ESTIMATING POTENTIAL TROUT PRODUCTION
OF NORTHERN CALIFORNIA HIGH MOUNTAIN LAKES

by

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ABSTRACT

High mountain lakes typically have relatively low carrying capacities for introduced fish populations. Stocking too many trout at one time or stocking on top of existing populations can cause the trout population density to approach or exceed the carrying capacity and significantly reduce the individual trout growth rates. Such a situation was thought to be occurring in lakes of the Marble and Salmon-Trinity mountains in northern California. It was decided that a lake productivity model was needed to help set trout stocking densities for those lakes.

My study comprised the first two years (1986 and 1987) of a four year project. I chose 12 lakes for the study and had them each stocked with approximately the same number per hectare of adipose-fin clipped juvenile rainbow trout (Oncorhynchus mykiss) in late spring, 1986. I then sampled the trout populations of the lakes during the two summers immediately following the trout planting, using gill nets and rod and reel. The growth rates of the marked trout and any previously planted trout were back-calculated from scale samples. Average fork length at age 1+ was selected as the growth parameter for further analyses.

During the summers of 1986/87, I also collected data on a series of physical, chemical, and biological parameters that described conditions in and around the lakes. The set of parameters were analysed with the average age 1+ rainbow trout fork lengths, using simple and multiple correlation.

The parameters were divided into two sets, those that directly measured lake productivity and those that influenced or indirectly measured lake productivity. The productivity-measuring parameters most highly correlated with trout growth were the number of aquatic plant genera, the number of aquatic invertebrate orders identified from stomach, kicknet, and Eckman grab samples, the number of aquatic invertebrate orders identified in age 1+ size class trout stomachs, the average number of newts (Taricha granulosa) per 10 m transect, and the number of aquatic invertebrate orders identified from the combined trout stomachs. The productivity-influencing parameters with the highest correlation values were the trout stocking density (trout/ha) of 1984, the average trout stocking density (1983-1986), the lake drainage area (with outliers removed), and the lake drainage/surface area ratio (with outliers removed). The highest multiple (two parameter) correlation values were for the 1984 stocking density paired with maximum lake depth and lake drainage area (with outliers removed) and the number of aquatic plant genera paired with the number of aquatic invertebrate orders identified from

all trout stomachs per lake. The strong influence of the stocking density from 1984 on trout growth made it difficult to analyse the effects of the other parameters on the trout. All of the aforementioned parameters except the stocking densities were suggested as model components. The less highly correlated parameter pair of maximum lake depth and conductivity, and the wet-meadow area parameter were also proposed for modeling.

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As for my family, I cannot say enough. They did not always understand why I was doing this, or why I was not done yet, or why I did not have a "real" life yet, but they accepted that I was doing what I wanted to do and supported me with their love throughout the entire project. I finished this project as much for my mother, father, and sister as for myself.

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INTRODUCTION

The factors influencing or useful in predicting the growth of fish in north temperate freshwater lakes have long been of interest to fisheries scientists. Sound management plans for commercial and sport harvest, including stock assessment, harvest regulations, and ecological manipulation, require knowledge of the size and age structure of the species involved and the interrelationships that mold that structure. Such knowledge has typically been gained through studies that assess fish populations under different environmental regimes, usually either within lakes as conditions change or between lakes with similar fish populations and different conditions. The vast array of parameters that may influence fish populations have been winnowed by researchers to select those that best predict the state of the fish populations. Various parameters have been proposed as predictors of fish growth and potential harvest for freshwater lake systems.

Earlier studies have used physical lake measurements to predict the productivity of lake fisheries. Rounsefell (1946) concluded that fish production exhibited a straight line logarithmic relationship with lake size, with smaller lakes having higher productivity per unit area. The proposed connection was based on the assumption that shallower waters were more fertile and that smaller lakes possessed proportionately greater areas of shallow water than larger lakes. Rawson (1951, 1952, 1955), and Hayes (1957) felt that lake depth could be used to predict lake and fishery productivity. But, the overall applicability of lake size or depth alone as productivity predictors was questionable. Most of the data used for those early studies came from relatively large eastern North American lakes and the various commercial fisheries that they supported. Moyle (1946) argued that lake size was not a good indicator of productivity in Minnesota moraine lakes, where the larger lakes were often shallow and the deepest lakes were only of moderate size. He also noted that while fish production in some Minnesota lakes did appear to be limited by the amount of littoral area, such limitations would be expected for the natural eastern percid, centrarchid, esocid, cyprinid, and catostomid species, for which littoral aquatic vegetation is essential in their life cycles. Moyle believed that littoral zone size would not necessarily limit fish production in western mountain lakes populated with formerly lotic salmonids with few ties to aquatic vegetation. Northcote and Larkin (1956), working in British Columbia lakes, discussed the influence of lake size and shape on the circulation of heat, nutrients, and dissolved gases, suggesting indirect control of the speed and magnitude of fish and invertebrate growth processes. They noted that mean depth did not adequately express the morphometric factors that may influence productivity. They pointed out that extensive littoral bottom fauna production contributed a large fraction to the total lake productivity only in very shallow lakes. In intermediate depth lakes the lower percentage of littoral environment may be offset by more extensive plankton and profundal bottom fauna production. They did note, however, a tendency of deeper lakes to have lower densities of plankton, bottom fauna, and fish, while those assemblages were highly variable in number in shallower lakes. Northcote and Larkin (1956) also suggested that total dissolved solids (TDS) and mean depth needed to be looked at together when studying productivity. Following along those lines, Ryder (1965) developed the morphoedaphic index, TDS/mean depth, to predict commercial fishery yields in large north-temperate lakes. He found mean depth to be highly correlated with yields, but the morphoedaphic index gave better results. It was stated, though, that the index as presented could only be applied to large, environmentally stable, north-temperate lakes with moderate to intensive, unrestricted fishing pressure.

More recent studies have had mixed results with correlating lake dimensions with fish growth. Johnston (1973), working in mountain lakes in Washington, felt that the percentages of lake area less than 3 m deep and from 3 m to 6 m deep were important parameters that could be used in a multiple parameter calculation to determine potential lake productivity for setting proper trout stocking densities. Donald et al. (1980) found that lake area and lake depth were not significantly correlated with trout growth when analyzed individually, but lake depth was a distinct factor in multi-variate analysis with trout weight when a broad set of parameters was used. Yet when only physical, chemical, and morphometric data were analyzed together, lake depth was again insignificant. That suggested that depth might have been tied to one of the biological parameters affecting growth rather than affecting growth directly. Donald and Anderson (1982) also found that depth was not significantly correlated to trout growth in simple analysis but was of some influence in a stepwise multiple regression. They found that depth was linked to the abundance of amphipods (Gammarus sp.), an important trout food, which could explain the findings in the earlier study.

Several other factors that describe high mountain lakes and their settings have been related to lake productivity. Northcote and Larkin (1956) concluded that climate had more influence on the number of aquatic organism crops produced per season than on standing crop size. Factors such as water temperature, elevation, air temperature, and exposure to sunlight have been looked upon as having influence on the productivity of lakes and the growth of fish (Hazzard 1933, Johnson and Hasler 1954, Baldwin 1956, Anderson 1971, Brylinsky and Mann 1973, Richards and Goldman 1977, Donald and Alger 1986a, Donald et al. 1980, Pip 1989, Sand-Jensen 1989). One generalization from these studies is that lower elevation lakes tend to be warmer, with longer growing seasons. These factors lead to higher macrophyte and phytoplankton productivity, increased production of zooplankton, and faster trout growth through metabolic stimulation and increased feeding. Higher elevation lakes tend to be colder, causing slower growth rates, shorter growing seasons, and lower overall productivity. Photo-inhibition of phytoplankton production in brightly lit higher elevation lakes was also suggested, leading to slumps in zooplankton production. Elevation and exposure to sunlight have also been shown to partially control the vegetation that grows in lake valleys and cirques (Palmer 1979, Ross 1983), which in turn could affect nutrient input to high lakes (Goldman 1961) and the availability of terrestrial insects.

The chemical makeup of lakes affects productivity through limiting the growth of phytoplankton (Cordone and Nicola 1970, Landers 1982, Carpenter and Kitchell 1984, Stoddard 1987) and aquatic macrophytes (Moyle 1945, Moyle 1946, Seddon 1972, Barko and Smart 1980, Pip 1984, Sand-Jensen 1989), which then provide food and/or substrate for many other lake organisms. The effects of the chemical concentrations thus can be found throughout the lacustrine food webs, ultimately influencing fish growth through the density, stability, and variety of the prey species base. Total dissolved solids (TDS), an inclusive measurement of total chemical concentration, has frequently been correlated with plant and animal productivity in lakes (Rawson 1951, Northcote and Larkin 1956, Ryder 1965, Ryder et al. 1971, Partridge 1978, Donald and Anderson 1982, Pip 1984). Other research has been more specific, studying the effects and correlations of various inorganic and organic chemicals on lake biota (Moyle 1945, Moyle 1946, Reimers et al. 1955, Reid 1961, Cordone and Nicola 1970, Carlson 1977, Partridge 1978, Barko and Smart 1980, Carpenter and Kitchell 1984, Pip 1984, Stoddard 1987, Pinel-Alloul et al. 1989, Trippel and Beamish 1989). Individual chemical factors have been shown to be of great importance through their ability to limit primary productivity, and thus the productivity of entire lake ecosystems (Cordone and Nicola 1970, Stoddard 1987).

Biological parameters used to predict potential fish productivity tend to be directly or indirectly related to different aspects of the prey base for the fish. Zooplankton and macroinvertebrate population structures and dynamics were studied as the food supplies upon which fish depend (Wales 1946, Johnson and Hasler 1954, Reimers et al. 1955, Northcote and Larkin 1956, Larkin et al 1957, Reimers 1958, Brooks and Dodson 1965, Galbraith 1967, Anderson 1972, Elliot and Jenkins 1972, Ware 1972, Efford and Tsumura 1973, Johnston 1973, Walters and Vincent 1973, Galbraith 1974, Pennak 1977, Langeland 1978, Reimers 1979, Anderson 1980, Donald et al. 1980, Donald and Anderson 1982, Pechlaner 1984, Pechlaner and Zaderer 1985, Donald and Alger 1986a, Crowder et al. 1987). The relationship of invertebrate populations to various lake conditions has been used as an index of productivity (Sprules 1977, Gannon and Stemberger 1978, Pejler 1983, Carpenter and Kitchell 1984, Pinel-Alloul et al. 1989). Aquatic macrophytes have been shown to be important as substrate for macroinvertebrates (Krecker 1939, Rosine 1955, Johannes and Larkin 1961, Minshall 1984, Talbot and Ward 1987, Diehl 1988, Schramm and Jirka 1989a, Schramm and Jirka 1989b), as indicators of the chemical makeup and fertility of the lakes (Seddon 1972, Canfield et al. 1983, Pip 1984), and for storing and recycling nutrients essential to themselves and to the phytoplankton and epiphytes used by the zooplankton and macroinvertebrates as food (Barko and Smart 1980, Landers 1982, Canfield et al. 1983, Carpenter and Lodge 1986). Terrestrial plants have been investigated because they have been identified as nutrient sources for the lake primary production (Reimers et al. 1955, Goldman 1961). Newts have been studied as potential competitors with trout for prey species (Efford and Tsumura 1973).

This study, which encompassed the first two years of a four year project, was developed to establish a set of parameters that could be used to predict trout growth in northern California high mountain lakes. It was based on the hypothesis that trout growth was controlled by lake productivity, and that measurable parameters could be found that predicted lake productivity, and thus predicted trout growth. An understanding of the relationship between trout growth and lake productivity was needed to assist in setting stocking rates for northern California high mountain lakes. Lakes have a carrying capacity for trout, a limit on the biomass of trout that the lake productivity will support (Wetzel 1983). Studies have shown that, if the number of trout in a lake reaches or exceeds the lake carrying capacity, then trout growth ceases until trout numbers decrease enough to allow further growth (Reimers 1958, Reimers 1979, Pechlaner 1984, Pechlaner and Zaderer 1985). The combination of low lake productivity, as in most high mountain lakes, and large numbers of young trout can result in populations of undesirably small (stunted) trout. Trout stocking has been one way that too many juvenile trout enter a lake ecosystem. Such overstocking has been suggested to be a major problem in the management of high mountain lakes (Needham and Sumner 1941, Reimers 1958). Dave Rogers (personal communication, California Department of Fish and Game, retired), suggested that this project was needed to address continuing problems with overstocking in northern California high mountain lakes. The objectives of this study were to select several physical, chemical, and biological parameters thought to directly or indirectly measure lake productivity, correlate the parameters with observed trout growth in a subset of high mountain lakes, and determine which parameters best predicted trout growth. This study was then to suggest which parameters should undergo more focussed examination during the latter half of the project. By the end of the project a model was to be created using some or all of the selected parameters to rank high mountain lakes based on their relative productivities. The model would most likely use numerical ratings of the included parameters, which would be summed to determine the relative lake rankings. The productivity ratings would then have to be related to trout stocking densities before the proposed model could be used to determine future stocking densities. The parameters chosen for this study were: lake elevation, lake surface area, lake drainage area, drainage area/surface area ratio, average depth, maximum depth, compass bearing of lake long axis, sun arc, alkalinity ($CaCO_3$), nitrate (NO_3), nitrite (NO_2), orthophosphate (PO_4), dissolved oxygen (O_2), pH, conductivity, number of zooplankton species, number of cladoceran species, average number of newts (Taricha granulosa) per 10 m transect, number of aquatic plant genera, wet meadow area/lake surface area ratio, total number of invertebrate orders from stomachs from all trout size classes, number of aquatic invertebrate orders from stomachs from all trout size classes, number of terrestrial invertebrate orders from stomachs from all trout size classes, total number of invertebrate orders from age 1+ size class stomachs, number of aquatic invertebrate orders from age 1+ size class stomachs, number of terrestrial invertebrate orders from age 1+ size class stomachs, and number of aquatic invertebrate orders collected in stomachs, kicknet samples, and Eckman grab samples.

METHODS

In 1986, twelve Northern California lakes were chosen for the study based on suggestions from California Department of Fish and Game (CDFG). Using information supplied by the CDFG, I chose lakes that were characterized by earlier investigators as low, medium, and high productivity waters. Preference was given to lakes in the same, or nearby, drainages to minimize travel time. Preference was also given to lakes populated entirely, or predominantly, with rainbow trout (Oncorhynchus mykiss), the target species.

The twelve lakes originally selected, all in Siskiyou County (Figure 1.), in the Klamath National Forest, were Blue Granite, Clear, Cuddihy #4, Hogan, Hooligan, Meteor, Section Line, Snyder, Steinacher, Syphon, Telephone, and West Boulder. In 1987 two lakes, Hooligan and Snyder, were removed from the study due to access difficulties, and were replaced with Chimney Rock and Mavis lakes.

The study lakes were stocked with young-of-the-year (age 0+) hybrid Shasta x Kamloops rainbow trout, averaging approximately 55 mm in length. All of the juvenile trout were adipose fin clipped for identification. A total of 13,600 trout was stocked in the twelve lakes in 1986, with Mavis and Chimney Rock lakes not receiving any marked trout

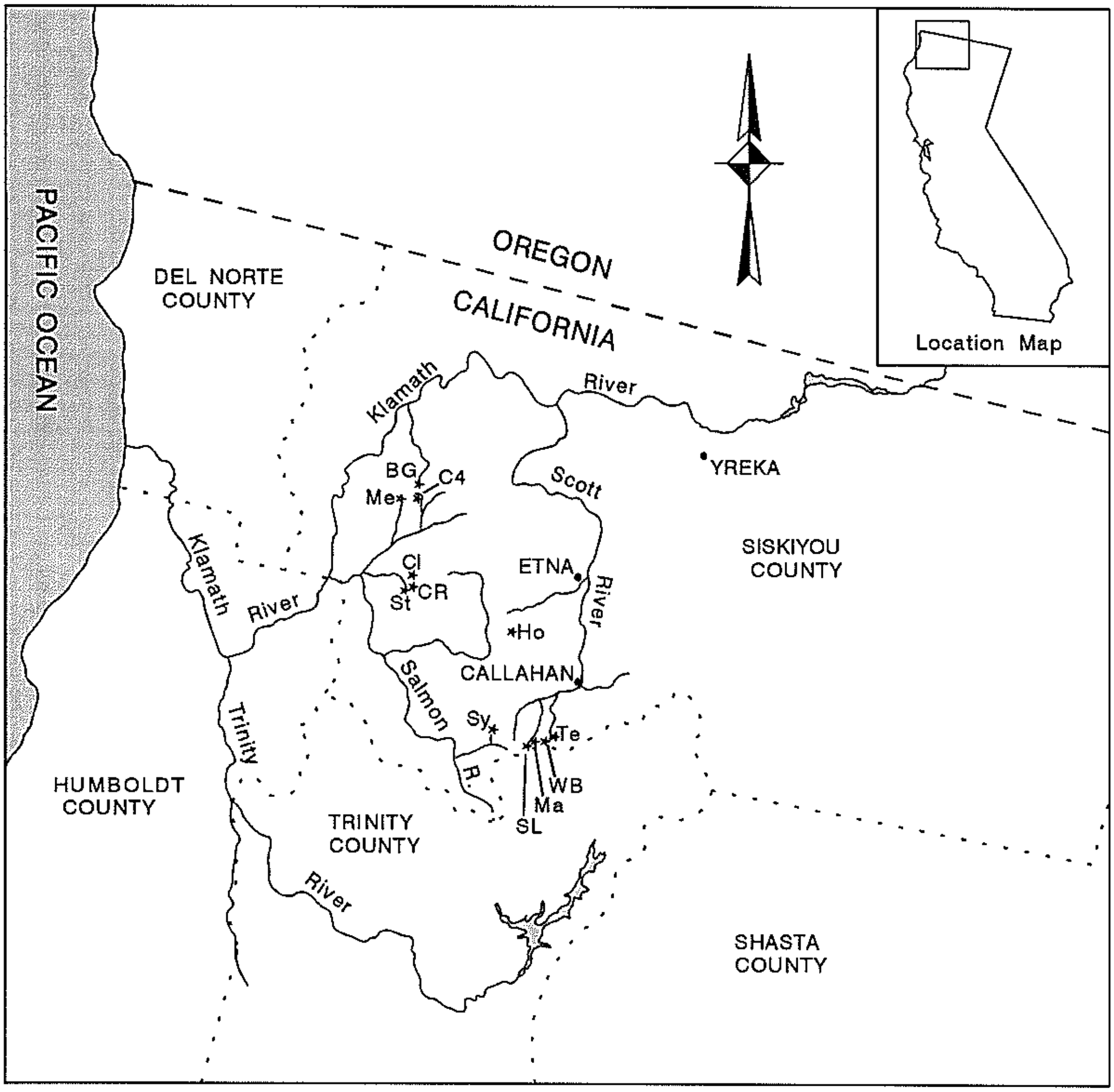

Figure 1. Location map for 12 high mountain lakes, Siskiyou County, California : Clear L. (Cl), Blue Granite L. (BG), West Boulder L. (WB), Hogan L. (Ho), Meteor L. (Me), Telephone L. (Te), Steinacher L. (St), Section Line L. (SL), Chimney Rock L. (CR), Syphon L. (Sy), Cuddihy #4 L. (C4), and Mavis L. (Ma).

until 1987. The number of trout stocked into each lake was approximately proportionate to the surface areas of the individual lakes. Some of the surface area data turned out to be in error, so that the stocking densities were more variable than originally intended. The fish were air-dropped into the lakes using a fixed-wing aircraft. Yearly stocking rates, the average stocking rate, and the species stocked from 1983-85 were examined on the assumption that those populations would affect the survival and growth of fish stocked during this study. Stocking density was calculated on the basis of trout per lake surface hectare; lake depth was not included in the calculations. Other studies indicated that rainbow trout show a preference for littoral and epilimnetic zones for feeding (Wales 1946, Partridge 1978, Donald and Anderson 1982), which suggested that total lake volume would not be as important a consideration for rainbow trout as for other species.

Trout were captured with Swedish variable mesh gillnets. The nets were set in the early evening and pulled the next morning. Daytime net sets and rod and reel fishing were sometimes used to supplement catches in order to obtain the desired sample size of thirty rainbow trout per lake. All trout caught were recorded by species, measured to the nearest millimeter, fork length (FL), and weighed to the nearest gram by volumetric displacement (1 ml. = @ 1 gm.). Scale samples were taken from all trout. Scales were later cleaned in a mild detergent solution, mounted between two slides and read using a high-magnification microfiche reader. Stomach samples were taken from the first five trout in each 50 mm size class, starting at 50 mm, or from ten trout if they were all in the same size category. Stomach samples were preserved in isopropyl alcohol.

Rainbow trout fork length data and corresponding scale annuli measurements were entered into the program GROWTH (Collins 1977) for back-calculation of size at age. The calculated lengths at age 1+ were used in further analyses because of their larger and more complete data set and their high correlation ($r=0.982$, $r_{0.06(2),8}=0.632$) with age 2+ lengths.

Stomach samples were analyzed by trout size category. Invertebrates were identified using a dissecting scope or microscope (for zooplankton) and invertebrate keys (Borror 1981, Cole 1969, Merrit and Cummins 1984, Pennak 1989, Usinger 1956, White 1983, Wiggins 1977). The number of aquatic orders, terrestrial orders, and the sum of aquatic and terrestrial orders identified per lake for all trout sampled and for the size classes that held age 1+ trout were used for statistical analyses. The odonate suborders Anisoptera and Zygoptera, and the families Ancylidae and Planorbidae, of the superorder Basommatophora, were counted as "orders" for analyses.

Shoreline aquatic invertebrates were sampled using a kicknet. Samples were taken from as many different shoreline habitats as possible within time constraints. Gammarid amphipods were particularly sought after. Zooplankton were sampled in three 5-minute plankton net tows. The fine-mesh plankton net was towed by swimming with snorkeling gear. Deepwater invertebrates were collected from Ekman grab samples. The grab samples were filtered through a 1 mm mesh screen to remove the invertebrates. All invertebrates were preserved in isopropyl alcohol and identified using the same methods as for stomach samples. Macroinvertebrate orders and zooplankton species were used for correlation analysis.

Rough-skinned newts, *Taricha granulosa*, were counted along three randomly selected 10 m transects in each lake. The average numbers of newts per transect in the lakes containing newts were used for statistical analysis. All other amphibians and reptiles associated with the lakes were noted and identified when possible. Potential trout predators were identified whenever detected.

Aquatic plants were identified to genus when possible. Percentage of coverage of the lake bottoms by aquatic plants was estimated using snorkeling gear. The number of aquatic plant genera identified per lake was correlated against trout growth. Ratios of wet meadow areas, willow (*Salix* sp.) and/or water birch

(Betula occidentalis) groves, and other lakes and ponds in the lake basins to the associated lake surface areas were calculated using stereo aerial photographs of the lake basins and a 100 mm by 100 mm dot grid. The final "meadow ratio" parameter was calculated by summing the areas of seeps, wet meadows, willow/water birch groves, and shallow ponds in the given lake drainage, and dividing by the lake surface area.

Lake drainage areas were calculated using 7.5 minute topographic maps and a dot grid. The drainage/surface area ratio was calculated by dividing the lake surface areas into their respective drainage areas. Lake surface areas were originally taken from data supplied by the CDFG, but were recalculated using 7.5 minute topographic maps and a dot grid when the older data were found to be in error. Lake elevation data were taken from CDFG data. Average and maximum lake depths were taken from CDFG data except for Syphon lake, for which the CDFG had no depth data. Syphon Lake was depth contour mapped using a wire transect line, a weighted depth line, and a compass. Sun arc over the lakes was measured using a clinometer. Lake axis orientation was determined with a compass. These physical parameters were used in correlation analyses with observed trout growth.

Additional physical measurements were made to better describe conditions in and around the lakes, but not for statistical purposes. Inflow and outflow streams, when present, were surveyed for potential trout spawning habitat and measured for width over their first 30 m from the lake. Lake bottom sediments were sampled with an Ekman dredge (grab sampler) to characterize the deepwater benthic environment. A temperature profile was developed for each lake using a YSI electronic temperature meter. Air temperatures were taken with a hand held thermometer. Secchi disk readings were taken but could not be used for analysis because the disk was still visible at the deepest point found in several of the lakes.

Water chemistry was tested at five shoreline sites around each lake. Conductivity was measured using a YSI electronic conductivity meter. A pocket pH meter, calibrated with pH 4.0 and 7.0 solutions, was used to measure pH. Alkalinity ($CaCO_3$), orthophosphate (PO_4), nitrate (NO_3), and nitrite (NO_2) were measured using Hach test kits. Oxygen (O_2) levels from the deepest area of each lake were measured with a Hach test kit in three samples taken with a Nansen bottle. Average values for each parameter were used for analyses.

The average, backcalculated size (FL) at age 1+ of rainbow trout was used to estimate the productivity of the lakes. Parameters thought to directly indicate the productivity of the lakes (e.g., counts of organisms) were seperated from parameters thought to influence lake productivity without directly measuring it. Both groups of parameters were analysed using simple correlation, with FL at age 1+ as the dependent variable. Pairs of parameters with high r values were then selected and correlated against FL at age 1+ to determine the extent of overlap of their correlations with trout growth. Due to the advisory nature of this study in the project modelling scheme, and the presence of confounding factors, parameter correlations were only required to differ significantly from zero (α=0.05), rather than higher levels (e.g., 0.5, 0.7), to warrant further consideration. Stocking densities from 1983-86 were correlated with the average age 1+ FL from each of their respective planted year classes, regardless of sample size from each of the years. Then, based on initial results from correlations of the yearly densities with the overall average age 1+ FL for each lake, the 1984 stocking density was correlated with the individual average age 1+ FL for the lakes from 1985 and 1986.

RESULTS

General Descriptions of Lakes

The study lakes were all located within Siskiyou County, California, in the Klamath National Forest (Figure 1). Blue Granite, Chimney Rock, Clear, Cuddihy #4, Meteor, and Steinacher lakes were in the Marble Mountain Wilderness. Mavis, Section Line, Telephone, and West Boulder lakes were along the northern edge of the Trinity Alps Wilderness. Hogan and Syphon lakes were in the Russian Wilderness.

The lakes were situated in glacially cut valleys, in cirques or behind moraines. The lake basins were carved into the hard granitic substrate by late Pleistocene glaciation, the lakes forming as the glaciers retreated approximately 10,000 years ago (Sharp 1960). Lake elevations ranged from 1600 m for Blue Granite Lake to 2210 m at Syphon Lake. The position of these lakes high in their respective drainages, above natural migration barriers, precluded natural establishment of fish populations, and, thus, the lakes were fishless until man introduced trout into them in the late 1800’s and the early 1900’s. These lakes were highly oligotrophic, with little mineral input from the insoluable granitic substrate and minimal organic input from the relatively sparse vegetation in the drainage basins.

Syphon Lake

The highest of the lakes in the study, Syphon Lake (2210 m) formed in a shallow cirque carved into the top of a granitic ridge line. Soil development in the basin appeared to be marginal at best, thin and mineralized, supporting dry, open stands of conifers with little ground cover other than scattered shrubs. No streams entered or left the lake; the lake level appeared to have been below the spilling point for a considerable time. A moderately sized seepage area above the west bank created a small wet meadow that drained into the lake throughout most of the year.

The lake was roughly oval in outline, without any coves or prominences. Banks were moderately to steeply sloped, with a steep granite wall along the northwest edge. The lake bottom near shore was composed of gravels and heavier rocks, but was smothered in organic fines a short distance from shore. Eckman grab samples and direct observation indicated that the deep bottom areas were a thick layer of the gelatinous material, which seemed to be composed primarily of zooplankton fecal pellets, with some conifer needles and other larger organic pieces. A number of large tree trunks were on the bottom, particularly at the west end of the lake. The trunks and branches probably provided fairly good cover for trout. It was difficult to set the gill nets without snagging the logs. Water clarity was fair, with the Secchi disc just about to fade from view as it reached the bottom at 7 m. Water temperature measurements indicated the presence of a thermocline from 3-4 m below the surface (Figure 2).

Plankton samples contained relatively low volumes of zooplankton in fairly high volumes of what appeared to be phytoplankton or other small organic particles. The dominant zooplankter was Holopedium gibberum (APPENDIXES A and B). Only a few macroinvertebrates were noted along the shore. Kicknet samples captured nine Trichoptera larvae and an odonate nymph (APPENDIX C). The Eckman grab samples contained only a few empty dipteran/trichopteran tubes. Scattered sedges growing at the water's edge and a few clumps of Isoetes in the shallows were the only semi-aquatic or aquatic plants found at the lake. Newts were present, but in very low numbers. Rainbow trout were the only fish found in the lake. Fishing pressure on the lake was probably moderate, since it was the first lake reached on an easy trail, but some anglers probably pass it by to fish the more attractive lakes a few more miles along the trail.

Meteor Lake

Set at the head of a steep-walled glacial valley, Meteor Lake was surrounded by lush wet meadows, heavy brush, and dense stands of conifers, that extended up to the rims of the valley. Soils around the lake appeared to be fairly

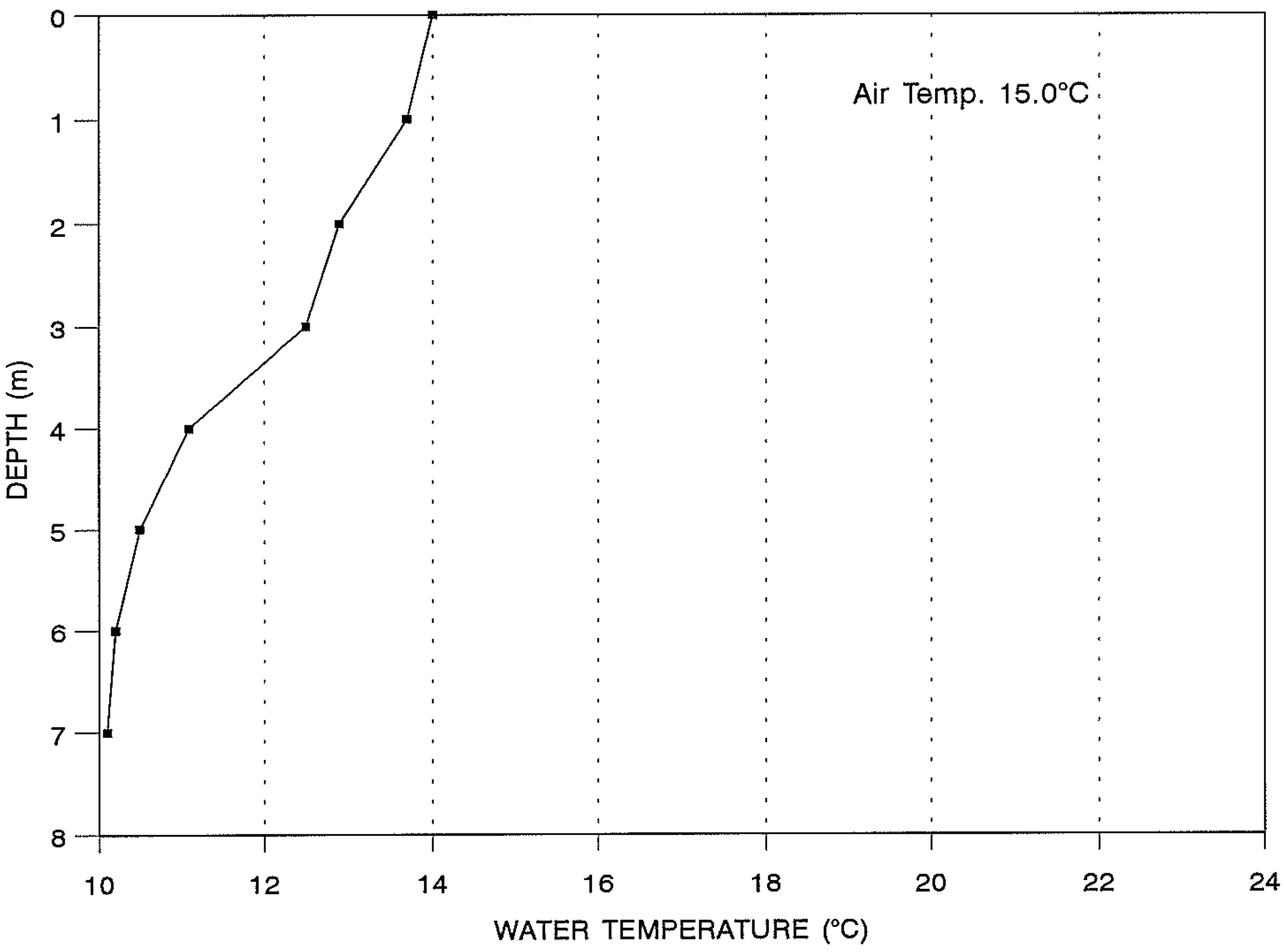

Figure 2. Temperature profile of Syphon Lake, Siskiyou County, California, 23 June 1987.

rich in organic matter, especially in the large meadows, where flowing water could be seen tunneling through the deep soil deposits. The entire margin of the lake was marshy, with five moderate to large seepage sites, the largest of which flowed out of a large wet meadow stretching from the lake edge up the back wall of the canyon. There was no suitable spawning stream flowing into the lake, but brook trout (Salvelinus fontinalis) probably spawned in the shoreline gravels kept flushed by springs. The outflow stream had an average width of 4.2 m for its first 30 m, and an average depth of 0.14 m. The stream mouth was clogged with logs and there was no visible flow in the initial stretches of the stream. Stream substrate consisted of a thin layer of soft organic muck over medium gravel, with the gravel exposed in some areas. At approximately 60 m from the lake, the channel narrowed to 0.3 m, the depth decreased to 0.05 m, and the flow picked up to approximately 0.25 cfs. Young-of-the-year (YOY) trout and one 100-150 mm trout, all unidentified, were observed in the small plunge pools that had begun to show up in the stream. YOY trout were also seen at the mouth of the stream. Rainbow trout could probably use the stream for spawning in a wet, warm spring, when the ice would leave early and the flow would be strong.

