act of 1973] becomes necessary" (Leisz 1978).

METHODS

The Middle Fork Eel River between Balm of Gilead Creek and the Eel River Ranger Station, and the lower part of Balm of Gilead Creek, usually were surveyed during the critical low flow, high temperature, period of late July and August, from 1966 through 1978. In 1969 and 1972 the surveys were rained out. On occasion, the surveys occurred as late as October because of scheduling problems. In some years the surveys started as far upstream as Robinson Creek and included the North Fork of the Middle Fork. Depending upon extent of coverage, the surveys required from 3 to 13 days to complete.

In all but the very shallow pools, the adult summer steelhead were counted by one or two divers using faceplate and snorkel. Numbers of fish in each pool were recorded on maps to permit a comparison of abundance and distribution from one year to another. Experiments in which we duplicated some survey sites indicate that we are counting a minimum of 95% of the adult steelhead present in the survey area.

In addition to population information, temperatures, streamflows and physical characteristics of the habitat were noted. Air and surface water temperatures were usually recorded hourly. Surface water and bottom temperatures were occasionally collected in some of the deeper pools. Tributary and Middle Fork water temperatures were collected immediately upstream of their confluences.

A pygmy flowmeter was used to measure streamflows in the river and tributaries in 1967, 1970, 1975 and 1977. During other survey years and where conditions limited use of the meter, streamflows were estimated visually. Tributary streamflows were measured immediately above their months.

In 1966, 1970 and 1976 the length and location of roughs and interrupted flow areas were recorded. Distances were estimated and grades measured with a clinometer. In 1977 the maximum depth of each pool was measured, using a sounding line, to determine whether a correlation between depth and fish abundance existed.

Miscellaneous observations, including the location and abundance of other species, the location of hazards and barriers to migration, and signs of predation and poaching, were collected during the surveys. Limited observations were made during the winter of 1976-77 in the Middle Fork and in Balm of Gilead Creek, to determine time and location of spawning.

The data collected during the surveys were recorded in English measurement units and converted to metric equivalents for this report.

RESULTS AND DISCUSSION

The number of adult summer steelhead counted during the annual surveys increased each year from 198 in 1966 to 1,522 in 1974, then declined to 377 in 1978 (Figure 3).

The distribution of summer steelhead in the Middle Fork Eel River varied from year to year, ranging from 23.2 km (14.4 miles) in 1966 to 32.0 km (19.9 miles) in 1975 (Figure 4). Fish have been found from Bar Creek as far upstream as Uhl Creek, a distance of 42 km (26 miles). Each year at least 90% of the population occurred within the 27 km (17 miles) reach of river between the Devils Den rough and the North Fork of the Middle Fork. Balm of Gilead Creek usually contained some steelhead, probably early arrivals which migrated through the lower holdover area when streamflows were high. As the habitat improved during the years following the flood, the increasing steelhead population expanded into the upper reaches of the holdover area between Rattlesnake Creek and the North Fork of the Middle Fork (Figure 5). Since then, although the numbers of fish have declined, their distribution has remained similar to that of the peak years (Figure 6).

Based on general observations, channel conditions following the flood of 1964 improved each year of the survey. In 1966, gravel deposits were extensive and stream flows were often subsurface. Pools were infrequent, with only a few, in roughs or areas adjacent to rocky canyon walls, as deep as 4.5 m (15 ft). The channel was devoid of riparian vegetation. In some instances, streamside stands of alder and fir were buried by 6 m (20 ft) of gravel.

In 1967, winter flows continued to remove accumulated gravels. As this occurred, remnant gravel berms adjacent to the channel appeared to increase in height as the channel deepened. By 1970 the major portion of the accumulation had been removed, leaving berms only in protected areas. Both the number and depth of pools increased substantially as gravel movement through the system stabilized. New willow and alder growth was evident. Since 1973 this regrowth has been vigorous.

The amount of habitat available to fish increased as stream conditions improved. In 1966, gravel deposits interrupted surface flows over 21.7 km (13.5 miles) or 52% of the holdover area. By 1971, as gravels were removed, this dropped to 15.9 km (9.9 miles) or 38%. In 1976, the area of interrupted flow decreased to 11.4 km (7.1 miles) or 27%. The eight roughs, which rarely contained fish, changed little physically since 1966.

