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QUANTIFICATION OF HUNGRY HORSE RESERVOIR WATER LEVELS NEEDED TO MAINTAIN OR ENHANCE RESERVOIR FISHERIES

Annual Report 1983

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QUANTIFICATION OF HUNGRY HORSE RESERVOIR WATER LEVELS NEEDED TO MAINTAIN OR ENHANCE RESERVOIR FISHERIES

By:

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Period covered:

October 15, 1983 to April 30, 1985

Project Number: BPA 83-465

EXECUTIVE SUMMARY

The study was initiated to determine the effects of reservoir operation upon principal gamefish species in Hungry Horse Reservoir and to quantify seasonal water levels needed to maintain or enhance the reservoir fishery The study is part of the Northwest Power Planning Council's fish and wildlife plan which has the responsibility to protect fish and wildlife resources impacted by hydroelectric development in the Columbia River Basin. The Hungry Horse study began in May 1983, and is scheduled to continue through 1987. This annual report includes data collected during the 1983 and 1984 field seasons.

The data collection methods have been tested and refined to provide information which will enable us to develop relationships between reservoir operation and gamefish populations.

Downstream fish traps were operated in five tributaries to Hungry Horse Reservoir in 1984. A total of 1,617 juvenile and 224 adult westslope cutthroat trout were caught in these traps. The spawning run of 389 westslope cutthroat trout ascending Hungry Horse Creek in 1984 was markedly less than in 1968-1972.

Stream habitat surveys were conducted on 84 reaches in 62 tributaries. Adfluvial cutthroat trout spawning and rearing habitat appeared to be confined to stream reaches with a gradient less than 10 percent.

Hungry Horse Reservoir was isothermal from approximately mid-November to mid-May, thermally stratified from mid-June through September and ice-covered from mid-January to about mid-April. Specific conductivity, pH, and dissolved oxygen values were generally in the optimum range for westslope cutthroat trout and appeared to have little direct influence on fish distribution. Water temperature had a major influence in fish distribution and activity through its regulation of metabolism, spawning periodicity and food availability.

There was little difference in mean zooplankton densities among the three geographic areas of the reservoir. Copepods dominated the zooplankton community followed in abundance by Cladocerans. Daphina densities were highest in the spring and fall and lowest during the summer and winter. The populations of Daphnia were comparable to those found in Flathead Lake, but less than recorded in Lake Koocanusa.

Surface insects were patchily distributed in the reservoir, resulting in large variances among samples. Little difference could be detected in densities between the near and offshore samples among the three geographic areas. Aquatic dipteran numbers were highest in the spring and fall, while terrestrial densities peaked from August through October.

Aquatic dieteran larvae were lowest in the depth strata which was dewatered in 1983 and 1984. Considerable colonization occurred in the dewatered areas in the summer and fall after they had been flooded.

Cutthroat trout feed primarily on terrestrial insects followed by aquatic Dipterans during the summer and fall, 1983. Daphnia was the major food ingested during the winter, with cutthroat selecting the larger Daphnia above 1.5 mm in length. The biomass of stomach contents in the winter was much less than during the remainder of the year.

Fish distribution throughout the reservoir appeared to be controlled primarily by water temperature and food availability. Westslope cutthroat trout were concentrated in the upper Six meters of the water column in the nearshore zone when surface water temperatures are below 17-18°C. At higher tempacaturies cutthroat moved into the deeper offshore waters. A similar distribution pattern was exhibited by bull trout and mountain whitefish, except these species are closely associated with the reservoir bottom. Northern squawfish were distributed throughout the water column in the nearshore zone during the summer and fall when water temperatures were above 15°C. When temperatures declined in October they moved into the deeper, offshore, zone, and became relatively inactive. The different temperature preferences of cutthroat and squawfish resulted in a temporal and spatial separation in use of the reservoir nearshore and offshore habitat zones.

The catch of westslope cutthroat trout in floating gill nets varied considerably seasonally and among the three reservoir areas. Water temperature reservoir elevation differences and pre-spawning movements accounted for most of the sampling variability. Cutthroat mean catches in 1984 ranged from a 0.2 fish per net in August to 4.8 per net in April. These mean catches were comparable to those recorded in Flathead Lake and Lake Koccanusa.

Bull trout mean catches in sinking gill nets were highest in May, intermediate in October and lowest in August. The mean catch Of 5.3 bull trout per net in the Spring was higher than recorded in Flathead rake and Lake Koocanusa.

The purse seine technique was not successful in obtaining reliable population estimates for westslope cutthroat trout. An increase in sampling intensity in the Sullivan area during the spring and fall should increase markedly the reliability of population estimates.

Movement patterns of cutthroat trout were influenced primarily by reservoir operation, location of spawning tributaries and food abundance. There appeared to be an up-reservoir movement in the spring associated with spawning and reservoir refill and a down-reservoir movement in the fall and winter associated with drawdown.

The annual refill and drawdown cycle had large impacts upon the morphometrics and thermal stability of the reservoir. The drawdown period caused large reductions in the surface area, volume, Shoreline length, wetted bed area volume in euphotic zone and hydraulic-residence times. These changes in reservoir habitat appearedtohave adverse effects upon fish food availability and reduced the quality and quantity of living space for most fish species. This probably translates into reduced growth and increased mortalities for westslope cutthroat trout during periods of extreme drawdown. The piscivorous bull trout may benefit from the diminished living space associated with drawdown. Predation efficiency should increase as fish are concentrated into less area.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance rendered by numerous persons associated with the study. Ray Zubik, Steve Glutting, Gary Michael and Beth Morgan spent many long hours in the field collecting data under adverse conditions and many tedious hours in the laboratory. Ray had overall reponsibility for processing collections of fish food organisms and wrote this section of the report. Analysis of fish stomachs was done primarily by Beth. Steve was responsible for analyzing stream habitat and electrofishing data and wrote the stream habitat section of the report. Gary aged fish scales, summarized fish trapping and movement data and prepared graphics. Terry Rolinger was an able field hand and Joyce Lapp's assistance in the laboratory was greatly appreciated. Bob Calamusso and Paul Suek helped collect field data and maintain equipment, boats and vehicles.

Delano Hanzel assisted in computer work and he and Scott Rumsey aided in the preparation of boat and barge for purse seining. Joe Huston provided background information on reservoir fish populations and tributary habitat. Janice Pisano and Jean Blair typed this and other manuscripts. Rich Clark provided data on reservation operation and water levels in Hungry Horse Reservoir. Lloyd Reesman and Bob Anderson (Hungry Horse Ranger District) provided a storage area and allowed us to use the cabins at Anna and Betty Creek.

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INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act passed in 1980 by Congress has provided a mechanism which integrates and provides for stable energy planning in the Pacific Northwest. The Act created the Northwest Power Planning Council and charged the Council with developing a comprehensive fish and wildlife program to protect and enhance fish and wildlife impacted by hydroelectric development in the Columbia River Basin. Implementation of the plan is being carried out by the Bonneville Power Administration. The Hungry Horse Reservoir study is part of that Council's plan.

Reservoir operation affects game fish production by altering the physical environment through changes in reservoir morphometrics such as surface area, water volume, mean depth and shoreline length. Annual drawdown for flood control and power production adversely affects primary productivity (Woods 1982), benthos production (Benson and Hudson 1975), and fish production in reservoirs (Jenkins 1970). Graham et al. (1982) indicated that increased levels of drawdown in Hungry Horse Reservoir from 1965 to 1975 adversely affected the growth and survival of westslope cutthroat trout (Salmo clarki lewisi).

A maximum drawdown of 85 feet was proposed by Graham et al. (1982). This drawdown proposal will need to be reviewed in light of the additional data that will be generated by this study and the proposed changes in operation due to the "water budget" flows designed to enhance downstream migration of salmon smolts in the Columbia River. This report presents data collected during the first two years of a four year study.

OBJECTIVES

This study proposes to quantify seasonal water levels needed to maintain or enhance principal gamefish species in Hungry Horse Reservoir. The specific study objects are listed below.

1. Quantify the amount of reservoir habitat available at different water level elevations.
2. Estimate recruitment of westslope cutthroat trout juveniles from important spawning and nursery tributaries.
3. Determine the abundance, growth, distribution and use of available habitat by major game species in the reservoir.
4. Determine the abundance and availability of fish food organisms in the reservoir.
5. Quantify the seasonal use of available food items by major fish species.

6. Develop relationships between reservoir drawdown and reservoir habitat used by fish and fish food organisms, and

7. Estimate the impact of reservoir operation on major gamefish species.

DESCRIPTION OF THE STUDY AREA

Hungry Horse Dam was completed in 1952 and the reservoir reached full pool elevation of 3,560 feet msl in July, 1953. The dam impounded the South Fork of the Flathead River eight km upstream from its confluence with the Flathead River (Figure l). Hungry Horse is a large storage reservoir, operated by the Bureau of Reclamation, whose primary benefits are flood control and power production. The principal power benefit comes from generation at downstream projects. Water passes through 19 downstream projects, generating approximately 4.6 billion kilowatt hours of energy as compared to 1.0 billion at the Hungry Horse project.

The South Fork drains an area of approximately 4,403 km^2 on the west side of the Continental Divide in northwestern Montana. The basin is underlain principally by sedimentary rocks. The drainage is almost entirely within lands administered by the U.s. Forest Service with the upper part in the Bob Marshall Wilderness area.

WATER QUALITY

Water quality data collected during 1978 indicated that Hungry Horse Reservoir is an oligotrophic body of water with low nutrient input and primary productivity. Low nutrient concentrations, transparent water and low algal standing crops are related to the basin's geology, the comparatively pristine nature of the South Fork watershed and reservoir morphology. Most of the drainage area is underlain by nutrient-poor Precambrian sedimentary rock which is frequently deficient in carbonates and phosphorous. Mean concentrations of surface water total phosphorous, and dissolved orthophosphorous ranged, from 0.008 to 0.029 mg/liter and 0.005 to 0.013 mg/liter, respectively. Average concentrations of chlorophyll _a_ in surface waters ranged from 0.45 to 0.82 mg/m^3 (Bureau of Reclamation 1981). Phosphorous concentrations were higher in the upper end of the reservoir, but chlorophyll _a_ concentrations were highest near the dam and lower towards the upper part of the reservoir.