The lake outline was a long oval. The banks were of low to moderate steepness, being steeper at the headwall end of the lake. The bottom consisted of soft organic ooze, fecal pellets and other fine particles, with a few boulders and logs in the shallower areas. Water clarity was fair, with the Secchi disk being visible on the bottom at 2.5 m. The water temperature profile did not indicate the presence of a thermocline (Figure 3).

Zooplankton samples revealed the highest densities of plankton found during the study and were dominated by cladocerans, primarily *Daphnia rosea*, *Holopedium gibberum*, and *Diaphanosoma brachyurum* (APPENDIXES A and B). Macroinvertebrates were plentiful in the near-shore waters. Kicknet sampling captured several odonate nymphs of four genera, along with numerous sialid larvae, aquatic coleopterans, Veneroida (fingernail clams), and hyalellid amphipods (APPENDIX C). Eckman grab samples accounted for two large leeches (Hirudinea).

Sedges and mosses grew out into the water along the marshy margins of the lake. Willows, alders, and water birch surrounded the seepages and overhung the water in some areas. Conifers grew down to the water edge. *Isoetes* and *Nitella* formed a moderately dense band around the lake from the shallows out to depths of approximately 2 m. Clumps of *Sparganium* were scattered through the shallow water along the banks, while 8-9 small *Nuphar* lilies were growing near the outfall of the largest of the seepages at the top of the lake.

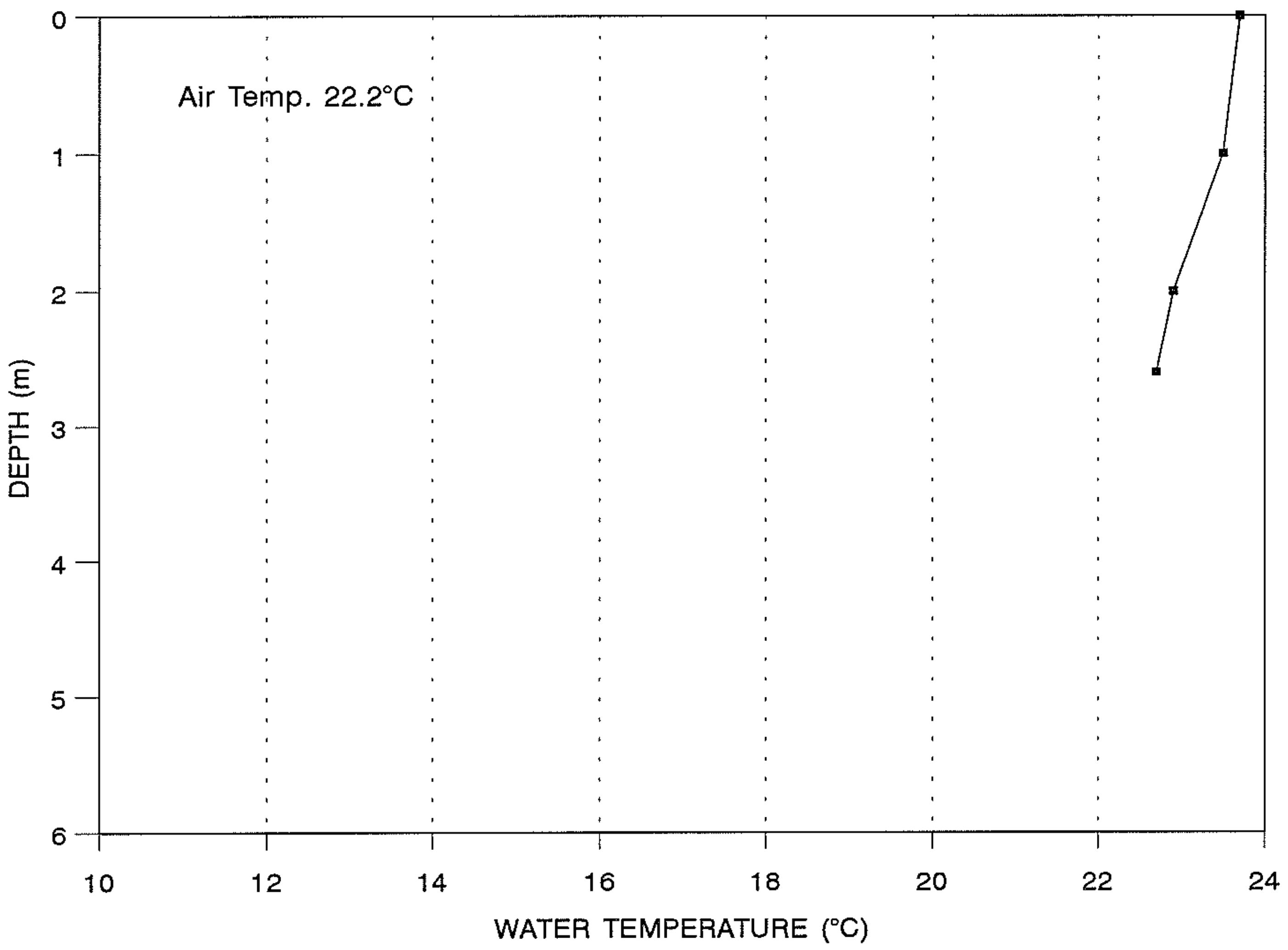

Figure 3. Temperature profile of Meteor Lake, Siskiyou County, California, 4 July 1987.

Brook trout seem to have established a breeding population in the lake, probably using the clean gravels near the seeps and in the outflow stream for spawning. The 1987 gillnet catch contained 39 brook trout and 21 rainbow trout. Of the 39 brook trout, the largest was 258 mm FL, five others were 230-240 mm, and the rest were less than 230 mm FL.

Newts were plentiful in the lake and outflow stream. Frogs were heard around the lake, probably Pacific treefrogs, *Hyla regilla*, and many tadpoles were observed in the shallows and in the stream. A garter snake, *Thamnophis* sp., was seen near the mouth of the outflow stream. An osprey, *Pandion haliaetus*, was observed perched in a lakeside conifer, but was not seen diving on any trout. Fishing pressure at Meteor was probably moderate. There were good camp sites around the lake, the setting was pleasant, and the lake was easily seen and reached from a very popular trail. However, there are larger, better known lakes in the area that probably drew much of the fishing pressure from Meteor Lake.

Cuddihy #4 Lake

Cuddihy #4 Lake was the last in a chain of lakes that formed in depressions in a broad granitic shelf at the head and along one side of a steep-walled valley. Most of the lake shore was bedrock, and what little soil there was around the lake was in the folds and hollows between rocky outcroppings and along the shore backing up against the valley wall. Conifers and shrubs were scattered throughout the soil pockets, with fairly heavy, stands of conifers and shrubs on the slope above the lake. On the side away from the valley wall the bedrock formed a raised lip around the lake, and then dropped off precipitously into the valley below. There were no streams entering or leaving the lake. The lake outfall was a narrow gap in the outer bedrock lip, through which the water could drain, drop a meter or two, then plunge down into the valley. There was no surface connection between Cuddihy #4 and Cuddihy #3. The two lakes were separated by over 30 m of rock and soil, though there could have been some subsurface exchange. There did not appear to be any seeps feeding into Cuddihy #4 along the valley wall.

The lake outline was similar to a somewhat crushed and stretched capital H, with rocky promontories dividing the sides perpendicular to the valley wall into paired coves, with an additional small cove off the end of the longest arm along the outer rim of the lake. The banks were steep along the areas of bedrock, quickly dropping off into deep water, with gentler slopes at the backs of the coves where soil and broken rock collected and moderated the angle of entry. The lake bottom consisted of intermingled fine organics, broken rock, and logs/branches in the coves, fine organics over bedrock along the sides and promontories, and a thick layer of organic muck with the occasional log and boulder in deep water. Water clarity was fair to good, with the Secchi disk visible on the bottom at 6 m. The temperature profile did not show any sign of a thermocline (Figure 4).

Plankton hauls captured relatively few zooplankton, with the dominant species being the copepod Hesperodiaptomus franciscanus, followed by the cladoceran Holopedium gibberum (APPENDIXES A and B). Aquatic insects, primarily trichopteran larvae, both anisopteran and zygopteran nymphs, and adult aquatic coleopterans, appeared to be numerous in the shallow coves (APPENDIX C), but were lacking on the more extensive bedrock surfaces. Eckman grab samples found large numbers of chironomid larvae and pupae, as well as small trichopteran larvae, in the deep water sediments. Aquatic plants were limited to a sparse, narrow band of Isoetes at depths between 0.5 and 2.5 m where there was enough soft bottom to sustain them, and a few patches of Sparganium at the backs of the coves. Newts were in low numbers in the shallows, but more seemed to be living in the deep water zone. A larval Pacific giant salamander, Dicamptodon ensatus, was captured in one of the coves. Frogs were heard at night, but no tadpoles were observed. An osprey was observed successfully fishing in the lake. Rainbow trout seemed to be constantly cruising just under the surface looking for fallen insects and were vulnerable to aerial

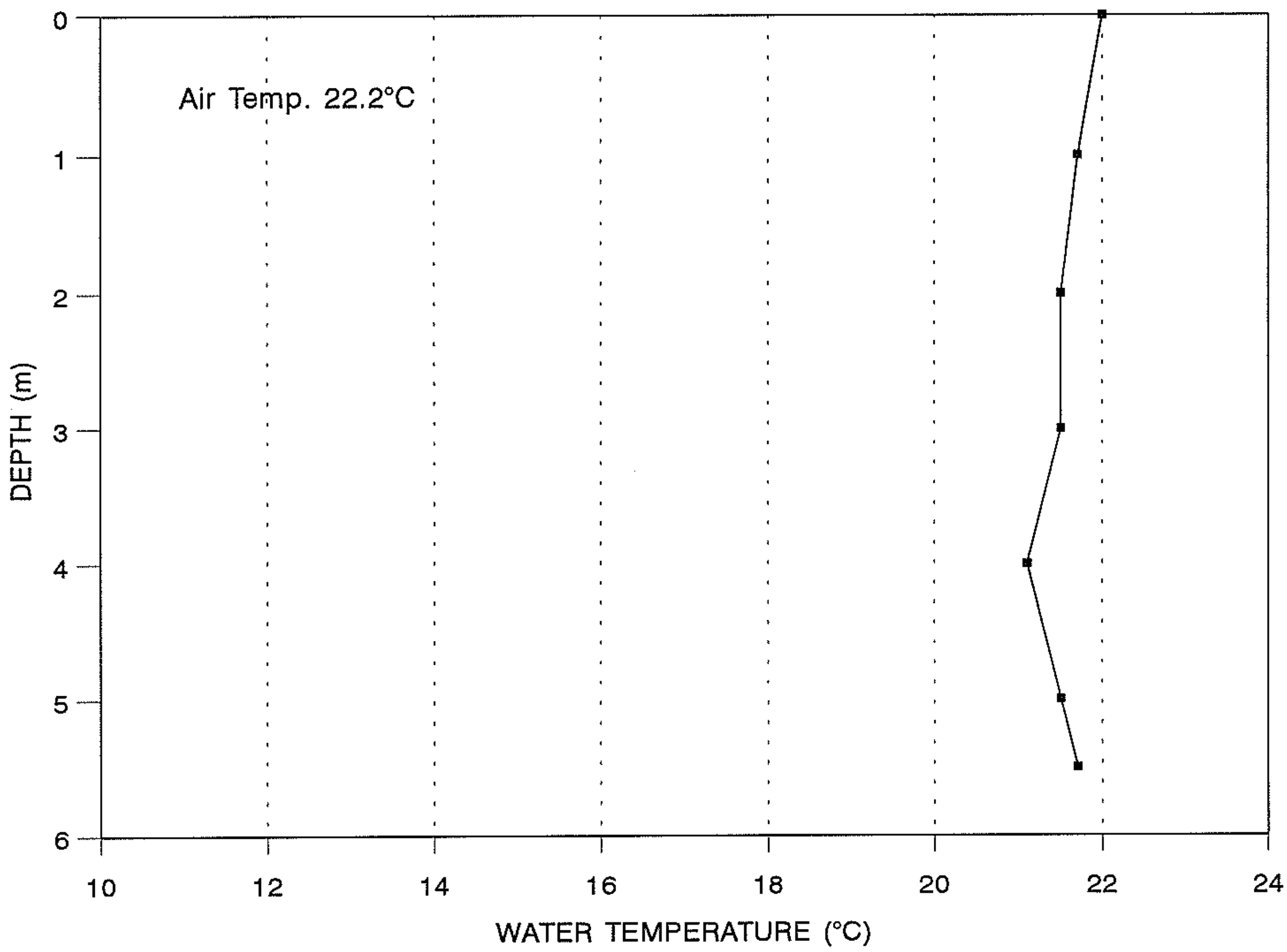

Figure 4. Temperature profile of Cuddihy #4 Lake, Siskiyou County, California, 7 July 1987.

predation. Fishing pressure at Cuddihy #4 was probably moderate to heavy. The lake was set away from most of the better camping areas in the basin, but the general area received heavy use by hikers and many anglers probably spilled over from the rest of the lake chain.

Blue Granite Lake

Blue Granite Lake formed in a depression scoured into a valley floor where two glaciers met and flowed together. Sandy loam has collected along the valley bottom, and the relatively rich soil supported dense stands of conifers, shrub thickets, and meadows. Two inflow streams that fed the lake from the two upper canyons were heavily overgrown with water birch. The streams entered the lake on the western shore, where they formed fairly large deltas of decomposed granite. The northernmost of the two had an average width of 0.7 m and an average depth of 0.05 m, for its first 22 m away from the mouth. Above that stretch was a large pool 4.5 m across and 0.3 m deep, followed by a plunge pool 1.2 m wide and 0.5 m deep. The other inflow stream averaged 0.9 m across and 0.15 m deep, topped by a 2.3 m wide, 0.3 m deep pool. Both streams had shallow undercut banks and sand, fine gravel, and small woody debris substrates. Small YOY trout, believed to be rainbows, were present in both streams. The total flow from the pair of streams was estimated at less than 0.5 cfs. Both streams could probably support spawning if the ice came off early enough. Data from scale samples indicated that the lake contained good numbers of rainbow trout from a 1985 cohort; planting records did not show any fish stocked in the lake that year. Natural spawning accounted for the discrepancy. The outflow stream averaged 3.0 m across and 0.4 m deep for its first 30 m. The stream had a broken canopy and several large logs covered portions of the channel. The substrate was primarily boulders and cobble. A fishing map claimed that brook trout could be caught in the stream but none were observed. The outflow stream could also be used for spawning under the right conditions.

The lake outline was roughly ovate, broad at the west end, tapering to the east end. The banks entered the water at low angles around most of the lake. The lake bottom in the shallows was made up of soft organic muck, considerable woody debris, logs, and many boulders, except at the mouths of the inflow streams where deltas of decomposed granite sand and gravel had formed. The bottom composition in deeper water was soft organic muck with numerous large tree trunks. Water clarity was fair, with a Secchi reading of 6.5 m. The temperature profile indicated the presence of a thermocline extending from 3 to 5 m below the surface in 6.5 m of water (Figure 5).

Zooplankton were sparse, although the phytoplankton density appeared to be quite high. The dominant zooplankter was the copepod Hesperodiaptomus franciscanus, followed by

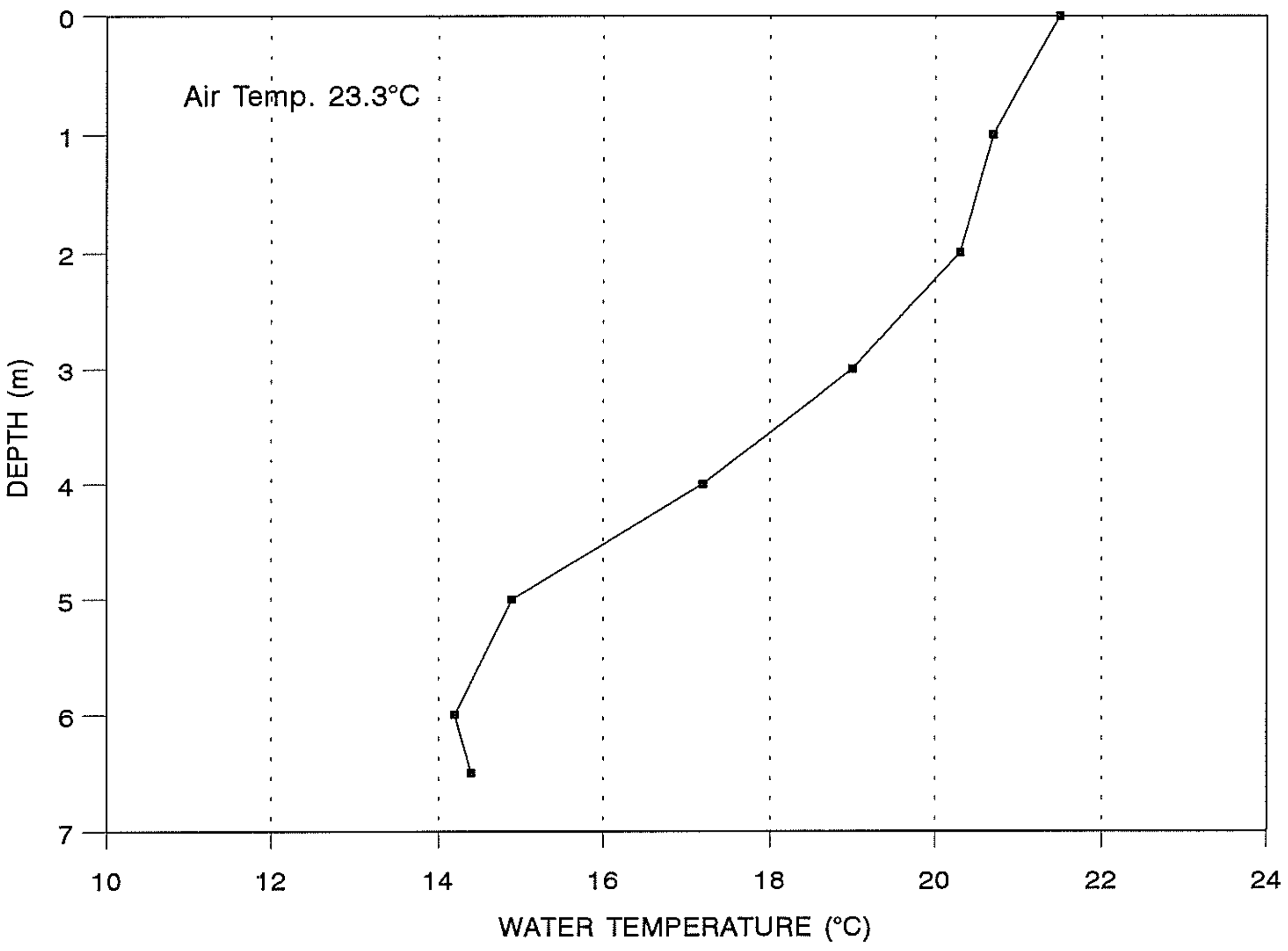

Figure 5. Temperature profile of Blue Granite Lake, Siskiyou County, California, 10 July 1987.

the cladoceran Holopedium gibberum (APPENDIXES A and B). Macroinvertebrates were numerous in the near-shore area. Many amphipods, trichopteran and sialid larvae, and ephemeropteran, zygopteran, and anisopteran nymphs were captured in kicknet samples (APPENDIX C). Eckman grab samples in deep water yielded only a few small dipteran or trichopteran cases. Bright green freshwater sponge grew on the branches of logs in deep water (3-4 m).

Aquatic plants were abundant. Sphagnum moss grew on the bottom along the lake margins, while Sparganium was scattered throughout the shallows. There was a dense zone of Isoetes at depths from 1-4 m. Heavy patches of Potamogeton and Ranunculus covered large areas out to depths of 4+ m. There was an extensive mat of Nuphar lilies covering the surface of the west end of the lake, growing up out of 2-3 m of water. Conifers, water birch, and sedges grew to the water edge around most of the lake.

Brook trout were present and probably breeding in the lake, although only three were caught in the gill nets. Newts were found everywhere throughout the lake and streams. Concentrations of newts were observed hovering over the lake bottom at depths of 3-5 m. Pacific treefrogs were seen and heard around the lake. A large larval Pacific giant salamander was seen in one of the inflow streams. Fishing pressure at Blue Granite Lake was probably heavy at times, since it was a popular camping area for backpackers and horse packers.

Clear Lake

Clear Lake was situated at the lower end of a hanging valley that dropped off into the upper drainage of Steinacher Creek. The lower edge and one side of the lake were exposed granitic bedrock. Soil around the lake and up the small valley was a sandy loam, rich enough to support dense stands of conifers along the north slope of the valley, heavy brush on the exposed slopes, thick riparian growth along the inflow and outflow stream channels, and large meadow areas up the canyon from the lake. A single stream flowed into the lake, draining a shallow, lily covered pond nearer the head of the valley. The average stream depth was 0.1 m and the mean width was 0.5 m, measured from the mouth up 30 m to a rock and log jam. The flow was 0.25-0.5 cfs. The channel was shaded by a closed canopy of water birch. Boulders with some fine gravel and small amounts of woody debris made up the substrate for the first 30 m of stream above the mouth. A large silty delta just beyond the mouth formed the only sizable shallow area in the lake. Spawning probably occurred in the inflow stream when spring conditions were right. The mouth of the outflow stream was clogged with logs and fine sediment. The rest of the stream bed was made up primarily of moss-covered boulders, with pockets of gravel and more logs. The average width and depth were 2.0 and 0.1 m respectively. The flow was about 0.25-0.5 cfs. The stream began to cascade sharply a short distance from the lake, making it unsuitable for spawning. There were at least two seepage areas along the west bank of the lake.

The lake outline was irregularly rounded, with one shore section slightly concave, and the opposite side somewhat convex. The banks were fairly steep around most of the lake; the bottom depth increased rapidly away from shore. The most extensive shallow region was the broad delta formed off the mouth of the inflow stream. The near-shore bottom was a mixture of sandy gravel and soft organic muck, with boulders strewn along the bottom of the rock wall that made up the south shore, and many large logs, several of which had collected at the mouth of the outflow stream. The deep water bottom was soft organic muck. The water clarity was good, with the Secchi disk visible to just beyond 9 m. Water temperature measurements indicated the presence of a strong thermocline from 3 to 7 m below the surface, over a bottom depth of approximately 18 m (Figure 6).

Zooplankton densities in the lake appeared to be moderately high. The predominant form was the cladoceran Daphnia rosea, followed by Holopedium gibberum, Diaphanosoma brachyurum, and the copepod Hesperodiaptomous franciscanus (APPENDIXES A and B). Kicknet sampling captured several

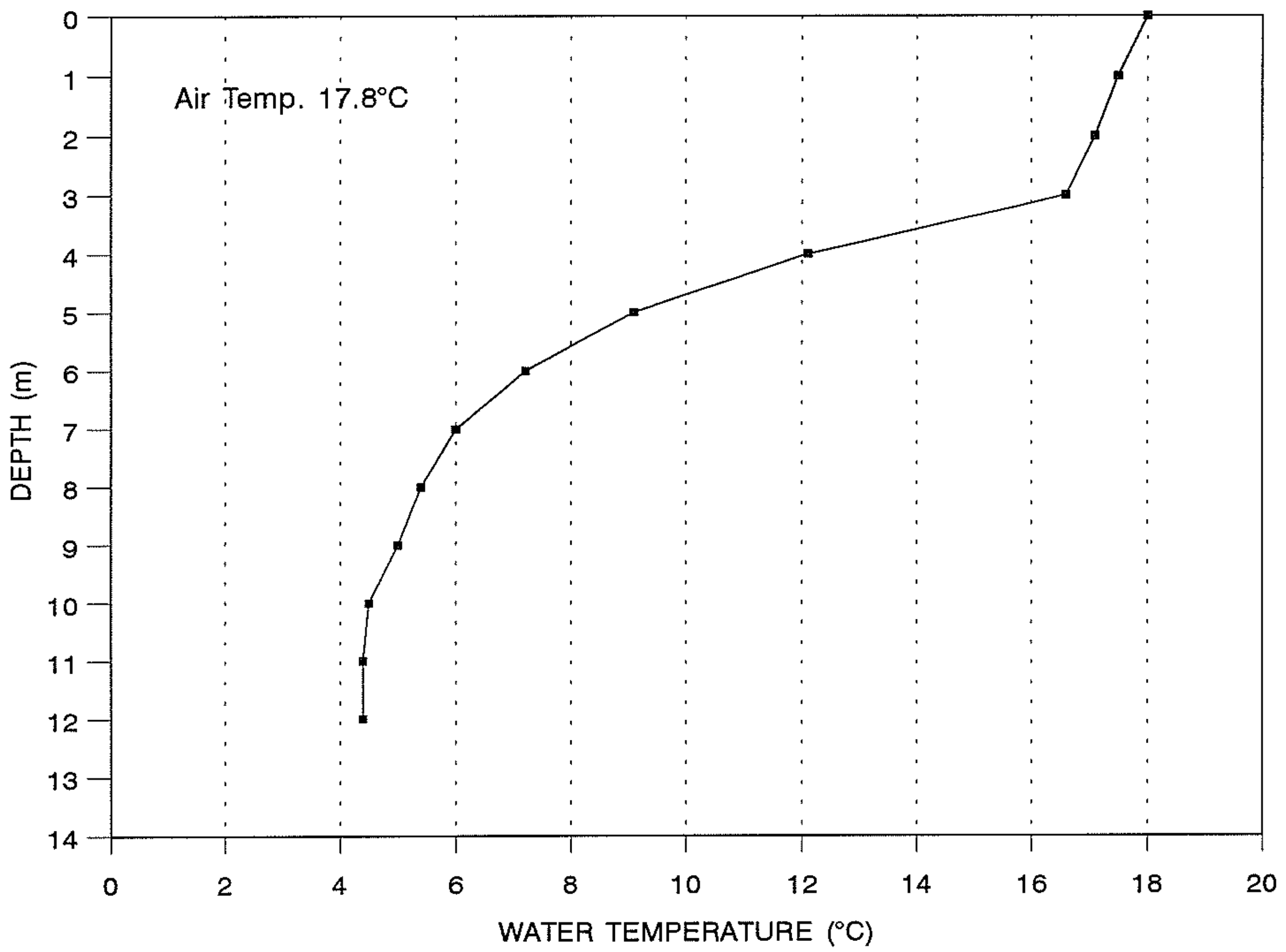

Figure 6. Temperature profile of Clear Lake, Siskiyou County, California, 20 July 1987.

species of macroinvertebrates, the most numerous being zygopteran and ephemeropteran nymphs, trichopteran larvae, and hyalellid amphipods (APPENDIX C). The deep water sediments sampled with an Eckman grab sampler yielded many blood-red chironomid larvae and empty trichopteran larvae cases, one trichopteran larva (Oecetis sp.), and a chaoborid (ghost midge) larva.

Clear Lake had the highest diversity of aquatic plants of the study lakes. Sphagnum moss was found throughout the shallows. Three Typha plants were growing along the north shore. A large patch of Nuphar lilies covered most of the silty delta at the west end of the lake, with a few other plants scattered around the lake margin. Clumps of Sparganium grew close to the bank around the lake. A moderately dense swath of Isoetes extended along depths of about 1 to 3 m. What were thought to be two species of Potamogeton formed heavy patches in the 3 to 5 m depth contour. Ranunculus was interspersed throughout the 1 to 5 m zone. Sedges, willows, water birch, and various shrubs grew along the water edge, with some large conifers encroaching on the banks.

The lake appeared to contain a healthy, breeding population of brook trout. The two largest brook trout, which were captured in 1986, were 314 and 297 mm long, weighing about 325 and 375 gm respectively. A single large brown trout, Salmo trutta, measuring 445 mm FL and weighing approximately 1.3 kg, was taken in a gill net in 1987. Five small larval Pacific giant salamanders were taken in kicknet samples. A large larval form, at least 175 mm long, was found entangled in a gill net. Two partially digested Pacific giant salamander larvae of similar size to the gill netted specimen were found in the stomach of the large brown trout. The lake also hosted a very large population of newts. An osprey was seen fishing successfully on the lake. Human fishing pressure was probably light to moderate. The lake had very nice campsites along the shores, but was situated at the far end of a long trail loop, several hours from the nearest trailhead, even on horseback.

Steinacher Lake

Steinacher Lake was formed at the base of the headwall of a glacier-cut valley, in a bowl bordered by the west and south (head) walls of a canyon, and a low rise that divided the valley floor longitudinally near its center. The bowl appeared to have filled with decomposed granite, forming the sandy loam which supported relatively dense stands of conifers, heavy brush patches, and lush wet meadow areas. Perhaps not very deep to begin with, the sediment input into the lake basin had left Steinacher with an average depth of only 0.91 m, making it the most shallow lake studied. Two small streams, which drained the same wet meadow at the south end of the lake, fed into Steinacher. The smaller of the streams averaged 0.5 m in width and

0.05 m in depth over the first 30 m stretch above the lake. It contained small pocket pools and areas of undercut banks, and had a substrate of firm mud and sandy gravel. The only canopy for the stream as it meandered through the open meadow was provided by overhanging grasses and some brush. YOY trout, thought to be rainbows because of their small size, were present in the stream. The larger of the two streams had an average width of 0.6 m and an average depth of 0.19 m. Relatively deep undercuts and pools, with a firm mud and sandy gravel substrate, were found throughout the meandering stream. Canopy was again provided by scattered bush willows and overhanging grasses. Many small trout were observed in the stream. Numerous newts were also present in both streams. The combined flow from the streams was probably less than 0.25 cfs. Spawning was probably possible in both streams after a mild winter and a wet spring. The outflow stream was choked with logs, organic muck, and silt in its first 30 m, but shortly thereafter the substrate cleared to become sandy gravel, and pools began to form. The average width was 2.1 m and the mean depth was 0.18 m. The canopy was open for the first 30 m, but after that water birch closed over the stream, forming a low, dense cover. Juvenile trout and one adult trout were seen in the stream. Spawning could occur in the stream and fish could return to the lake afterwards. Several seeps also fed into the lake along the shoreline.

Steinacher Lake was a long oval in outline. The banks all entered the water at shallow to moderate angles, whereupon the bottom gradually deepened as it approached the middle of the lake. The lake bottom appeared to be made up of a network of logs and branches buried in deep, soft, organic muck, with only small patches of sandy gravel at the mouths of the inflow streams. The buried logs made wading in the lake quite treacherous. Many logs also lay across or above the bottom, particularly at the lower end of the lake, and provided good cover for trout. The water clarity appeared to be good, but no comparable Secchi disk measurements could be taken because of the shallow nature of the lake. The temperature profile showed less than a 1 degree centigrade difference between the surface and the bottom in 1.33 m of water (Figure 7).

Plankton hauls indicated that zooplankton densities were fair to moderate, dominated by <u>Daphnia</u> <u>rosea</u>, <u>Diaphanosoma</u> <u>brachyurum</u>, and the copepod <u>Hesperodiaptomus</u> <u>franciscanus</u> (APPENDIXES A and B). Kicknet sampling revealed a fairly diverse macroinvertebrate fauna, dominated by ephemeropteran and odonate nymphs, and hyalellid amphipods (APPENDIX C). Green freshwater sponge was also present. Eckman grab sampling found only a few small trichopteran cases.