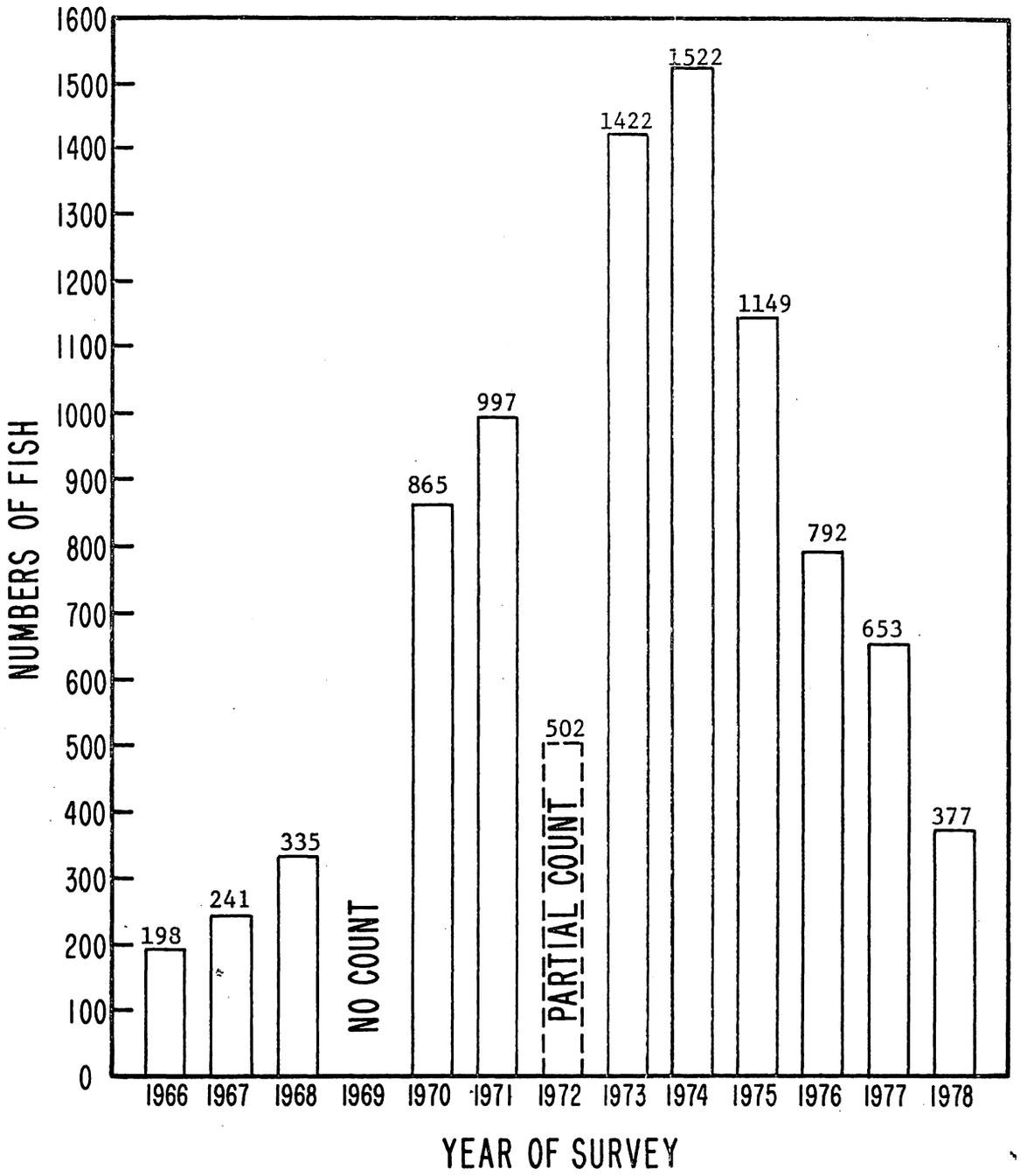

Figure 3. Annual counts of adult summer steelhead in the Middle Fork Eel River, 1966 through 1978.