MORPHOMETRICS

At full pool the reservoir is 56 km in length with an area of 23,800 acres and a volume of 3,468,000 acre-feet. Usable storage for power production starts at elevation 3,336 msl and includes

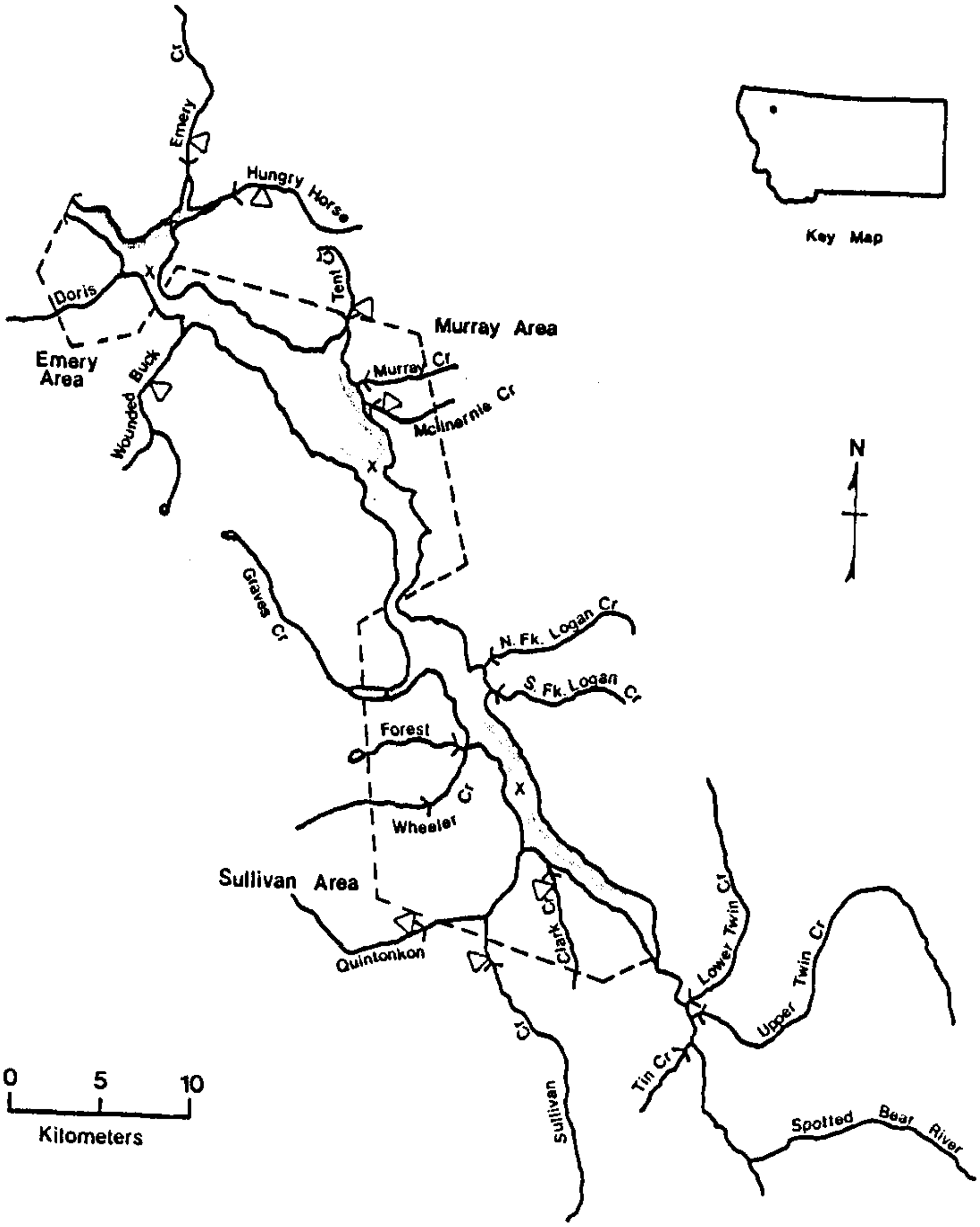

Figure 1. Map of Hungry Horse Reservoir showing study areas netting areas (,::::), Water quality, vertical net and zooplankton stations (x), fish trap location (>), and electrofishing sections (Δ).

2,982,000 acre-feet which is 86.0 percent of total full pool volume. Maximum drawdown of 224 feet would leave only 14.0 percent of full pool capacity (Table 1). The maximum drawdown on record of 128 ft. in 1972 reduced the volume to 37 percent of full pool. The recommended drawdown of 85 ft. reduces reservoir volume to 53 percent of full pool capacity.

RESERVOIR OPERATION

Reservoir operation has varied considerably since Hungry Horse was first filled. Historic operation can be classified into three periods based on average annual maximum drawdown: 1) 1955-64 when drawdown averaged 64 ft., 2) 1965-75 when drawdown averaged 92 ft. and when drawdown for advance power began; and 3) 1976-82 when drawdown averaged 66 ft. Maximum drawdown has ranged from 31 ft. in 1963 to 128 ft. in 1972 with a mean of 76 ft. (Figure 2). Maximum drawdown has been below the proposed 85 foot level in eight of 29 years of record. Water requirements for water budget flows may modify reservoir operation in the future.

The operation of Hungry Horse Reservoir is controlled by a combination of interacting factors which include: flood control, generation of hydroelectric power, recreational use of the reservoir, resident fish flows for the Flathead River and water budget flows. The reservoir is drafted in the fall to provide advance power for direct service industries. The major evacuation of water, however, occurs from December through March for flood control and power production. The reservoir is usually filled by the end of July and remains at full pool until after Labor Day to provide summer recreation opportunities. Operation is also regulated to provide flows for kokanee spawning and incubation of eggs in the Flathead River downstream from the mouth of the South Fork. From October 15 to December 15, flows in the Flathead River near Columbia Falls are maintained between 3,500-4,500 cfs. A minimum flow of 3,500 cfs is maintained the remainder of the year for incubation of kokanee eggs and for spawning and rearing of other fish species. In the future additional water may be provided for water budget flows in the spring to facilitate the downstream movement of salmon smolts in the Columbia River.

Power generation at Hungry Horse Dam is part of the Pacific Northwest power system. The firm load for the Pacific Northwest is 18,200 megawatts. In an average water year, 14,500 megawatts are generated by hydropower and 3,700 from other energy sources, primarily thermal. Approximately 6,400 megawatts are produced by other resources in a critical water year as compared to 11,800 by hydropower. The amount of secondary power (that sold out of the region or supplied to high energy industry) is based on availability of water in excess of that needed to meet firm loads. During all but the driest years, hydropower produces secondary power.

Table 1. Morphometric data for Hungry Horse Reservoir.

Drainage area (sq. miles)	1,700 (4,403 sq. km)
Average annual discharge (acre-ft)	2,386,918 (2.95 cubic km)[a]
Surface area (acres)	23,800 (9,632 ha)
Pool length (miles)	35 (56 km)
Shoreline length (miles)	133 (213 km)
Shoreline development	5.95
Mean depth (ft.)	146 (44.5 m)
Storage capacity (acre-ft)	3,468,000 (4.24 cubic km)
Useable storage (acre-ft)	2,982,000 (3.68 cubic km)
Storage ratio	1.45
Elevation at full pool (ft)	3,560 msl (1085.8 m)
Elevation at minimum pool (ft)	3,316 msl (1011.4 m)

[a] Based on unregulated flow from 1929-51.

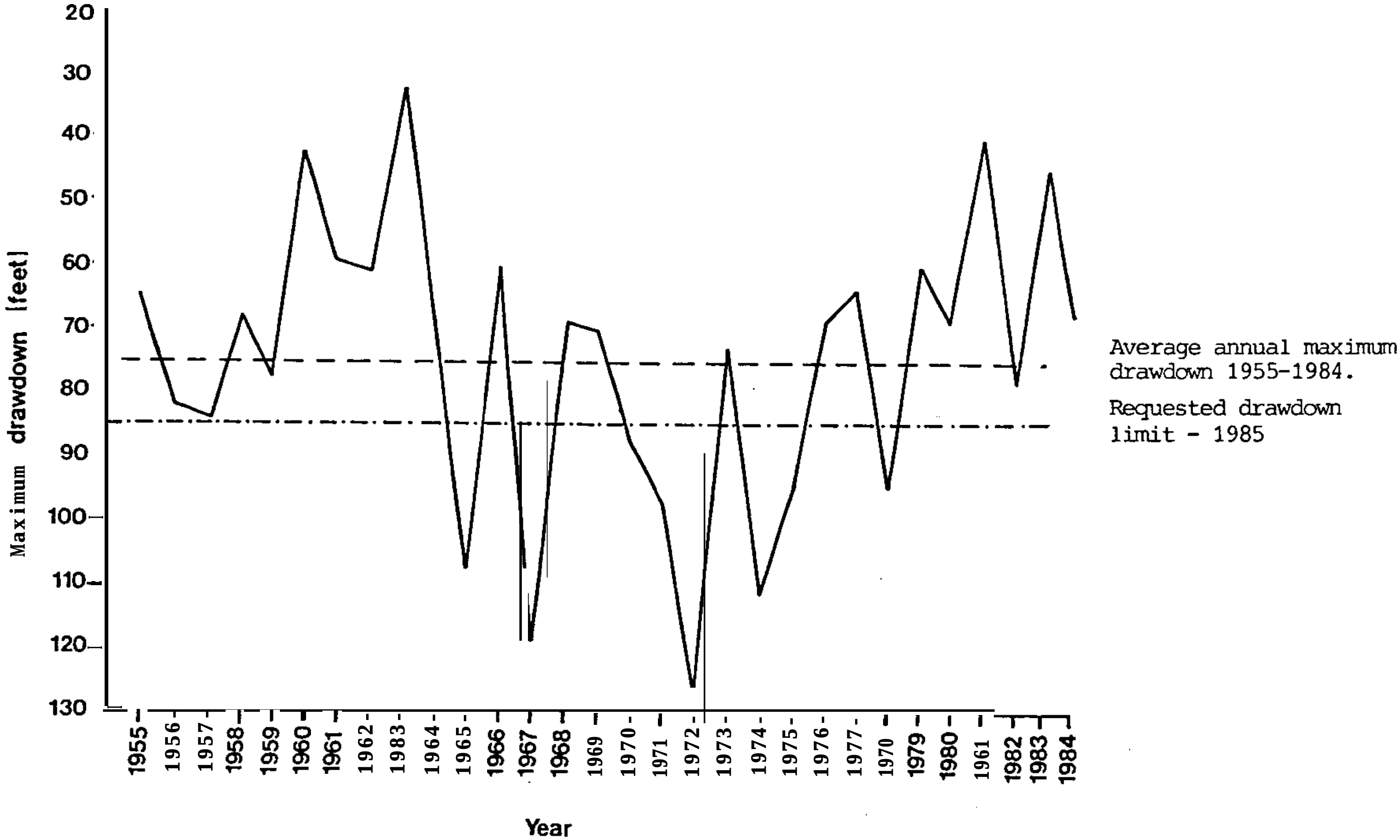

Figure 2. Annual maximum drawdown of Hungry Horse Reservoir for the years 1955-1984 Includes drafting for flood control as well as power production. Reservoir did not fill during 1973 and 1977.