Even though Steinacher was only a few miles from Clear Lake, and at the same elevation, it contained less

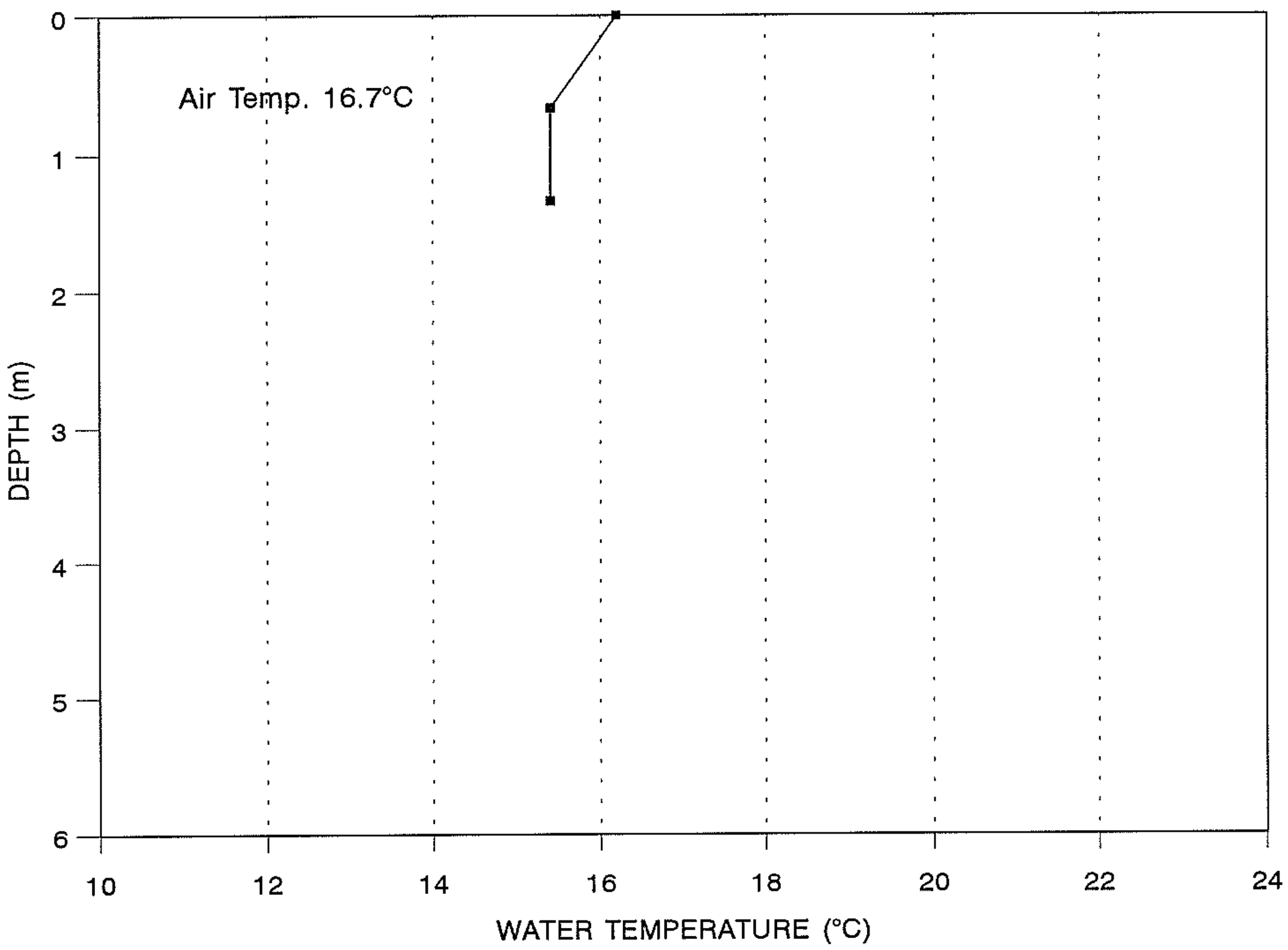

Figure 7. Temperature profile of Steinacher Lake, Siskiyou County, California, 25 July 1987.

than half of the aquatic plants genera found in Clear Lake. Sparganium was scattered in the shallows near shore, while Isoetes and patches of Ranunculus were distributed across most of the lake bottom. Conifers and shrubs grew down to the water along the east and west banks.

Newts were plentiful in the lake and the streams. Two adult ranid frogs, possibly the Cascade frog, Rana cascadae, were seen, along with tadpoles, in the streams above the lake. A Pacific giant salamander larva was captured in a kicknet in the lake. The osprey that was seen fishing at Clear Lake was also seen flying in the direction of Steinacher and Chimney Rock lakes, which were just a mile or so away. The lack of depth in Steinacher Lake could expose the trout to considerable aerial predation. Human fishing pressure on the lake was probably minimal since the lake was a long walk from the nearest public trailheads. The last half mile to the lake was over trailless, rugged terrain. Only two small campsites were found around the lake.

Chimney Rock Lake

Chimney Rock Lake was in a small cirque carved into a granitic mountain side. The lake margins consisted of a glacially polished granite wall along one side, the opposite edge being a boulder and shrub covered lip dropping off into the valley below, with stands of conifers, brush, and a little meadow at the north and south ends of the lake.

Soils around the lake were limited to pockets of sandy loam that had collected at either end of the lake, with very little on the slope above the lake. A small stream entered the south end of the lake, but had no flow and only a few pools of standing water were observed. The dry channel ranged from 0.5 to 2.0 m wide, while the remaining pool depth was up to 0.3 m. The substrate was sandy gravel and silt. There were shallow undercuts along the banks and considerable overhanging vegetation. There were no fish seen in the standing pools. Trout could probably spawn in the stream, but the flow probably dropped too soon to allow hatching or the return of fry to the lake. The outfall stream was not suitable for lake spawners. It dropped over a 0.8 m fall to leave the lake, formed a large pool, then cascaded steeply downhill from pool to pool, finally plunging over the cirque edge and down the valley wall below. There were adult trout in the pools below the lake, but they had no way to return to the lake.

The lake sides were relatively straight, the corners rounded. The north shore was longer than the south, so that the east and west sides converged toward the head of the lake. The banks were steep and rocky, comprised of either large boulders or bedrock, except off the mouth of the inflow stream, where a broad fine gravel and silt delta extended out into the lake. Around most of the lake the bottom dropped off rapidly into deep water. The bottom composition was mainly boulders with some bedrock along the shoreline, except for a silty gravel area off the stream mouth, with several logs resting on the bottom and extending out into deeper water. The deep bottom areas appeared to be gelatinous organic muck with a fairly high percentage of conifer needles and other woody debris. Water clarity was good, the Secchi disk still clearly visible on the bottom at 6.2 m. There was a narrow thermocline in the upper meter of the water column at the time of sampling (Figure 8).

Zooplankton density was relatively low. The community seemed to be dominated by the copepod *Hesperodiaptomus franciscanus* (APPENDIXES A and B). The major cladoceran species was *Diaphanosoma brachyurum*. Macroinvertebrates were reasonably numerous, with kicknet samples containing numbers of odonate nymphs, trichopteran and sialid larvae, and a few members of other orders (APPENDIX C). Many adult damselflies were flying around the lake, but none of their nymphs showed up in the samples. No organisms were indentified from Eckman grab sampling. Aquatic plants were limited to some *Sphagnum* moss and *Sparganium* in the shallows, low densities of *Isoetes* out to about 2.5 m depth, and a single *Nuphar* lily in the southwest corner of the lake. Newts were plentiful throughout the lake. A ranid frog, probably the Cascade frog, was spotted along the lake shore. Only rainbow trout were found in the lake. The same osprey that was feeding at Clear Lake

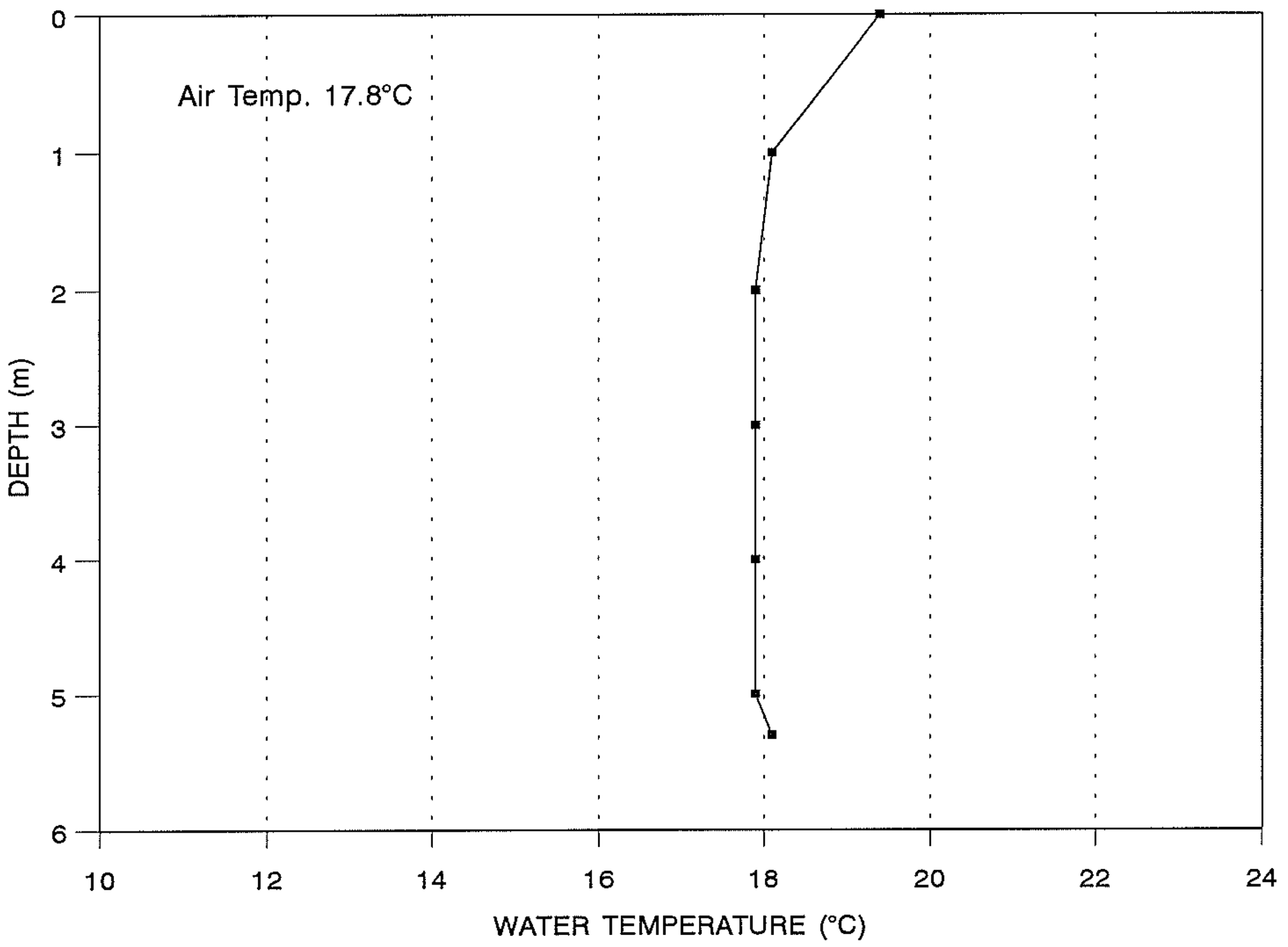

Figure 8. Temperature profile of Chimney Rock Lake, Siskiyou County, California, 27 July 1987.

probably fished at Chimney Rock Lake as well. Human fishing pressure was probably sporadic and light, the lake being far from the trailheads, and fairly well hidden from view from the main trail. There were a few small campsites at the lake.

West Boulder Lake

From a distance, the deep cirque wherein lay West Boulder Lake, was well hidden by the heavy growth of conifers on the slopes above and below its bowl, and the rugged, unbroken appearance of the mountain side on which it resided. Climbing the slope from the valley floor below, the steep pitch seemed to continue right up to the distant ridgeline, glimpsed periodically through the trees, when suddenly the slope leveled and then just dropped away at your feet, revealing the lake spread out below you. Although the trees formed a thick carpet over the general area, the available sandy soil was a thin cover on top of the solid granite of the mountain. The trees grew down into the lake basin, but stopped short of the shoreline, leaving only a few willow clumps to grow at the water edge and hang out over the lake. No streams entered the lake. The entire backside of the basin was a steep, rocky slope extending from the shore up to the ridge top, down which nothing seemed to flow except perhaps an occasional avalanche. The outfall of the lake was not a stream but instead seemed to fall into a granite catch basin below the lip of the cirque and then either filtered downslope through the boulders of the moraine or cascaded down a rocky fold in the mountain side. Any trout that left the lake when it spilled could not return. No surface seeps were visible around the lake, but some areas of clean appearing gravel at depths of around 3-4 m at the southwest corner of the lake suggested that springs might be rising up through the lake bottom, providing water and dissolved minerals to the lake.

The lake outline was similar to that of a baseball field, with the sides forming the lip of the cirque having very straight and nearly perpendicular shorelines, while the headwall gave a more curved arc to the shore it formed. A small, shallow, narrow-mouthed bay cut into the northwest corner of the basin between the north edge of the cirque and the west wall, forming the outfall of the lake. It was the only area in the lake with an expanse of low angle bank and slowly deepening bottom. The rest of the banks around the lake were steep, entering the water sharply and dropping to deep water just a few meters from shore. The bottom composition in the water from the shore out to 4-6 m seemed to be mainly organic fines over decomposed granite, with many large to very large boulders and bedrock, along with several large logs. The deepest bottom areas were organic muck with the occasional log. The water clarity was very good, with the Secchi disk visible on the bottom in 8.9 m of water. The surface layer of water down to 1 m depth cooled rapidly enough to constitute a thermocline (Figure 9).

As might be guessed from the water clarity, little zooplankton was found in the lake. The sparse community was dominated by an unidentified cyclopoid copepod, followed by the cladoceran Holopedium gibberum (APPENDIXES A and B). On the other hand, kicknet samples indicated that the macroinvertebrate community of the lake was both diverse and plentiful. Good numbers of trichopteran larvae, ephemeropteran nymphs, odonate nymphs from both Anisoptera and Zygoptera, hyalellid amphipods, large benthic cladocerans, Veneroida (fingernail clams), and gastropods (snails), amongst others, were collected (APPENDIX C). Eckman grab samples uncovered fairly high numbers of small trichopteran larvae and cases in the deep water sediments.

Aquatic plants were scarce in the lake, represented by some Sparganium scattered along the shoreline shallows and in the little bay, some dense patches of Sphagnum moss extending down to about 3 m depth on the south side, and a band of the ubiquitous Isoetes from the shallow margins out to around 4 m. Shoreline vegetation was sparce as well, with only some sedges along the edges, a few annual species, and four large willow clumps that grew out to 2 m over and into the water, providing good cover for young trout.

No newts or other salamanders were found in the lake, although tadpoles of unknown genera were observed in

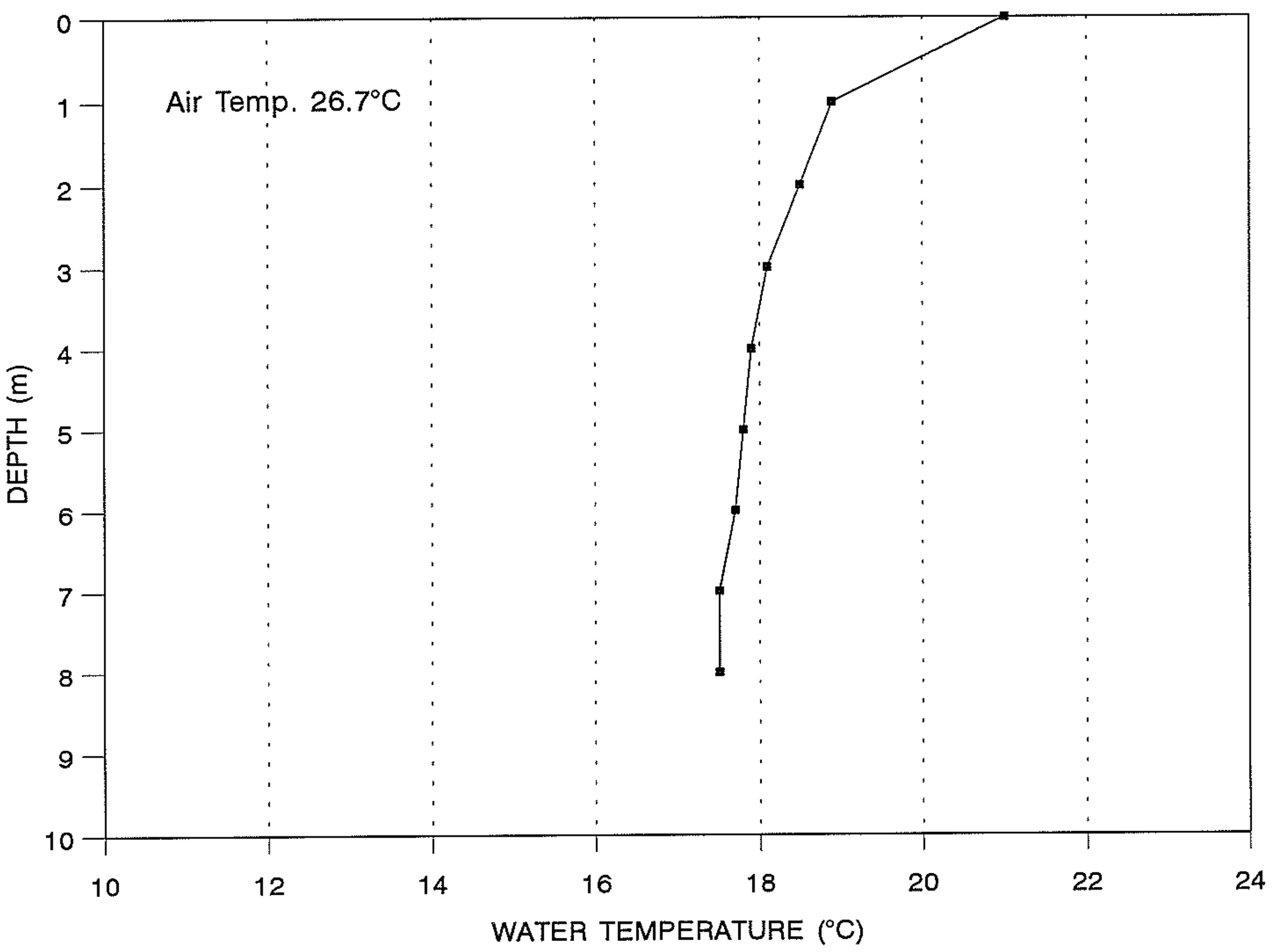

Figure 9. Temperature profile of West Boulder Lake, Siskiyou County, California, 5 August 1987.

the shallows. Brook trout maintained a healthy population in the lake. YOY brook trout were seen along the shore, and with the lack of inflowing streams, added credence to the belief that springs bubbling up from the lake bottom provided spawning areas for the brook trout. Brook trout captured in the gillnets ranged up to 269 mm FL, larger than any of the rainbow trout taken. Fishing pressure at the lake was probably moderate. It was located in a popular hiking and horse packing area, and had two well used campsites at the lake. Other campsites in the main valley below were within a short hike. The lake, however, would be difficult to find if one had not been there before, and the hike in was not easy.

Telephone Lake

Telephone Lake was formed in a shallow depression on top of a low rise off to one side of a long, wide glacier-cut valley. The rise may have been created from the lateral moraine of the glacier collected in a pocket protected by a shoulder of the mountain that formed the backdrop for the lake. Alternatively, the rise, and the lake-filled depression on top of it, may have been formed by the toe of a small glacier flowing off the side of the valley. Whatever its origin, the lake boundaries were a steep slope rising to a high ridgeline on the east side, a steep hill or extension of the ridge on the south end, a small hill on the northwest corner, and the low lip of the depression along the west side. The local soil seemed to be shallow and rocky, supporting open stands of conifers, a little brush, and scattered annuals and grasses. A small stream cascaded down a narrow cleft in the hill at the south end of the lake basin, draining part of a large wet meadow higher on the mountain side. The flow did not reach the lake on the surface, but went subsurface 10 m from the lake edge in a small wet meadow, and then entered the lake through several seepage points along the south end. Even at high flows the stream would probably not be suitable for spawning, the defined channel being too shallow and the flow being too dispersed. There was no outflow stream for the lake. At times of high water it appeared that the lake simply spilled over a low point at the northwest corner.

The lake shape was a long oval with an irregularly rounded, narrow-mouthed bay extending off the west side. The banks were moderately steep around most of the lake except for the bay, which was quite shallow relative to the lake. The bottom of the main lake dropped into deeper water quite quickly after only a few meters from shore. The south end of the lake had a more extensive shallow area due to the input of sediments from the inflow stream, which, despite its low flow, seemed to have created a fairly large delta of fine gravel and silt out into the south end of the lake. The bottom composition of the shallow areas was soft organic muck over fine gravels and silt along the stream delta, and soft organic muck over coarser gravel and considerable numbers of small boulders for the rest of the main lake and the bay. There were only a few logs on the bottom in the shallows. The deep water bottom consisted of thick organic muck, silt, and a small percentage of conifer needles and parts, with a scattering of logs. The water clarity was only fair, with a Secchi disk reading of 5.3 m. As in West Boulder Lake, the main change in the temperature profile came in the first meter below the surface, but there was also a second, weaker but broader, thermocline from about 3 to 6 m below the surface, in 7 m of water (Figure 10).

Three plankton hauls captured only small quantities of zooplankton. Small in size but high in numbers, copepod nauplii dominated the samples, followed by an unidentified cyclopoid copepod, and the cladoceran Ceriodaphnia laticaudata (APPENDIXES A and B). This was the only lake in the study where Ceriodaphnia was a dominant cladoderan. The macroinvertebrate community was rich in diversity and numbers, with 11 orders represented in the kicknet samples. The most numerous forms seemed to be ephemeropteran nymphs, odonate nymphs, trichopteran larvae, chironomid larvae, adult coleopterans, hyalellid amphipods, veneroidans, and gastropods (APPENDIX C). The heavy stony cases of the large trichopteran larvae in the lake were particularly evident in the stomachs of the trout, that often seemed to gorge on them, being easily felt through the body walls of the

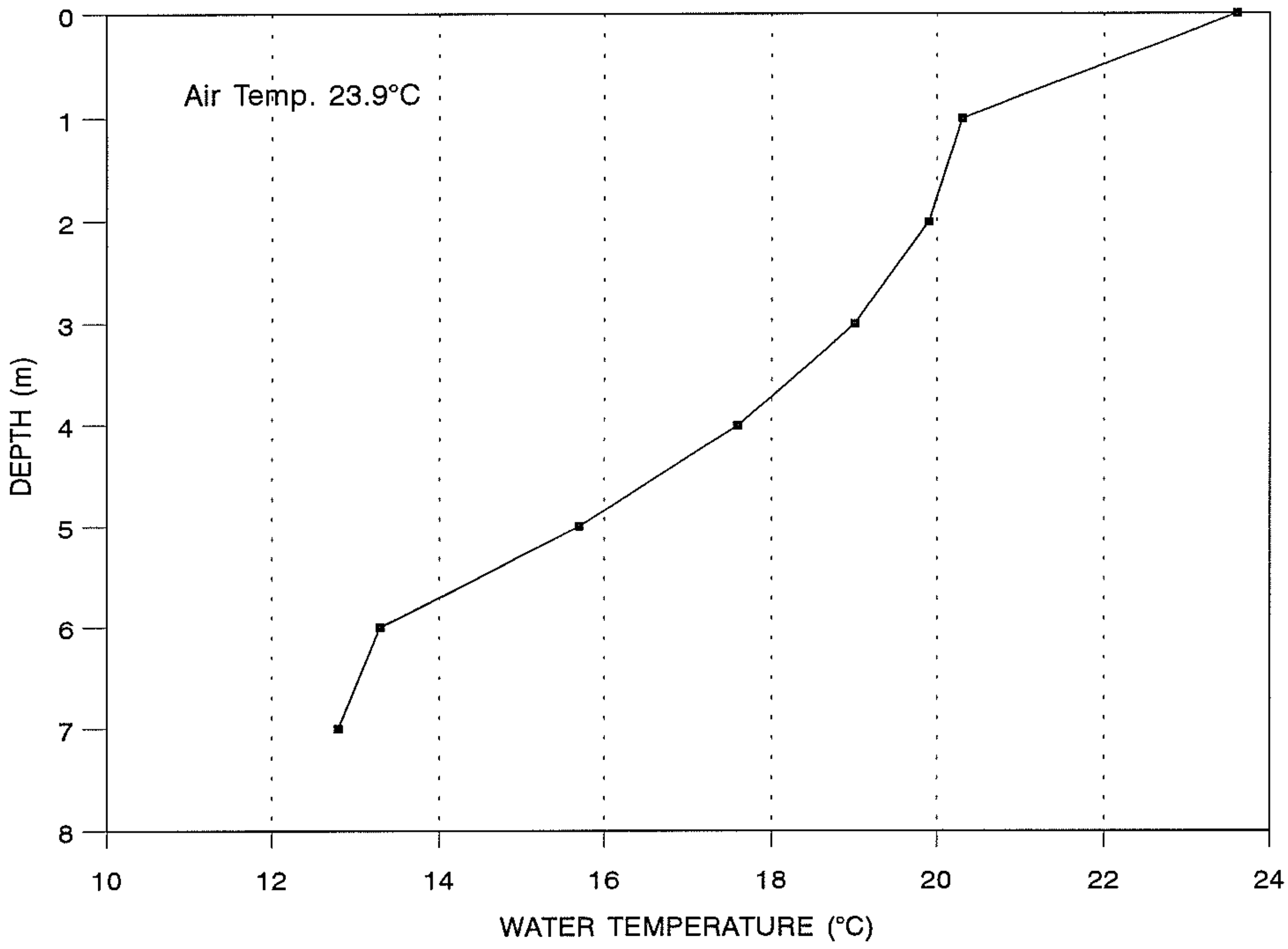

Figure 10. Temperature profile of Telephone Lake, Siskiyou County, California, 7 August 1987.

stuffed trout. Eckman grab samples found relatively high densities of chironomid larvae in the deep water sediments.

Telephone was the only lake that contained the aquatic plant *Eleocharis*, which grew in high density in the bay and along the south end seeps. *Sparganium* grew here and there along the shore of the main lake, while *Isoetes* once again covered the bottom in deeper water, although this might have been a different form than that found in the other study lakes, in that it was a smaller plant that sometimes formed dense mats out to about 2 m depth. Sedges were the major plant along the bank edges, with a few clumps of willow growing higher on the shore at the high water mark. Conifers also came down to near the high water mark.

There were no newts in the lake. An adult frog, probably a Cascade frog, was seen in the lake. Several adult toads, most likely *Bufo boreas*, were observed hopping around the margin of the bay late at night. Large *Rana* sp. tadpoles and smaller *Bufo* sp. tadpoles were in large numbers in the shallow water on the stream delta. Rainbow trout were the only fish found in the lake. A garter snake was also seen at the south end of the lake. A belted king fisher, *Ceryle alcyon*, was fishing the lake at times. Human fishing pressure at the lake was probably moderate to high, since it was only an hour hike in on a popular trail, and had well developed campsites next to the lake.

Section Line Lake

The cirque that held Section Line Lake was backed by a high talus slope along the east wall of the bowl, the broken rock reaching from the ridgeline down into the lake. The west face of the cirque headwall was just as steep but supported a moderately dense stand of conifers and brush. The outer edge of the lake bowl appeared to be made up of the broken granite scooped out from the base of the ridge by the glacier. Soils around the lake basin were thin and rocky, probably low in humus and slightly acidic from the conifer duff that appeared to be their major component. There were no streams entering or leaving the lake, just a few seeps that formed small marshy spots or tiny wet meadows around the banks of the lake. The water did not seem to spill from the basin so much as it simply drained through the porous boulder field that formed the lip of the depression.

The lake outline was generally oval, but with an irregular edge. The banks along the headwall were steep and rocky, dropping off into deep water soon after entering the lake. The shoreline formed by the outer edge of the cup was less steep, with more soil over the rock, entering the water at a low to moderate angle, the more slowly descending bottom creating a broader area of shallow water. The bottom composition near shore consisted of small to large boulders covered with a layer of organic fines, with pockets and broader areas of organic muck in between the rocks, along with a few logs. In deeper water the bottom became a thick blanket of organic muck with a considerable portion of small woody debris. Operating the Eckman grab sampler was difficult because the little branches and bark chunks wedged the grab jaws slightly open, allowing the soft fine sediments to wash out on the way to the surface. A few large logs were on the bottom in the deep water. The water clarity was fair, appearing slightly turbid from the surface but failing to completely obscure the Secchi disk as it rested on the bottom in 4.8 m of water. The temperature profile showed a sharp drop in water temperature through the first meter below the surface, but no other signs of a thermocline at depth (Figure 11).

The volume of zooplankton collected in the net hauls was very low, indicating either very low plankton density or a failure of the net. The sample community was dominated by the copepod Hesperodiaptomus franciscanus, followed by the cladoceran Daphnia rosea (APPENDIXES A and B). The aquatic macroinvertebrate sampling revealed a strong population of odonate nymphs, both anisopterans and zygopterans, along with good numbers of ephemeropteran nymphs, trichopteran larvae (cases), gastropods, veneroidans, and a few other forms (APPENDIX C). The Eckman grab captured 6 trichopteran cases, 2 chironomid larvae, and 3 leeches (Hirudinea).

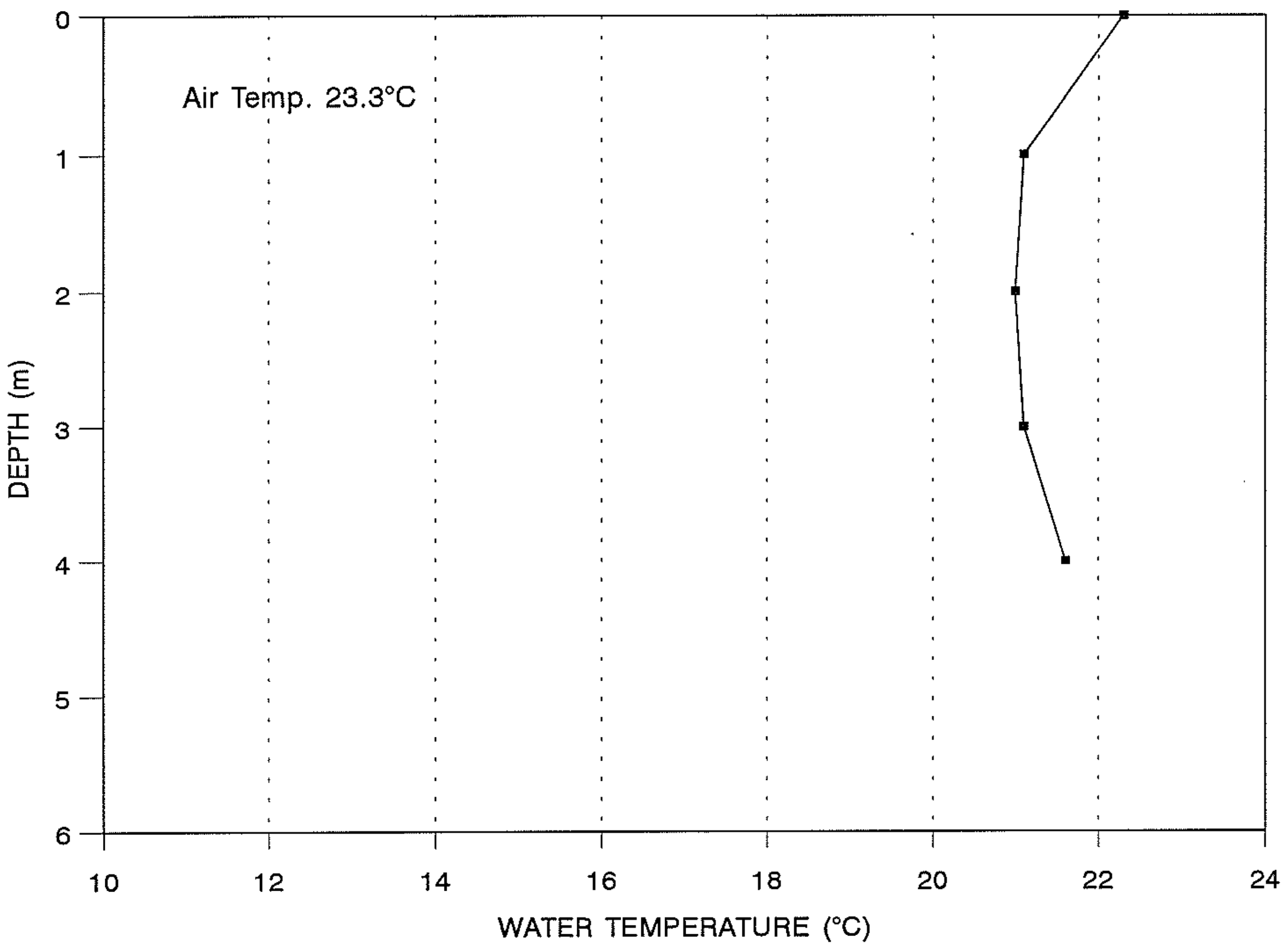

Figure 11. Temperature profile of Section Line Lake, Siskiyou County, California, 12 August 1987.

The aquatic plant community appeared to consist of only a little _Sphagnum_ moss in the shallows, some scattered patches of _Sparganium_ along the shore, and the usual sparse band of _Isoetes_ in water from 0.5 to 2.5 m deep. Sedges grew along the shoreline all around the lake, while a few ferns were near the water at the base of the talus slope. The local conifers grew down to the high water mark.

A single brook trout was caught in the gill nets in 1987. It appeared that the brook trout population in the lake had died out. No newts or other salamanders were found in the lake. The tadpoles of an unknown frog species were seen in the shallows. Fishing pressure on the lake was probably light. There were no obvious trails to the lake, and the campsites at the lake had seen only light use.

Mavis Lake

The basin that held Mavis Lake appeared to be more of a low spot gouged out by a descending glacier than an actual cirque formed at the glacial origin. The soil deposited around the lake basin was considerably deeper than at Section Line Lake, with a richer humus content. The surrounding forest seemed to be healthier, with a greater degree of canopy closure and more of an understory of shrubs and ferns. A small stream, with a flow of less than 0.1 cfs, cascaded down a steep, rocky mountain side to reach the lake. Only in the last 20 m before the lake did the stream level out to the point where fish could ascend it even if there was enough water. The average stream width of the level area was 0.5 m, with an mean depth of 0.01 m. The substrate of the level zone was mainly sandy silt with a little fine gravel. The mouth was choked with logs, branches, silt, and sedges, and gave little indication that conditions had ever been favorable for spawning. Rainbow trout probably could not use the stream to spawn. The outflow stream was dry, and did not appear to run very often. The mouth was solidly clogged with logs and silt and had no spawning potential. There were a few seepage areas around the lake shore against the mountain on the south side.