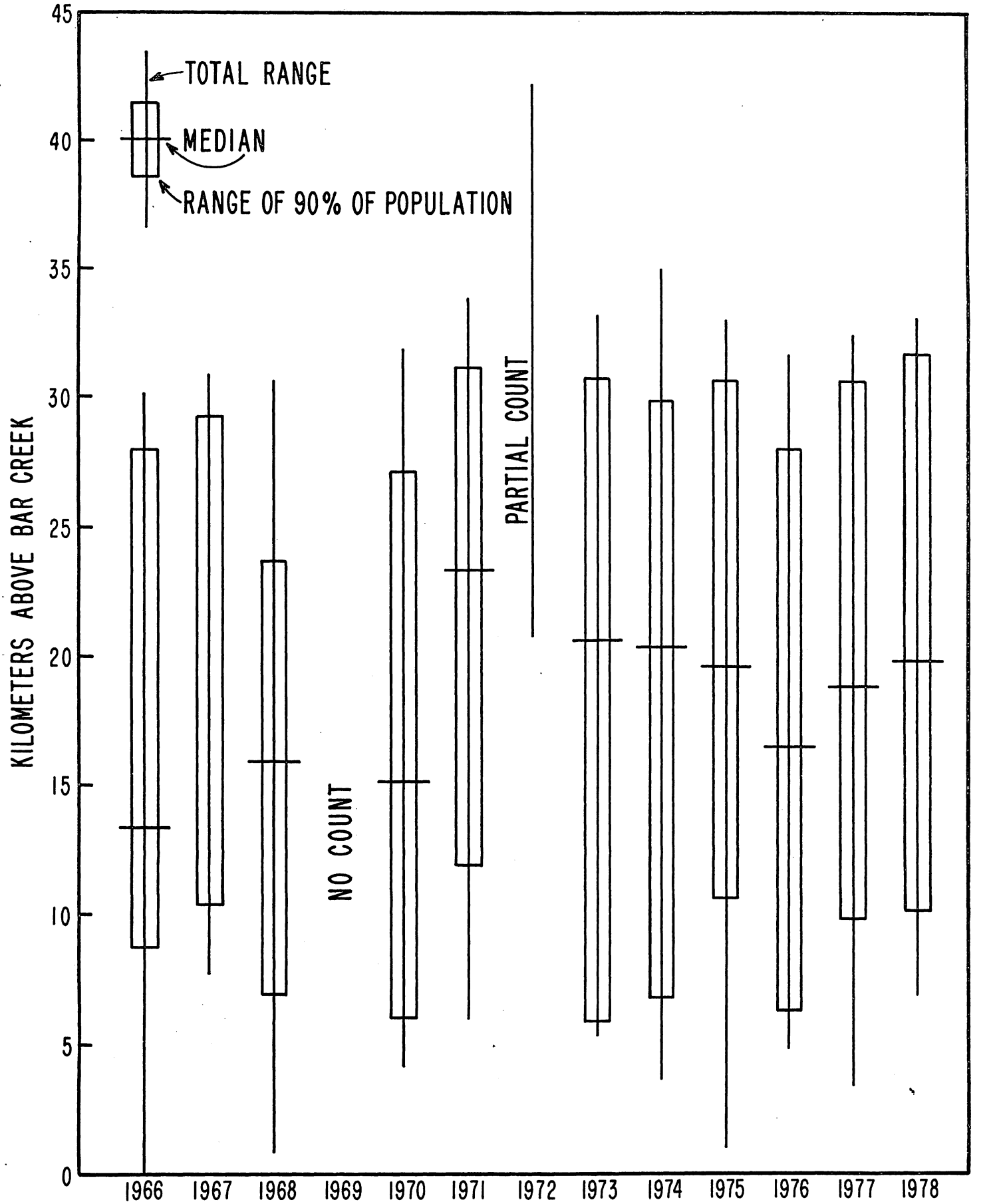

Figure 4. Distribution of adult summer steelhead in the Middle Fork Eel River.