In summary the operation of the Hungry Horse project is controlled by several factors including flood control, power generation, resident fish flows, water **budget** flows and recreation in the reservoir. Reservoir operation varies seasonally and annually with changes in these factors and precipitation in the drainage. It follows that changes in reservoir operation to benefit game fish populations would impact other variables controlling reservoir operation except for precipitation.

FISH SPECIES

Historic Status

Prior to construction of Hungry Horse Dam in 1952, the South Fork Flathead River drainage was considered the major spawning area for adfluvial fish stocks from Flathead Lake. Substantial numbers of bull trout and westslope cutthroat trout spawned in the South Fork drainage along with smaller numbers of mountain whitefish and kokanee salmon (Oncorhynchus nerka). Native fish species in the South Fork drainage prior to dam construction included westslope cutthroat, bull trout, mountain whitefish, northern squawfish, largescale sucker (Catostomus macrocheilus), longnose sucker (Catostomus catostomus pygmy whitefish (Prosopium coulteri) and sculpins (Cottus sp.).

The native species comprise almost the entire fish population in the reservoir. They are considered abundant except for pygmy whitefish and longnose suckers which are rated as rare and cosmon, respectively (Table 2). Pygmy whitefish may be more abundant than net data indicates, because they are not vulnerable to being caught in shoreline net sets.

Exotic species, which include arctic grayling (Thymallus arcticus), yellowstone cutthroat (Salmo Clarki bouvieri), and rainbow trout (salmo gairdneri), are present but rarely collected. Approximately five million grayling fry were planted in the reservoir in the mid-1950's and 13,000 adult fish in 1965. No other fish species have been planted in the reservoir. However, rainbow trout and Yellowstone cutthroat trout reached the reservoir by drifting downstream from high mountain lakes planted from the 1930's through 1960. Since 1970, westslops cutthroat trout has been the only species planted in the South Fork drainage. Interbreeding has occurred between westslope cutthroat, Yellowstone cutthroat and rainbow trout in six tributaries which have lakes as their source (Leary et al. 1983). The adfluvial strain of westslope cutthroat trout inhabiting the reservoir appears to be a pure strain, but more electrophoretic work is needed to substantiate the stock integrity.

Table 2. The relative abundance of fish species in Hungry Horse Reservoir as determined by gill net catches and creel surveys from 1958 to 1983. Abbreviations are given in parentheses.

Species	Scientific name	Relative abundance[a]
	Native Species	
Westslope cutthroat trout (WCT)	Salmo clarki lewisi	A
Bull trout (DV)	Salvelinus confluentus	A
Mountain whitefish (MWF)	Prosopium williamsoni	A
Pygmy whitefish (PWF)	Prosopium couteri	R[b]
Northern sguawfish (NSQ)	Ptychocheilus oregonensis	A
Largescale sucker (CSU)	Catostomus macrocheilus	A
Longnose sucker (LnSU)	Catostomus catostomus	C
Sculpin species	Cottus sp	R
	Exotics	
Rainbow trout (RB)	Salmo gairdneri	R
Yellowstone cutthroat trout (YCT)	Salmo lewisi bouvieri	R
Arctic grayling (GR)	Thymallus arcticus	R

[a] Relative abundance: A = abundant, C = common, R = rare.

[b] Pygmy whitefish may be more abundant than net catches indicated because they inhabit deep offshore waters and are not vulnerable to shoreline net sets.

Fisheries studies on Hungry Horse Reservoir began in 1958 and consisted primarily of monitoring spawning runs of westslope cutthroat trout into Hungry Horse Creek, modifying and/or removing barriers to upstream fish migration and monitoring reservoir fish populations with sinking gill nets.

Cutthroat populations in the reservoir were initially limited by inadequate recruitment of juveniles from the tributary streams. Fish passage problems caused by poor culvert installation on the road around the reservoir were improved from 1963 to 1965 by the Montana Department of Fish, Wildlife and Parks and U.S. Forest Service (Huston 1970). This program resulted in increased spawning success and subsequent recruitment of juvenile cutthroat to the reservoir.

Westslope cutthroat trout is the primary species sought by anglers in Hungry Horse Reservoir. From 1961 through 1969, westslope cutthroat comprised 95 percent of the catch with the remainder consisting of mountain whitefish, bull trout and grayling (Huston 1971). A fishery for mountain whitefish occurs in tributary streams having fall spawning runs.

The larger average drawdown from 1965-1975 appeared to adversely affect westslope cutthroat trout populations (Huston 1975). Spawning runs into Hungry Horse Creek declined and growth of age IV cutthroat trout was slower during this period than during periods of lesser drawdowns.

Westslope Cutthroat and Bull Trout Life Cycles

Cutthroat trout inhabiting Hungry Horse Reservoir are thought to be derived from Flathead Lake fish trapped behind Hungry Horse Dam when it impounded the South Fork. Three distinct life history patterns of westslope cutthroat commonly occur throughout their native range (Behnke 1979). Juvenile adfluvial westslope cutthroat spend one to three years in the tributaries before emigrating to Hungry Horse Reservoir. They generally reside in the reservoir for one to three years, mature and return to their natal stream in June and July to spawn and complete the life cycle. Fluvial westslope cutthroat trout are found in the mainstem of the South Fork. These fish have a similar life cycle to the adfluvial strain, except that they grow and mature in a large river rather than a lake or reservoir. The resident strain of westslope cutthroat trout completes its entire life cycle in small headwater streams. These fish seldom reach total lengths longer than 200 mm, whereas fluvial and adfluvial cutthroat trout attain total lenghts up to 400-45Omn.

Bull trout also have populations which exhibit the resident, fluvial, and adfluvial life cycle patterns. Bull trout, however, are fall spawners and their eggs hatch in March as compared to July and August for cutthroat. Bull trout mature at an older age, live longer and adults are piscivorous.

METHODS

TRIBUTARY HABITAT AND FISH POPULATIONS

Habitat Surveys

Habitat surveys were conducted on tributaries of Hungry Horse Reservoir to evaluate spawning and rearing habitat available to adfluvial cutthroat and bull trout.

Streams were divided into reaches according to valley characteristics, stream gradient and stream order. Exact lengths and gradients were calculated for each reach using a Numonic 2400 Digittablet provided by the Flathead National Forest Service.

For each reach surveyed, a two-member survey crew walked the entire reach and recorded the following: 1) square meters of spawning gravel, 2) locations of bank instability, 3) location of barriers, 4) stream pattern, 5) flow character, 6) width of valley flat, 7) turbidity, 8) stage and 9) number of class I, II, and III pools according to the classification system used by Graham et al. (1980).

In addition, a more intensive habitat survey was conducted in a representative section within each reach which consisted of 30 random transects, one-meter wide across the stream. The information collected at each transect was recorded on stream survey data sheets (Appendix Al).

Stream reaches that were considered too steep or too small to support an adfluvial fish population were. not surveyed. Furthermore, when obvious natural barriers to fish migration were encountered, stream surveys were discontinued.

Data will be recorded on standard Montana Interagency Stream Fishery Data forms (Holton et al. 1981) then entered into the statewide data base system, Total surface area of cutthroat spawning and rearing habitat in tributaries of Hungry Horse Reservoir will be estimated. Suitable spawning habitat will be classified as total area of the streambed predominated by material 12.7 to 76.2 mm and covering areas of at least 0.28 square meters. Total rearing habitat will be estimated using stream width and stream length. Quality of rearing habitat will be estimated using stream gradient, substrate composition, percent pools, percent of instream cover, percent of overhead cover and depth. We will adapt models developed by Fraley and Graham (1981) to predict potential number of juvenile salmonids produced in tributaries to Hungry Horse Reservoir. Population estimates will be made by reach in important spawning tributaries to compare predicted trout numbers to existing populations.

Culvert Evaluations

Fish passage was evaluated at culverts installed in streams crossing the main road around the reservoir. Flow and velocity measurements were taken weekly during the spawning run of westslope cutthroat trout. Length and diameter of culvert, depth of jump pool and height of jump into culvert from the pool was also recorded. Visual observations of fish passage attempts were noted,

Population Estimates

Population estimates were obtained on seven streams in 1983 (Figure 1) to determine fish abundance. The two-pass procedure (Zippin 1956) was used to make estimates in streams with flows less than about 10-15 cfs. For streams with higher flows the mark-and-recapture method was utilized (Vincent 1971). The section length for the mark-recapture estimate was 300 m as compared to 150 m for the two-pass method. A braided nylon block net (12.7 mm mesh) was placed at the lower and upper boundary of the shocking section for two-pass estimates. The fish were collected by electrofishing. A stationary plate located in the water near the generator was used as the cathode. The anode was hand held and connected to the Variable Voltage Pulsator with enough electrical cord to extend over the entire section. In general, methods outlined by Shepard and Graham (1983a) were used, except that block nets were not used in the mark-recapture sections.