The lake outline was roughly ovate with an irregularly rounded edge. The banks were all of low to moderate steepness, with the bottom descending slowly into deeper water. The nearshore bottom out to about 3 m depth was comprised of decomposed granite and a few boulders, all covered with a layer of organic muck and conifer needles. Many logs crisscrossed the bottom, particularly along the southwest side and at the mouth of the outflow stream. The deep water bottom was made up of soft organic fines and small woody debris. The water clarity was good, with the Secchi disk clearly visible on the bottom in 5 m of water. The only rapid change in water temperature was seen in the upper meter below the surface (Figure 12).

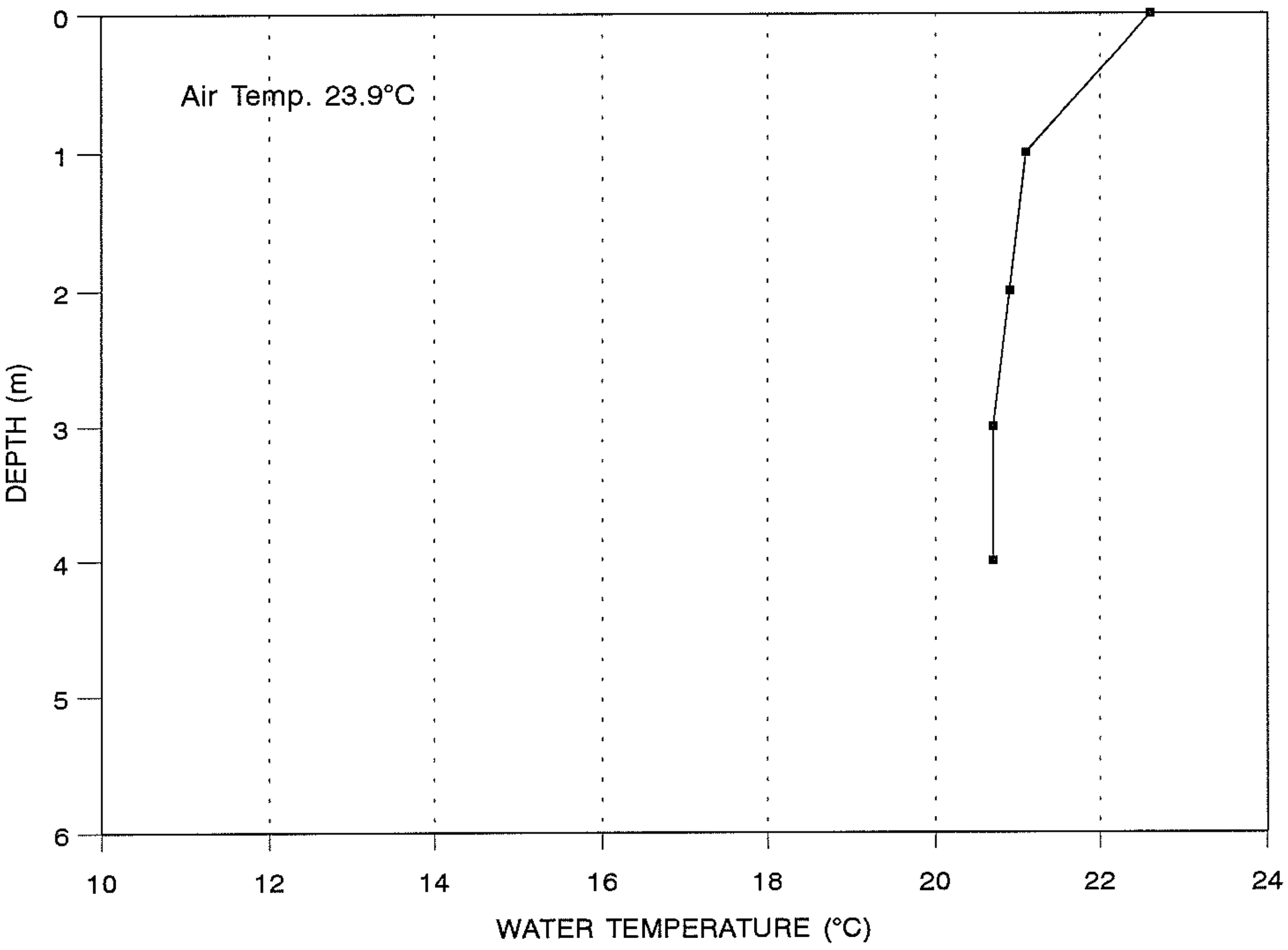

Figure 12. Temperature profile of Mavis Lake, Siskiyou County, California, 10 August 1987.

Plankton hauls indicated a low density of zooplankton in the lake. The numerically dominant form was Hesperodiaptomus franciscanus, followed by Daphnia rosea (APPENDIXES A and B). Odonate nymphs appeared as the most numerous aquatic macroinvertebrates from a community with 12 orders represented in the kicknet samples. Other strong components in the samples were trichopteran larvae, adult coleopterans, hyalellid amphipods, chironomid larvae, veneroid clams, and gastropods (APPENDIX C). Green freshwater sponge was also present in the lake. Aquatic plants were not well represented in Mavis. Only two genera were identified: Isoetes in a band between depths of 0.5 and 2.0 m, and Potamogeton scattered in patches at depths from 1 to 3 m. Sedges were growing along the lake margin, and a few willows were in clumps dotted around the lake, but primarily clustered at the mouth of the inflow stream. The forest conifers were growing down to the high water line on all sides.

Both brook trout and brown trout had been heavily stocked into the lake up to the first year of my study. No brook trout were captured in the gill nets, which suggested that they had not done well since the last stocking. On the other hand the brown trout, while not numerous, had grown to sizes ranging from 284 to 330 mm. They posed a definite threat to the survival of new plants of fingerlings, including the young rainbow trout stocked into the lake for my study. There were no newts seen in the lake. Tadpoles were observed in the shallows. A belted kingfisher was seen flying about the area. Human fishing pressure was probably quite heavy at times. The campsites around the lake appeared to receive heavy use, and the snarls of fishing line and other signs of fishing use around the lake were plentiful.

Hogan Lake

The basin that contained Hogan Lake seemed to have been gouged out of the bedrock by glaciers flowing out of cirques high up on the mountainsides and down the steep, hard granite walls that surround the lake valley, grinding a hollow where the slope suddenly leveled off. Most of the basin was still made up of the exposed granite, as either solid walls or talus slopes, but enough rocky soil had formed to allow the growth of open stands of conifers, willow/water birch thickets, small meadows, and brush patches around the lake. One stream fed into the lake, draining out of the Big Blue Lake basin higher up on the mountain. The lower 100 m of the stream appeared to be accessible to trout, with an average width of 1.2 m and a mean depth of 0.04 m. The flow was approximately 0.25 cfs. The instream habitat was mainly small pools and longer riffles, with a substrate of gravel and smaller portions of fines and cobbles, with scattered boulders breaking up the current. Much of the stream bank was meadowy, and clumps of water birch grew along the streamside, providing a moderate degree of canopy. A large number of stonefly (Plecoptera) nymphs were found in the substrate. Spawning was possible in the stream if the thaw occurred at the right time. A delta of fine gravel and silt had been pushed out into the lake off the stream mouth. The outflow stream for the lake was clogged with logs and silt for the first 10 m, broke out into a 15 m silt-bottomed pool 2 m wide and 0.15 m deep, seeped between 5 m of boulders, and finally opened up into a gravel/cobble/boulder bottomed stream with moss growing on the rocks, a partial willow/water birch canopy, and many young of the year trout present. During high spring flows the stream may allow spawning and a return to the lake afterward. There were also a few marshy seeps around the shoreline.

The lake shape was somewhat like that of a parallelogram, with the opposite sides roughly parallel but not square. The banks around 2/3 of the lake entered the lake at low angles, with the bottom only gradually deeper towards the middle of the lake. The banks of the south corner and the west side of the lake were much steeper, entering the water and dropping off to depth only a few meters from shore. The bottom composition of the nearshore areas was a layer of organic fines over boulders, logs, and fine gravel, except at the mouth of the inflowing stream, where the bottom was primarily fine gravel with a light layer of silt on top. In deeper water the organic layer of muck was heavier, and contained a high proportion of conifer needles and small woody debris, but underneath it were large boulders and logs, chiefly in the deepest area off the southwest corner of the lake. The water clarity was fairly good, with the Secchi disk clearly visible on the bottom in 4 m of water. The temperature profile did not indicate the presence of a thermocline in the deep area (Figure 13).

Very low densities of zooplankton were found in the lake. The most numerous of the mircrocrustaceans was Holopedium gibberum, a cladoceran, followed by Bosmina longirostris and Daphnia rosea. The copepods were poorly represented, with only a few cyclopoids found (APPENDIXES A and B). The kicknet samples of macroinvertebrates were made up mainly of odonate nymphs, some gastropods, and a few chironomid larvae, with a scattering of one or two individuals from five other orders (APPENDIX C). Eckman grab samples came up with 3 dipteran larvae and 3 hirudineans.

Aquatic plants cover much of the bottom of Hogan, although without a great deal of diversity. As usual, Sparganium was scattered along the shallows next to the banks. One stand of Typha, mostly eaten down by cattle, was growing out into the water on the southeast shore. Most of the rest of the lake bottom between the 0.5 and 2.5 m depths was covered in low, dense beds of Isoetes and Ranunculus.

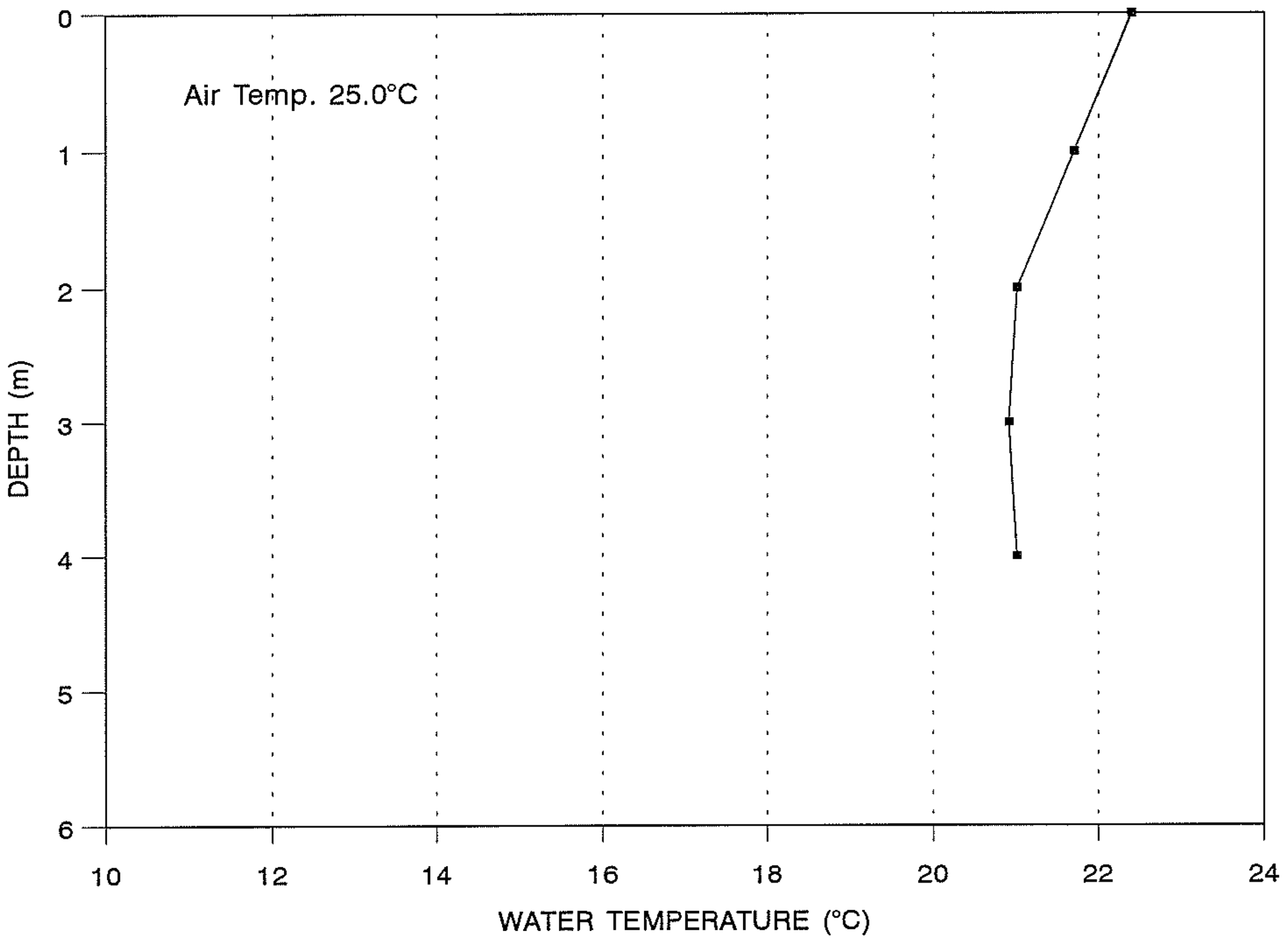

Figure 13. Temperature profile of Hogan Lake, Siskiyou County, California, 20 August 1987.

Sedges were growing around most of the lake margin, along with some willow clumps. Conifers and water birch grew down to the high water mark.

The lake supported a thriving brook trout population, producing chunky adults up to over 290 mm FL. The brook trout were obviously breeding successfully, probably using the clear gravel off the mouth of the inflow stream. They did not appear to be stunted. Newts were present in the lake, but only a few were counted on the transects. Other amphibians included a Pacific giant salamander larva caught in a kicknet, a probable adult Cascade frog spotted in the water off the mouth of the inflow stream, and a tadpole of the tailed frog, _Ascaphus truei_, caught in a kicknet in the inflow stream. Also seen around the lake were an osprey, an American dipper, _Cinclus mexicanus_, and a belted kingfisher, that was feeding on a school of YOY trout holding in the shallow water off the stream mouth. Human fishing pressure on the lake was probably moderate, since the trails into the area were not the best, but there were still some well used campsites around the lake.

Rainbow Trout Stocking and Growth

Average, back-calculated age 1+ rainbow trout fork lengths ranged from 107.1 mm in Cuddihy #4 Lake, to 177.7 mm in Clear Lake (Table 1). Mavis Lake received its initial

Table 1. Fork lengths (FL) back-calculated to age 1+ for rainbow trout sampled from 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Lake	Sample Size	Minimum FL (mm)	Maximum FL (mm)	Average FL (mm)	Standard Deviation
Clear	29	139.9	207.4	177.7	14.25
Blue Granite	41	133.3	191.7	164.8	14.37
West Boulder	31	128.2	185.5	160.6	13.48
Hogan	17	112.7	176.2	150.4	16.98
Meteor	31	108.6	165.0	141.2	16.63
Telephone	50	101.7	171.7	133.9	14.92
Steinacher	22	108.3	170.5	133.8	17.59
Section Line	39	111.2	150.9	130.4	10.02
Chimney Rock	36	102.7	149.6	129.5	11.59
Syphon	55	87.8	176.3	127.4	15.42
Cuddihy #4	47	84.0	129.3	107.1	10.38
Mavis	0	-	-	-	-

rainbow trout plant in the spring of 1987, and did not contain any rainbow trout older than age 0+ at the time of sampling (APPENDIX D). Average, back-calculated age 2+ fork lengths ranged from 137.9 mm to 246.5 mm, for Cuddihy #4 and Clear lakes, respectively (Table 2). No rainbow trout older than age 1+ was captured in Hogan Lake. Only one pair of lakes, Section Line and Steinacher, exchanged positions in the rankings from highest to lowest average fork lengths from age 1+ to age 2+, with Section Line moving from 7th to 6th place, and Steinacher switching from 6th to 7th place. The majority of the older fish caught in the lakes were 3+ years old, with only a few fish reaching 4+ years (Table 3). Only three rainbow trout were aged at greater than 4+ years.

In 1986 rainbow trout were stocked in 11 of the 12 lakes, at densities ranging from 385 fish/ha in Syphon Lake to 654 fish/ha in Chimney Rock Lake (APPENDIX D). Mavis Lake received combined stockings of brown and brook trout for a density of 1744 fish/ha. The Chimney Rock and Mavis Lake plantings were not planned for this study, since those lakes were not selected for the study until 1987, but were part of the CDFG regular schedule of high lake plants. Rainbow trout plants in 1985, 1984, and 1983 ranged from 0 to 1235 fish/ha, 149 to 1818 fish/ha, and 0 to 1307 fish/ha, respectively (APPENDIX D). The widely varying stocking densities were the result of differing stocking schedules

Table 2. Fork lengths (FL) back-calculated to age 2+ for rainbow trout sampled from 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Lake	Sample Size	Minimum FL (mm)	Maximum FL (mm)	Average FL (mm)	Standard Deviation
Clear	18	217.5	297.8	246.5	16.10
Blue Granite	21	211.8	281.0	239.9	16.80
West Boulder	10	213.9	239.7	224.4	8.64
Hogan	0	-	-	-	-
Meteor	20	183.8	224.6	201.6	10.32
Telephone	39	157.7	220.8	185.0	13.41
Steinacher	18	134.2	187.0	168.6	11.55
Section Line	16	133.0	198.7	170.2	18.98
Chimney Rock	27	146.3	199.8	167.5	13.94
Syphon	40	131.7	198.2	164.0	17.30
Cuddihy #4	42	111.5	170.2	137.9	11.15
Mavis	0	-	-	-	-

Table 3. Age structure and year stocked for rainbow trout sampled from 12 high mountain lakes, Siskiyou County, California, by sample year, 1986-1987.

	Rainbow Trout Ages Year Stocked									
	1986					1987				
Lake	1+ 1985	2+ 1984	3+ 1983	4+ 1982	5+ 1981	1+ 1986	2+ 1985	3+ 1984	4+ 1983	5+ 1982
Clear	3	1	2	-	-	8	5	8	2	-
Blue Granite	8[a]	1	-	-	-	12	18[a]	2	-	-
West Boulder	4	-	-	-	-	17	10	-	-	-
Hogan	1	-	-	-	-	17	-	-	-	-
Meteor	4	5	1	-	-	7	12	2	-	-
Telephone	6	4	7	-	-	5	18	6	4	-
Steinacher	-	4	-	-	-	5	12	2	-	-
Section Line	5	2	1	-	1	18	4	6	2	-
Chimney Rock	-	-	-	-	-	9	6	13	8	-
Syphon	7	5	11	2	-	8	14	6	-	2
Cuddihy #4	3	4	-	-	-	5	-	32	3	-
Mavis	-	-	-	-	-	-	-	-	-	-

[a] No record of an aerial plant in Blue Granite Lake in 1985; may indicate natural spawning success.

prior to this study and the planting of same-sized allotments of fish without regard to lake size.

Lake Physical Parameters

The lakes were located at elevations from 1600 m at Blue Granite Lake, to 2210 m at Syphon Lake, with an average elevation of 1914 m (Table 4). Lake surface areas averaged 2.05 hectares. The largest lake was Blue Granite, with a surface of 4.80 ha, while the smallest lakes were Section Line, Steinacher, and Syphon, all at 1.04 ha (Table 4). Lake drainage areas averaged 49.89 ha, varying from the steep-walled, 7.23 ha cirque around Section Line Lake, to the 173.07 ha triple cirque complex that drains into Hogan Lake (Table 4). Drainage area to surface area ratios were lowest at West Boulder Lake, at 5.75, and highest at Hogan Lake, with 51.66, with a mean of 19.85 (Table 4). The drainage areas for Hogan and West Boulder lakes were outliers. An upper lake basin, which constituted approximately 50% of the Hogan Lake drainage area, probably acted as a nutrient trap, effectively reducing the drainage area to 86.54 ha and the drainage area/surface area ratio to 25.83. West Boulder Lake contained subsurface springs, that may have fed water into the lake from a much greater area than was apparent on the surface. Average lake depth ranged from 0.91 m for Steinacher Lake, to 7.01 m for Clear Lake, averaging 4.09 m (Table 4). Maximum lake depth varied from

Table 4. Physical parameters for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Lake	Elevation (m)	Surface Area (ha)	Drainage Area (ha)	Drainage/ Surface Ratio	Average Depth (m)	Maximum Depth (m)	Lake Axis (deg.)	Sun Arc (deg.)
Clear	1768	3.09	96.57	31.25	7.01	18.90	100	165
Blue Granite	1600	4.80	155.47	32.39	4.88	8.08	163	150
West Boulder	2140	2.61	15.02	5.75	6.40	9.75	146	150
Hogan	1811	3.35	173.07	51.66	2.13	5.49	100	133
Meteor	1753	1.65	32.62	19.77	1.83	3.05	268	157
Telephone	2109	1.62	19.98	12.33	7.01	9.75	156	164
Steinacher	1768	1.04	28.42	27.33	0.91	1.83	180	125
Section Line	2164	1.04	7.23	6.95	3.35	5.49	150	148
Chimney Rock	1865	1.53	28.42	18.58	4.88	6.71	170	152
Syphon	2210	1.04	13.93	13.39	4.57	6.71	260	158
Cuddihy #4	1737	1.10	7.71	7.01	3.05	6.86	257	158
Mavis	2043	1.71	20.19	11.74	3.05	4.88	163	153
AVERAGE	1914	2.05	49.89	19.85	4.09	7.29	176	151

1.83 m for Steinacher Lake, to 18.90 m for Clear Lake, with a mean of 7.29 m (Table 4). The average lake axis orientation was 176 degrees, with measurements ranging from 100 degrees for Clear and Hogan lakes, to 268 degrees for Meteor Lake (Table 4). Sun arc was measured from 125 degrees for Steinacher Lake, to 165 degrees for Clear Lake, averaging 151 degrees (Table 4).

Lake Chemical Parameters

Hach kit test results for orthophosphate (PO_4) and nitrite (NO_2) indicated that the levels of those compounds in the lakes were below the sensitivity of the kits (Table 5). Nitrate (NO_3) levels were also at the extreme low end of the test kit range, so that the difference in nitrate concentrations between the lakes was not accurately measured (Table 5). Oxygen concentrations from below the thermocline or at the deepest point of each lake ranged from 7 to 10 mg/l, averaging 8.7 mg/l (Table 5). Alkalinity values, which measured calcium carbonate ($CaCO_3$) concentrations, averaged 23.1 mg/l, the lowest concentrations being 13.6 mg/l at Syphon and Cuddihy #4 lakes, and the highest concentration being 36.7 mg/l at Telephone Lake (Table 5). Average pH values ranged from 6.8, at Cuddihy #4, to 8.4, from Telephone, averaging at 7.6 (Table 5). Conductivity was lowest in Chimney Rock Lake, at 6.2 μmhos, and highest at Telephone, at 30.6 μmhos, with a

Table 5. Average water chemistry values for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

	CaCO3 (mg/l)	NO3 (mg/l)	NO2 (mg/l)	PO4 (mg/l)	O2 (mg/l)	pH	Conductivity (µmhos/cm)
Clear	27.2	8.8	0.0	0.33	7	7.09	16.8
Blue Granite	20.4	4.4	0.0	0.0	10	7.42	17.6
West Boulder	27.2	4.4	0.0	0.0	10	7.60	16.4
Hogan	23.1	4.4	0.0	0.33	9	7.60	15.0
Meteor	27.2	8.8	0.0	0.0	7	7.25	17.0
Telephone	36.7	6.2	0.0	0.33	10	8.40	30.6
Steinacher	27.2	8.8	0.0	0.33	8	7.76	21.0
Section Line	20.4	4.4	0.0	0.33	8	7.43	10.4
Chimney Rock	16.3	4.4	0.0	0.33	10	6.94	6.2
Syphon	13.6	4.4	0.0	0.0	9	7.40	6.6
Cuddihy #4	13.6	8.8	0.0	0.0	8	6.83	11.8
Mavis	24.5	4.4	0.0	0.33	8	7.37	16.6
AVERAGE	23.1	6.0	0.0	0.19	8.7	7.65	15.5

mean of 15.5 μmhos (Table 5). The chemical parameters from Telephone Lake were well outside the "normal" range of values, and were deemed outliers, at least for pH, conductivity, and $CaCO_3$.

Lake Biological Parameters

Aquatic macrophytes were found in all of the study lakes (APPENDIX E). Of the nine genera identified only Isoetes was observed in all of the lakes. Syphon Lake contained only sparse stands of Isoetes, while Clear Lake had seven plant genera, one of which, Potamogeton, appeared to have two species present (APPENDIX E). The average number of genera was 3.5 (Table 6).

The "meadow ratio" parameter ranged from 0.0 for West Boulder Lake, to 2.7, for Hogan Lake, with a mean of 1.1 (Table 6). The 0.0 meadow ratio for West Boulder Lake was questionable, in that nutrients normally supplied to the lake by a wet meadow might have been supplied by subsurface springs.

The number of aquatic invertebrate orders identified from stomach, kicknet and Eckman grab samples ranged from 8 in Cuddihy #4 Lake, to 15 in Clear and West Boulder lakes, averaging 12.4 (Table 7 and APPENDIX F). No Gammarus sp. were found in any of the lakes. The total number of invertebrate orders found in all size class stomach samples for each lake averaged 17.3, with a low of 13 orders

Table 6. Biological parameters for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

	Total Plankton Species	Cladocera Species	Average No. Newts/ 10 m Transect	Aquatic Plant Genera	Meadow Ratio[a]
Clear	6	4	24	7	1.76
Blue Granite	7	5	34	6	2.23
West Boulder	3	2	0	3	0.00
Hogan	5	4	2	4	2.72
Meteor	6	4	14	4	1.83
Telephone	6	4	0	3	0.88
Steinacher	6	4	17	3	2.10
Section Line	4	2	0	3	0.04
Chimney Rock	7	5	14	4	0.34
Syphon	3	2	1	1	0.06
Cuddihy #4	6	4	3	2	0.56
Mavis	6	4	0	2	0.21
AVERAGE	5.4	3.7	14	3.5	1.06

[a] Combined estimated area of seeps, wet meadows, willow/water birch groves, and shallow ponds in the given lake drainage, divided by the lake surface area.

Table 7. Invertebrate parameters for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

	Invertebrate Orders						
	From Trout Stomach Samples All Size Classes			From Trout Stomach Samples Age 1+ Size Class			S/K/E[a] Techniques
Lake	Total	Aquatic	Terrestrial	Total	Aquatic	Terrestrial	Aquatic
Clear	17	12	5	12	9	3	15
Blue Granite	15	10	5	15	10	5	13
West Boulder	23	13	10	19	9	10	15
Hogan	17	8	9	17	8	9	11
Meteor	15	8	7	11	7	4	13
Telephone	17	11	6	15	9	6	14
Steinacher	20	12	8	18	11	7	14
Section Line	19	10	9	17	8	9	12
Chimney Rock	16	8	8	13	7	6	10
Syphon	19	10	9	16	7	9	10
Cuddihy #4	13	7	6	2	2	0	8
Mavis	17	10	7	12	5	7	14
AVERAGE	17.3	9.9	7.4	13.9	7.7	6.3	12.4

[a] Collected from stomach, kicknet, and Eckman grab samples.

identified from Cuddihy #4 Lake, and a high of 23 orders from West Boulder Lake (Table 7). The number of aquatic invertebrate orders found in the combined stomach samples varied from seven for Cuddihy #4, to 13 for West Boulder Lake, with a mean of 9.9 (Table 7). Clear and Blue Granite lakes rainbow trout of all size classes consumed members of only five orders of terrestrial invertebrates, compared to an average of 7.4 orders, and a high of 10 terrestrial orders from West Boulder Lake fish (Table 7; APPENDIX G). Age 1+ size class trout stomachs for each lake contained an average of 13.9 invertebrate orders, with a low of two orders from Cuddihy #4 Lake, and a high of 19 orders for West Boulder Lake (Table 7). Aquatic invertebrate orders from age 1+ size class trout stomachs ranged from two for Cuddihy #4 Lake, to 11 from Steinacher Lake, with an average of 7.7 orders (Table 7; APPENDIX H). Terrestrial invertebrate orders from age 1+ size class trout stomachs ranged from zero from Cuddihy #4 Lake, to 10 at West Boulder Lake, averaging at 6.3 orders (Table 7; APPENDIX I).

The distribution and abundance of zygopterans (damselflies) and ancylids (freshwater limpets) followed patterns different from those of the other aquatic invertebrate orders identified in the stomach samples (APPENDIXES J and K). Zygopterans were abundant in the diets of the trout in four of the top five growth rate lakes and absent or in low numbers in trout stomachs from five of the six lowest growth rate lakes. Ancylids were in moderate to high numbers in trout stomachs from the same four of the top five lakes and absent from fish stomachs of the six slower growth rate lakes. Trout from lakes with slower growth rates appeared to have consumed a greater number and variety of small terrestrial invertebrates than trout in all the higher growth rate lakes except West Boulder Lake (APPENDIX L). This was particularly evident in Syphon and Section Line lakes, which were also the highest elevation lakes in the study. Stomach samples from West Boulder Lake, which had the third highest trout growth rate, differed from samples from the four other high growth rate lakes in all three of the categories just mentioned. West Boulder samples contained very few zygopterans, no ancylids, and a large quantity and variety of terrestrial invertebrates from numerous orders (APPENDIXES K and L). All of those features were shared with the lowest trout growth rate lakes. It should be noted that West Boulder was the third highest elevation lake, at essentially the same altitude as Section Line Lake, which was in a neighboring drainage.

The number of zooplankton species captured in the lakes ranged from three for Syphon and West Boulder lakes, to seven for Blue Granite and Chimney Rock lakes, averaging 5.4 (Table 6). The number of cladoceran species identified in each lake varied from two in Section Line, Syphon, and West Boulder lakes, to five in Blue Granite and Chimney Rock lakes, averaging 3.7 (Table 6). West Boulder Lake was again different from the other high trout growth rate lakes in having noticeably fewer cladoceran and other zooplankton species.

No newts were observed in Mavis, Section Line, Telephone, or West Boulder lakes. The absence of newts from the four lakes appeared to be related to the fact that their stream drainages flowed into the upper Scott River. The average number of newts counted along 10 m transects in the other eight lakes was 14, with a high of 34 newts per transect in Blue Granite Lake, and a low average of one per transect in Syphon Lake (Table 6).

Correlation Analyses

Productivity-measuring Parameters

Simple correlations were tested between rainbow trout fork lengths at age 1+ and parameters thought to reflect overall lake productivity rather than directly affect trout growth (Table 8). Rainbow trout age 2+ fork length was added to the list more for comparison, but not as a parameter. As previously mentioned, age 1+ and age 2+ fork lengths were highly correlated, with a Pearson coefficient of 0.982 ($r_{0.05(2),8}=0.632$) (Table 8; Figure 14). The analyses indicated that the number of aquatic plant genera (r=0.804), the number of aquatic invertebrate orders eaten by age 1+ size class trout (r=0.643), and the total

Table 8. Simple correlation analyses for productivity-measuring parameters correlated with average age 1+ rainbow trout fork lengths (FL) sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Parameter	Pearson Coefficient	H_0 : r = 0 Significance Probability	Number of Observations	Degrees Freedom	Critical Value $r_{0.05(2),df}$
Age 2+ FL	0.982	0.0001	10.00	8.00	0.632
Aquatic Plant Genera	0.804	0.0029	11.00	9.00	0.602
Newts per Transect	0.697	0.0549	8.00	6.00	0.707
Aquatic Invert.[a]	0.545	0.0831	11.00	9.00	0.602
Terrestrial Invert.[b]	-0.204	0.5471	11.00	9.00	0.602
Total Invertebrates[c]	0.259	0.4418	11.00	9.00	0.602
Aqua. Invert. Age 1+[d]	0.643	0.0328	11.00	9.00	0.602
Terr. Invert. Age 1+[e]	0.153	0.6528	11.00	9.00	0.602
Total Invert. Age 1+[f]	0.418	0.2002	11.00	9.00	0.602
Aqua. Invert. S/K/E[g]	0.737	0.0097	11.00	9.00	0.602
Zooplankton Species	0.034	0.9215	11.00	9.00	0.602
Cladocera Species	0.104	0.7600	11.00	9.00	0.602

[a] Aquatic invertebrate orders identified from all trout stomachs/lake.
[b] Terrestrial invertebrate orders identified from all trout stomachs/lake.
[c] All invertebrate orders identified from all trout stomachs/lake.
[d] Aquatic invertebrate orders identified from age 1+ size class trout stomachs/lake.
[e] Terrestrial invertebrate orders identified from age 1+ size class trout stomachs/lake.
[f] All invertebrate orders identified from age 1+ size class trout stomachs/lake.
[g] Aquatic invert. orders identified from stomach, kicknet, and Eckman grab samples/lake.