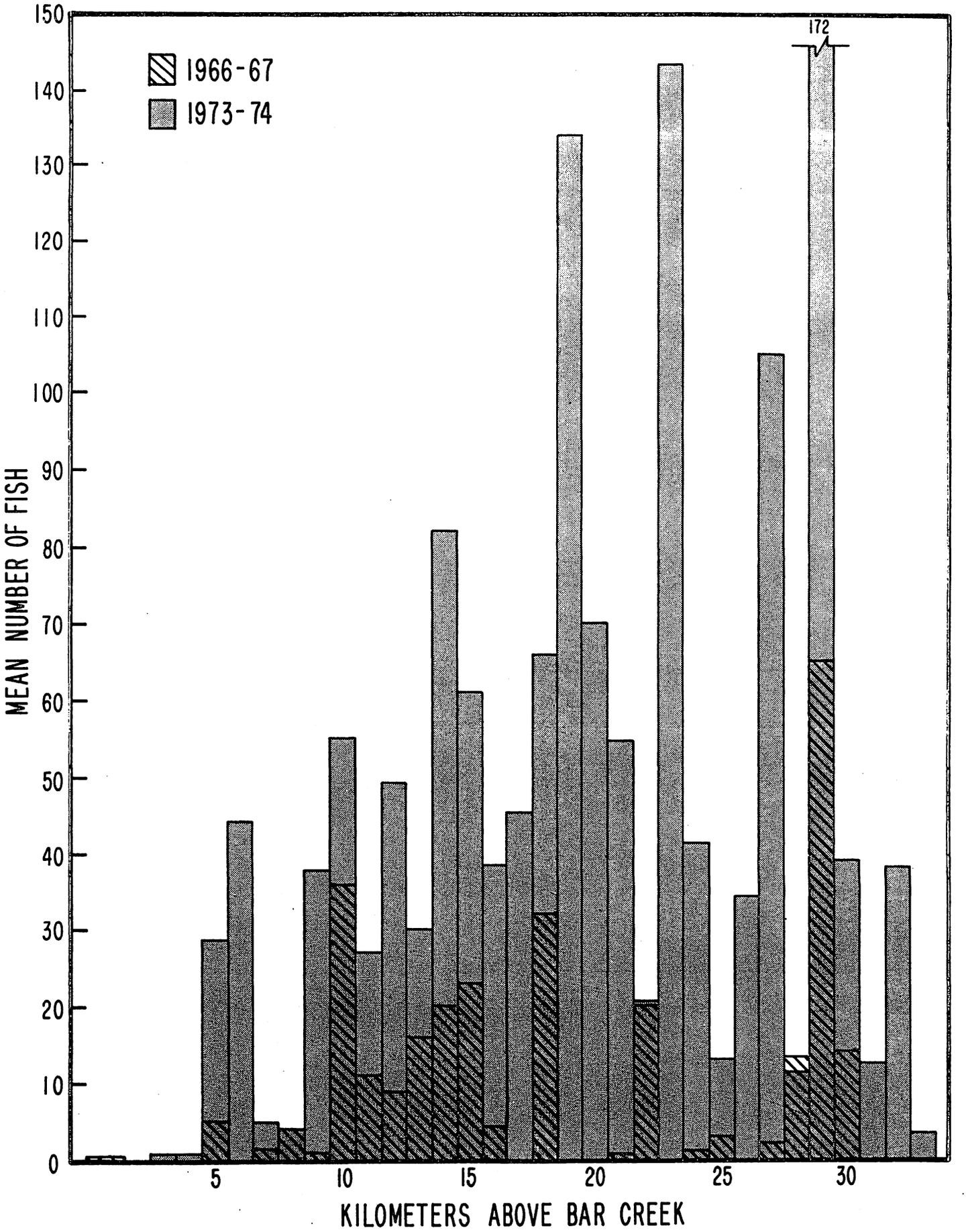

Figure 5. Comparison of distributions of adult summer steelhead in the Middle Fork Eel River during years of minimum (1966-68) and maximum (1973-74) counts.

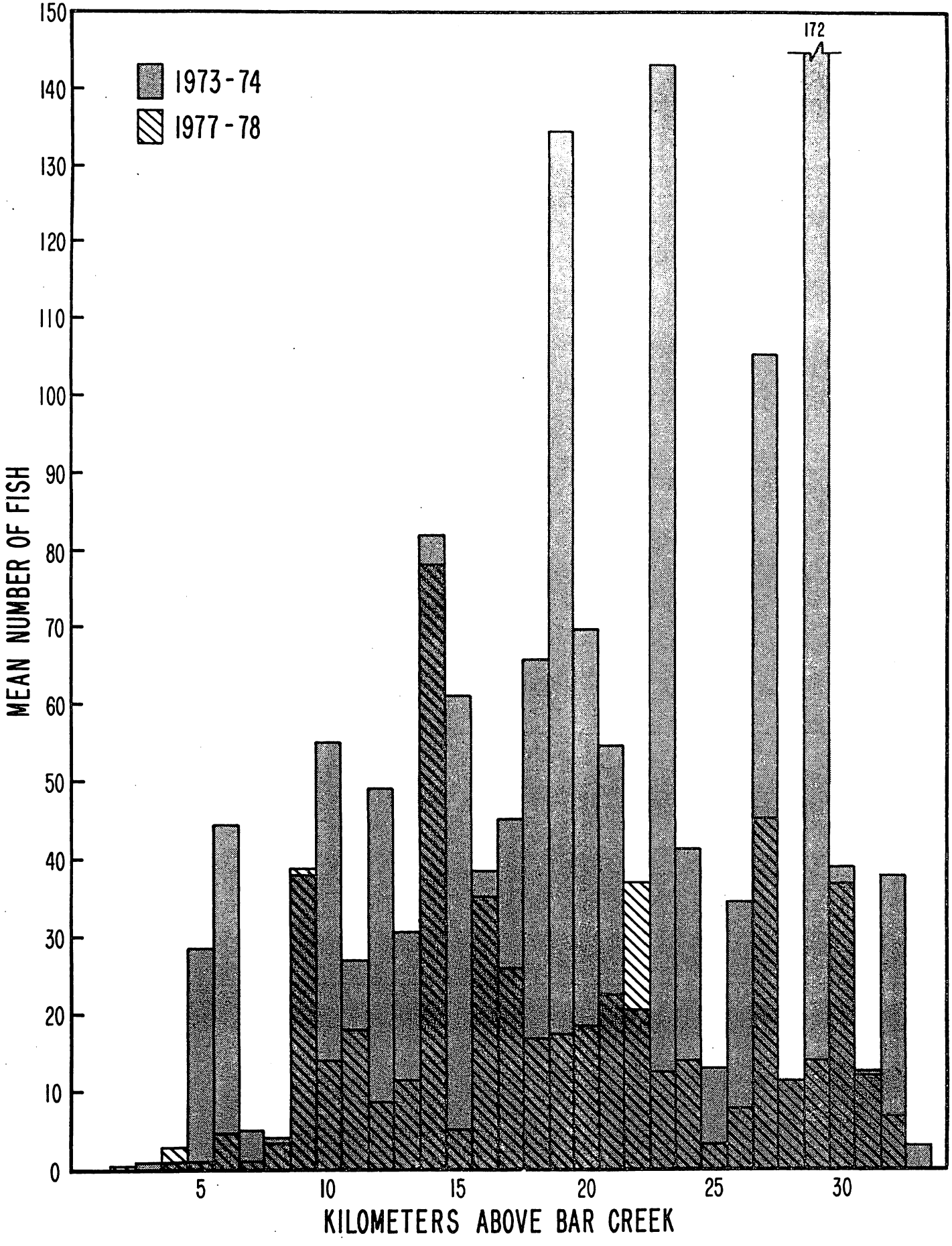

Figure 6. Comparison of distributions of adult summer steelhead in the Middle Fork Eel River during years of maximum (1973-74) and recent (1976-78) counts.