Fish Trapping

Box traps and leads covered with 6.4 mm square mesh hardware cloth were installed in 1983 in Emery, Hungry Horse, Tent, Murray McInernie, N.F. Logan, S.F. Logan, Lower and Upper Twin, Tin, Clark, Sullivan and Wheeler creeks (Figure 1). Downstream traps were fished in 1984 in Emery, Forest, Clark and Quintonkon Creeks. Traps were checked twice daily and all fish were removed, anesthesized, measured and weighed. Species, length, weight, tag number and tag type were recorded for each fish. All fish longer than 250 mm were tagged with numbered anchor tags and fish 100 to 250 mm in length were tagged with numbered dangler tags. Scales were taken for age determination from representative samples of fish from each stream.

A velocity barrier and upstream trap was designed and installed at the permanent trap site in Hungry Horse Creek (Figure 1). A Wolfe type downstresm trap was installed in the spring of 1984 to monitor the downstream movement of juvenile and adult westslope cutthroat trout. An upstream box trap was installed in the bypass channel to capture spawning adults. Adults caught in the upstream trap were marked with a left pelvic punch. Spent spawners collected in the downstream trap were inspected to determine if they had been previously captured and marked during the spawning run. The total number of fish in the spawning run was estimated using the formulas taken from Vincent (1971).

$$N = \frac{(M+1)\ (C+1)}{(R+1)} - 1 \text{ where}$$

N = Population estimate
M = Number of fish marked (upstream trap catch)
C = Number of fish in catch sample (downstream trap catch)
R = Number of marked fish in recapture sample (C)

$$\text{Variance} = \frac{N^2\ (C-R)}{(C+1)\ (R+2)}$$

RESERVOIR HABITRT

Hungry Horse Reservoir was segregated into the Emery, Murray and Sullivan areas based on reservoir morphometry and the effects of drawdown (Figure 1). Within each of these study areas a permanent station was selected for water quality and zooplankton data collection. Vertical fish distribution and benthic macroinvertebrate samples were collected near these permanent sites. In addition to permanent sampling sites, transects were established across the reservoir at visual landmarks where randomly selected zooplankton, surface insect and purse seine samples were collected.

The reservoir habitat was divided into nearshore (littoral) and offshore (limnetic) zones. the littoral zone included the area less than the depth of the euphotic zone (approximately 20 meters) and less than 100 maters from the shoreline.

For this report, contour maps of the reservoir made prior to impoundment were used to determine surface area and shoreline length of the reservoir at 20 foot contour intervals. Contour intervals were digitized by geographic area (Emery, Murray and Sullivan).

Eventually, each 10-foot contour interval will be digitized by geographic area. The area and volume of each 10-foot interval can then be computed using the program GEOSCAN developed by MDFWP (Lonner and Paxton, in prep.) This program can be used to determine volume of water in euphotic zone, volume of water in prescribed temperature range, surface area, volume and bottom area dewatered at 10 foot contour intervals.

Monthly lake-filling and hydraulic-residence times were calculated using the formulas adapted from Woods (1982). Lake-filling time represents the time required to replace the volume of a reservoir at a given inflow whereas hydraulic-residence time represents the time required to replace the volume of a reservoir at a given outflow.

$$LET = \frac{V}{I} \times 0.0833$$

$$HRT = \frac{V}{O} \times 0.0833$$

LFT = lake - filling time in years
HRT = hydraulic - residence time in years
V = reservoir volume in acre feet
I = monthly inflow in acre feet
O = monthly outflow in acre feet
0.0833 = conversion of months to years

PHYSICAL LIMNOLOGY

Water temperature (°C), dissolved oxygen ($mg.l^{-1}$), pH and specific conductivity ($umhos.cm^{-1}$) were measured at the permanent sites. Measurements were taken biweekly from May through October with a Martek Mark V digital water quality analyzer, and monthly from November through March when access to the reservoir was available. The vertical profile data were collected inmediately below the water surface, 1, 3, 5, 7, 9, 11, 13, 15, 18, 21 m and every three meters down to 60 m, then every five meters from 60 m to 100 m or the bottom. Calibration of the mater was done in the field from May through October and in the laboratory inmediately prior to field measurements from November through March when ambient air temperatures were below freezing.

Light transmittance was measured in foot candles using a Protomatic photometer. Incident light was measured innediately above the water's surface. Light penetration was measured at depths of 90, 60, 30, 15, 5, 1 and 0.1 percent of the incident light. Greeson et al. (1977) defined the lower boundary of the euphotic zone as the 1.0 percent of incident light depth.

Water temperature, dissolved oxygen, pH, conductivity and light transmittance profile data were entered into computer data files and transferred to the U.S. Geological Survey WATSTORE system and the Environmental Protection Agency STORET system. Isopleth diagrams were generated using a computer program titled STAMPEDE (Woods and Falter 1982). This data base will be used in correlation analyses of vertical zooplankton and fish distribution.

Several problems were encountered during measurements of physical-chemical profiles. Field calibration of the Martek meter requires approximately one hour at each sampling station. At ambient air temperatures below freezing, field calibration was impossible and the conductivity probe would not function.

FISH FOOD AVAILABILITY

Zooplankton

Crustacean zooplankton were sampled from the upper 30 m of the water column. Three 30 m vertical tows were made biweekly in the Emery and Sullivan areas and two in the Murray area from April through June, 1984. An additional tow was taken in each area from July through October. Samples were collected monthly from November through April when access to the reservoir was possible. A 153-micron mash conical plankton net having a diameter of 0.115 m was used. In each area samples were collected at the permanent limnological buoy and two randomly selected sites. An additional sample was taken in the Emery and Sullivan areas in Emery and Graves bay, respectively. Samples were collected according to mathods presented in Leathe and Graham (1982).

Vertical distribution of zooplankton was assessed using a 28.1 liter plexiglass Schindler plankton trap (Schindler 1969). A plankton trap sample series consisted of duplicate samples collected from the surface and every three meters down to 15 m, and then every five meters down to 30 m. Plankton trap sample series were collected monthly in the three areas at the permanent limnological buoys from mid-August through mid-December.

All zooplankton samples were preserved in the field with a mixture of four percent formalin and 40 $g \cdot l^{-1}$ sucrose. Plankton net samples were diluted or concentrated in the laboratory to a volume where each one ml subsanple contained approximately 50 to 100 organisms. Five 1.0 ml subsamples were counted and identified in a Sedgewick-Rafter counting cell using a binocular compound microscope at 40X total magnification. Separate counts were made to estimate the densities of Leptodora and Epischura using a Bogorov counting chamber (Gannon 1971) with a dissecting microscope at 38X total magnification. These organisms were relatively large, but seldom appeared in subsamples due to their low densities. Schindler trap samples were concentrated to approximately 10 ml. One ml subsamples were counted and identified in a Sedgewick Rafter counting cell until the whole sample had been enumerated.

Cladocerans were classified to genus (Daphnia, Leptodora, Bosmina), and copepods were segregated into Calanoids (genus Diaptomus and Epischura and Cyclopoids (genus Cyclops) All juvenile copepods were identified as nauplii. Densities were calculated for adults only and were expressed as number per liter except for Epischura and Leptodora which were expressed as number per m^3 due to their low numbers. One random one ml subsample was used to measure carapace length of each individual plankter, using a graduated field in one ocular of the microscope. Biomass of zooplankton was calculated using length - weight regressions in Bottrell et al. (1976).

Bosmina LnW = 3.0896 + 3.0395 LnL

Daphnia LnW = 1.4681 + 2.8292 LnL

copeppoda LnW = 1.9526 + 2.3990 LnL

Where: Ln = natural log
W = dry weight (ug)
L = length of zooplankton in mm

The weight of Leptodora zooplankton was taken from Cummins et al. (1969).

Analyses of zooplankton, surface insects, and benthic macroinvertabrates were based on density data. biomass and numbers of each of these three major food categories will be determined on either an area1 or volumetric basis.

Surface Insects

Surface insects were sampled using a net towed along the water surface. The net consisted of a one meter wide frame attached to 3.17 mm mesh ace bobbin netting which tapered back to 1.59 mm mesh bobbin netting with a collar. A removable plexiglass bucket was attached to this collar. The bucket had a panel of 80 micron mesh netting to filter the surface water and retain all insects.

Two randomly selected sites in each area were sampled biweekly in 1983 and from May through June 1984. An additional sample was collected from July through October 1984. The frequency of sampling was reduced to once monthly in November 1984. Two samples were collected at each sample site. One tow was made within 100 m of the shore and one further than 100 m from shore. Each sample was collected by towing the net at approximately 1.0 m*sec^{-1} for 10 minutes in a zig-zag pattern. The time of sampling was standardized to afternoon.

All insects were preserved and individuals were identified to order and counted. Blotted wet weights of insect orders were measured in grams. Densities of insects were expressed as numbers per hectare.

Benthos

Benthos samples were collected during the spring, fall and winter season from a permanent transect in each area with a Peterson dredge which sampled .092 sq. meters of reservoir bottom. Three replicate samples were taken from each of the following depth intervals for a total of nine samples: 1) full pool elevation (3,560 ft.) to recommended drawdown elevation of 3,475 feet; 2) recommended to maximum drawdown on record at elevation 3,432 feet: and 3) below elevation 3,432 feet.

Benthos samples were sieved in the field through 5.6, 0.85, and 0.52 mm sieves and the material retained on the 0.52 mm sieve was preserved. All macroinvertebrates were picked from the sample and identified to order or class. Number and total blotted wet weights were determined and densities were expressed as number$\cdot m^{-2}$ and grams$\cdot m^{-2}$, respectively.

FOOD HABITS

The year was stratified into four seasons based on reservoir operation and surface water temperatures.

1. Winter (mid-November through April) - when the reservoir is evacuated for flood control and pcwer production, surface water temperatures are below 8.0°C and the reservoir is isothermal;

2. Spring (May and June) - when the reservoir is refilled and surface water temperatures are between 10-15°C; and increasing.