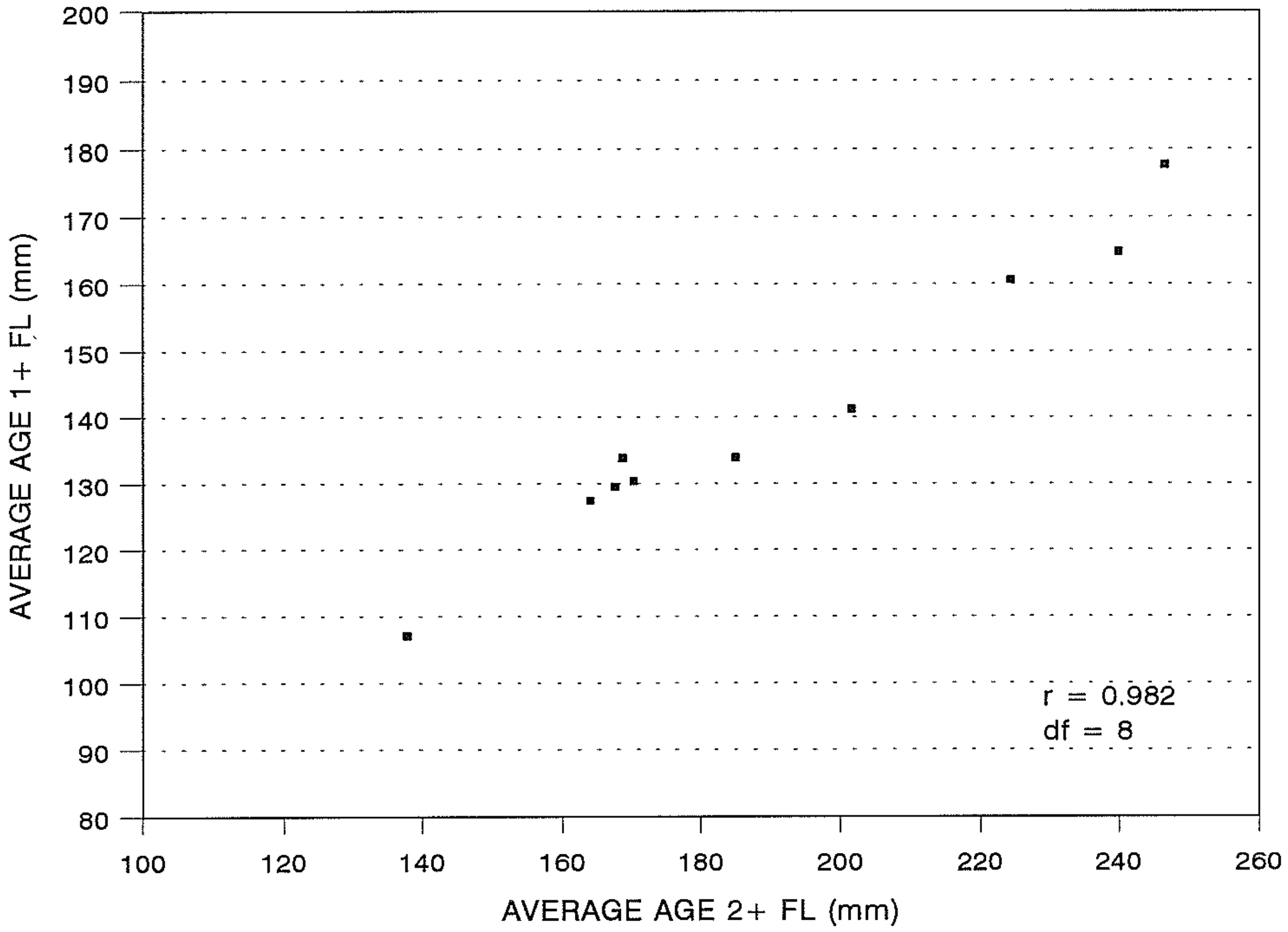

Figure 14. Average age 2+ rainbow trout fork lengths correlated with average age 1+ rainbow trout fork lengths for 10 northern California (Siskiyou County) high mountain lakes

number of aquatic invertebrate orders gathered by all techniques except zooplankton nets (r=0.737) were significantly correlated with age 1+ fork lengths ($r_{0.05(2),9}$=0.602) (Table 8; Figures 15-17), while the average number of newts per transect (r=0.697) and the number of aquatic invertebrate orders from all stomach samples per lake (r=0.545) were bordering on significant correlations with age 1+ fork lengths ($r_{0.05(2),6}$=0.707 and $r_{0.05(2),9}$=0.602, respectively) (Table 8). Correlations between age 2+ fork lengths and the list of parameters followed much the same pattern, except for the newts (Table 9). The newt density Pearson coefficient rose from 0.707 to 0.854 ($r_{0.05(2),5}$=0.755) (Table 8 and 9; Figures 18 and 19), becoming significantly correlated with age 2+ fork lengths. The change was probably due to the loss of Hogan Lake, which had no age 2+ rainbows and had a very low newt count in the age 1+ analysis (Table 6).

Productivity-influencing Parameters

Parameters thought to influence lake productivity rather than directly reflecting the productivity of the lakes were also analysed using simple correlation analysis (Table 10). Density dependent factors appeared to strongly affect the growth of the trout, with the 1984 stocking densities and average stocking densities having Pearson coefficients of -0.846 and -0.697, respectively ($r_{0.05(2),9}$=0.602) (Table 10; Figures 20 and 21). When the

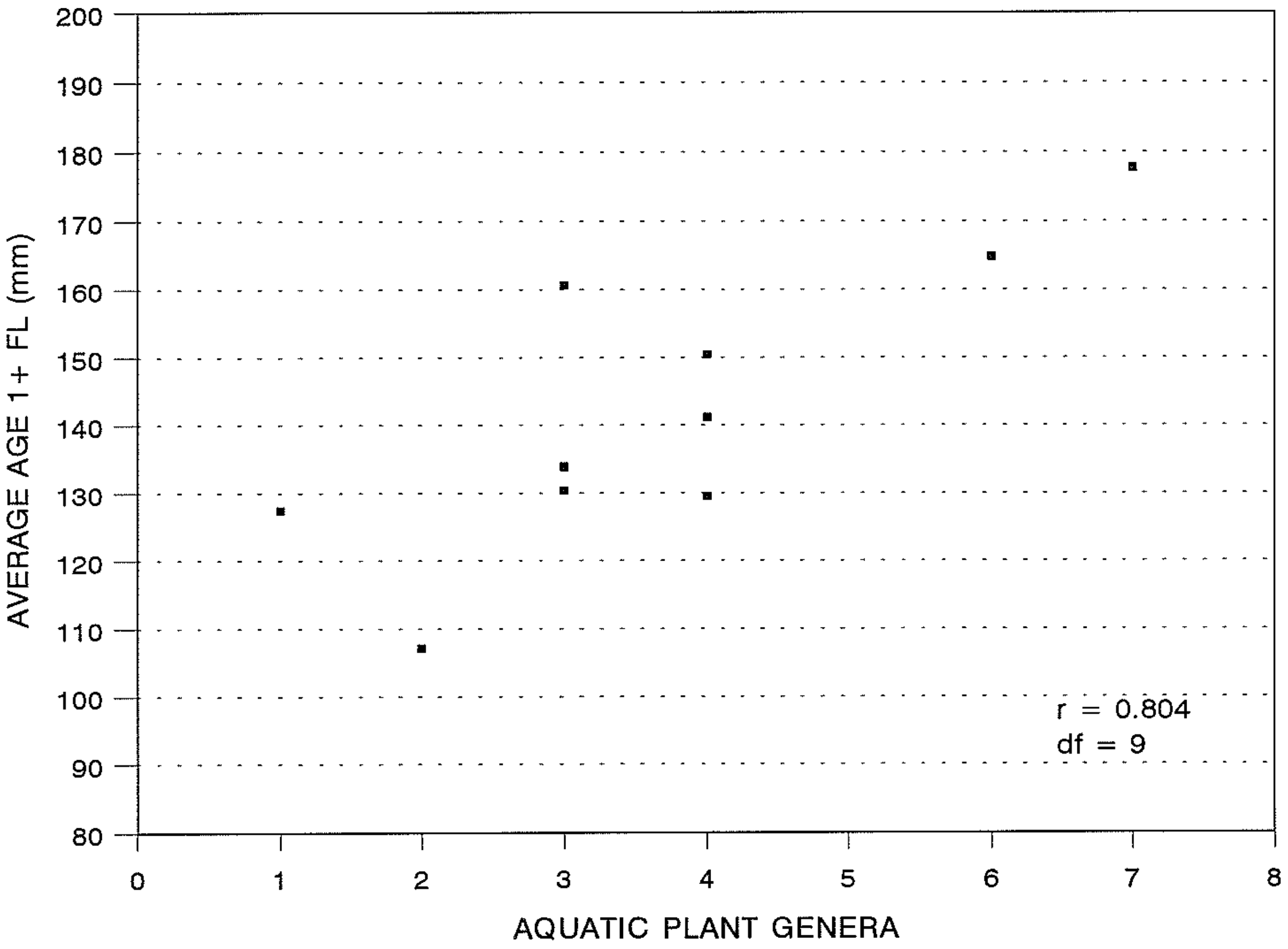

Figure 15. Aquatic plant genera correlated with average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

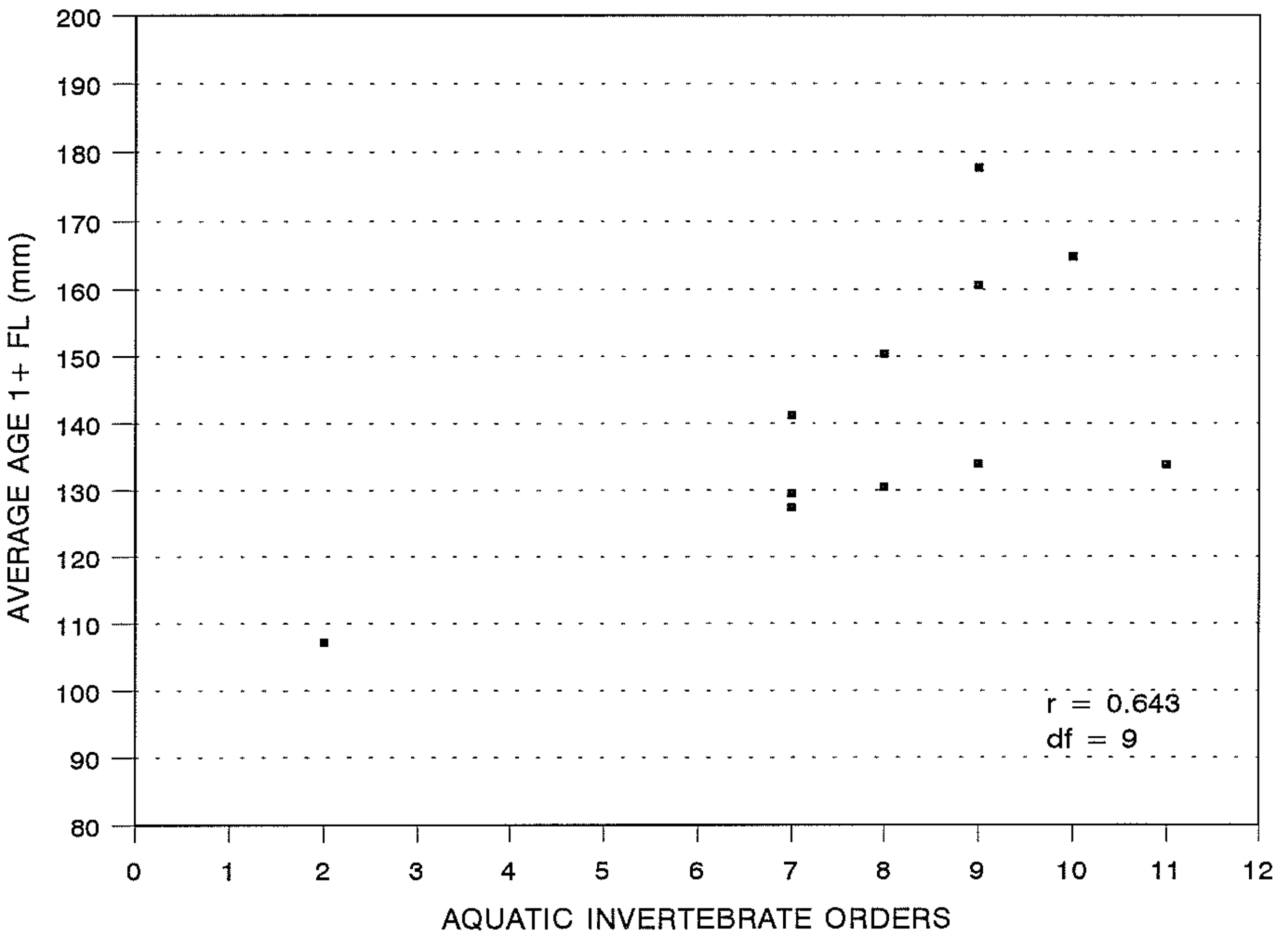

Figure 16. Aquatic invertebrate orders from age 1+ size class stomachs correlated with average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

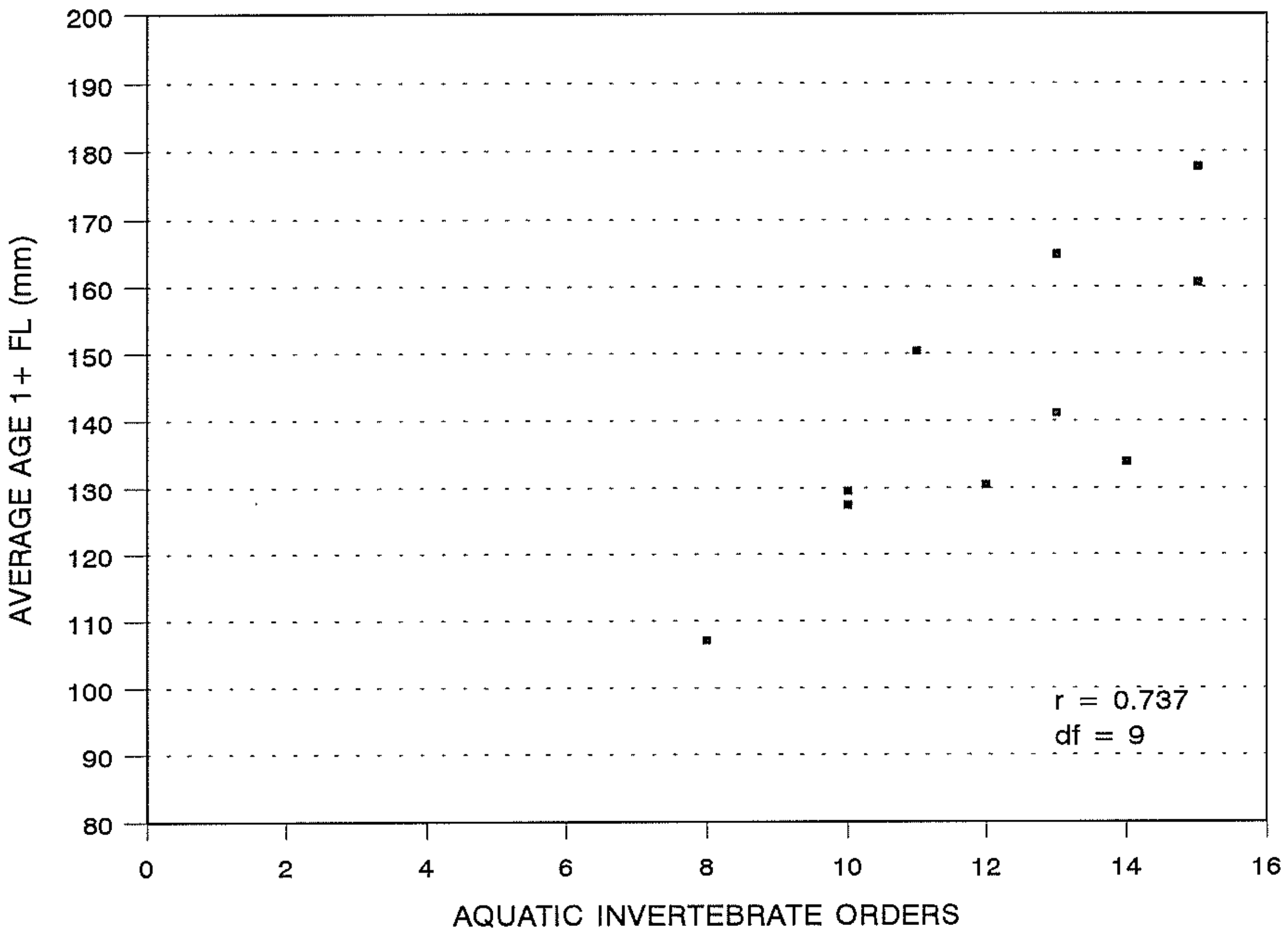

Figure 17. Aquatic invertebrate orders from stomach, Eckman, and kicknet samples correlated with average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

Table 9. Simple correlation analyses for productivity-measuring parameters correlated with average age 2+ rainbow trout fork lengths (FL) sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Parameter	Pearson Coefficient (r)	H_0 : r = 0 Significance Probability	Number of Observations	Degrees Freedom	Critical Value $r_{0.05(2),df}$
Aquatic Plant Genera	0.805	0.0049	10.00	8.00	0.632
Newts per Transect	0.854	0.0143	7.00	5.00	0.755
Aquatic Invert.[a]	0.540	0.1072	10.00	8.00	0.632
Terrestrial Invert.[b]	-0.330	0.3519	10.00	8.00	0.632
Total Invertebrates[c]	0.165	0.6491	10.00	8.00	0.632
Aqua. Invert. Age 1+[d]	0.589	0.0745	10.00	8.00	0.632
Terr. Invert. Age 1+[e]	0.050	0.8919	10.00	8.00	0.632
Total Invert. Age 1+[f]	0.329	0.3537	10.00	8.00	0.632
Aqua. Invert. S/K/E[g]	0.759	0.0109	10.00	8.00	0.632
Zooplankton Species	0.092	0.8000	10.00	8.00	0.632
Cladocera Species	0.137	0.7052	10.00	8.00	0.632

[a] Aquatic invertebrate orders identified from all trout stomachs/lake.
[b] Terrestrial invertebrate orders identified from all trout stomachs/lake.
[c] All invertebrate orders identified from all trout stomachs/lake.
[d] Aquatic invertebrate orders identified from age 1+ size class trout stomachs/lake.
[e] Terrestrial invertebrate orders identified from age 1+ size class trout stomachs/lake.
[f] All invertebrate orders identified from age 1+ size class trout stomachs/lake.
[g] Aquatic invert. orders identified from stomach, kicknet, and Eckman grab samples/lake.

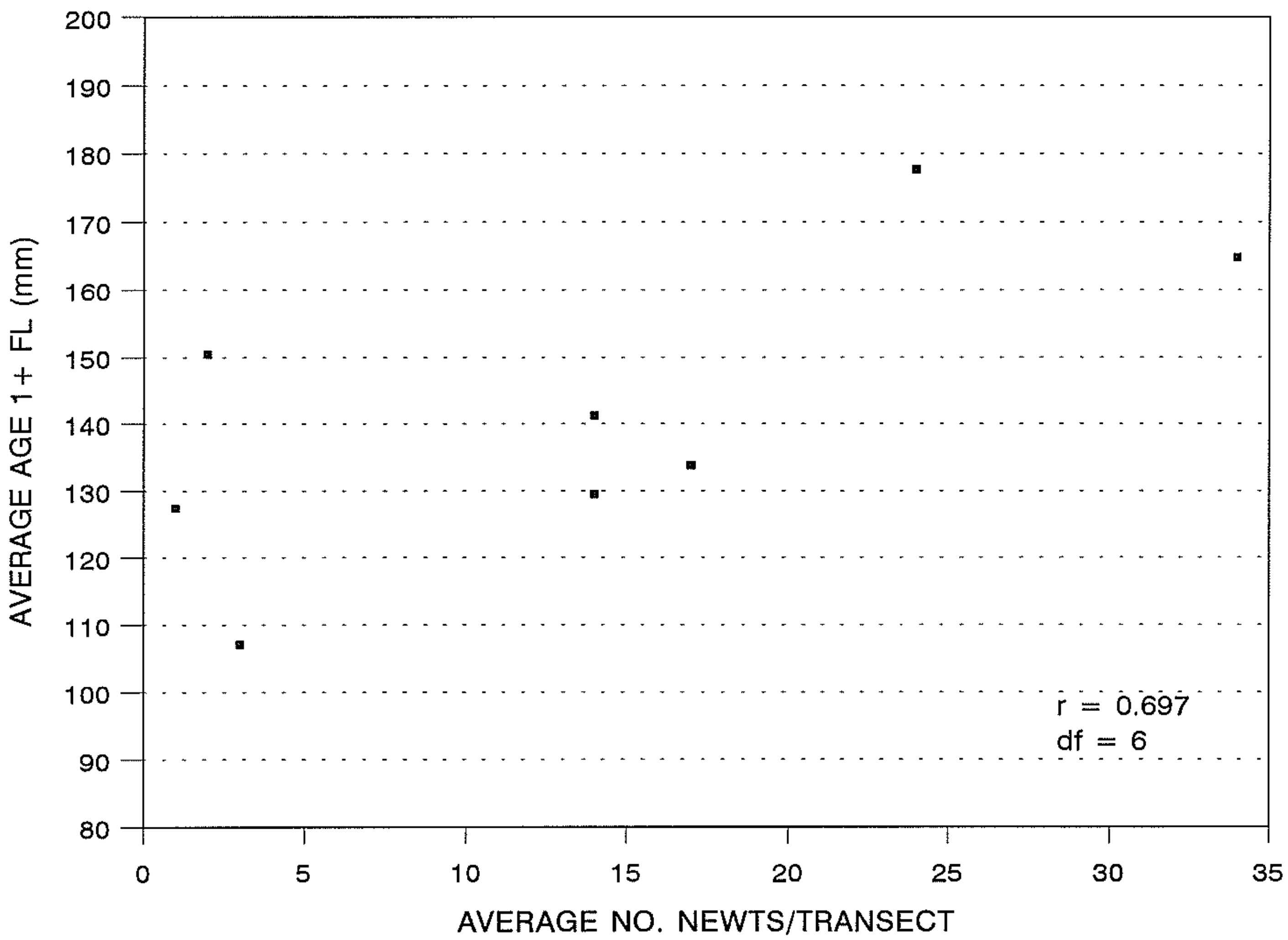

Figure 18. Average number of newts per 10 m transect correlated with average age 1+ rainbow trout fork lengths for eight northern California (Siskiyou County) high mountain lakes.

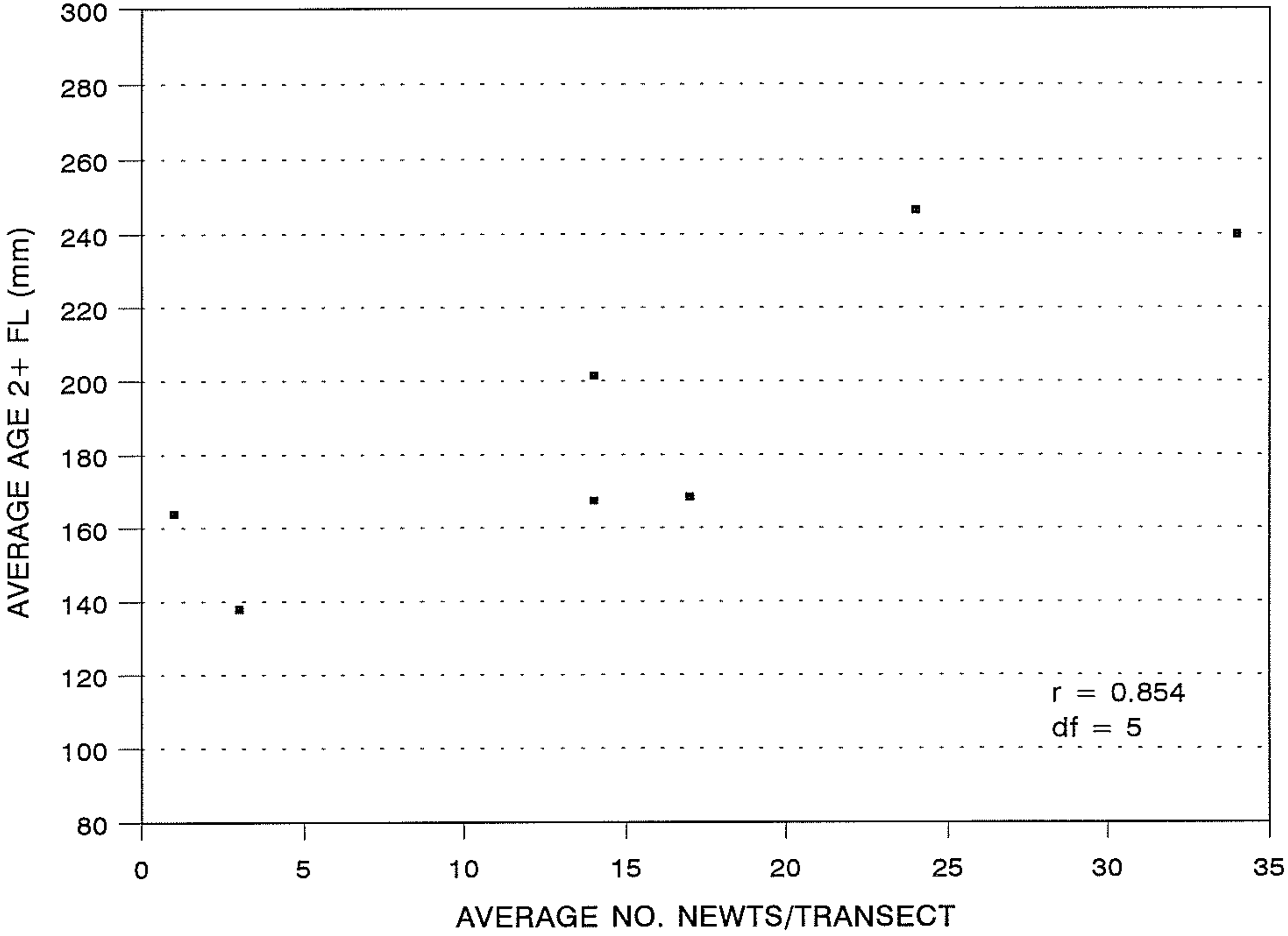

Figure 19. Average number of newts per 10 m transect correlated with average age 2+ rainbow trout fork lengths for seven northern California (Siskiyou County) high mountain lakes.

Table 10. Simple correlation analyses for productivity-influencing parameters correlated with average age 1+ rainbow trout fork lengths (FL) sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Parameter	Pearson Coefficient (r)	H_0 : r = 0 Significance Probability	Number of Observations	Degrees Freedom	Critical Value $r_{0.06(2),df}$
Stocked Density 1986	0.281	0.4032	11.00	9.00	0.602
Stocked Density 1985	-0.158	0.6430	11.00	9.00	0.602
Stocked Density 1984	-0.846	0.0010	11.00	9.00	0.602
Stocked Density 1983	-0.686	0.0198	11.00	9.00	0.602
Ave. Stocked Density	-0.697	0.0172	11.00	9.00	0.602
Elevation	-0.229	0.4980	11.00	9.00	0.602
Surface Area	0.802	0.0030	11.00	9.00	0.602
Drainage Area	0.628	0.0386	11.00	9.00	0.602
Drainage/Surf. Area	0.496	0.1203	11.00	9.00	0.602
Average Depth	0.427	0.1906	11.00	9.00	0.602
Maximum Depth	0.600	0.0509	11.00	9.00	0.602
Lake Axis	-0.648	0.0311	11.00	9.00	0.602
Sun Arc	0.035	0.9189	11.00	9.00	0.602
Meadow/Surface Area	0.450	0.1653	11.00	9.00	0.602
pH	0.107	0.7548	11.00	9.00	0.602
Conductivity	0.269	0.4246	11.00	9.00	0.602
Alkalinity	0.424	0.1938	11.00	9.00	0.602
Nitrate	-0.095	0.7813	11.00	9.00	0.602
Nitrite	-	-	11.00	-	-
Orthophosphate	0.061	0.8578	11.00	9.00	0.602
Dissolved Oxygen	0.017	0.9596	11.00	9.00	0.602

Table 10. Simple correlation analyses for productivity-influencing parameters correlated with average age 1+ rainbow trout fork lengths (FL) sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987 (continued).

Parameter	Pearson Coefficient (r)	H_0 : r = 0 Significance Probability	Number of Observations	Degrees Freedom	Critical Value $r_{0.05(2),df}$
Drainage Area[a]	0.845	0.0021	10.00	8.00	0.632
Drainage/Surf. Area[a]	0.838	0.0025	10.00	8.00	0.632
Meadow/Surface Area[b]	0.644	0.0444	10.00	8.00	0.632
pH[c]	0.304	0.3924	10.00	8.00	0.632
Conductivity[c]	0.535	0.1114	10.00	8.00	0.632
Alkalinity[c]	0.668	0.0347	10.00	8.00	0.632

[a] Minus West Boulder Lake; Hogan Lake drainage area reduced 50%.
[b] Minus West Boulder Lake.
[c] Minus Telephone Lake.

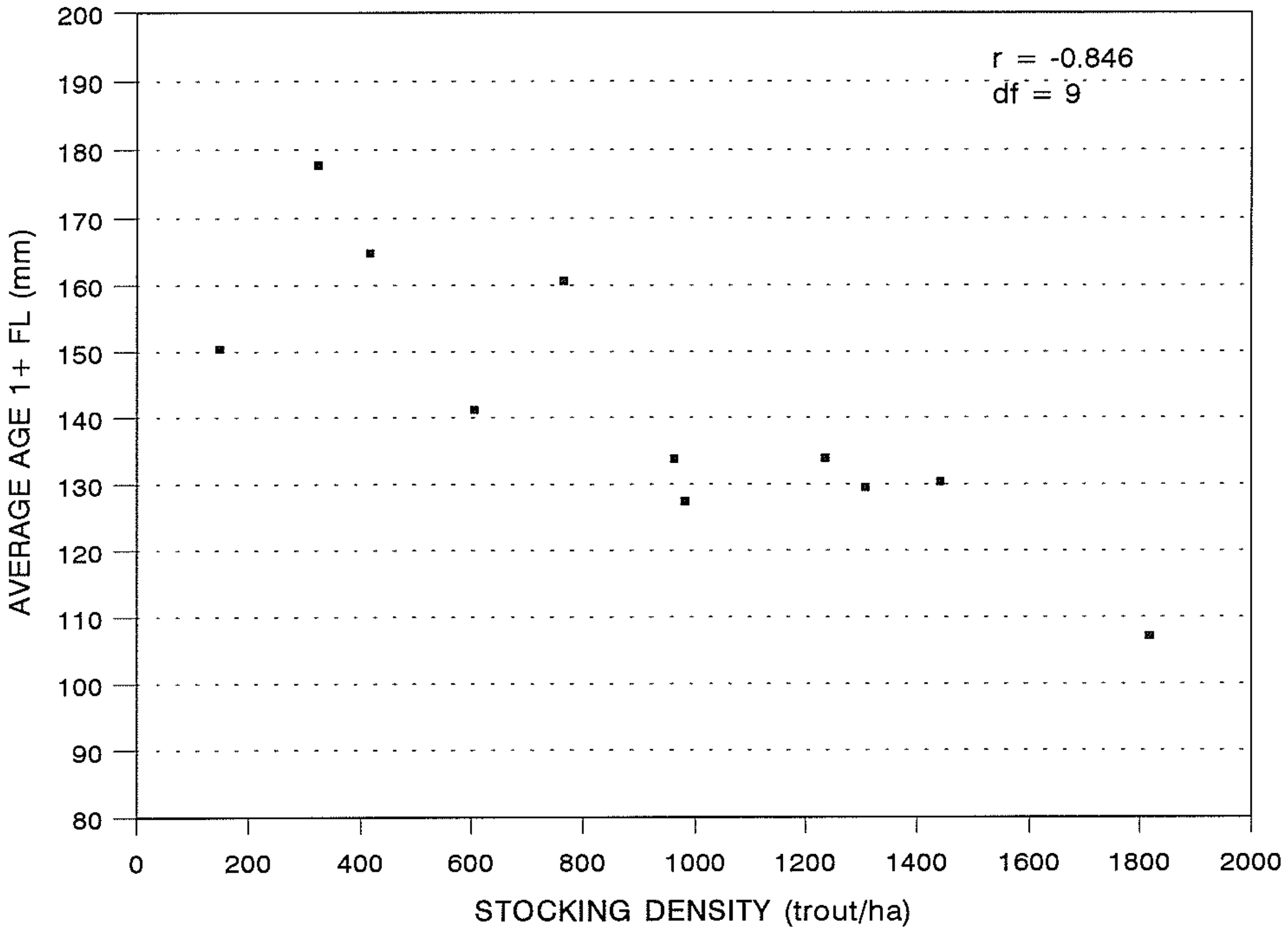

Figure 20. 1984 stocking densities correlated with average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

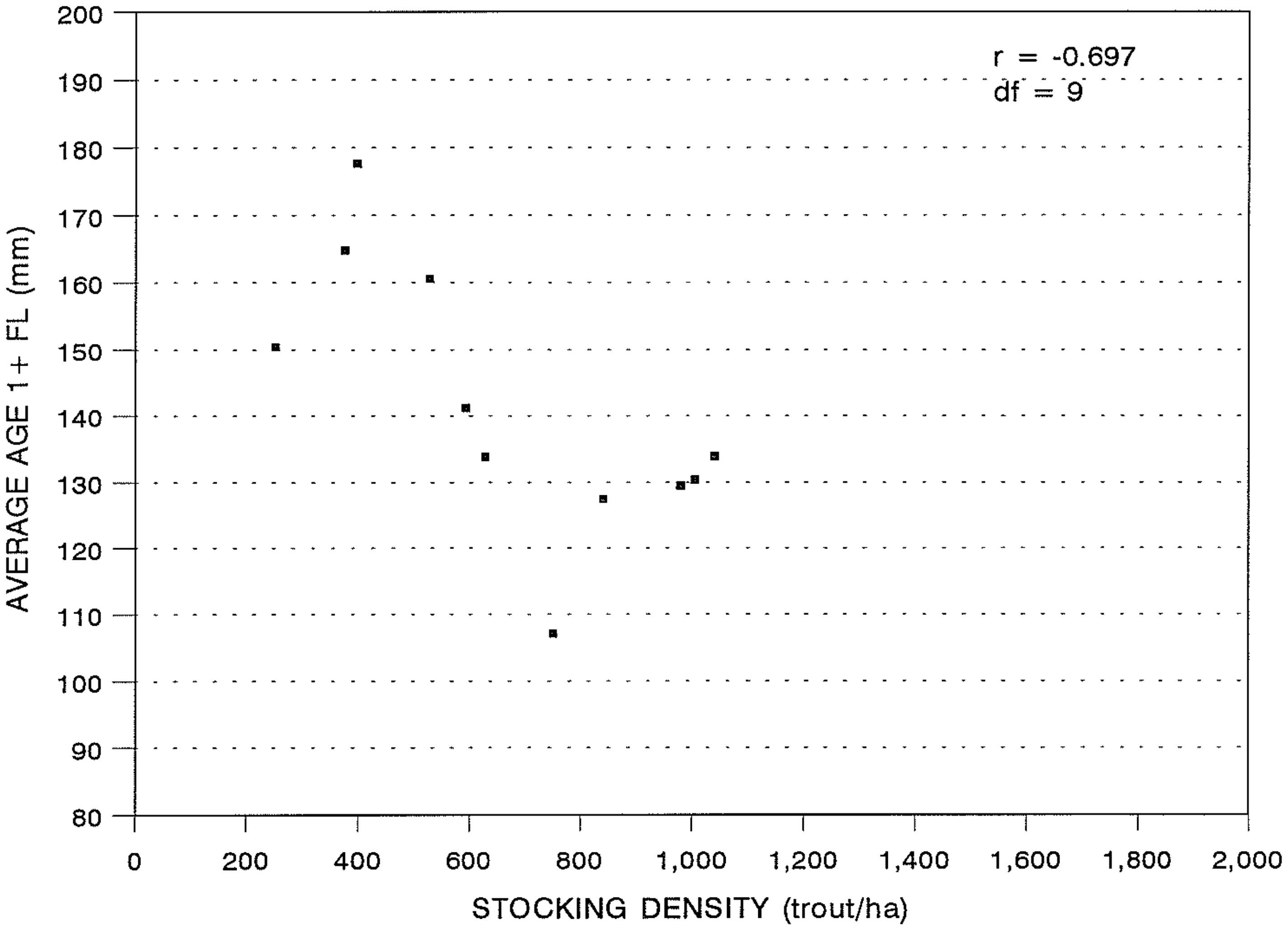

Figure 21. Average stocking densities correlated with average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

average age 1+ lengths were broken down by year class (Table 11) and correlated with their respective year's stocking densities, the r value for the combined data set was -0.608 ($r_{0.05(2),33}$=0.334) (Table 12). The data sets from 1983, 1984, 1985, and 1986 yielded r values of -0.668, -0.922, -0.513, and 0.341, respectively (Table 12; Figure 22). The 1984 data set was significantly correlated with the 1984 age 1+ fork lengths ($r_{0.05(2)7}$=0.666). Correlations between the 1985 and 1986 year class average age 1+ FL and the 1984 stocking densities resulted in significant Pearson coefficients of -0.776 and -0.719, respectively (Table 12; Figures 23 and 24).