Late summer streamflows in the study area were low. In the upper Middle Fork above the confluence of Balm of Gilead Creek flows were lowest, averaging about 0.01 m^3/s (0.5 cfs). The discharge of Balm of Gilead Creek generally equalled that of the Middle Fork at that point. The North Fork of the Middle Fork added approximately 0.04 m^3/s (1.5 cfs). Additional contributions by other tributaries throughout the length of the holdover area increased flows to 0.6 m^3/s (20 cfs) near the Eel River Ranger Station.

Surface water temperatures within the Middle Fork study area ranged from 17.2-23.7°C (63-74.7°F) (Figure 7). Afternoon temperatures above 21.1°C (70°F) were common downstream from Devils Den roughs. Near the Eel River Ranger Station, temperatures were often above 23.9°C (75°F) for prolonged periods during July and August, considerably above the 15-20°C (59-68°F) best suited for survival of wild steelhead (Kubicek and Price 1976).

The accumulated flow from the steep, narrow, well-shaded tributary streams provides as much as 95% of the flow in the holdover area during the critical late-summer period. This water is 3.1-4.8°C (5.6-8.6°F) cooler than that of the Middle Fork itself and its influence is essential in preventing river temperatures from becoming excessive. Activities which might result in increased temperatures or reduced flows in the tributaries must be planned carefully if negative impacts are to be avoided.

Detailed information on numbers, depths and temperatures of pools was collected in 1977. Of 560 pools in the holdover area, 81% were less than 1.5 m (5 ft) deep; 15% were 1.6-3.0 m (5.1-10 ft); and 4% were 3.1-6.1 m (10.1-20 ft) (Figure 8). Most pools deeper than 1.5 m (5 ft) were thermally stratified, with temperatures varying up to 8.4°C (15°F) between bottom and surface. However, the average difference between bottom and surface temperatures was 1.8°C (3.2°F).

A comparison between fish numbers and pool depths shows the majority of fish used the deeper pools. Fifty-two percent were found in pools 1.6-3.0 m (5.1-10 ft) deep, and 41% occupied pools 3.1-6.1 m (10.1-20 ft) deep. Only 7% were found in pools 1.5 m (5 ft) deep or less.

Steelhead are often impeded in their migration through the roughs. Occasionally hundreds of fish congregated below a cascade too steep and narrow to pass, where they remained vulnerable to poachers and predators until flow conditions improved. Continuing observations and occasional modification of these barriers is necessary to ensure adequate steelhead passage.

During the summer, adult steelhead are vulnerable to predation in the clear pools. Predation by otters was evident during the early years of the survey but now appears to be minimal.

The causes of the extreme population fluctuations are unclear. The increase through 1974 was probably in response to improving habitat, particularly the increase in the number and depth of the pools. The subsequent decline, however, has occurred even though there has been no apparent concurrent habitat degradation.