3. Summer (July through mid-September) - when the reservoir is near full pool and surface water temperatures are between 16-22°C and the reservoir is thermally stratified.

4. Fall (mid-September through mid-November) - when drafting of the reservoir begins for power production and surface water temperatures are between 10-15°C and declining.

Fish samples for the food habits study were collected with gill nets from each area of the reservoir during the seasonal gill net series. Approximately twenty of each cutthroat, bull trout, mountain whitefish and northern squawfish were collected from each area seasonally.

a. Zooplankton in the stomachs were identified to genus and carapace lengths of Daphnia determined from the relationship between the length of the post-abdominal claw and the carapace. The regression formula is:

$$Y = 0.0553 + 11.74x$$

Where: Y = carapace length
X = post-abdominal claw length
R = .962

This regression was developed from measurements of approximately 50 Daphnia from zooplankton samples collected at the permanent stations during the period when Daphnia appeared in fish stomachs (winter). The length of post-abdominal claws in cutthroat trout stomachs was determined by measuring 20-25 claws from fish <300 mm and >300 mm in length, keeping each area of the reservoir separate. Biomass of Daphnia was then calculated from the carapace length - weight regression taken from Bottrell et al. (1976).

b. Insects were identified to order and the wet weight of each order determined with on an analytical balance.

c. Fish were identified to species and then wet weight determined gravimetrically.

d. Food habits data was summarized for each species by season and size class in each area. If there is little difference among areas, the data will be lumped for the whole reservoir.

e. The numder frequency of occurrence, and weight of each food item will be calculated and combined into an index for relative importance (IRI). The IRI values range from 0 to 100, with a value of 100 indicating exclusive use of the food item.

In general, food habits data was summarized according to methods presented by Leathe and Graham (1982). Feeding selectivity will be assessed using the natural log of the odds ratio (Gabriel, 1978)

$$O = \frac{P_1 \ (1-P_1)}{P_2 \ (1-P_2)}$$

where:

Θ = odds ratio

P_1 = percentage of diet composed by a given prey taxon

P_2 = percentage of food complex in environment comprised by the given prey taxon.

Diet overlap will be evaluated using the Schoener index (Schoener 1970). This index is calculated as follows:

$$a = 1 - 0.5 \sum^{N} | P_{xi} - P_{yi} |$$

where: a = Schoener overlap index,

P_{xi} = proportion of food category i in the diet of fish species x,

P_{yi} = proportion of food category i in the diet of fish species y.

This index ranges between 0 and 1.0, with a value of 1.0 indicating a large amount of diet overlap between the two species.

FISH ABUNDANCE AND DISTRIBUTION

Floating and Sinking Gill Nets

Standard experimantal floating and sinking gill nets were used to sample fish in near-shore areas. These nets are 38.1 m long and 1.8 m deep and consist of five equal length panels of 19, 25, 32, 38, and 51 mm square mesh. Floating nets sampled from the surface down to 1.8 m and sinking nets sampled from the bottom up 1.8 m. A floating net set consisted of two floating nets tied end to end (double floater) and fished perpendicular from shore. A sinking net consisted of a single net fished perpendicular from shore. In each area seven double floaters and five sinkers were set in the evening and retrieved the next morning (Figure 1). The netting series were done monthly frcm July through November 1983 and from April through June 1984 and seasonally the rest of the year. Nets were set two nights in each area during the seasonal netting. The seasonal floating net sample size (14 double floaters) will allow us to identify a significant difference in the catch of westslope cutthroat of 20 percent at the 95 percent confidence levels. The sinking net sample size (10 sets) will enable us to ascertain significant differences in bull trout and mountain whitefish catches of greater than 30 percent at the 80 percent confidence level.

All fish were removed from the nets, identified to species, with length (mm) and weight (g) recorded for each fish. Sex and state of sexual maturity (ripe, spent, mature, immature) were recorded for game fish. Scale samples were taken from all game fish and representative numbers from nongame fish. Otoliths were collected from westslope cutthroat trout beginning in Decer&r, 1984.

Horizontal gill nets were effective in sampling for all fish species when they were distributed in inshore areas, except for pygmy whitefish and sculpins (Cottus sp). Gill net data was analyzed using catch per single net night by species. A Wilcoxon matched-pairs signed-ranks test will be used to determine if a significant difference exists between inner versus outer floating gill nets within each double floating set (Daniel 1978). We will transform the net catch data to logrithmic numbers in order to normalize it. This will enable us to use normal statistics so that we can simulataneously evaluate differences between areas, seasons and years. Correlation and regression analyses will be used to relate environmental and food abundance variables to fish distribution and abundance.

Vertical Gill Nets

Eight vertical gill nets were set in October and November, 1983 in two banks of four at permanent buoys in the Emery and Murray areas (Figure 1). Vertical net series were done in May, June and July, 1984 in all three areas of the reservoir at the permanent stations. Nets were set in the evening and retrieved the next morning using the methods described by Horak and Tanner (1964) . The vertical nets used were 3.7 m wide and 45.6 m deep. Depths were narked in 1.0 m increments. Each bank of four nets included nets of mesh size 19, 25, 32, and 38 mm Fish were removed as nets were retrieved and their depth of capture recorded along with mesh size.

All fish were removed from the nets, identified to species with length recorded for each fish. The data was analyzed using catch per single net night by species.

Acoustical Sampling

Hydroaccoustical sampling was conducted using a Sitex Model HE 356A recording chart depth sounder. In each area three permanent transects located near the vertical net buoys were sampledin October and November 1983 and May, June and July, 1984. Accoustical runs were made during the day and night in conjunction with the vertical net series.

Pure seine Population Estimates

A 183 m long by 9.1 m deep purse seine comprised of 19 mm mesh net was used to collect fish in the spring and fall of 1984. Experimental purse seining was done in the spring throughout the reservoir in order to become proficient in the use of the seine and refine the methods required to make a population estimate. Thirty hauls were made in the Sullivan area and 19 in the Murray area in the fall when surface water temperature were below 15°C. At these tempatures, cutthroat trout are typically concentrated in the upper 6 m of the water column.

An area density formula was used to estimate population numbers from the seine catches in the limnetic zone. The seine samples an area of 0.266 ha (0.66 acre). This estimate includes cutthroat trout in the upper 6m of the water column in the limnetic zone.

An estimate Of cutthroat in the near zone was determined by use of a correction factor applied to the plrse seine estimate for the limnetic zone. Double floating nets were set at five stations in the nearshore zone in the two areas prior to and after the purse seine sampling. At the same time, five double floaters were set offshore of the littoral stations in the limnetic zone. The ratio of cutthroat caught in the littoral zone versus the limnetic zone was used to adjust the purse seine estimate. For example, if the catch in littoral nets was 2.2 times as great as the limnetic net catch, the density estimate for cutthroat in the limnetic area derived from purse seining would be multiplied by 2.2 to obtain the littoral estimate.

we used the follrwing estimator to calculate population nunbers in the limnetic zone (Everhart and Young, 1975):

$$N = \frac{A}{a} \sum_{i=1}^{a} N_i$$

where: N = estimated population

A = number of equal sampling units (a) in limnetic area

a = the area sampled by the purse seine = 0.266 ha

N_i = the number of cutthroat in each purse seine haul. The estinkate variance for this estimator is:

$$V(N) = \frac{A^2 - aA}{a} \cdot \frac{a \sum N_i^2 - \left(\sum N_i\right)^2}{a(a-1)}$$

The estimator for the littoral area is:

$$N = CF(A)\,\bar{X}$$

where: N = estimated population

CF = correction factor

A = number of equal sampling units (a) in littoral area

$\bar{X}$ = mean catch per haul in limnetic area

The standard deviation for the littoral estimate is

$$s = CF\,(A)^2\,(V\bar{X})$$

where: S = standard deviation

$V\bar{X}$ = variance of the mean catch per haul in limnetic area

The estimate will be based on surface area and the assumptions associated with this method are:

1. All the cutthroat are found in the upper 6.0 meters of the water column sampled by the purse seine. When surface water temperatures drop below 15°C, cutthroat are concentrated in the upper 6 meters of the water column. If fish are found below 6.0 meters the estimate would be negatively biased.

2. The purse seine will collect all cutthroat in a 0.266 ha area to a depth of 6.0 meters. Purse seines are considered to be one of the most efficient and least selective gears to use for sampling salmonids in limnetic zones (Hartt 1975). If cutthroat escape the plrse seine, the estimate would be negatively biased.

3. The total surface area of the reservoir is known. We have area-capacity tables for the reservoir and will have digitized maps of the reservoir by area.

4. Cutthroat are distributed uniformly throughout the limnetic zone in each geographic area, or if their distribution is not uniform, the sampling distribution is proportional to the density of fish in different parts of the reservoir.

Electrofishing

Near-shore zones in the Sullivan area were sampled in the spring, Sumner and fall to determine the utilization of this habitat by westslope cutthroat trout juveniles. Sanpling was done at night using an electrofishing boat with boom mounted electrodes. Pulsed direct current of approximately three amps and 200 volts was used. Fish collection was confined to shoreline areas less than 2 meters in depth.

FISH MOVEMENT

During the study approximately 6,000 adfluvial cutthroat trout juveniles and 2,000 adults will be tagged with numbered dangler tags and anchor tags, respectively. These fish will be collected with downstream traps, electrofishing gear, purse seine and by angling. Tag returns will be provided by anglers, creel census interviews and fish sampling activities in the reservoir and tributary streams. Tne program RTRN (Graham et al. 1980) will be used to sort and analyze fish movement data.

GAMEFISH GROWTH

Total body length of cutthroat, bull trout and mountain whitefish collected during the study was measured to the nearest millimeter. Body weight was determined to the nearest gram for fish weighing 500 grams or less and to the nearest 45 grams (0.1 pound) for fish weighing more than 500 grams. Scales were taken from an area just above the lateral line along an imaginary line drawn between the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. Otolith bones were removed from cutthroat trout and stored in scale envelopes in a dry state. Otoliths will be aged by Dr. Ed Brothers from Cornell University to determine seasonal growth.