The surface area of the lakes, used to calculate the stocking densities, had a significant Pearson coefficient of 0.802, when correlated with age 1+ fork lengths (Table 10). Correlations of the age 1+ trout sizes with the remaining 15 unmodified parameters resulted in significant r values for drainage area, maximum depth, and lake axis (r=0.628, 0.600, and -0.648, respectively, $r_{0.05(2),9}$=0.602) (Table 10). The removal of the West Boulder Lake datum as an outlier from the lake drainage and lake drainage/surface (D/S) area ratio parameters, along with the reduction of the overall Hogan Lake drainage area by 50% in those parameters, resulted in the r values increasing for the drainage and D/S ratio parameters, from 0.628 and 0.496 to 0.845 and 0.838, respectively ($r_{0.05(2)8}$=0.632) (Table 10; Figures 25 and 26).

Table 11. Average age 1+ fork lengths (FL) in millimeters and sample size (SS) of rainbow trout, by year class, for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Lake	1986 FL (SS)	1985 FL (SS)	1984 FL (SS)	1983 FL (SS)	1982 FL (SS)	1981 FL (SS)
Clear	183.2 (8)	176.0 (8)	174.0 (9)	178.6 (4)	-	-
Blue Granite	163.8 (12)	165.8 (26)	156.3 (3)	-	-	-
West Boulder	156.4 (17)	165.8 (14)	-	-	-	-
Hogan	150.4 (17)	-	-	-	-	-
Meteor	149.3 (7)	133.5 (16)	147.7 (7)	163.4 (1)	-	-
Telephone	153.7 (5)	139.3 (24)	131.2 (10)	115.4 (11)	-	-
Steinacher	165.9 (4)	-	128.9 (16)	108.5 (2)	-	-
Section Line	129.6 (18)	133.2 (9)	131.1 (8)	131.1 (3)	-	111.2 (1)
Chimney Rock	142.3 (9)	130.1 (6)	124.6 (13)	122.5 (8)	-	-
Syphon	125.0 (8)	138.3 (21)	127.9 (11)	114.8 (11)	107.5 (4)	-
Cuddihy #4	113.1 (5)	-	106.7 (35)	104.9 (7)	-	-
Mavis	-	-	-	-	-	-

Table 12. Simple correlation analyses for yearly stocking densities correlated with average rainbow trout age 1+ fork lengths, by year class, sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Stocking Density Year(s)	Age 1+ Fork Length Year Class(es)	Pearson Coefficient (r)	Number of Observations	Degrees Freedom	Critical Value $r_{0.05(2),df}$
1983-1986	1983-1986	-0.608	35.00	33.00	0.334
1986	1986	0.341	11.00	9.00	0.602
1985	1985	-0.513	7.00	5.00	0.755
1984	1984	-0.922	9.00	7.00	0.666
1983	1983	-0.668	8.00	6.00	0.707
1984	1986	-0.719	11.00	9.00	0.602
1984	1985	-0.776	8.00	6.00	0.707

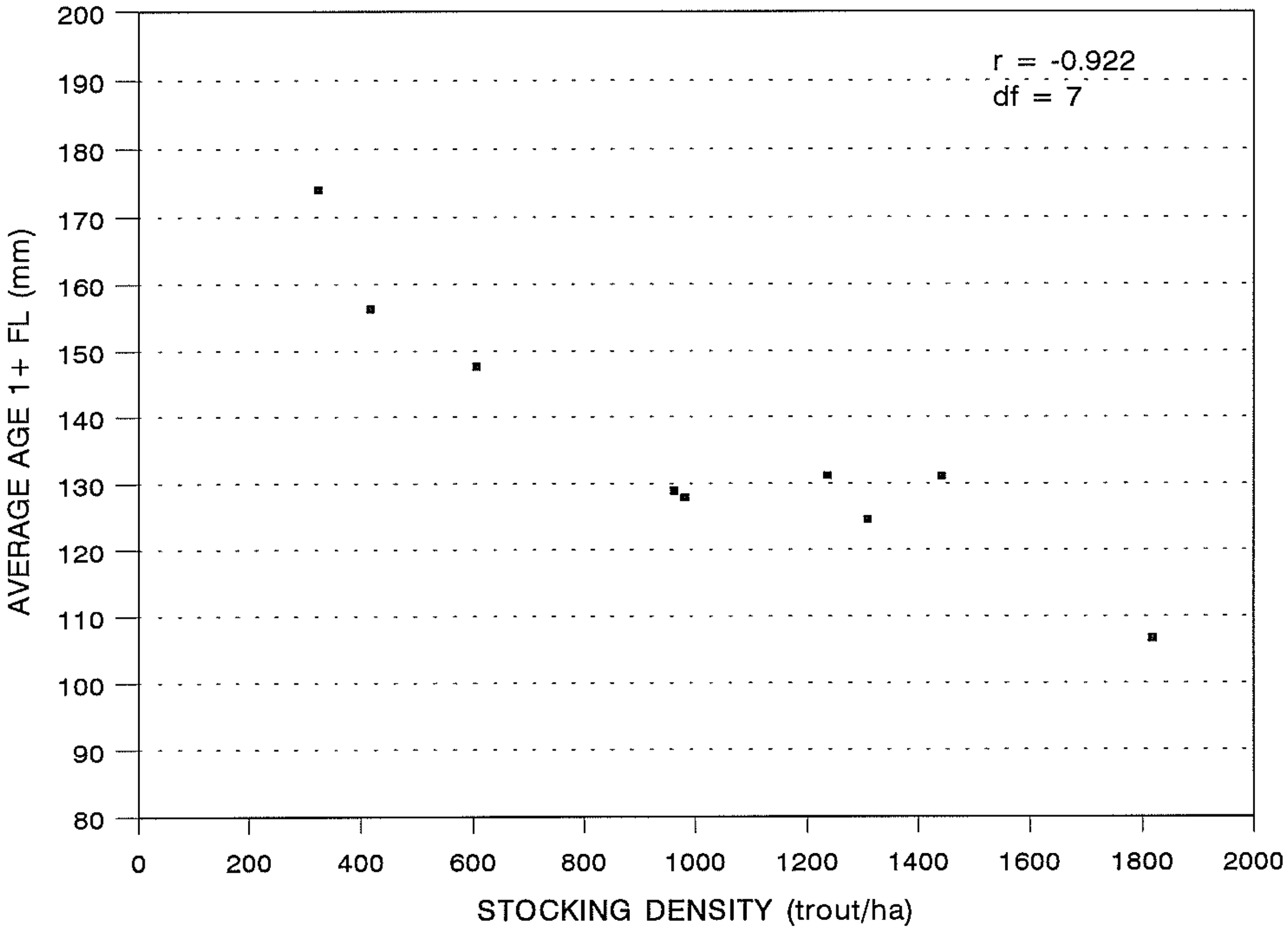

Figure 22. 1984 stocking densities correlated with 1984 average age 1+ rainbow trout fork lengths for nine northern California (Siskiyou County) high mountain lakes.

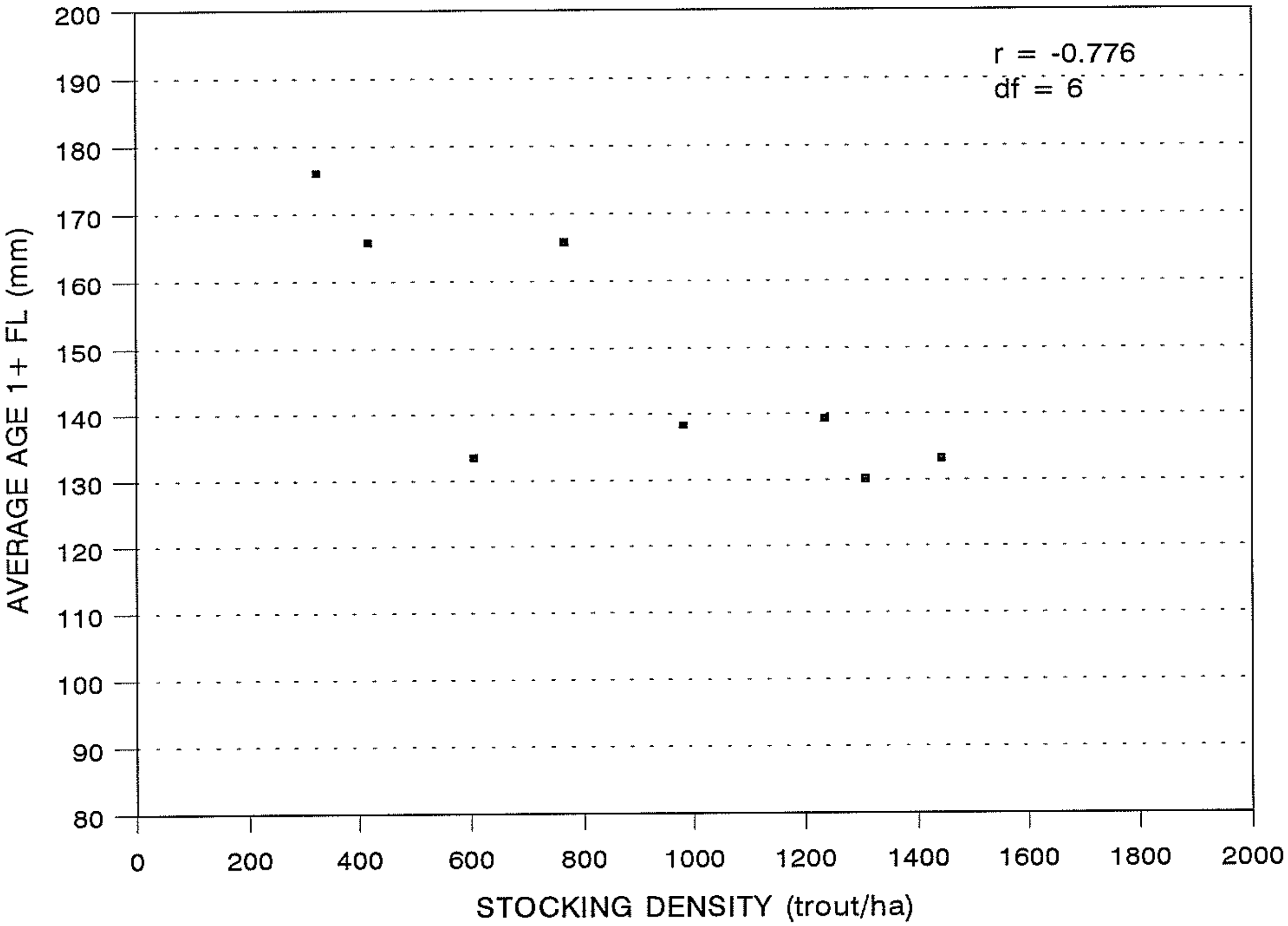

Figure 23. 1984 stocking densities correlated with 1985 average age 1+ rainbow trout fork lengths for eight northern California (Siskiyou County) high mountain lakes.

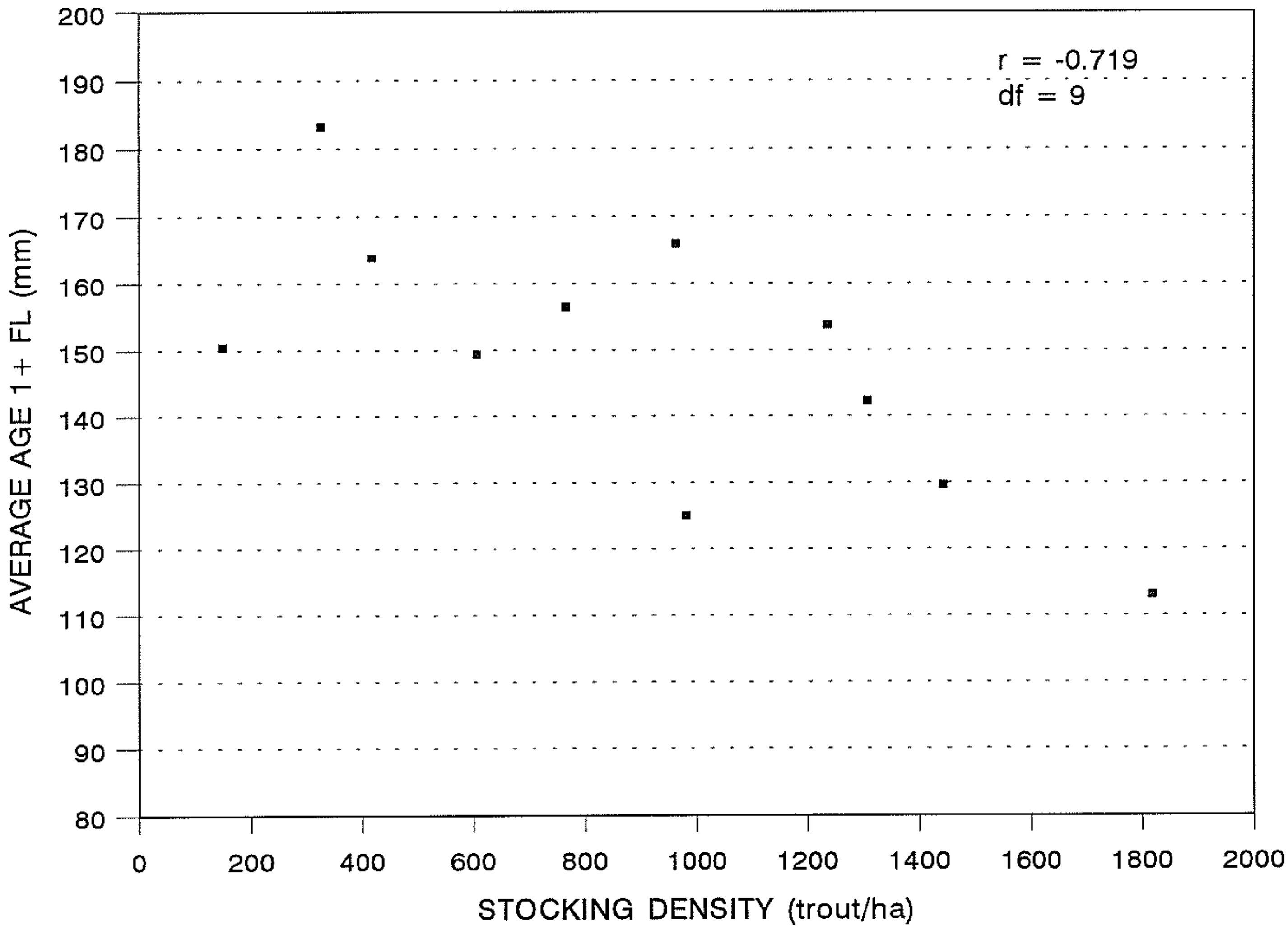

Figure 24. 1984 stocking densities correlated with 1986 average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

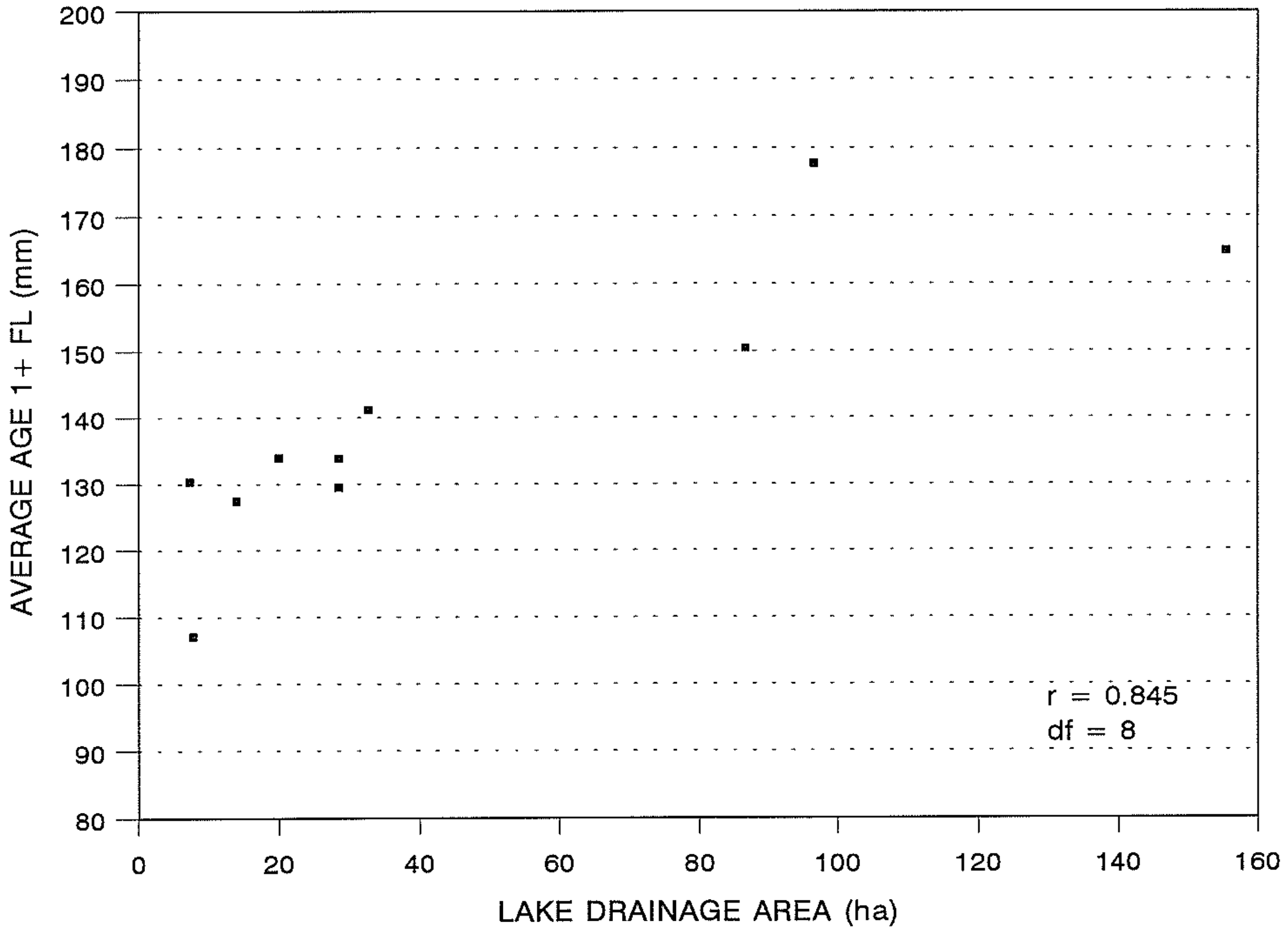

Figure 25. Drainage area (modified) correlated with average age 1+ rainbow trout fork lengths for 10 northern California (Siskiyou County) high mountain lakes.

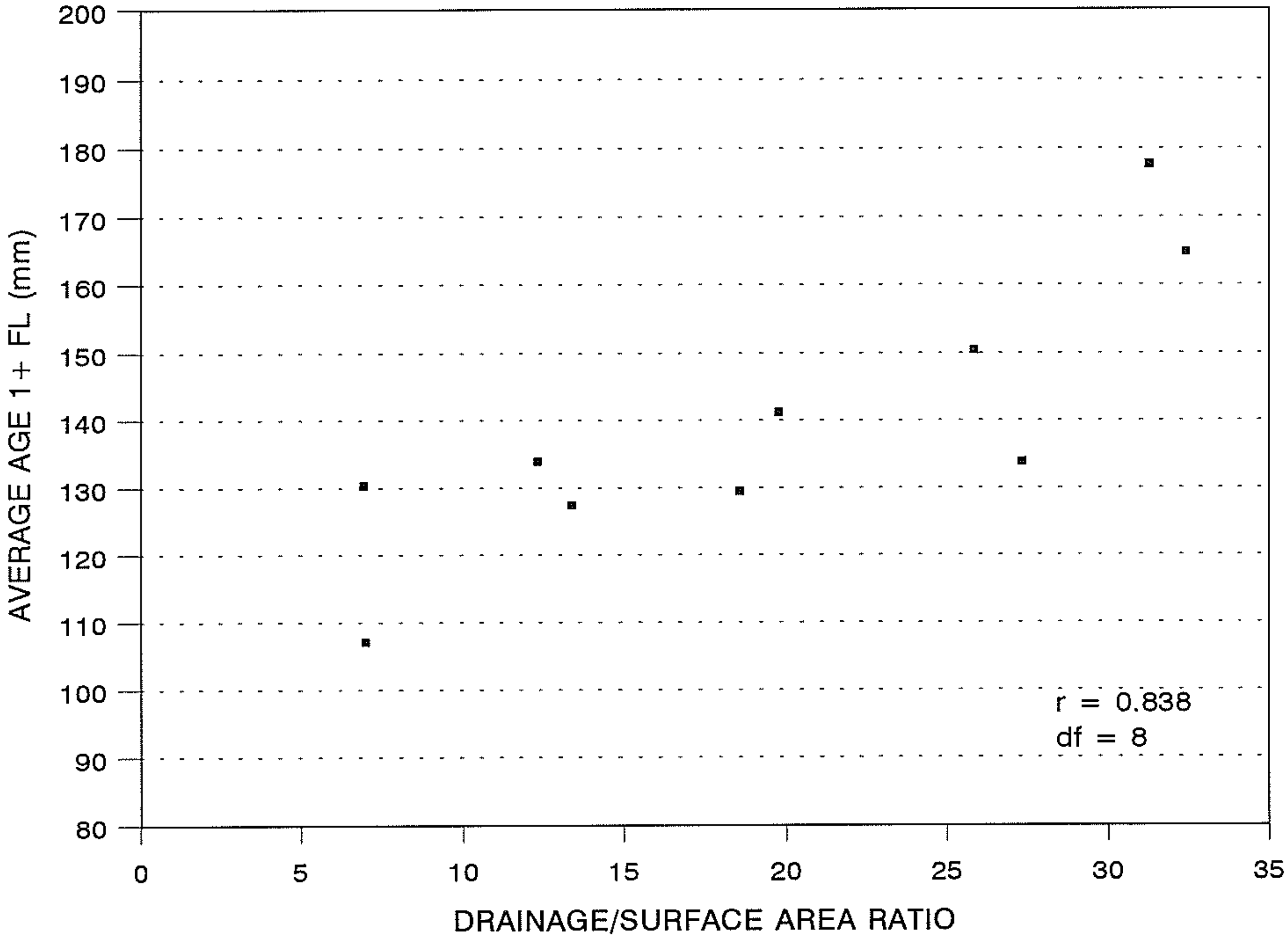

Figure 26. Drainage/surface area (modified) correlated with average age 1+ rainbow trout fork lengths for 10 northern California (Siskiyou County) high mountain lakes.

Correlation of the meadow/surface area ratios, minus the proposed West Boulder outlier datum, with age 1+ trout sizes, increased the r value from 0.450 to 0.644 ($r_{0.05(2)8}$=0.632). Similarly, removal of the proposed Telephone Lake outlier data from correlations of pH, conductivity, and $CaCO_3$ with age 1+ trout lengths raised the r values from 0.107, 0.269, and 0.424, to 0.304, 0.535, and 0.668, respectively ($r_{0.05(2)8}$=0.632) (Table 10).

Multiple Correlations

Parameters with significant or high r values were chosen from the different parameter sets for use in multiple correlation analyses with age 1+ FL. The aquatic plant genera, newts per transect, aquatic invertebrate orders (all size stomachs), aquatic invertebrate orders (age 1+ size stomachs), and aquatic invertebrate orders (S/K/E samples) parameters were selected from the productivity-measuring parameter set (Table 8). The 1984 stocking density, drainage area (modified), D/S ratio (modified), maximum depth, meadow ratio (modified), conductivity (modified) and $CaCO_3$ (modified) parameters were selected from the productivity-influencing parameter set (Table 10). Lake axis was not included because its relatively high r value was not thought to be biologically justifiable and was considered to have been a case of coincidence. The 1984 stocking density was selected over average stocking density for its higher r and simply because it seemed to be the overwhelming factor controlling trout growth in the lakes during the study. Multiple correlations were only run for parameter pairs from the same parameter set to avoid undo complication of the analyses.

The aquatic plant genera parameter was paired with each of the four other productivity-measuring parameters and correlated with age 1+ FL (Table 13). All of the parameter pairs produced significant R values. The pairing with newts/transect had the lowest R value of the four correlations, 0.892 ($F=9.748$, $F_{0.05(2),2,6}=8.43$). Aquatic plant genera and aquatic invertebrate orders from all trout stomachs resulted in the highest R value, 0.904 ($F=17.959$, $F_{0.05(2),2,8}=6.06$). Pairings with aquatic invertebrate orders from age 1+ size class stomachs and aquatic invertebrate orders from stomach, kicknet, and Eckman grab samples returned R values of 0.871 and 0.893, respectively ($F=12.597$ and 15.795, respectively, $F_{0.05(2),2,8}=6.06$) (Table 13).

Stocking density 1984 was paired with six other parameters and correlated with age 1+ FL (Table 14). Stocking density 1984 and maximum depth returned the highest R value, 0.934 ($F=27.147$, $F_{0.05(2),2,8}=6.06$), and did not require a modified data set. The other multiple correlations resulted in significant R values ranging from 0.850 to 0.908, but all of the other values came with losses of data points from modified data sets (Table 14). Maximum depth and conductivity (modified), similar to the parameters of

Table 13. Multiple correlation analyses for productivity-measuring parameter pairs correlated with average age 1+ rainbow trout fork lengths sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Parameter pairs	Multiple Correlation Coefficient (R)	F Value	Number of Observations	Residual Degrees Freedom	Critical Value $F_{0.05(2),2,df}$
Aquatic Plants Genera and Newts/Transect[a]	0.892	9.748	8.00	5.00	8.43
Aquatic Plants Genera and Aquatic Inverts[b]	0.904	17.959	11.00	8.00	6.06
Aquatic Plants Genera and Aqua Invert 1+[c]	0.871	12.597	11.00	8.00	6.06
Aquatic Plants Genera and Aqua Invert SKE[d]	0.893	15.795	11.00	8.00	6.06

[a] Average number of newts per 10 m transect/lake.
[b] Aquatic invertebrate orders identified from all trout stomachs/lake.
[c] Aquatic invertebrate orders identified from age 1+ size class trout stomachs/lake.
[d] Aquatic invert. orders identified from stomach, kicknet, and Eckman grab samples/lake.

Table 14. Multiple correlation analyses for productivity-influencing parameter pairs correlated with average age 1+ rainbow trout fork lengths sampled from 11 high mountain lakes, Siskiyou County, California, 1986-1987.

Parameter pairs	Multiple Correlation Coefficient (R)	F Value	Number of Observations	Residual Degrees Freedom	Critical Value $F_{0.05(2),2,df}$
1984 Stocked Density and Maximum Depth	0.934	27.147	11.00	8.00	6.06
1984 Stocked Density and Drainage Area[a]	0.908	16.427	10.00	7.00	6.54
1984 Stocked Density and D/S[b]	0.888	13.027	10.00	7.00	6.54
1984 Stocked Density and Meadow Ratio[c]	0.869	10.750	10.00	7.00	6.54
1984 Stocked Density and Conductivity[d]	0.850	9.140	10.00	7.00	6.54
1984 Stocked Density and Alkalinity[d]	0.866	10.448	10.00	7.00	6.54
Maximum Depth and Conductivity[d]	0.821	7.218	10.00	7.00	6.54

[a] Minus West Boulder Lake; Hogan Lake drainage area reduced 50%.
[b] Drainage/Surface Area; Minus West Boulder Lake; Hogan Lake drainage area reduced 50%.
[c] Meadow/Surface Area; Minus West Boulder Lake.
[d] Minus Telephone Lake.

the morphoedaphic index of lake productivity (average depth and total dissolved solids), were also correlated with age 1+ FL because of that well known connection, although both parameters were of only borderline significance at best (Table 10). The resulting R value (0.821) was the lowest for the set, but was still significant ($F=7.218$, $F_{0.05(2),2,8}=6.06$). The removal of Telephone Lake from maximum depth and conductivity values may have been particularly important. Average depth was not used in a multiple correlation due to its low r value (Table 10).