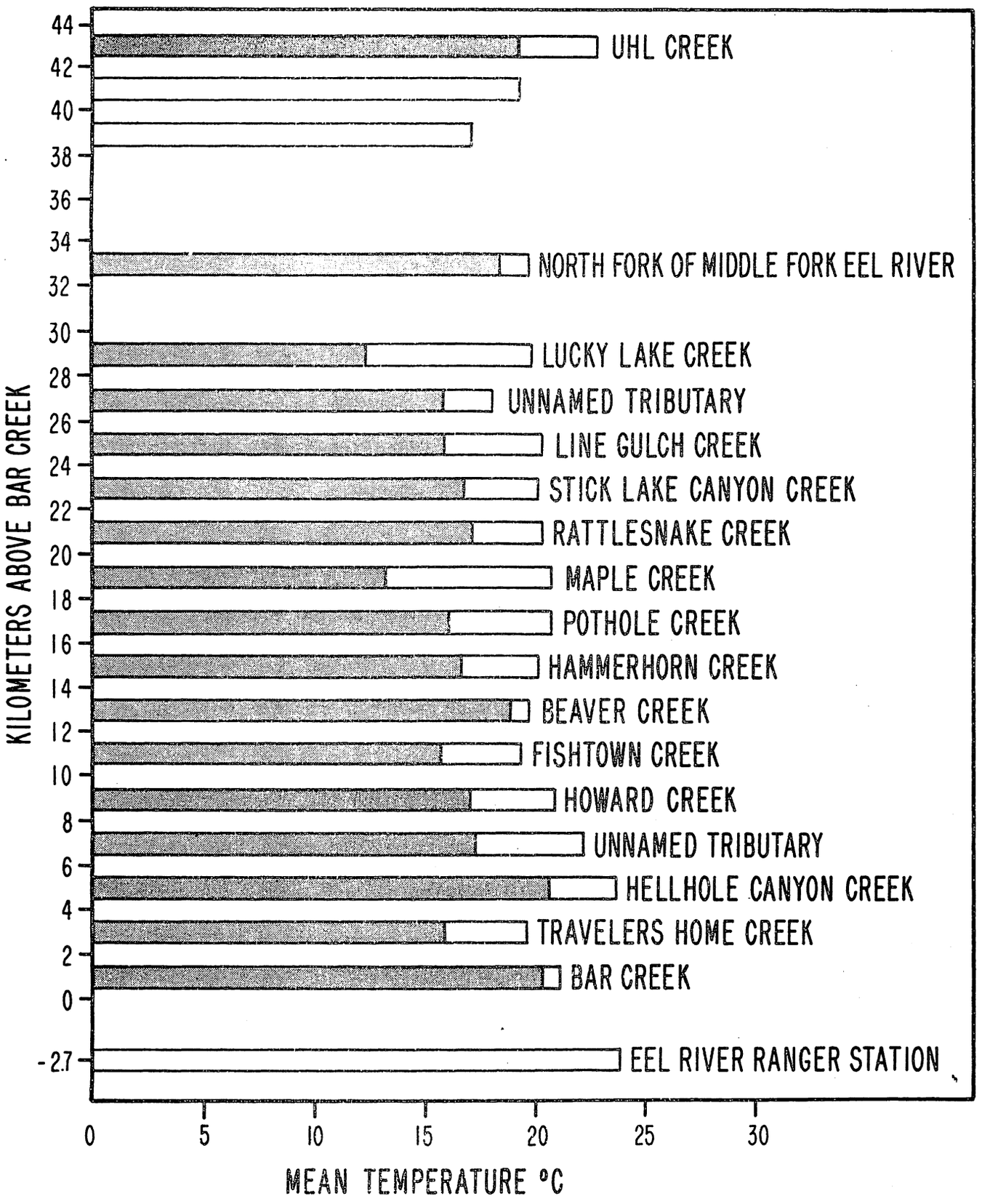

Figure 7. Mean late-summer temperatures of the Middle Fork Eel River and tributaries, 1966-78. River temperatures are averaged for 2 km sections. The tributaries named enter the MFER within the 2 km sections.