Cellulose acetate impressions of scales were examined using microfiche readers. Distances from the focus to annuli were measured to the nearest millimeter using transparent plastic rules and recorded directly onto computer coding sheets.

Age and growth information will be analyzed using the FIRE 1 computer program described by Hesse (1977) and the AGEMAT program devised by MDFWP personnel. Body length-scale radius relationships are most accurately described using log-log plots constructed from pooled samples of tributary and lake fish. Condition factors were calculated as $(W \times 10^5)/L^3$, where "W" equaled weight in grams and "L" equaled total fish length in millimeters.

Aging techniques will be validated by the methods described by Bemish and McFalane (1983). Annual back-calculated growth estimates will not be completed until the final report (1986-87). This will enable us to pool the growth data from the entire study to establish the body-scale regression line.

ANNUAL MORTAKITY ESTIMATES FOR WESTSLOPE CUTTHROAT TROUT

Total annual mortalitly will be estimated for cutthroat trout using the annual population estimates calculated from purse seine data. The formula is:

$$\mathrm{Ln}\ Nt/No = -zt$$

Where Ln = natural log
Nt = number of estimated age n+l and older fishes at end of year
No = number of age n and older fish at beginning of year
-z = mortality rate
t = year

Mortality estimates will be cross checked using a variety of additional methods including catch curves and mark-recapture data from Hungry Horse trap operation.

STATISTICAL ANALYSIS OF FISH, ZOOPLANKTON, BENTHOS AND SURFACE INSECT DATA

Numerical catch values of target fish species in gill nets, zooplankton, benthos and surface insect collection will be transformed for analyses (Mayhew, 1977):

$$Y_{ijk} = \log (X_{ijk} + 1)$$

where: Y_{ijk} = transformed value of X_{ijk}

X_{ijk} = numerical catch in the k^{th} sampling period, at the j^{th} area, in the i^{th} year.

Transformation will be necessary to achieve uniform variance among the residuals and eliminate zero catches that occasionally occur. Examination of probability plotting on preliminary data adjusted to normal variates was nearly a straight line indicating normality is a reasonable assumption.

Sources of variation in target fish, zooplankton, benthos, and surface macroinvertebrate abundance will be determined by factorial analysis of variance in a random effects model corresponding to the least squares function:

$$X_{ijk} = u + Y_i + S_j + A_k + (YS)_{ij} + (YA)_{ik} + (SA)_{jk} + E_{ijk}$$

where:

X_{ijk} = expected catch

u = overall mean catch

Y_i = random effects of the i^{th} y-r

S_j = random effects of the j^{th} season

A_k = random effects of the k^{th} area

$(YS)_{ij}$, $(YA)_{ik}$, $(SA)_{jk}$ = first order interactions

E_{ijk} = residual error.

Significant differences between years would indicate total maximun drawdown affected abundance. Differences between seasons and areas mean different seasonal use of sampled habitats and would imply seasonal operation may affect abundance.

One-way analysis of variance will also be used to look for differences among years, seasons or areas.

RESULTS AND DISCUSSION

TRIBUTARY HABITAT AND FISH POPULATIONS

Habitat Surveys

During the 1983-84 field season, stream surveys were completed on 52 tributaries to Hungry Horse Reservoir which included 84 reaches and 229 km of stream. Seven reaches remain to be surveyed; they include one reach in Deep Creek, one reach in Soldier Creek and five reaches in the Graves Creek Drainage.

The 1983 and 1984 stream survey results are listed in Appendix A2 and A3. The drainage areas in Appendix A2 and A3 are given for the major streams only and include the drainage areas of their subordinate tributaries. Stream habitat considered useful to adfluvial cutthroat or bull trout in Hungry Horse tributaries have gradients less than 10.0 percent. Platts (1979) found that high cutthroat densities were associated with stream gradients between 6.0 and 8.0 percent. Furthermore, MacPhee (1966) suggested that cutthroat densities increased at 4.0 percent gradient and attributed this increase to interspecific competition between cutthroat and brook trout at gradients under 4.0 percent. Since brook trout are not found in the Hungry Horse drainage, Cutthroat and bull trout utilize stream reaches Under 4.0 percent gradient. At the gradients greater than 13 percent Leathe and Enk (in prep) found relatively high densities of resident cutthroat. However, stream surveys on Hungry Horse Reservoir tributaries indicated that gradients greater than 10.0 percent were associated with small cascading first-Order Streams with barriers to adfluvial cutthroat and bull trout migration.

East-side Tributaries

Drainage areas on the east-side of Hungry Horse Reservoir ranged from 3.7 to 52.8 km^2. Amounts of spawning gravel ranged from 8.0 m^2 in Murray Creek to 786.7 m^2 in the Hungry Horse Creek Drainge. A total of 1,929 m^2 of spawning gravel was found in the east-side tributaries. Culverts blocked access to 325 m^2 of spawning gravel to migrating cutthroat trout during part or all of the spawning period.

Stream gradients ranged from 1.3 to 47.5 percent. There was a total of 134.4 km of stream with gradients less than 10.0 percent; 52.7 km were inaccessible to adfluvial cutthroat and bull trout due to culverts and natural barriers. In addition, 10.9 km of stream were considered too small to support an adfluvial fish population.

West-side Trebutaries

Drainage areas on the west-side of the reservoir ranged from 0.9 to 15.6 km^2. Amount of spawning gravel varied between 14.1 m^2 in Battery Creek to 1,146.5 m^2 in the Sullivan Creek Drainage. A total of 3,482.8 m^2 of spawning gravel was found in the west-side tributaries downstream from culverts and natural barriers.

Stream gradients ranged from 1.1 to 32.2 percent. There was a total of 135.7 km of stream with gradients less than 10.0 percent: 42.5 km were unavailable to adfluvial cutthroat and bull trout due to culverts and natural barriers. In addition, 8.8 km were considered too small to support an adfluvial fish population.

Initial analysis of the stream habitat survey data indicates that spawning and rearing habitat in tributaries to the reservoir is not sufficient to produce the number of westslope cutthroat trout inhabiting the reservoir. Probably a significant part of the westslope cutthroat recruitment comes from tributaries of the South Fork River. An evaluation should be made of the relative contribution which South Fork tributaries make to the cutthroat trout recruitment to the reservoir.

Culvert Evaluations

Passage at 12 culverts located in tributary streams on the main road around the reservoir was evaluated during the cutthroat trout spawning run, June 5 - July 13, 1984. Cutthroat trout passage at four of the culverts was good throughout the spawning run, five culverts had passage problems at higher flows and at three culverts upstream movement was not possible during the spawning period (Table 3). Passage problems at most culverts were due primarily to water velocities greater than 6-7 ft/sec. at the higher flows. Metsker (1971) noted that the water velocity through a culvert should be no greater than six feet per second to insure passage for a15 inch trout. Paint, Riverside, Felix and Clayton Creeks also had jumps of greater than three vertical feet at the culvert entrance which made entrance into the culvert extremely difficult at high flows (Evans et al. 1972).

The relationship between flow and fish passage needs to be better defined for Harris, McInernie, Murray, Logan and Riverside Creeks in order to determine the magnitude of fish passage delay problem. Flow and velocity readings should be taken weekly during the cutthroat spawning season in 1985. In addition, spawning and rearing habitat data above all problem culverts should be analyzed in order to determine the amount of habitat that is not available for cutthroat trout spawning and rearing.

Table 3. Evaluation of westslope cutthroat trout passage at culverts in 12 tributary streams to Hungry Horse Reservoir. Measurements were taken from June 5 - July 13, 1984 during the cutthroat trout spawning run. The culverts were located on the main access road around the reservoir.

	Culvert				Velocity			
stream	Length (ft)	Width (ft)	Vertical jump (ft)	Pool depth (ft)	upper end	lower end	Flow (CFS)	Fish passage
Clayton	–	8.0	3.0	5.0	5.0-6.0	7.9-10.0	27-80	No
Clark	–	3.0	none	none	1.7-4.4	0.6-2.8	5-29	Yes
Felix	–	—	3.0	none	>10.0	6.0>10	62-65	No
Forest	–	5.0	none	none	5.0-6.8	1.7-4.9	20-58	Yes
Harris	–	5.0	1.0	2.0	2.1-6.4	3.5-6.0	7-25	Marginal at flows >20 cfs
Margaret	70	4.0	1.0	2.5	4.0-4.2	5.0-5.8	20-45	Yes
McInerrie	89	5.0	1.0	2.3	3.3-7.9	5.0-7.9	2.0-22	Marginal at flows >15 CfS
Murray	77	4.0	none	none	3.2-7.8	3.7-9.7	6-21	Marginal at flows >l5 CfS
Logan, N.Fk.	–	–	0.7	3.0	8.0>10.0	2.7-6.5	19-54	Marginal at flows >20-25 cfs
Logan S.Fk.	–	5.0	none	none	5.4-5.8	3.0-3.6	17-22	Yes
Faint	–	4.5	8.0	1.5	5.6	6.7	10.5	No
Riverside	95	10.0	3.0	4.0	5.2>10.0	2.5>10.0	13-72	No at flows >30 CfS

Population Estimates

Electrofishing population estimates were made in 1983 for westslope cutthroat trout in seven streams and for bull trout in three streams. Data from these estimates indicated that cutthroat and bull trout densities in the Hungry Horse Reservoir tributaries were comparable to other headwater streams in the Flathead drainage (May and McMullin 1984).

We plan to make estimates in the 8 reaches of Hungry Horse Creek during 1985. This will enable us to establish the relationship between standing crops of juvenile cutthroat trout and the number that emigrate from the stream. This relationship can be used to help estimate potential yield of cutthroat trout from other important cutthroat spawning and rearing tributaries. Additional population estimates will be made in other important cutthroat rearing streams to relate standing crops of cutthroat with habitat quality.

Fish Trapping

A total of 1,617 juvenile and 224 adult westslope cutthroat trout were caught in downstream traps operated in five tributaries of Hungry Horse Reservoir in 1984 (Table 4). The number of cutthroat trout caught in each stream represents only part of the total juvenile emigration due to fish emigrating prior to and after trap installation and removal. In addition, trap efficiencies were considerably less than 100 percent. Traps were installed later in west side tributaries because stream flows remained high until mid-July.