DISCUSSION

With only 11 lakes containing rainbow trout at least one year old, and only relatively small numbers of trout sampled from each lake, analysis of the growth of trout for the study purposes was severely limited. Yet, some trends still seemed to be strong enough to warrant further investigation. It quickly appeared, upon examination of the data and the results, that stocking densities, and particularly those of the 1984 plantings, were the most important factors determining the average size at age 1+ of rainbow trout in the study lakes through the 1987 season (Tables 10 and 12). Walters and Vincent (1973) suggested that the ability of yearly trout plantings in alpine lakes to grow catchable sized fish was extremely sensitive to stocking rates, with holdover fish from previous years competing with incoming year classes for food. Needham and Sumner (1941) stated that overstocking was a worse problem than understocking in high mountain lakes. The magnitude of the correlation of the 1984 stocking densities with the observed average rainbow trout size (r=-0.846) suggested that the 1984 year class of rainbow trout in the study lakes was a particularly strong one, exerting significant influence on following year classes as well as its own. It was noted that the 1984 plants had the widest range and greatest diversity of densities for the years studied, ranging from 324 rainbow trout per hectare in Clear Lake to 1818 rainbow trout per hectare in Cuddihy #4 Lake, with three other lakes having received over 1200 rainbow trout per hectare each (APPENDIX D). The 1983 plantings, some of which were also at relatively high densities, probably acted in conjunction with the 1984 plantings to set the growth patterns for the future year classes, but the sample sizes from 1983 were too small and incomplete to offer much information. I suspect that the r value of -0.686 was more a reflection of the similarity in stocking density patterns between 1983 and 1984 than an expression of the control of the 1983 densities over later trout growth. If the age structure of the trout caught in the gill nets in 1987 was a fairly accurate reflection of the true age structure in the lakes, then the 1984 rainbow trout were still moderately abundant in most of the lakes, while the 1983 year class appeared to be very low in numbers (Table 3). Donald and Alger (1986b) found that age structure was not consistent for rainbow trout in the subalpine lakes that they studied in western Canada. Dominant year classes appeared, often associated with warmer than average summers. With the limited data it was hard to determine whether the 1984 year class was any more persistant than those of the other years; such a strong year class was a possibility. The absence of trout plants at three of the lakes in 1985, with the resultant lack of age 1+ trout lengths to add to the average, probably bolstered that appearance of strength, but also confused the issue of what was really happening. In the hope of clarifying the issue, the analysis of yearly stocking rates and the yearly age 1+ lengths was attempted, even though the number of trout caught from the different year classes was often small (Table 11). The correlation of the yearly stocking densities with their respective year's average age 1+ lengths resulted in a wedge-shaped distribution with an r value of -0.608 ($r_{0.05(2),33}$=0.334) (Table 12). When viewed graphically (Figure 27), the distribution suggested an upper limit to trout growth that decreased with increasing density, but the individual year distributions did not appear to follow any useful pattern except for the lot from 1984. When broken out of the overall set, the correlation of the 1984 stocking densities with the 1984 year class average age 1+ lengths yielded an r of -0.922 (Table 12). In comparison, the r values for the 1985 and 1986 stocking densities and their associated average age 1+ trout lengths were not significant (-0.513 and 0.341, respectively). Yet, when the 1984 stocking densities were correlated with the average lengths from the later years, the r values reached significance at -0.776 ($r_{0.05(2),6}$=0.707) for the 1985 data and -0.719 ($r_{0.05(2),9}$=0.602) for the 1986 lengths, suggesting a much more powerful influence of the wide ranging 1984 densities on the later

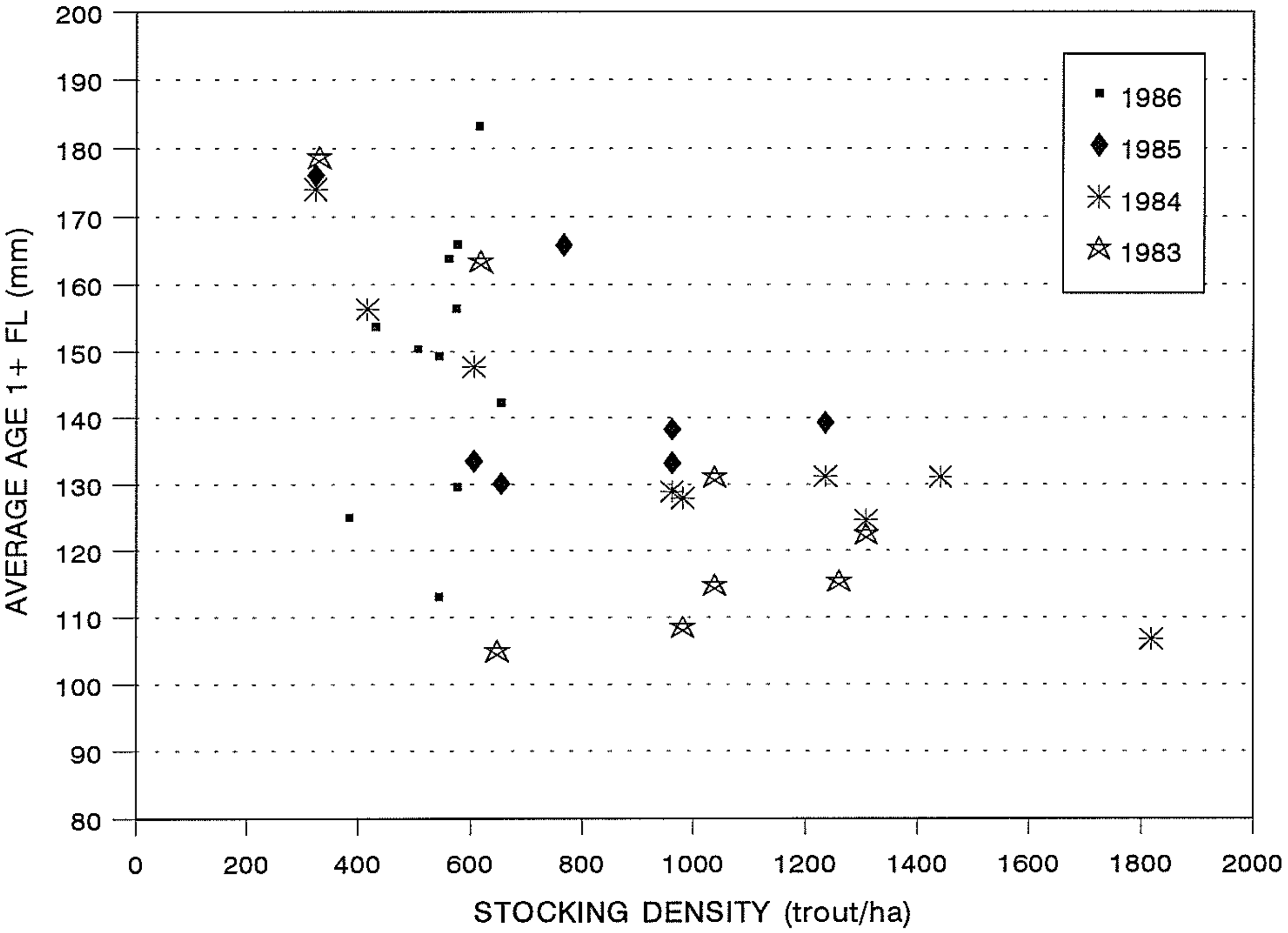

Figure 27. 1983-1986 stocking densities correlated with respective average age 1+ rainbow trout fork lengths for 11 northern California (Siskiyou County) high mountain lakes.

rainbow trout year classes than the actual densities of those year classes. Rainbow trout in the northern California high mountain lakes were thought to have a life span of only 3-4 years. Cordone and Nicola (1970) noted that catch records from Castle Lake in Northern California indicated that very few rainbow trout from Mt. Shasta Hatchery, the source of fish for my study, ever reached age 4. A similar 3-4 year life span for rainbow trout in high lakes in the Colorado Rockies was observed by Nelson (1978). By the summer of 1987, the trout from the 1984 plants would be nearing the end of their expected life span, at 3+ to 4+ years. The influence of the 1984 trout on future year classes would be expected to decrease as those fish died out. So the correlation results followed a logical pattern of decrease with time, even with the small numbers of fish sampled. The small sample size of both lakes and year classes within lakes made analysis of the problem less powerful than I would have liked, but the trends were strong enough and logical enough to make a good case for their validity. I decided that the relationship was real.

Several studies have pointed out the growth limiting effects of overcrowding on trout in oligotrophic mountain lakes (Needham and Sumner 1941, Reimers 1958, Johnston 1973, Reimers 1979, Donald and Anderson 1982, Pechlaner 1984, Pechlaner and Zaderer 1985, Donald and Alger 1986b, Nelson 1987). The removal of too much of the aquatic prey base was the indicated cause for low growth rates in most of the cases. My stomach analysis data (Tables 7; APPENDIXES K and L), which I will discuss in detail later, were limited by a lack of temporal range, but the data suggested that trout in the low growth rate lakes were feeding at least part of the time on more terrestrial invertebrates, both in number and diversity, than the trout in most of the higher growth rate lakes, pointing to a possible shortage of aquatic prey in the low growth rate lakes. Whether the lack of aquatic invertebrates was natural to the lakes or caused by the introduced trout populations was not certain.

Alternatively, Johnson and Hasler (1954), studying rainbow trout populations in dystrophic lakes, suggested that intraspecific interactions at higher trout densities, through a variety of mechanisms, kept the rainbow trout from feeding efficiently, and may have been responsible for lowered trout growth rates even when food did not seem to be limiting. I did not observe enough trout interaction in my study lakes to document density dependent stress and aggression levels, but if the fish were susceptible to such pressures then the relatively clear water in most of the lakes would enhance such interactions.

I was more inclined to believe in resource limitations created by high trout densities in the study lakes, with less obvious factors working to alter the initial rainbow trout stocking densities. Reimers et al.

(1955) reported a case similar to the situation in some of my study lakes. While studying the lakes of the Convict Creek basin in the southern Sierra Nevada they found that rainbow trout in Dorothy Lake were growing slightly faster than rainbow trout in Mildred Lake. Dorothy Lake was steep-sided and deep, possessing little plankton and few benthic invertebrates, with the only inflow coming from small seeps, and contained brook trout as potential competition, conditions very similar to those found in West Boulder Lake. Mildred Lake had a shallower basin, more plankton and macroinvertebrate prey resources (including *Gammarus* amphipods), and a perennial stream draining an extensive meadow that should have provided considerable amounts of nutrients to the lake. Other than the presence of *Gammarus*, the description could be for Hogan Lake in my study. Like the difference between the trout in West Boulder and Hogan, the trout in Dorothy Lake outgrew the trout in Mildred Lake, even though Mildred Lake appeared to have been much better qualified to grow trout at a higher rate. The authors concluded that trout density appeared to be the problem. Reimers et al. (1955) also suggested that the brook trout in Dorothy Lake may have been cropping off the rainbow trout fingerlings as they were planted, which reduced rainbow trout density and resulted in increased growth of the survivors.

The effect of the presence of other salmonid species, primarily brook trout, was not quantifiable, but may have been significant. I noted brook trout predation on aerially dropped rainbow trout fingerlings during the third year of this study at Meteor Lake, in 1988. I caught four small brook trout (approximately 160-180 mm FL) four hours after the rainbow fingerlings were dropped into the lake. The brook trout had eaten twenty of the juvenile rainbow trout. One of the brook trout contained ten of the stocked trout. Brook trout could have removed a significant portion of the initial planted cohort. Brook trout were plentiful in my five highest trout growth rate lakes, and were not found or were in very low numbers in five of the six lowest growth rate lakes (APPENDIX D). Mavis Lake, for which I had no rainbow trout growth data, contained a moderate number of moderately sized brown trout. Clear Lake, which had the highest rainbow trout growth rate, also contained large brown trout, although seemingly in low numbers. Wales and Borgeson (1961) believed that in Castle Lake the rainbow trout were even more cannibalistic than brook trout. I did not find any evidence to support that, but many of the rainbow trout in Clear and Blue Granite lakes were large enough to consume small rainbow trout. The overall effect of adult trout on the growth rate of rainbow trout in the study lakes was unknown, but any numerical decrease in trout densities where growth was density dependent would presumably increase growth. Predation by adult trout was probably greatest immediately after stocking, when the young trout were still disoriented from being dropped into the lakes. Wales and Borgeson (1961) noted that young rainbow trout planted by truck showed greater survival than those planted by plane in Castle Lake, which contained a naturally reproducing brook trout population. Trout predation in the lakes in this study probably lessened as the young rainbow trout learned to seek cover for protection, and probably stopped after a few months when the surviving trout were too large to be eaten. Rainbow trout probably did not outgrow predation by the large brown trout in Clear Lake until after the rainbows' first year of growth. Predation by trout on the rainbows may have provided the survivors more space and resources for growth, especially if there was resource partitioning existing between species, as has been reported in other studies (Wales 1946, Reimers et al. 1955, Partridge 1978, Donald and Anderson 1982). The uncertainty of this senario was manifest by the rainbow trout in Hogan Lake. Though only moderately stocked in 1984, 1985, and 1986 (APPENDIX D), the rainbow trout were present in even lower numbers than expected. Only one rainbow trout from plants prior to 1986 was captured in the first two seasons. The apparent high productivity of the lake should have allowed the young rainbows planted in 1986 to grow rapidly. Yet they did not achieve as high a growth rate as those in three other lakes, which had higher stocking densities than Hogan, and one of which, West Boulder, was probably less productive than Hogan. None of the other lakes in the study were judged to contain as high a density of brook trout as Hogan Lake. I believe that the growth discrepancy may have been caused in part by the shallow depth pattern of the Hogan Lake. The separation by depth and feeding mode between rainbow trout and brook trout noted in the other studies (Wales 1946, Reimers et al. 1955, Partridge 1978, Donald and Anderson 1982) was not as likely in Hogan Lake, where compressed foraging areas led to a greater chance of competition. Competition resulting in inhibited growth was demonstrated between young brook trout and rainbow trout in streams where the species initially shared the same habitat (Rose 1986). The other three lakes, Clear, Blue Granite, and West Boulder, were all deeper than Hogan, perhaps allowing the different species to coexist with less competition.

Bird predation may also have been a factor controlling rainbow trout densities. The propensity of rainbow trout to feed at or near the surface (Partridge 1978), especially when aquatic foods had become reduced (Donald and Anderson 1982), as in Cuddihy #4 and Syphon lakes, would expose the fish to predation by kingfishers and ospreys. The extreme shallowness of the water in Steinacher

Lake forced the fish to forage near the surface even more frequently than in deeper lakes.

The effect of angling pressure on the trout populations in the study lakes was unknown. Curtis (1935) suggested that heavy angling pressure held a Sierra Nevada high lake golden trout population below carrying capacity, resulting in higher growth rates. This may have accounted for the relatively high trout growth rate in Telephone Lake even with the high density of the trout stocked there. Telephone Lake was a popular camping area, close to a good trailhead for both hikers and horse packers. High fishing pressure may have reduced the trout density in the lake to ensure a decent growth rate of survivors. Yet anglers would also tend to remove trout above a desirable size (Ricker 1969), resulting in a lake with a high trout growth rate but with fewer large fish than expected. The removal of fish by gill netting during the study was another source of mortality. Nelson (1987) expressed concern that the losses to netting could substantially alter survivorship and growth results from trout studies in high lakes in Colorado. The number of trout captured in 1986 for this study was not very high in most of the lakes (Table 3), but still amounted to additional fish loss, particularly in Syphon and Telephone lakes. It was possible that the size of age 1+ trout in 1987 could have been somewhat affected by lowered fish density in the lakes with the highest catches in 1986.

Yearly gill nettings could have a significant cumulative impact by the last year of the study.

Trout density appeared to be a powerful factor in limiting trout growth. Yet the project was not planned to be a study of the affect of stocking density on trout populations, but rather a study of other growth regulating factors and productivity indicators that could be used to determine optimum stocking rates. The magnitude of the density effect made it difficult to distinguish the influence of the other parameters on trout growth. It appeared that trout density determined the ranking of the growth rates between the lakes and then other parameters only adjusted the relative positions in the ranking. Other studies have suggested that fish population density must be below some undefined point for the effects of other parameters to become manifest (Johnson and Hasler 1954, Reimers et al. 1955, Donald and Anderson 1982, Pechlaner and Zaderer 1985). Since lake surface area determined most of the stocking densities, parameters such as lake basin size and lake depth, which were correlated with lake size, may have had falsely high correlations with age 1+ trout growth because of their indirect correlation to trout density.

Lake size and depth did not appear to influence productivity in my study lakes in the same ways as reported in earlier studies (Rounsefell 1946, Rawson 1951, Rawson 1952, Rawson 1955, Hayes 1957, Ryder 1965), in which the authors believed that lake size and depth could be used to predict productivity levels. Larger, deeper lakes were viewed as less productive in those studies. In this study, the larger, deeper lakes did not appear to suffer any loss of productivity (Table 4). Of course the scale of the lakes was different. Much of the early work was performed on lakes large enough to support commercial fisheries, where depths were great enough to limit production in deeper water through light attenuation (Rounsefell 1946, Rawson 1952, Rawson 1955, Ryder 1965). In none of my study lakes was the depth so great or the water clarity so low that light could not penetrate down through the water column. Planktonic and benthic production should not have been limited by depth under such conditions. The greatest variety of aquatic macrophytes observed in this study, growing in extensive beds out into deep water, were found in Clear Lake (APPENDIX E), which had the highest trout growth rate as well as the greatest maximum depth and the highest average depth (Table 4). The positive r values of maximum and average depth on average trout lengths suggested that increases in depth may have actually benefitted productivity, probably by providing additional volume in which to grow plankton and lake bottom area for benthic production. But as mentioned, the larger, deeper lakes also had the lowest stocking densities, which could drive correlations with depth in a positive direction. Johnston

(1973) included the percentage of lake areas less than 10 feet deep and between 10 and 20 feet deep in a list of parameters developed to calculate potential lake productivities. He gave the highest points on his scale to lakes with high percentages of the two depth zones. My lakes did not appear to follow his scale; the slower growth rate lakes seemed to score more points than the faster growth rate lakes. Donald et al. (1980), studying a variety of parameters, found lake area, lake volume, and mean depth showed no significant correlations with trout growth. Donald and Anderson (1982) felt that shallower lakes should usually be more productive for rainbow trout, because rainbow trout seemed to prefer littoral invertebrate species as prey. They did not find mean depth or lake area to be significantly correlated to trout weight. I believe that depth had its place in estimating the trout growth potential in the lakes in this study, but only as part of a larger set of parameters. The fact that the multiple correlation of maximum depth and conductivity with trout length (R=0.821) was significantly stronger than the either of their simple correlations (r=0.600 and 0.535, respectively), suggested to me that the pair of parameters or an actual morphoedaphic analysis might work well in the study lakes at lower trout densities.

The influence of the area of high mountain lake drainage basins and the ratio between the basin areas and the respective lake surface areas on lake productivity have not been extensively studied. I suspect that most researchers have used chemical measurements such as TDS and conductivity to judge the nutrient loading of lakes, rather than trying to grasp the complexities of the possible sources and magnitudes of available nutrients in a given watershed. I wanted to test the possibility of not having to actually visit the lakes in order to estimate the potential influence of nutrient input on the productivity of the lakes, which would have have saved many man-hours of field time. However, the size of the lake drainage areas and the ratio of the drainage areas to the sizes of the lakes varied in the same pattern as did lake size, with big lakes having big drainage basins and small lakes having relatively smaller basins (Table 4). The multiple correlations of the drainage ratio (drainage area/lake area) and absolute drainage area paired with the 1984 stocking density suggested that both parameters overlapped considerably with the density effects (Table 13), but the pair containing the absolute area of the drainage basins did result in a particularly strong correlation with trout length. The parameter may work for lakes with lower trout densities. Using topographic maps gave only rough estimates of the drainage areas and the ratios. Richards and Goldman (1977) stated that productive lowland lakes typically have a ratio of 10:1 watershed to lake area, and that mountain lakes usually range from 5:1 to <1:1. My ratios ranged from about 32:1 down to just under 6:1 (Table 4). The magnitude of the difference was inexplicable.

Moyle (1946) stated that the length of the growing season was important to consider when comparing the productivities of lakes at different latitudes and altitudes. Air temperature, one of the controls on growing season length, has been linked to trout growth (Donald and Alger 1986b) and general lake productivity (Brylinsky and Mann 1973). I did not directly measure the growing season at my study lakes, nor did I take enough daily air temperature readings for comparisons between lakes, but I did compare elevation data (Table 4). Northcote and Larkin (1956) pointed out that as elevation increased, the average air temperature decreased (-2.2°C per 305 m elevation gain in inland British Columbia), and the growing season shortened, resulting in lower annual production in higher lakes. The two highest lakes in this study, Syphon and Section Line, showed very low trout growth rates, while the two lakes with the highest growth rates, Clear and Blue Granite, were at relatively low altitudes (Table 4). Elevation has also been tied to lake productivity through the increased intensity of light at altitude, which can inhibit the growth of phytoplankton (Richards and Goldman 1977). This was possibly why the three highest elevation lakes in this study had the lowest diversity of zooplankton

(Table 6). Zooplankton have been shown to be negatively correlated with elevation (Pinel-Alloul et al. 1989). Anderson (1971) found twice as many species of cladocerans in subalpine lakes (1550-2200 m elev.) than in alpine lakes (2200-2400 m elev.). Elevation and exposure to sunlight also partially control the vegetation that grows in the lake valleys and cirques (Palmer 1979, Ross 1983), which in turn could affect nutrient input to the lakes (Goldman 1961) and the availability of terrestrial insects. Elevation was significantly negatively correlated with trout growth in various studies (Johnston 1973, Donald et al. 1980, Donald and Anderson 1982). In my study, although portions of the data set seemed to fit into a logical pattern, the full data set showed no relationship between trout growth and elevation (Table 10). The failure of the estimated productivities to stratify by elevation was perhaps due in part to the narrowness of the range of elevations studied. Johnston (1973) used three 2000 ft (610 m) elevation intervals to scale the potential productivity of Washington high lakes. The highest and lowest lakes in my study were separated by only 610 m.

The relationship between elevation, air temperature, and water temperature would result in higher lakes being cooler. Water temperature profile data (Figures 2-13) indicated that my study lake surface temperatures were consistently within a few degrees of the air temperature when measured in the early to mid afternoon. In most of the lakes the water column temperature was closely related to the surface temperature. Donald et al. (1980) associated faster growth with higher water temperatures, and higher water temperatures with lower elevations. Water temperature has been shown to be linked to trout growth through metabolic processes (Hazzard 1933, Purkett 1951). As poikilotherms, trout body temperatures and metabolic rates rise and fall with changes in water temperature. Studies have shown that trout growth can be inhibited at both high and low temperatures within their tolerance range (Hazzard 1933, Johnson and Hasler 1954, Baldwin 1956). Cooler average temperatures found at higher elevations have been shown to shorten the growing season of trout. Purkett (1951) found that at higher elevations the water temperature in lakes did not reach optimal growing temperatures for trout for as long a period on a daily and seasonal basis as at lower elevations. Northcote and Larkin (1956) used 10°C as the lower temperature limit for trout growing season days. Donald and Alger (1986b) found the number of degree-days above 0°C for June, July, and August to be positively correlated with trout year class strength in some lakes. I did not collect data that directly indicated the period or intensity of cold water experienced by the trout in the study lakes. I assumed that the higher elevation lakes froze earlier and iced off later than the lakes at lower elevations, so trout at higher elevations probably experienced shorter growing seasons. Temperatures ranging from 15-21°C have been linked to slower trout growth in some lakes (Johnson and Hasler 1954). That conflicted somewhat with a study by Donald and Anderson (1982) that found mid-summer water temperature and brook trout weight to be positively correlated, indicating that higher temperatures were linked to greater trout growth. But Donald and Anderson (1982) also found that the abundance of amphipods, a favored trout prey in their study lakes, was correlated with water temperature, so that the trout growth might not have been related as much to increased temperatures as to an increased food supply. In temperature preference tests, young rainbow trout selected water temperatures averaging 14.3°C (Peterson et al. 1979). Selected temperatures are not fixed, but can vary on a seasonal basis (Sullivan and Fisher 1953). Eight of my study lakes had afternoon temperature profiles with the low temperature above 15°C (Figures 3, 4, 7-9, 11-13), usually with the entire water column only a degree or so cooler than the surface temperature. If the findings of Johnson and Hasler (1954) were correct, the trout in most of those eight lakes were probably experiencing some temperature stress. In five of the lakes, the low temperature was above 20°C (Figures 3, 4, 11-13). I assume that temperatures at that level would inhibit growth. Surface temperatures at all of the study lakes appeared to follow the air temperature, with some influence by wind and cloud conditions. On hot days, the trout had no choice of cooler water temperatures unless inflowing streams, seeps, or underwater springs produced localized cool zones. If such high temperatures did inhibit trout metabolism, that could partly explain why trout fishing was often best in the cool of the mornings and evenings and poor during the rest of the warm days. Lethargic trout would be less interested in chasing spinners and cruising for dry flies. It should be noted that the two highest trout growth rate lakes, Blue Granite and Clear, had broad thermoclines during mid and late July, which gave trout the choice of temperatures below 15°C (Figures 5 and 6). Richards and Goldman (1977) pointed out that deeper lakes stayed cooler but keep their heat longer than shallow lakes, which heated up faster but also cool down faster. Thus deeper lakes, like Clear Lake, provided a more stable temperature environment for trout, with fewer heat stressed days and a potentially longer growing season; the slower release of heat may have kept deep lakes from freezing over as early as shallow lakes at the same altitude. Johnson and Hasler (1954) suggested that water temperature and length of growing season controlled trout growth when the trout were at a low population density. That might explain some of the order of growth rates in the four or five lowest trout density lakes in my study, and also the seeming unimportance of temperature and elevation as expressed by growth rates in the high trout density lakes.

Johnson and Hasler (1954) found that the density of the zooplankton, upon which the trout in their study lakes depended for food, reached a low point in mid summer, possibly from either natural population cycles, high temperature effects, or photo-inhibition of phytoplankton. I noted a drop in the volume of my plankton samples through mid to late summer in 1987, which I at first attributed to net clogging but which may have been indications of a slump in zooplankton populations brought on by higher light intensity and warmer water temperatures. Plankton production was probably inhibited only at the highest temperatures. Warm water usually should benefit plankton communities. Northcote and Larkin (1956) concluded that climate had more influence on the number of aquatic organism crops produced per season than on standing crop size. Warmer waters allowed for more generations. They found no clear relationship between growing season length or water temperature and the number of fish or bottom fauna, but plankton did seem to be more numerous in warmer lakes. Aquatic macrophyte productivity may also have been increased in warmer lakes, particularly the deeper lakes that did not experience high and low temperature spikes on a regular basis. Sand-Jensen (1989) indicated that aquatic macrophyte photosynthesis rates were stimulated by higher temperatures, but pointed out that different species had specific optimum temperatures. Pip (1989) stated that the species richness of aquatic macrophytes in lakes was significantly positively correlated with water temperatures in mid summer. Warmer lakes tended to have more macrophyte species.

Sun arc measured the arc through which sunlight could directly reach the lake surface, as determined by the heights of lakeside trees and sunward mountains and their nearness to the lake. Lake axis orientation measured the direction to the lake outfall, assumed to be the direction in which the lake valley or cirque was most open towards lower elevations. Together they estimated the exposure to direct sunlight that the surfaces of study lakes received. Johnston (1973) used the direction of exposure of lakes in his productivity calculations. His highest values were given to southerly exposure, which received the most sunlight and had longer growing seasons. My analysis indicated no relationship between sun arc and average trout length (Table 10). Sun arc measurements suffered from a lack of range in which to express variation. The majority of the values fell between 150 and 165 degrees, with no great extremes (Table 4). Low variation in a parameter that would typically only act to modify stronger parameters would not be expected to cause noticeable trends in measurements. Lake axis orientation was probably the weakest of the physical parameters. Its effect would be noticeable only if some of the lakes were sunlight limited through restricted sun arcs and others received significantly more sunlight due to the direction of their long axes. None of the lakes were sunlight limited. The r value of -0.648 was not biologically explicable and was probably coincidental.

Most of the chemical values were at very low levels (Table 5), which was expected. The literature on high lakes limnology showed that few lakes at higher elevations contained high chemical concentrations (Reimers et al. 1955, Bradford et al. 1968, Richards and Goldman 1977, Partridge 1978, Stoddard 1987). My data indicated that nitrate (NO_3), nitrite (NO_2), and orthophosphate (PO_4) levels were below or at the minimum sensitivity of the Hach test kits I used. Studies in other California high mountain lakes have found similarly low levels of NO_3, NO_2, and phosphate (Reimers et al. 1955, Partridge 1978, Stoddard 1987). No relationship to trout growth was indicated for the three parameters in either my or the reported studies. Pip (1984) found NO_3 and NO_2 to be moderately important in the distribution of aquatic macrophytes over a broad area of Canada. Nitrate has also been shown to be correlated to zooplankton in some Quebec lakes (Pinel-Alloul et al. 1989). Measurements of phosphate levels may have been misleadingly low in my lakes. Carpenter and Lodge (1986) indicated that phosphorus can be rapidly assimilated by phytoplankton and epiphytes when it entered the lake water column, or it can be trapped in the oxidized surface sediments found in oligotrophic lakes. Barko and Smart (1980) found that aquatic macrophytes can remove phosphorus from the sediments and maintain good net growth on it alone. Aquatic macrophytes can store phosphorus removed from the sediments or assimilated during earlier periods of inflow, which is then released into the water when the plants decay (Landers 1982, Canfield et al. 1983). I suspect that such recycling and storage was occurring in relatively plant-rich Clear, Blue Granite, Hogan, and Meteor lakes, where orthophosphate levels measured no higher than in the almost plant-barren lakes like Syphon and Section Line (Table 5).

The data in this study indicated that pH was not linked to trout growth (Table 10). The pH value from Telephone Lake, 8.4, was unexpectedly high, but even its removal as an outlier only brought the r value up to 0.304. Moyle (1945) noted that aquatic macrophytes showed preferences for certain pH ranges in their distributions, but he later stated (Moyle 1946) that he felt that pH was not a reliable productivity index because it was too localized and variable. Partridge (1978) did not find a pattern between rainbow trout growth and pH in six California high lakes. Pip (1984) found pH to be very important in the distribution of aquatic macrophytes in Canadian lakes. There has also been some correlation shown between pH and zooplankton (Pinel-Alloul et al. 1989).

Conductivity tends to be closely proportional to the concentration of the major ions (Wetzel 1983) and has been used a TDS surrogate (Donald et al. 1980). Since several studies have indicated that both conductivity and TDS were strongly positively correlated with fish, invertebrate, plant, and plankton productivity (Rawson 1951, Northcote and Larkin 1956, Ryder 1965, Partridge 1978, Donald et al. 1980, Donald and Anderson 1982, Trippel and Beamish 1989), I expected similar results. My data failed to show a significant relationship between conductivity and trout growth (Table 10). Telephone Lake was again an outlier, being much higher than any of the other values, yet its removal only gave an r of 0.535. That may have again been a case of the density driven growth patterns masking other growth influencing factors. The multiple correlation of conductivity (modified) and the 1984 stocking density with trout length showed little increase in the level of correlation beyond that of the simple density correlation, which suggested complete overlap in their patterns (Table 14). As mentioned earlier, the multiple correlation of conductivity (modified) and maximum depth with trout length may be important at lower fish densities. Conductivity might also work well in a larger multiple correlation under similar conditions.

Alkalinity ($CaCO_3$) effects were probably masked like those of conductivity. Numerous investigations have determined that alkalinity was positively correlated with fish, invertebrate, and plant productivity and distribution (Moyle 1945, Moyle 1946, Reid 1961, Seddon 1972, Johnston 1973, Partridge 1978, Pip 1984, Pinel-Alloul et al. 1989). Yet my data indicated only a weak correlation at best with trout growth (Table 10). When Telephone Lake was removed as an outlier the r value increased to 0.668. The value must remain suspect, though, since alkalinity may be related to drainage area size, which had strong ties to lake surface area, and through lake area, to stocking densities. With such minimal differences in alkalinity values between the lakes, there was also the chance of variation in other parameters obscuring any pattern. The multiple correlation of $CaCO_3$ (modified) and the 1984 stocking density with trout length indicated that the density pattern almost completely encompassed the $CaCO_3$ pattern (Table 14).

The final chemical parameter measured was dissolved oxygen. Although dissolved oxygen measurement has been used in an index of lake trophic state (Walker 1979) it has not typically been correlated with fish productivity. I used it to detect whether or not any of the lakes were experiencing oxygen depletion at depth, which could limit trout use to the upper water column. The deep waters of all of the study lakes were found to be oxygen rich and no pattern was noted with regard to trout growth (Tables 5 and 10).

The ratio of the areas of wet meadow and associated broad-leafed nitrogen-fixing deciduous shrubs and trees (*Salix* and *Alnus*) with lake surface areas was designated a biological parameter because it dealt with living materials, yet its affect was thought to be chiefly chemical in nature, acting as a rich source of nutrients that could wash down into the lakes and provide much of the nutritional needs of phytoplankton and aquatic macrophytes. Reimers et al. (1955) acknowledged the potential benefits of a large meadow that drained into one of the high lakes in their study. The contribution of nutrients to Castle Lake by lakeside alder trees, *Alnus tenuifolia*, was documented by Goldman (1961). Alders were estimated to have been adding enough nitrogen to the lake to account for 15.5% of the average total nitrogen in the lake from June to October. I hoped that estimating the combined areas of wet meadow and willow/water birch groves (nitrogen fixing trees) and dividing the total by the surface area of the associated lake would result in a parameter that would be significantly correlated with trout growth. Upon analysis, the meadow ratio failed to correlate significantly ($r=0.450$, $r_{0.05(2)9}=0.602$) with age 1+ trout FL (Table 10). West Boulder Lake appeared to be an outlier, since it ranked third on the growth rate scale, yet had no meadow areas in its drainage and only a few willow clumps on the shore. But, on a snorkeling survey, I believe I observed underwater springs, which have been shown to be high in dissolved minerals (Goldman 1961, Stoddard 1987). Those springs might have made up for the lack of other nutrient sources. Brook trout, which require a source of clean, aerated gravel like a spring for spawning, were successfully breeding in the lake, which strengthened my belief in the existence of the springs. Analysis without West Boulder resulted in a significant r value of 0.644 with trout growth (Table 10). I believe that the parameter would produce more significant results if trout density were not such a problem. I would like more accurate measurements; I was forced by time constraints to estimate areas from aerial photographs without ground proofing. Multiple correlation analysis of the meadow ratios and the 1984 stocking densities with trout growth showed very little change from the simple correlation of the stocking density with age 1+ FL (Tables 10 and 14). Using lake surface area in the ratio may have caused a part of the overlap.

Zooplankton were a difficult group in my analyses. They have been used in several studies as indicators of lake productivity (Sprules 1977, Gannon and Stemberger 1978, Pejler 1983, Carpenter and Kitchell 1984, Pinel-Alloul et al. 1989) but when correlated against trout growth they were not significant (Donald et al. 1980, Donald and Anderson 1982). My initial sampling attempts seemed to be promising, with reasonable volumes of plankton per sample. But, towards mid-summer, the volumes dropped dramatically. As previously mentioned, such a change could have been part of a natural population cycle or caused by high water temperatures and/or sunlight inhibition (Johnson and Hasler 1954, Richards and Goldman 1977). Zooplankton abundance and composition can also change dramatically as a result of predation by a dense fish population (Brooks and Dodson 1965, Galbraith 1967, Anderson 1972, Langeland 1978, Anderson 1980, Pechlaner 1984, Crowder et al. 1987). Trout densities in several of the study lakes were probably high enough to cause some changes. The plankton sampling results did not follow a discernible pattern (Table 6 and 8; APPENDIX A and B) and I concluded that Moyle (1946) was correct when he stated that plankton were too seasonally variable to be of use in evaluating lake productivity. Syphon Lake, the one lake that I visited twice in 1987, was an example. I did not find _Daphnia_ _rosea_ present in plankton net or stomach samples in late June, yet when I returned in mid-September trout stomach samples contained large numbers of _D._ _rosea_ (APPENDIXES B and K).