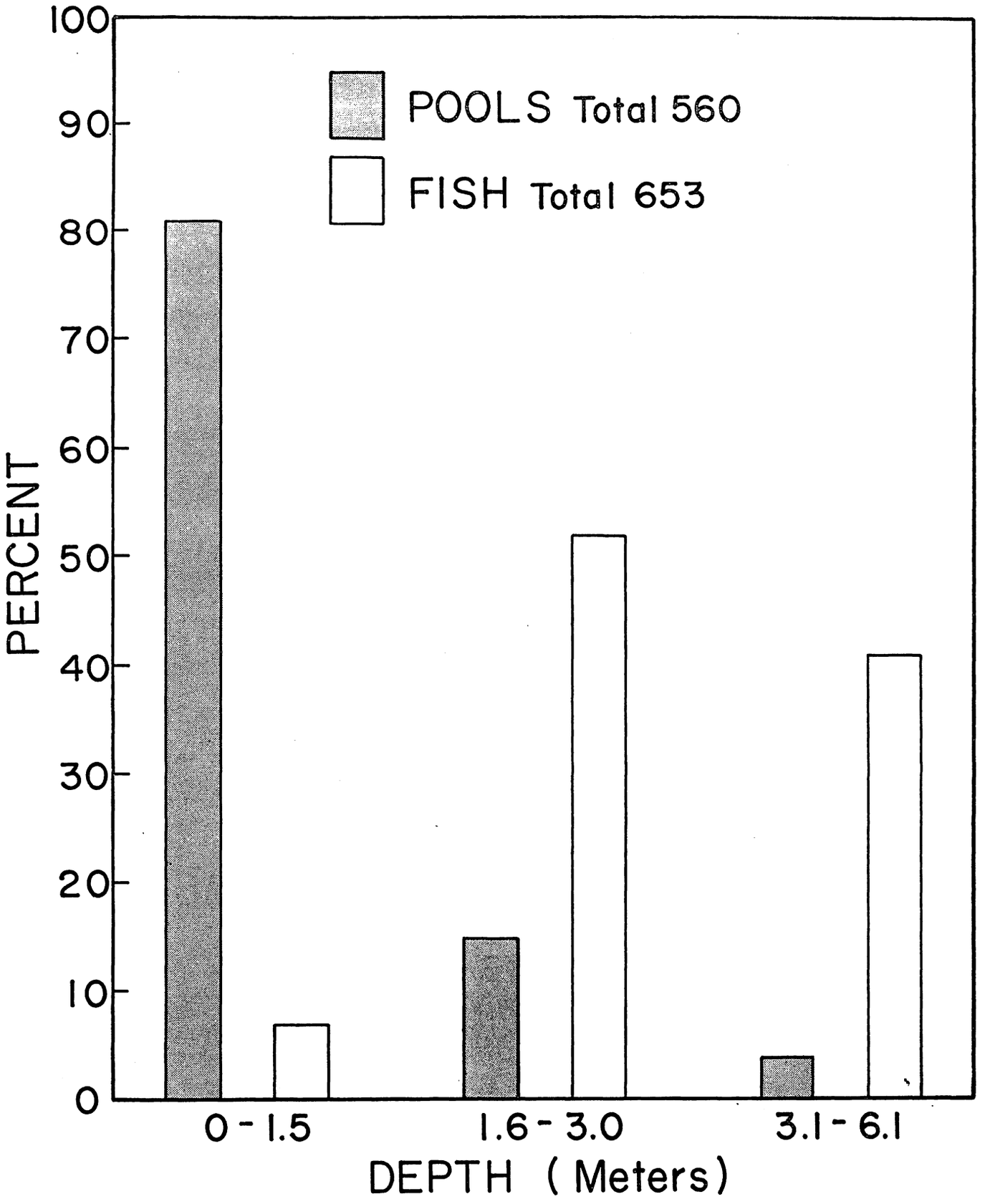

Figure 8. Distribution of pools and summer steelhead according to pool depth, Middle Fork Eel River, 1977.

One factor which is inadequately documented, but which could relate to the decline is water temperature. During the early surveys much of the flow between the pools was subsurface where it was shielded from the warming effect of the sun. As the condition of the channel improved, the surface flow increased substantially which could have resulted in significant increases in mean and maximum river temperatures. This increase, if it has occurred, might be inhibiting survival or reproductive success of the adults, or survival of the progeny. If temperature is the critical factor, we may not see a resurgence in this population until the returning riparian vegetation grows enough to shade the stream from the sun's effects.

Until such time as the causes of the decline of this population are identified and the problem(s) rectified, it is essential that these fish be protected from additional stresses. There appear to be two primary threats at this time: further habitat degradation and illegal harvest.

The USFS has experienced problems with careless logging practices in the Mendocino National Forest, which includes the Middle Fork Eel River watershed (Lorenzana 1968). Bulldozing of debris into tributaries, improper location of skid trails and roads, removal of streamside trees and other riparian vegetation, and the use of the streambed to move equipment and logs, are all detrimental to steelhead habitat. Increased use of "clean" logging methods (skyline and helicopter) and conscientious avoidance of highly erosive areas can minimize problems.

Grazing and mining, while not a problem at present, could cause erosion and siltation problems in the future. The glades, slides and slumps adjacent to the river are particularly vulnerable to erosion associated with overgrazing.

Poaching within the fishing closure may be significant. Large pools near major trail crossings often had fewer fish than expected and the presence of discarded or lost fishing gear in the vicinity indicates poaching occurs in these areas. Although patrol of the holdover area by wildlife protection officers is hampered by the rugged terrain and difficult access, more surveillance is badly needed.

The remoteness of the Middle Fork Eel River summer steelhead holdover area has contributed to the survival of this population. However, further increases in recreational use, especially with off-road vehicles, may jeopardize this sanctuary. Construction of additional roads and campsites could accelerate erosion and provide easy access for poachers.

RECOMMENDATIONS

Summer steelhead in the Middle Fork Eel River are threatened by habitat change induced by nature and man. To protect this unique fish, an effective, coordinated multidisciplinary effort will be required to implement the following recommendations.

1. BLM adopt the designation of the summer steelhead in the Middle Fork Eel River as a "sensitive" species.

2. Establish an ad hoc committee representing Federal, State and private interests to formulate a management plan for the wise use and protection of the upper Middle Fork Eel River watershed. Problems of erosion and streambed sedimentation, public use and access, habitat improvement and other problems that may have an impact on summer steelhead, should be addressed.

3. Strengthen law enforcement activities designed to protect both fish and habitat in the summer steelhead holdover area.

4. Conduct additional Middle Fork summer steelhead life history studies as directed by the management plan. Data are needed on the relationship between winter and summer races of steelhead and resident trout. Information is also needed on spawning time and location, and timing of downstream migration.

5. Monitor water quality, including temperature and sediment load, and flows in the Middle Fork and tributaries, particularly in areas under development, to identify adverse changes which may occur.

ACKNOWLEDGEMENTS

I wish to acknowledge and express my thanks to all in the U. S. Forest Service and the California Department of Fish and Game who contributed to the study over the years. A special word of thanks to Dave Jones, John Lorenzana and Emil Ekman of the U. S. Forest Service, and Don La Faunce and Ken Hashagen of the California Department of Fish and Game.

This report was prepared under the supervision of Phillip H. Baker, Associate Fishery Biologist; Elden H. Vestal, Fisheries Management Supervisor; and Eugene V. Toffoli, Regional Manager, Region 3.

REFERENCES

Brown, W. M., and J. R. Ritter. 1970. Sediment transport and turbidity in the Eel River basin, California. U. S. Geol. Serv., Wat. Res. Div. 139 p.