Hungry Horse Creek

<u>Spawning Run</u>

The upstream trap was operated from May 3 to July 11. The first adult cutthroat was collected on May 23 and the last spawner was captured on July 5. The peak of the upstream movement took place from June 5 through June 15 (Figure 3). Spent spawners began moving downstream in late June and most fish had migrated downstream by the end of July.

A total of 201 cutthroat spawners were caught in the upstream trap as compared to 184 in the downstream trap. The estimated run was 389 cutthroat which was markedly less than the 1,160 and 590 fish recorded for the 1968 and 1972 runs, respectively (Table 5). There has been a declining trend in the spawning run from 1968 to 1984. The reduction in numbers of fish spawning in Hungry Horse Creek from 1968-1971 was attributed to poor reservoir survival of both juvenile and adult cutthroat (Huston 1973). He noted that the low survival was probably related to increased reservoir drawdown from 1965-1971 and a change in the operational schedule to an

Table 4. The catch of adult and juvenile westslope cutthroat trout in downstream traps fished in tributaries to Hungry Horse Reservoir, 1984.

			Juveniles					Adult				
stream	Period Trap Operated	Days Operated	Range and mean length Of catch (mm)	June	July	Aug.	Total	Range and mean length Of catch (mm)	June	July	Aug.	Total
Clark	07/11-07/30	20	117<152>205	–	64	–	64(3)[a]	–	–	–	-	–
Emery	06/26-08/03	37	92<142>215	53	355	1	409	311<360>395	6	18	-	24
Forest	07/11-08/14	33	118<170>258	–	143	7	150(8)	350<385>405	–	10	-	10
Hungry Horse	06/30-08/09	40	52<143>225	10	904	57	971	285<366>422	–	162	1	183
Quintonkon	07/13-07/30	17	104<164>208	–	23	–	23(6)	341<375>410	–	7	-	7
				63	1,489	65	1,617(17)		26	197	1	224

[a] Juvenile bull trout caught in parentheses.

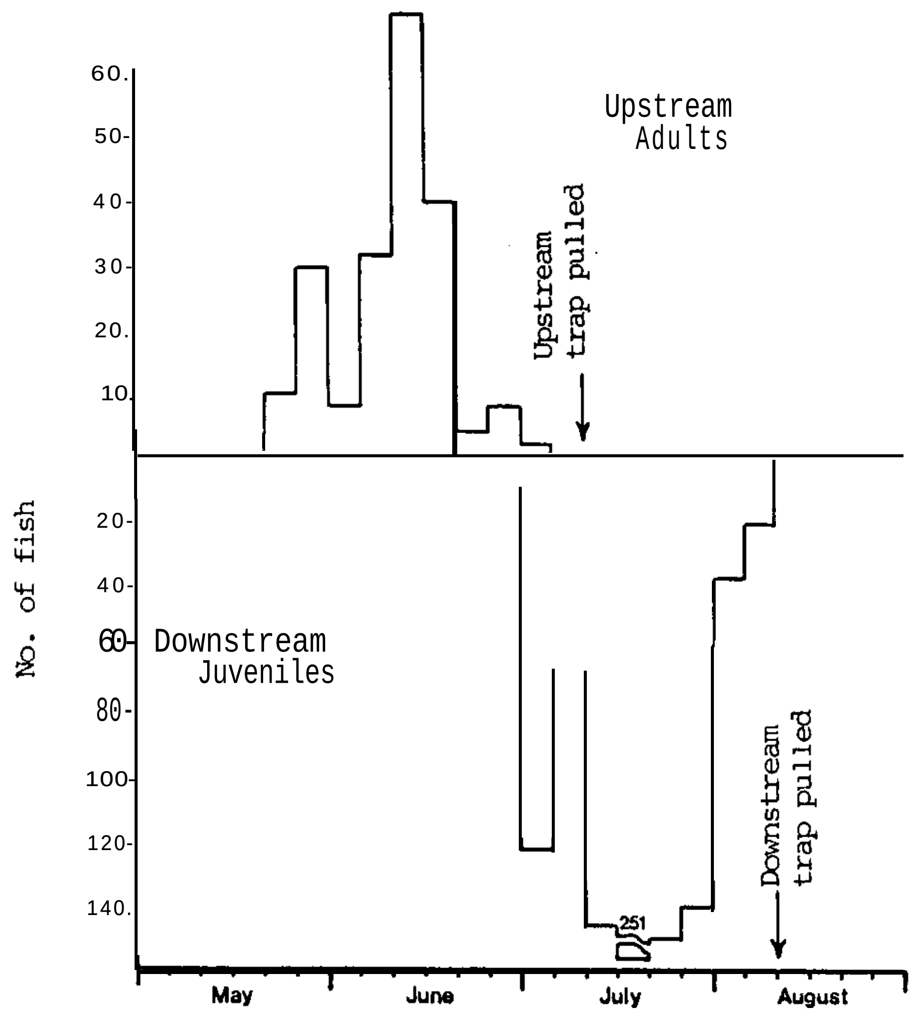

Figure 3. Upstream and downstream trap catches of westslope cutthroat trout in Hungry Horse Creek by five day periods, 1984.

Table 5. Estimated number of spawners, sex ratio and mean length of westslope cutthroat trout spawning runs into Hungry Horse Creek. The 95% confidence limits is given in parentheses as the percent of the point estimate.

Year	Estimated run	Sex ratio Male : Female		Mean length (mm)	
		Male	Female	Male	Female
1968	1160	1.0 :	3.7	373	368
1969	1050 (3.7)	1.0 :	5.3	368	371
1970	1001 (3.9)	1.0 :	5.6	358	361
1971	702 (3.2)	1.0 :	6.2	350	358
1972	590 (3.6)	1.0 :	4.0	371	358
1984	388(13.8)	1.0 :	4.4	375	370

earlier drawdown in the fall. The reasons for the reduction in the run between 1972-1984 are not known. The maximum drawdown from 1976-1982 averaged 66 ft which is similar to the 1955-64 mean of 64 ft, however, the advent of the drawdown in the fall was still earlier than prior to 1965. The mortality of tagged juvenile and adult cutthroat trout migrating to the reservoir from Hungry Horse Creek and returning to spawn will be determined during this study. Annual mortality rates will be correlated with reservoir operation to ascertain if there is a relationship between mortality and operation.

The mean length of males and females in the run varied little from 1968 to 1984. Males in 1968 averaged 373 mm in length as compared to 375 in the1984 run. Mean length of females was 368 and 370 mm in 1968 and 1984, respectively.

Juvenile Emigration

The downstream trap in Hungry Horse creek was operated from June 30 through August 9, 1984. Stream flows were too high prior to June 30 to allow operation of the trap. The outmigration of juvenile cutthroat peaked during July when 904 juveniles were collected (Table 4 and Figure 3). The catch declined markedly in August and the trap was removed on August 9th. A total of 971 cutthroat trout juveniles were caught during the period of trap operation. The trap catch in 1984 represented only a part of the juvenile emigration, because juvenile cutthroat move downstream prior to and after the trap operation period and the trap efficiency is probably only about 50-60 percent.

The catch of 971 juvenile cutthroat in 1984 was approximately half of the catch from 1968-71 which ranged from 1,950-2,110 (Huston 1970, 1973). The period of trap operation was similar among the years so the difference in catch between 1984 and the 1968-71 period probably represents a significant decline in the number of juvenile cutthroat trout emigrating from Hungry Horse Creek. Part of the decline is due to the removal of 1,150 cutthroat trout juveniles by electrofishing in 1983 and 1984 (Huston in prep). These fish were used to replace the westslope cutthroat trout brood stock at Murray Springs Fish Hatchery which has genetic problems. The removal of the 1,150 fish probably represents a reduction in the 1984 trap catch of less .than 200 fish, assuming a trap efficiency of approximately 50 percent. In addition, most of the 670 fish removed in 1983 would have emmigrated to the reservoir that year and the fish holding over to 1984 would have incurred approximately a 50-70 percent mortality. Likewise not all the fish removed in 1984 would have emmigrated in 1984. Other factors which may have influenced the reduced emigration of juveniles are inadequate escapement to seed rearing habitat, habitat degradation in the watershed from logging and associated road building and natural population fluctuations.

The juvenile migrants averaged 143 mm in length and ranged from 52 to 225 mm There was little difference in the mean lengths of fish caught in June, July and August (Appendix B1 and B2).

Operation of the downstream trap in 1985 will be changed in order to obtain a more reliable estimate of the total number of outmigrant juveniles. The trap will be installed as soon as water flows permit and operated through October. Trap efficiency will be estimated for each two week period by placing marked fish caught in the downstream trap upstream from the trap and determining the number recaptured by size class.

Clark Creek

Clark Creek is a small westside tributary which enters the reservoir upstream from Sullivan Creek (Figure 1). A downstream trap was operated in Clark Creek from July 11 to July 30, 1984 (Table 4 and Figure 4). A total of 64 westslope cutthroat trout juveniles were captured in the trap. The fish ranged in total length from 117 to 205 mm with an average of 152 mm (Appendix B3).

Emery creek

Emery Creek is located on the eastside of the reservoir (Figure l), and is an important spawning and rearing stream for westslope cutthroat trout. A downstream fish trap was operated from June 26 through August 3 (Table 4 and Figure 4). A total of 409 cutthroat trout juveniles were caught in the trap during the period. The mean and range lengths were similar to that recorded in Hungry Horse Creek (Appendix B4). In addition to the juveniles, 24 spent adult cutthroat trout were trapped.

Forest Creek

Forest Creek is a medium sized stream located on the westside of the reservoir (Figure 1). This is the first time that a downstream trap has been operated and it appears to have a substantial run of cutthroat. Approximately 150 juvenile and 10 spent adult cutthroat trout were caught from July 11 to August 14 (Table 4 and Figure 4). The mean length of 170 mm for juvenile cutthroat was larger than those recorded for juveniles in the other streams trappad (Appendix B3).