Various studies have demonstrated the importance of the availability of both macroinvertebrates and zooplankton in trout diets for the continuance of growth (Reimers et al. 1955, Reimers 1958, Johnston 1973, Walters and Vincent 1973, Reimers 1979, Donald et al. 1980, Donald and Anderson 1982, Pechlaner 1984, Pechlaner and Zaderer 1985). The trout in my study lakes ate a wide variety of aquatic invertebrates, zooplankton, and terrestrial invertebrates (APPENDIXES K and L). I chose to evaluate the food habits by the diversity of the orders represented in the samples, making the assumption that throughout the summer most of the potential trout prey species would be available to the trout and would probably be found in the stomachs. Lakes with the highest diversity of prey species would probably have the greatest potential for trout growth because the trout would have a more constant abundance of invertebrates as different species reached population peaks at different times. The number of aquatic invertebrate orders found in the stomachs of trout in the size classes defined by the maximum age 1+ fork lengths was significantly correlated with the average trout FL at age 1+ ($r=0.643$, $r_{0.05(2),9}=0.602$), as was the total number of aquatic invertebrate orders identified through stomach samples, Eckman grab samples, and kicknet samples ($r=0.737$, $r_{0.05(2),9}=0.602$) (Table 8). The number of aquatic invertebrate orders identified among all the stomach samples per lake was not quite significantly correlated with trout length. The correlations were strong enough to suggest that invertebrate diversity might be an index of productivity. The presence of gammarid amphipods has been correlated with trout growth in some mountain lakes (Johnston 1973, Donald et al. 1980). Gammarus spp. were not found in my lakes, but two other invertebrate groups may be productivity indicators. Zygopterans were consumed in large numbers in four of the top five growth rate lakes, while they were absent or in very low numbers in the stomachs from all of the low productivity lakes (APPENDIX J). Ancylids were also eaten in moderate to large numbers in the same four of the five highest growth rate lakes and were absent from the stomachs from all of the other lakes (APPENDIX J). West Boulder Lake was the exception to the pattern. It had a high trout growth rate but few zygopterans in the trout stomachs, and contained no ancylids. The lack of ancylids might also have been related to the absence of an outflow stream connecting West Boulder Lake, and most of the other low growth rate lakes, to lower waters. The trout in the lake fed on diverse aquatic invertebrates, but most were in low numbers. Most numerous were small trichopterans (<u>Mystacides</u> sp., <u>Gumaga</u> sp.), small chironomids, and <u>Daphnia</u> <u>rosea</u> (APPENDIX K). The trout must have burned a lot of calories feeding on such small prey. Chironomids and cladocerans have been shown to be quite low in nutritional value (Sugden 1973), so nutritional rewards would not be great per individual capture. West Boulder trout also fed extensively on terrestrial insects, particularly small forms of coleopterans, hemipterans, thysanopterans, hymenopterans (mainly minute chalcid wasps), and dipterans (APPENDIX L). The only other lakes in the study where trout fed on such a mix of terrestrial forms were Section Line and Syphon, both low growth rate lakes at the two highest elevations in the study (West Boulder was at the third highest elevation). The most numerous invertebrates in trout from Section Line and Syphon lakes were also chironomids and cladocerans (APPENDIXES G and J). Some studies have noted that trout from a stunted or slow growing population fed extensively on terrestrial invertebrates, while trout in faster growing populations ate more large aquatic invertebrates (Donald and Anderson 1982, Pechlaner 1984, Pechlaner and Zaderer 1985). Trout can react to larger prey at significantly greater distances (Ware 1972), which makes hunting larger prey more efficient. Larger forms like zygopteran naiads also have high nutritional value (Sugden 1973). Other studies, though, have suggested that terrestrial invertebrates were a very important part of high lake trout diets (Elliot and Jenkins 1972, Pennak 1977), and in some cases faster growth occurred if the terrestrial forms were readily available (Walters and Vincent 1973). The forested slopes around and above West Boulder Lake may have provided enough invertebrates to explain the difference in trout growth rates between West Boulder, Syphon, and Section Line lakes. The conifer stands around Syphon Lake were particularly dry and open. Then again, the density of the trout in the lakes may have been the overriding factor. West Boulder received about 37% fewer trout per hectare than Syphon and 48% fewer trout per hectare than Section Line from 1983 through 1986 (APPENDIX D).

Newts may be a useful predictor of lake productivity and trout growth potential. They were present in eight of the twelve lakes and they were more plentiful in the more fertile lakes (Table 6). The correlation of newt density versus age 1+ trout FL was on the lower limit of statistical significance ($r=0.697$, $r_{0.05(2),6}=0.707$). Newt density should be more stable than invertebrate numbers because newts have a longer life span and generation time than most high lake invertebrates. Predation should not be a problem, due to the toxic nature of their skin secretions. There are few animals that can survive eating them (Brodie 1968) and trout leave them alone (Efford and Mathias 1969). Newts were not wary and were easy to count because they moved about throughout the day and were readily observed. My shoreline transects did not sample deep water habitats and probably undersampled newts in all of the lakes. Newts feed on essentially the same invertebrates as trout (Efford and Tsumura 1973, Strohmeier and Crowley 1989), so that their population levels would likely reflect the abundance, or lack, of the foods also available to trout. As mentioned earlier, newts were not in all of the study lakes. Their absence seemed to be distribution related and not environmental.

Roelofs (1944) felt that aquatic macrophyte abundance and distribution could be used as an index of fishery productivity for lakes. I attempted to count the number of aquatic macrophyte genera in each lake while snorkeling, although I was limited by the depth at which the plants often grew, the clarity of the water in some lakes, and time constraints. My observations in the lakes were not systematic enough to accurately estimate the density and area covered with plants, but were extensive enough for basic enumeration of genera (APPENDIX E). Macrophyte counts were significantly correlated with trout growth ($r=0.804$, $r_{0.05(2),9}=0.602$), the highest correlation among the biological parameters (Table 8). Aquatic macrophyte diversity could be related to trout growth in a number of ways. Diversity of aquatic macrophytes can be positively correlated with chemical and physical factors directly or indirectly conducive to trout growth (Moyle 1945, Seddon 1972, Pip 1984, Pip 1989, Sand-Jensen 1989). I believe that the lakes with the greatest diversity of aquatic macrophytes also had the highest plant density and area covered. As mentioned earlier, aquatic macrophytes recycle and store nutrients, which can are later released, to the benefit of the entire food web (Barko and Smart 1980, Landers 1982, Canfield et al. 1983, Carpenter and Lodge 1986). Aquatic macrophytes also provide substrate and shelter for epiphytes and the invertebrates that feed on them. Aquatic invertebrate numbers have been related to the type and density of aquatic plants in lakes (Krecker 1939, Rosine 1955, Johannes and Larkin 1961, Minshall 1984, Talbot and Ward 1987, Diehl

1988, Schramm and Jirka 1989a, Schramm and Jirka 1989b). Invertebrates at times prefer plants growing in denser patches, and those with a greater complexity of leaf structure, adding greater surface area per unit volume (Krecker 1939, Rosine 1955). Clear and Blue Granite lakes, with the highest trout growth rates, had large, dense patches of Ranunculus and Potamogeton, both of which had more leaf area than Isoetes, the one plant found in all of the lakes (APPENDIX E). The four lowest growth rate lakes did not contain Ranunculus or Potamogeton. Multiple correlation analyses using the aquatic plant genera parameter paired with different aquatic invertebrate parameters and the newt density parameter resulted in only small increases in correlation with age 1+ trout FL (Table 13) from the simple correlation for aquatic plant genera (Table 8). The results suggest that aquatic plant diversity is strongly related to aquatic invertebrate diversity and newt density in the study lakes. Aquatic macrophyte abundance should make a usable parameter for further studies in the high lakes. Aquatic macrophytes were also less prone to the sudden changes than aquatic invertebrates. The parameter would probably work best at lower trout densities than were present in most of my lakes.

CONCLUSIONS

Proper stocking densities must be stressed in the management of high mountain lake fisheries. This study has shown the influence of stocking density on trout growth. Yet to predict the responce of trout growth to different stocking densities is still difficult. Four lakes in my study: Clear, Blue Granite, West Boulder and Hogan were stocked in 1986 at a density higher than their averages for the three previous years (APPENDIX D). Clear Lake received the highest stocking density scheduled for the study. Of the four lakes, the age 1+ FL at Clear Lake increased, it decreased slightly in Blue Granite, definitely decreased in West Boulder, and could not be compared in Hogan for lack of previous year classes (Table 11). Donald and Anderson (1982) suggested that, at some point, the trout density in mountain lakes can drop below a threshold where growth becomes independent of trout numbers and other factors then limit trout growth. Trout density in Clear Lake may still have been below the threshold even at the higher level. Lower trout numbers in all of the study lakes would probably increase trout growth but too few fish would probably result in dissatisfied anglers. Walters and Vincent (1973) obtained a maximum trout harvest at a stocking density of 120 fish per hectare in an alpine lake. Such a low stocking rate may not be necessary in the subalpine lakes in this study, especially if they receive regular fishing pressure. Johnston (1977) set up a series of stocking densities for lakes ranked by level of estimated productivity and the time it would take the stocked fish to reach carrying capacity. The result was a range from 988 trout/ha, for a high productivity lake where the fish would attain carrying capacity in 1-2 years, to 124 trout/ha, for a low productivity water where the fish could grow for five years or more before reaching a resource limit. My lakes were most similar to the moderate productivity lake range proposed by Johnston (1977), in which the trout reached carrying capacity in 3-4 years, with stocking densities of 741 trout/ha for high productivity lakes, 494 trout/ha for medium productivity lakes, and 274 trout/ha in low productivity lakes. His densities may still be high for other areas of high lakes, especially where Gammarus are absent. From my work, I suggest an upper limit of 600 trout/ha, and would rather use a more conservative 500 trout/ha, even in lakes as rich as Clear. The lower limit would probably be similar to the 274 trout/ha mentioned above by Johnston (1977). Most of my lakes were in the medium productivity range; Syphon, Section Line, and Cuddihy #4 were in the low range; Clear, Blue Granite, and perhaps West Boulder and/or Hogan were in the high range. West Boulder and Hogan had too many unanswered questions for them to be categorized with certainty. Mavis Lake could not be properly analyzed due to the lack of rainbow trout in the lake before the 1986 planting. I would place it in the medium growth rate range.

My study was the first half of a four year project intended to develop a set of parameters that could be used to predict lake productivity in order to calculate stocking densities which would provide reasonably high growth rates and survival of trout. Many of the parameters chosen for the study appeared to be of value in a multivariate analysis, but their effects were masked by the stocking densities. The final selection of parameters for modelling lake productivities will require further study under lower trout densities, which will be achieved by the second half of the project. Some parameters can be suggested for closer study. Lake drainage area and maximum lake depth appeared to be the lake physical parameters most related to trout growth. Conductivity and alkalinity showed the strongest relationship to age 1+ FL of the lake chemical parameters. Newt density, aquatic macrophyte diversity/abundance, and meadow ratio showed promise as biological parameters. The "meadow ratio" may have to be modified to include underwater springs like those in West Boulder Lake.

An additional management concern should be predation on small stocked trout. The low returns of rainbow trout from Hogan Lake suggest that predation could be a problem.

I predict that a similar problem will occur with the large brown trout and small rainbow trout in Mavis Lake. Planting rainbow trout on top of established brook trout and brown trout populations must be considered in calculations of stocking density.

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APPENDIX A. Zooplankton species identified in 12 high mountain lakes, Siskiyou County, California, 1986.

Order Family Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Cladocera												
Bosminidae												
Bosmina coregoni				X					a			a
Bosmina longisrostris		X										
Chydoridae												
Alona affinis				X								
Chydorus sphaericus	X	X		X	X		X			X	X	
Daphnidae												
Ceriodaphnia laticaudata						X	X					
Ceriodaphnia reticulata				X								
Daphnia rosea	X	X	X	X	X	X	X	X				
Scapholeberis kingii												
Holopedidae												
Holopedium gibberum			X			X		X		X	X	
Macrothricidae												
Streblocercus serricaudatus				X								
Polyphemidae												
Polyphemus pediculus	X	X			X			X				
Sididae												
Diaphanosoma brachyurum	X	X		X	X		X				X	

APPENDIX A. Zooplankton species identified in 12 high mountain lakes, Siskiyou County, California, 1986 (continued).

Order Family Species	Lake Cl	 BG	 WB	 Ho	 Me	 Te	 St	 SL	 CR	 Sy	 C4	 Ma
Copepoda												
Cyclopoidae												
Unknown	X	X	X	X	X	X	X	X		X	X	
Diaptomidae												
Hesperodiaptomus franciscanus	X	X			X	X	X	X		X	X	
TOTAL SPECIES	6	7	3	8	6	5	6	5		4	5	
CLADOCERA SPECIES	4	5	2	7	4	3	4	3		2	3	

[a] Not sampled in 1986.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX B. Zooplankton species identified in 12 high mountain lakes, Siskiyou County, California, 1987.

Order Family Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Cladocera												
Bosminidae												
Bosmina coregoni		X										
Bosmina longisrostris				X								
Chydoridae												
Alona affinis												
Chydorus sphaericus							X		X	X	X	X
Daphnidae												
Ceriodaphnia laticaudata						X	X					X
Ceriodaphnia reticulata												
Daphnia rosea	X	X	X	X	X	X	X	X	X		X	X
Scapholeberis kingii				X								
Holopedidae												
Holopedium gibberum	X	X	X	X	X	X		X	X	X	X	X
Macrothricidae												
Streblocercus serricaudatus												
Polyphemidae												
Polyphemus pediculus	X	X			X				X		X	
Sididae												
Diaphanosoma brachyurum	X	X			X	X	X		X			

APPENDIX B. Zooplankton species identified in 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Family Species	Lake Cl	 BG	 WB	 Ho	 Me	 Te	 St	 SL	 CR	 Sy	 C4	 Ma
Copepoda												
Cyclopoidae												
Unknown	X	X	X	X	X	X	X	X	X	X	X	X
Diaptomidae												
Hesperodiaptomus franciscanus	X	X			X	X	X	X	X		X	X
TOTAL SPECIES	6	7	3	5	6	6	6	4	7	3	6	6
CLADOCERA SPECIES	4	5	2	4	4	4	4	2	5	2	4	4

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX C. Aquatic invertebrates identified from kicknet samples for 12 high mountain lakes, Siskiyou County, California, 1987.

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Trichoptera												
Leptoceridae												
Mystacides		5	3									
Unknown	8											
Limnephilidae												
Halesochila taylori						7				8	30	
Limnephilus						6						
Psychoglypha					4				4			
Unknown	2											
Polycentropodidae												
Polycentropus			6									
Sericostomatidae												
Gumaga	18		10									7
Unknown		9		1	2		4	8		1		2
Ephemeroptera												
Baetidae												
Callibaetis	12	3	4			34	24	12			2	2
Leptophlebiidae												
Paraleptophlebia			5			1						
Unknown		2				3						
Coleoptera												
Carabidae					1							
Chrysomelidae												
Donacia	1								3		7	

APPENDIX C. Aquatic invertebrates identified from kicknet samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake Cl	 BG	 WB	 Ho	 Me	 Te	 St	 SL	 CR	 Sy	 C4	 Ma
Coleoptera (continued)												
Dytiscidae												
Agabus			1		9							2
Deronectes		2									2	
Dytiscus											2	
Hydroporus					1						2	4
Oreodytes			3			19						
Rantus												1
Hydrophilidae												
Ametor		1										
Tropisternus				1								
Ptylodactylidae						1						
Staphylinidae			1									
Odonata												
Anisoptera												
Aeshnidae												
Aeshna	2		7	8	7	3	5	15	6	1	3	11
Corduliidae												
Cordulia	3	2		4	5	10	2	4	1		5	7
Stomatochlora	1		3		1	1	3	4	3		6	7
Libellulidae												
Leucorrhinia				1	1							

APPENDIX C. Aquatic invertebrates identified from kicknet samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Odonata (continued)												
Zygoptera												
Coenagrionidae												
Coenagrion	23	2	7	2		6		8			21	1
Lestidae												
Lestes							1					
Neuroptera												
Sialidae												
Sialis	2	3			12				4		1	3
Hemiptera												
Corixidae												
Cenocorixa			1			1						
Hesperocorixa	1								3			1
Gerridae												
Limnogonus					3							
Notonectidae												
Notonecta					5							
Unknown				2			5					
Diptera												
Ceratopogonidae												4
Chironomidae	2	2	7	3	1	17	4	4			1	14
Tipulidae						1						
Unknown		1										

APPENDIX C. Aquatic invertebrates identified from kicknet samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species						Lake						
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Amphipoda												
Hyalellidae												
Hyalella azteca	16	21	33		29	19	12					19
Cladocera												
Daphnidae												
Simocephalus serrulatus			11						2			1
Simocephalus vetulus						13						
Unknown											1	
Basommatophora[a]												
Ancylidae		2		2								
Planorbidae												
Gyraulus			8	5		13		4				10
Veneroida												
Sphaeridae												
Musculium	9	4	20		14	20	3	11	1		7	16
Hirudinea[b]	6		3	1		3	4	1			2	2

[a] Superorder.
[b] Class; Order not known.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX D. Stocking density and species stocked, by year, for 12 high mountain lakes, Siskiyou County, California, 1983-1986.

Lake	1986 Density fish/ha	Species	1985 Density fish/ha	Species	1984 Density fish/ha	Species	1983 Density fish/ha	Species	Average Density fish/ha
Clear[a]	615	RTSxKJ	324	RTS	324	RTS	330	RTKJ	398
Blue Granite[b]	562	RTSxKJ	0		417	RTS	148	RTKJ	376
West Boulder[b]	575	RTSxKJ	766	RTS	766	RTSH	0		527
Hogan[b]	507	RTSxKJ	149	RTS	149	RTS	203	BKS	252
Meteor[b]	545	RTSxKJ	606	RTS	606	RTS	618	RTSxKJ	594
Telephone	432	RTSxKJ	1235	RTS	1235	RTSH	1259	RTSxKJ	1040
Steinacher[b]	577	RTSxKJ	0		962	RTS	981	RTSxKJ	630
Section Line[b]	577	RTSxKJ	962	RTS	1442	RTSH	1038	RTS	1005
Chimney Rock	654	RT	654	RT	1307	RT	1307	RT	980
Syphon	385	RTSxKJ	962	RTS	981	RTS	1038	RTS	841
Cuddihy #4	545	RTSxKJ	0		1818	RTS	647	RTKJ	752
Mavis[c]	1744	BK, BN	1163	BK	1744	BK, BN	1744	BK, BN	1599

[a] Brook trout and brown trout in lake.
[b] Brook trout in lake.
[c] Brown trout in lake.

RT = Rainbow Trout, strain unspecified
RTS = Rainbow Trout, Shasta strain
RTSH = Rainbow Trout, Klamath River Steelhead
RTKJ = Rainbow Trout, Junction Reservoir Kamloops
RTSxKJ = Rainbow Trout, Shasta crossed with Kamloops
BN = Brown Trout, strain unspecified
BK = Brook Trout, strain unspecified
BKS = Brook Trout, Shasta strain

APPENDIX E. Aquatic plant genera identified in 12 high mountain lakes, Siskiyou County, California, 1986-1987.

	Lake											
Genus	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Typha	X			X								
Nuphar	X	X			X				X			
Potamogeton	X	X										X
Ranunculus	X	X		X			X					
Sparganium	X	X	X	X	X	X	X	X	X		X	
Eleocharis						X						
Isoetes	X	X	X	X	X	X	X	X	X	X	X	X
Nitella					X							
Sphagnum	X	X	X					X	X			
TOTAL GENERA	7	6	3	4	4	3	3	3	4	1	2	2

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX F. Aquatic invertebrate orders identified from stomach, kicknet, and Eckman grab samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Trichoptera	X	X	X	X	X	X	X	X	X	X	X	X
Ephemeroptera	X	X	X	X	X	X	X	X		X	X	X
Anisoptera[a]	X	X	X	X	X	X	X	X	X	X	X	X
Zygoptera[a]	X	X	X	X	X	X	X	X	X		X	X
Coleoptera	X	X	X	X	X	X	X	X	X	X	X	X
Neuroptera	X	X	X		X		X		X		X	X
Hemiptera	X		X	X	X	X	X	X	X			X
Diptera	X	X	X	X	X	X	X	X	X	X	X	X
Acarina	X	X	X			X	X		X	X		X
Amphipoda	X	X	X		X	X	X					X
Cladocera	X		X		X	X	X	X	X	X		X
Podocopa	X									X		
Cyclopoida			X			X	X	X		X		

APPENDIX F. Aquatic invertebrate orders identified from stomach, kicknet, and Eckman grab samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987 (continued).

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Basommatophora[b]	X	X		X	X							
Basommatophora[c]	X	X		X		X				X		
Veneroida	X	X	X	X	X	X	X	X	X		X	X
Hirudinea[d]	X	X	X	X	X	X	X	X		X		X
TOTAL ORDERS	15	13	15	11	13	14	14	12	10	10	8	14

[a] Suborder, counted as seperate "order".
[b] Superorder Basommatophora, family Ancylidae, counted as seperate "order".
[c] Superorder Basommatophora, family Planorbidae, counted as seperate "order".
[d] Class; Order not known.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX G. Number of terrestrial invertebrates identified by order from all trout stomach samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Coleoptera	1	20	99	10	12	10	12	106	23	41	14	5
Neuroptera		3	1	1	1			4	4		2	
Hemiptera	2		109	2	3	9	2	76	3	47		3
Homoptera			14		7	4	5	36	5	233	11	3
Lepidoptera	17	1	9	12		3	2	33	2	6	1	
Orthoptera			2							2		
Thysanoptera			34		2			2		1		11
Isoptera				1								
Hymenoptera	3	4	101	66		12	14	344	42	184	10	18
Psocoptera					1		2					
Diptera	1	3	46	5	3	5	5	68	8	7	1	1
Araneae			6	3			1	21	3	8		3
Scorpiones				1								

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX H. Number of aquatic invertebrates identified by order from age 1+ size class trout stomach samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Trichoptera	25	5	12	2	350	2	13		35	20	125	[a]
Ephemeroptera	27	77		3	3	48	144	7				
Anisoptera[b]	1	10	6	48	2	1	26	26	119	1		
Zygoptera[b]	49	13		59	3			2	1			
Coleoptera		2	2	5		2	2	1	2	3		
Neuroptera	1	4					1		1			
Hemiptera			1					3				
Diptera	43	257	414	41	175	280	109	100	500	140	2100	
Acarina		9	2			2	1					
Amphipoda	5	2	5			2	1					
Cladocera	200		150		130	500	950	75	3	620		
Podocopa	3									6		
Cyclopoida			13			7	5					

APPENDIX H. Number of aquatic invertebrates identified by order from age 1+ size class trout stomach samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987 (continued).

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Basommatophora[c]		10		64	19							
Basommatophora[d]								2				
Veneroida				1			3					
Hirudinea[e]										34		

[a] No age 1+ rainbow trout were sampled.
[b] Suborder, counted as seperate "order".
[c] Superorder Basommatophora, family Ancylidae, counted as seperate "order".
[d] Superorder Basommatophora, family Planorbidae, counted as seperate "order".
[e] Class; Order not known.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX I. Number of terrestrial invertebrates identified by order from age 1+ size class trout stomach samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Coleoptera	1	5	51	10	3	2	11	92	4	11		[a]
Neuroptera		2	1	1	1			2				
Hemiptera	1		63	2	1	7	1	65		24		
Homoptera			12			3	3	35	1	104		
Lepidoptera	17	1	9	12		3	1	19	1	4		
Orthoptera			1							1		
Thysanoptera			30		1			2		1		
Isoptera				1								
Hymenoptera		2	64	66		1	13	313	5	77		
Psocoptera							2					
Diptera		2	35	5		2	3	55	4	5		
Araneae			6	3			1	17	1	3		
Scorpiones				1								

[a] No age 1+ rainbow trout were sampled.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX J. Number of aquatic invertebrates identified by order from all trout stomach samples for 12 high mountain lakes, Siskiyou County, California, 1986-1987.

Order (or Other Major Taxon)	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Trichoptera	100	31	65	2	1185	81	20	8	77	40	210	9
Ephemeroptera	30	88		3	15	52	172	10		2	3	8
Anisoptera[a]	1	18	8	48	18	18	28	42	142	4	1	98
Zygoptera[a]	54	47	6	59	16		2	2	8		5	1
Coleoptera	1	5	2	5	2	5	5	2	3	5	3	
Neuroptera	98	13	5				2		5		8	3
Hemiptera			1			3		4				
Diptera	213	762	416	41	500	519	214	158	937	187	5100	153
Acarina	25	11	3			2	9		3	1		3
Amphipoda	6	9	7			29	6					
Cladocera	250		550		131	600	1000	575	4	1200		130
Podocopa	86									6		
Cyclopoida			13			7	5	1		10		
Basommatophora[b]	96	12		64	101							
Basommatophora[c]			1			5		7				4
Veneroida			1	1			3					3
Hirudinea[d]										34		

[a] Suborder, counted as seperate "order".
[b] Superorder Basommatophora, family Ancylidae, counted as seperate "order".
[c] Superorder Basommatophora, family Planorbidae, counted as seperate "order".
[d] Class; Order not known.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX K. Aquatic invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987.

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Trichoptera												
Limnephilidae												
Limnephilus						15						
Halesochila taylori	69	2				60			2		4	
Hesperophylax										16		
Brachycentridae									1			
Leptoceridae												
Mystacides	1		29	2		2				7		
Oecetis	3	18			1185		19				200	
Unknown	10	3						8	73			7
Polycentropodidae												
Polycentropus			2									
Sericostomatidae												
Gumaga	17	8	5		1				1		4	2
Unknown			29			4	1			13	2	
Ephemeroptera												
Baetidae												
Callibaetis	27	87				48	172				3	7
Unknown	3	1		3	15	4		10		2		1
Odonata												
Anisoptera												
Aeshnidae												
Aeshna			6		2	2	1	22	9	4		4

APPENDIX K. Aquatic invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake Cl	 BG	 WB	 Ho	 Me	 Te	 St	 SL	 CR	 Sy	 C4	 Ma
Odonata (continued)												
Anisoptera (continued)												
Corduliidae												
Cordulia	1	18	2	22	16	13	13	7	133			86
Stomatochlora						3	13					8
Unknown				16				11			1	
Libellulidae												
Leucorrhina				9								
Unknown				1			1	2				
Zygoptera												
Coenagrionidae												
Coenagrion	54	47	6	50	16			2	8		5	1
Lestidae												
Lestes							1					
Unknown				9			1					
Coleoptera												
Chrysomelidae												
Donacia		1		5			2	2	1			
Dytiscidae												
Dytiscus							1					
Hydroporus										2		
Oreodytes			1			5			1	3	1	
Elmidae												
Optioservus					1							
Phanocerus	1											
Unknown		4					2		1		2	

APPENDIX K. Aquatic invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Coleoptera (continued)												
Haliplidae												
Haliplus					1							
Hydrophilidae			1									
Neuroptera												
Sialidae												
Sialis	98	13	5				2		5		8	3
Hemiptera												
Corixidae			1			1						
Notonectidae												
Notonecta						2						
Gerridae								3				
Naucoridae								1				
Diptera												
Ceratopogonidae	1	2			1		3		2		6	
Chaoboridae							3					1
Chironomidae	210	757	402	38	464	502	202	85	935	171	5100	137
Culicidae					1							
Empididae	1	3	15	3	34	17	4	7		10		13
Ephydridae			3					65		2		2
Simulidae							1					
Tabanidae	1						1			3		
Tipulidae								1		1		

APPENDIX K. Aquatic invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Acarina												
Hydrachnellidae	25	11	3			2	9		3	1		3
Amphipoda												
Hyalellidae												
Hyalella azteca	6	9	7			29	6					
Diplostraca												
Cladocera												
Daphnidae												
Daphnia rosea	250		550		131	350	1040	575		1200		125
Simocephalus						241			4			
Scapholeberis kingii												5
Holopedidae												
Holopedium gibberum										20		
Podocopa	86									6		
Cyclopoida												
Cyclopoidae			13			7	5	1		10		

APPENDIX K. Aquatic invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Suborder Family Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Basommatophora[a]												
Ancylidae	96	13		64	101							
Planorbidae												
<u>Gyraulus</u>			1			5		7				4
Veneroida												
Sphaeriidae												
<u>Musculium</u>			1	1			3					3
Hirudinea[b]										34		

[a] Superorder.
[b] Class, Order not known.

Cl = Clear BG = Blue Granite WB = West Boulder Ho = Hogan Me = Meteor Te = Telephone
St = Steinacher SL = Section Line CR = Chimney Rock Sy = Syphon C4 = Cuddihy #4
Ma = Mavis

APPENDIX L. Terrestrial invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987.

	Lake											
Order Superfamily Family Subfamily Genus Species	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Coleoptera												
Anobiidae			1		1						1	
Cantharidae		10			1	3	3		8		1	
Carabidae										1		
Cerambycidae						1		1	2		2	1
Coccinellidae			14			1		4	4	5		
Colydiidae												
Lasconotus										5		
Cryptophagidae							1					
Curculionidae		1	2		1							
Dermestidae								1				
Elateridae		6	9	1	3			1	1	5	3	
Melandryidae												
Anapsis		1	12					3	1			1
Melyridae			13					68	1	1		
Oedemeridae										1		
Phalacridae			1									
Platypodidae				9					1	3		
Scarabaeidae		1										
Scolytidae			20			1		5		6		1
Staphylinidae			6		3	1		14		5	2	
Unknown	1	1	21		3	3	8	9	5	9	5	2

APPENDIX L. Terrestrial invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Superfamily Family Subfamily Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Neuroptera												
Chrysopidae			1		1							
Hemerobiidae											1	
Raphidiidae		3		1				3	4		1	
Unknown								1				
Hemiptera												
Anthcoridae					1	5	1	1		1		
Berytidae			2									
Lygaedidae			84					64	3	40		
Miridae						1						
Nabidae	1			1						2		
Saldidae			2									
Tingidae			6					1				
Unknown	1		15	1	2	3	1	10		4		3
Homoptera												
Aphididae			2		6	2	1	12	1	149	10	2
Cicadellidae			12		1	2	1	6	2	71	1	1
Eriostomatidae								5	1	5		
Membracidae							2			5		
Psyllidae							1	13	1	2		
Unknown										1		
Lepidoptera	17	1	9	12		3	2	33	2	6	1	
Orthoptera												
Gryllidae			2									
Unknown										2		

APPENDIX L. Terrestrial invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Superfamily Family Subfamily Genus Species	Lake Cl	 BG	 WB	 Ho	 Me	 Te	 St	 SL	 CR	 Sy	 C4	 Ma
Thysanoptera												
Phlaeothripidae			6					1		1		
Thripidae			28		2			1				2
Isoptera												
Hodotermitidae				1								
Hymenoptera												
Apidae												
Apis mellifera	1						1					
Aulacidae				1								
Bethylidae				1				13		5		
Braconidae				2		1	1	11	1	3		3
Ceraphronidae								3				
Chalcidoidea		1	59	1			1	181	20	11	4	12
Cynipidae	1		12				2	19	3		2	
Diapriidae				1			1	10	1			
Formicidae												
Formicinae		2	6	3		3	3	13	12	92	4	
Myrmicinae			10	40		1		1		49		
Halictidae				5		1		5	3	1		
Ichneumonidae	1	1	4	4		2	1	53	1	7		1
Platygasteridae			1					8				
Proctotrupidae								2				
Sphecidae				1		3		1	1	1		
Tenthredinidae										1		

APPENDIX L. Terrestrial invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Superfamily Family Subfamily Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Hymenoptera (continued)												
Vespidae							1					
Xyelidae			1	1			3	5				
Unknown			8	7		1		19		14		
Psocoptera												
Polysocidae					1							
Unknown							2					
Diptera												
Anthomyiidae		2	18					10				
Asilidae						2		13	1	1		
Cecidomyiidae										1		
Chamaemyiidae										1		
Chloropidae		1	1					5	1			
Dolichopodidae			1			1		1				
Drosophilidae											1	
Lauxaniidae	1											
Muscidae			1	1				1	1			
Mycetophilidae								2				
Phoridae			3					7				
Pipunculidae			1									
Psychodidae									1			

APPENDIX L. Terrestrial invertebrates identified from stomach samples for 12 high mountain lakes, Siskiyou County, California, 1987 (continued).

Order Superfamily Family Subfamily Genus Species	Lake											
	Cl	BG	WB	Ho	Me	Te	St	SL	CR	Sy	C4	Ma
Diptera (continued)												
Sciaridae										1		
Syrphidae				1				1				
Tephritidae			1					2				
Unknown			20	3	3	2	5	26	4	3		1
Araneae			6	3			1	21	3	8		3
Scorpiones				1								

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