California Department of Water Resources. 1964. North coast area investigation. Appendix A, Watershed management of the Eel River basin. Calif. Dep. Wat. Res., Bull. 136. 141 p.

Curry, R. R. 1976. Report to the California Regional Water Quality Control Board on Middle Fork, Eel River. Univ. of Montana. 12 p.

Goodson, L. F., and R. B. Blake. 1970. Anadromous fisheries minimum streamflow requirements from proposed Dos Rios and English Ridge Dams. Calif. Dep. Fish and Game. Office Report. Unpaged.

Hickey, J. J. 1968. Variations in low water streambed elevations at selected stream gauging stations in northwestern California. U. S. Geol. Survey, Water Supply Paper 1879-E. 33 p.

Kubicek, P. F., and D. G. Price. 1976. An elevation of water temperature and its effect on juvenile steelhead trout in geothermally active areas of Big Sulphur Creek. Pacific Gas and Elec. Co. Rep. No. 7784.4-75. 37 p.

Leisz, D. E. 1978. Interim Directive No. 2, Threatened and endangered species, U.S. Forest Service, Manual Supplement, Chapter 2630, Management of Wildlife Habitat.

Lorenzana, J. 1968. Fisheries habitat management plan 2620, forest fisheries, Mendocino National Forest. U. S. For. Serv. 61 p.

Puckett, L. K. 1975. The status of spring-run steelhead (Salmo gairdneri), of the Eel River system. Dep. of Wat. Res. and Dep. of Fish and Game, Memo. Rep. 22 p.

Shapovalov, L., and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri) and silver salmon (Oncorhynchus kisutch). Calif. Dep. of Fish and Game, Fish Bull. 98. 375 p.

Smith, E. J., Jr., and R. F. Elwell. 1959. Supplementary basic fisheries data, Middle Fork of Eel River investigation. Calif. Dep. Fish and Game, Contract Services, unpublished rep. Unpaged.

Smith, E. S., and P. H. Arend. 1969. The effects of Middle Fork Eel River development on wildlife resources. Calif. Dep. Fish and Game, Office Rep. 57 p.

APPENDIX 1

Summary of Cattle Grazing
in The Upper Middle Fork Eel River Drainage*

Year initiated	Area	Number of head+
Before 1960	Henthorne Lake (FS)	80
Before 1960	Big Butte (BLM)	400
Before 1960	Willow Creek (FS)	130
1972	Howard Lake (FS)	75
1976	Dewell Garden (FS)	80
1976	Anthony Peak-Baldy Ridge (FS)	100
	Total	865

* Data provided by Robert Barnes, U. S. Bureau of Land Management (BLM), Ukiah, pers. comm.; and Thomas Mower, U. S. Forest Service (FS), Covelo, pers. comm.

\+ These allotments are year-round and are usually filled.

APPENDIX 2

Stream Survey Dates and Locations,
Middle Fork Eel River, 1966 through 1978

1966; August 29 to September 2

Middle Fork Eel River; confluence of Balm of Gilead Creek to Eel River Ranger Station (ERRS).

1967; August 19 to 25

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; lower 1.6 km (1 mile).
Middle Fork; Wright's Valley to ERRS.

1968; September 3 to 5, and October 9 to 11

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; lower 1.6 km (1 mile).
Middle Fork; Wright's Valley to ERRS.

1969; No survey

1970; September 1 to 3

North Fork of the Middle Fork; lower 1.6 km (1 mile).
Middle Fork; 0.8 km (0.5 miles) above Balm of Gilead Creek to ERRS.

1971; August 30 to September 5

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
Middle Fork: Wright's Valley to ERRS.

1972; August 1 to 6, 14, 15, 30 and 31, and September 1 to 5

North Fork of the Middle Fork; Willow Creek to mouth.
Willow Creek; all.
Morrison Camp Creek; all.
Robinson Creek; all.
Middle Fork; Robinson Creek to Rattlesnake Creek.

1973; July 30 to August 3

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
Middle Fork; 1.6 km (1 mile) above Alder Basin Creek to ERRS.

1974; July 29 to August 2

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; Morrison Camp Creek to mouth.
Middle Fork; 1.6 km (1 mile) above Wright's Valley Creek to ERRS.

1975; July 27 to 30, and August 25 to 29

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; Morrison Camp Creek to mouth.
Middle Fork; Wright's Valley Creek to ERRS.

1976; August 2 to 5, and 30

Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; Willow Creek to mouth.
Middle Fork; Balm of Gilead Creek to ERRS.

APPENDIX 2 (continued)

1976; December 29 and 30
Middle Fork; Howard Creek to 3.2 km (2.0 miles) below Howard Creek.

1977; July 30 ro August 2
Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; Morrison Camp Creek to mouth.
Middle Fork; Wright's Valley Creek to ERRS.

1978; July 31 to August 4
Balm of Gilead Creek; lower 1.9 km (1.2 miles).
North Fork of the Middle Fork; Willow Creek to mouth.
Middle Fork; Wright's Valley Creek to ERRS.