Quintonkon Creek

Quintonkon Creek is a major tributary to Sullivan Creek on the westside of the reservoir (Figure 1). Only 23 juvenile and seven adult cutthroat were caught in the downstream trap (Table 4 and Figure 4). Quintonkon has a much larger emmigration of juvenile

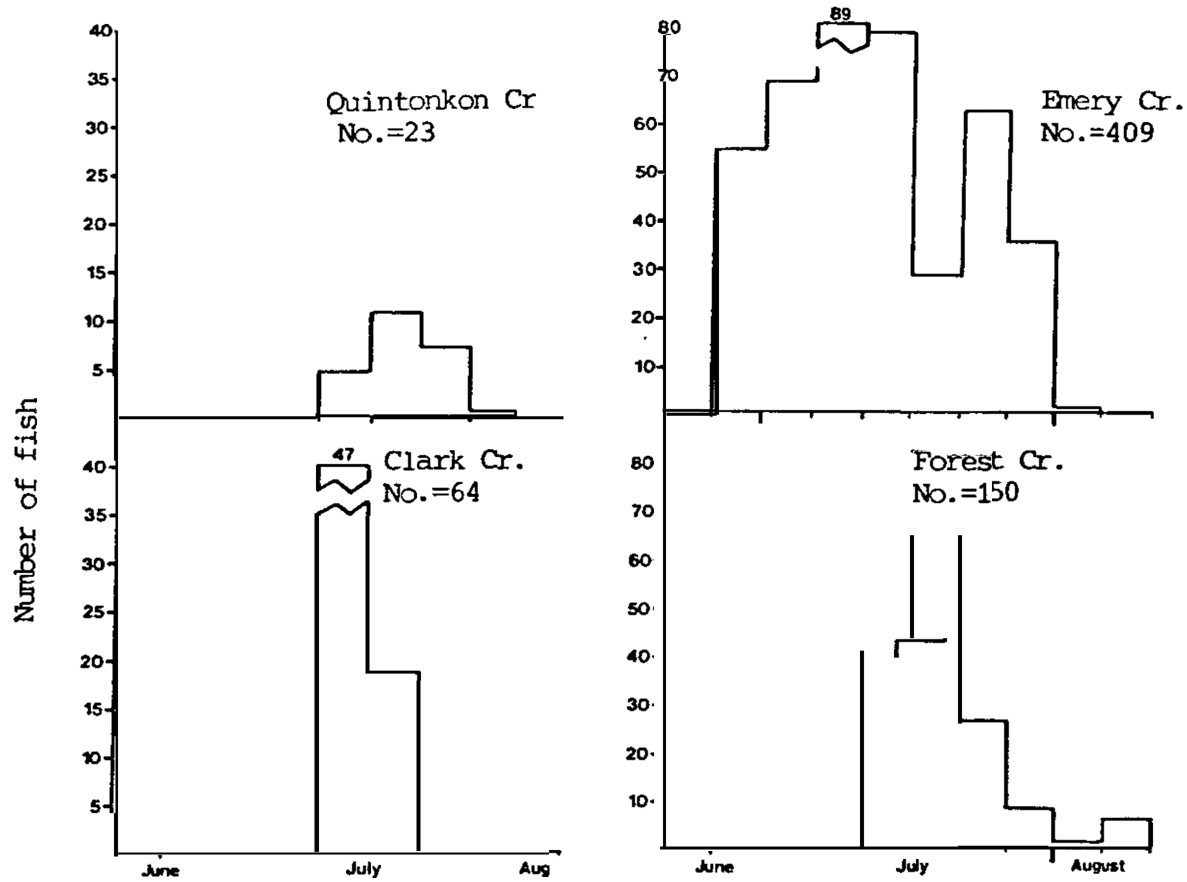

Figure 4. Downstream trap catches of juvenile westslope cutthroat trout by five day periods in tributaries to Hungry Horse Reservoir, 1984.

cutthroat trout than indicated by the trap catch in 1984. The low catch was due to poor trap efficiency and late installation. Quintonkon is a difficult stream to trap efficiently due to its large size.

RESERVOIR HABITAT

The reservoir habitat for fish food organisms and fish is influenced by reservoir operation. The annual drawdown and refill cycle causes large changes in surface area, water volume, depth, shoreline development and in lake-filling and hydraulic-residence times. The amount of littoral area varies with reservoir elevation along with volume of water in the euphotic zone, volume of water in preferred temperature ranges for zooplankton and fish growth, and area of reservoir bottom dewatered. The thermal structure of reservoirs is influenced by the large seasonal inflow and outflow volumes (Woods 1982).

Reservoir volume and surface area decrease rapidly as reservoir elevation declines (Figure 5). Inflection points on the surface area curves for the three geographic areas of the reservoir occur at approximately elevation 3,480 where extensive littoral areas are dewatered, especially in the upper part of the reservoir (Figure 6 and Appendix Cl). These littoral areas provide good habitat for benthic macroinvertebrates and cutthroat trout when they are flooded. Reduction in volume is largest from elevations 3,560 -3,480 where 45 percent of the storage capacity is contained.

Shoreline length declines from elevation 3,560-3,540, increases from 3,540-3,520 then declines steadily with further reduction in reservoir elevation. The increase in shoreline length between elevation 3,540 - 3,520 is due to an unusual increase in the meander pattern of the shoreline between these elevations.

The lake-filling and hydraulic-residence times for Hungry Horse are high when compared to Lake Koocanusa. The annual lake-filling times for Lake Koocanusa varied between 0.14 to 0.66 year (Woods 1982) as compared to 2.51 to 3.12 years for Hungry Horse Reservoir (Table 6). The lake-filling and hydraulic-residence times for the first two years of the Hungry Horse study were comparatively high because of below normal inflows to the reservoir. It appears that reservoir operation has less effect upon the thermal structure of Hungry Horse Reservoir than Lake Koocanusa. This is primarily due to the fact that in Hungry Horse the usable storage capacity of 2,982,000 acre feet is higher than the mean annual discharge of 2,386,000 acre feet.

Hydraulic-residence times appear to have an important influence on zooplankton production (Mayhew 1977). He found that hydraulic-residence times of below one year were associated with reduced zooplankton populations. Increased flushing rates resulted in cooler water temperatures and the density of zooplankton

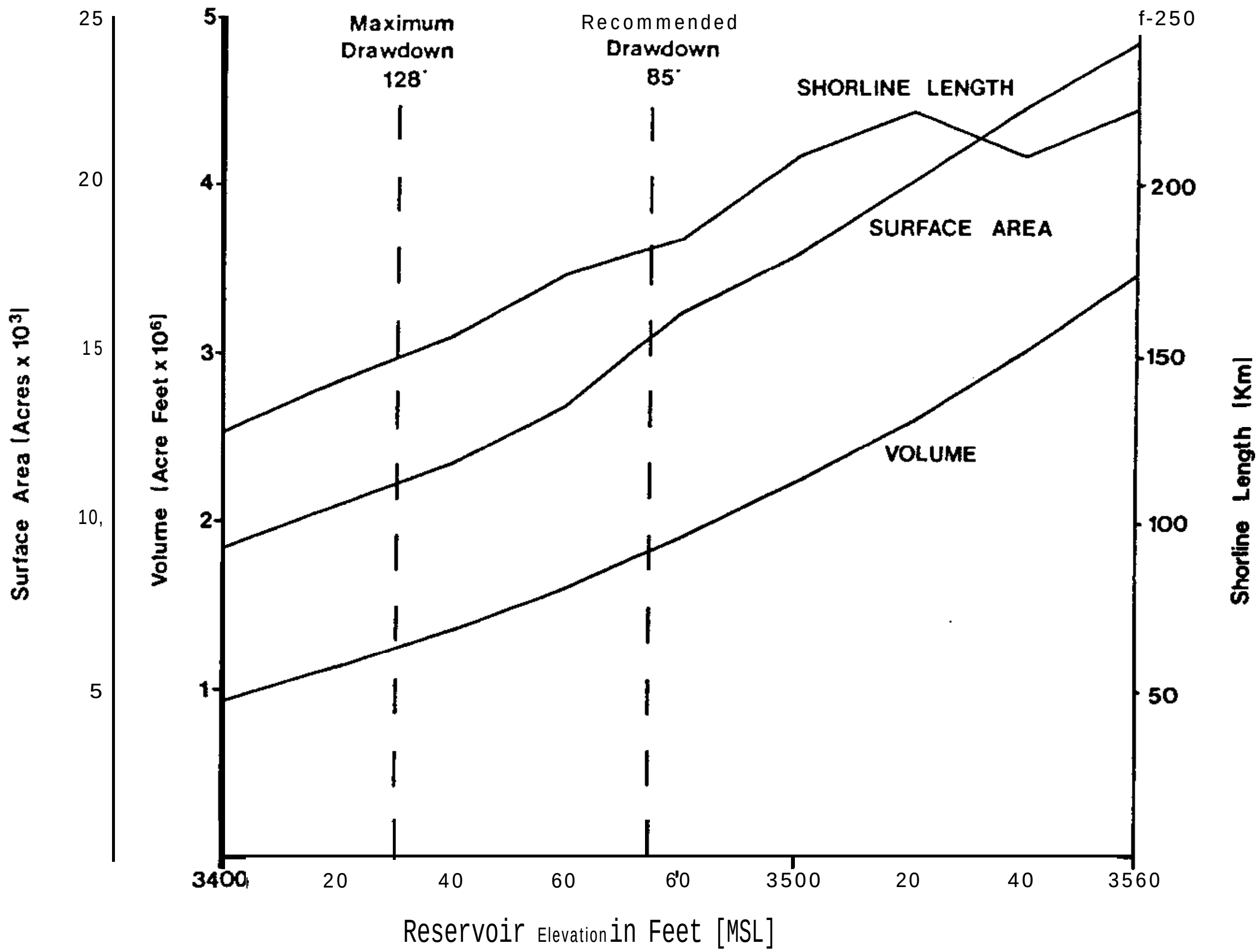

Figure 5. The relationship of reservoir elevation to surface area, volume and shoreline length of Hungry Horse Reservoir.

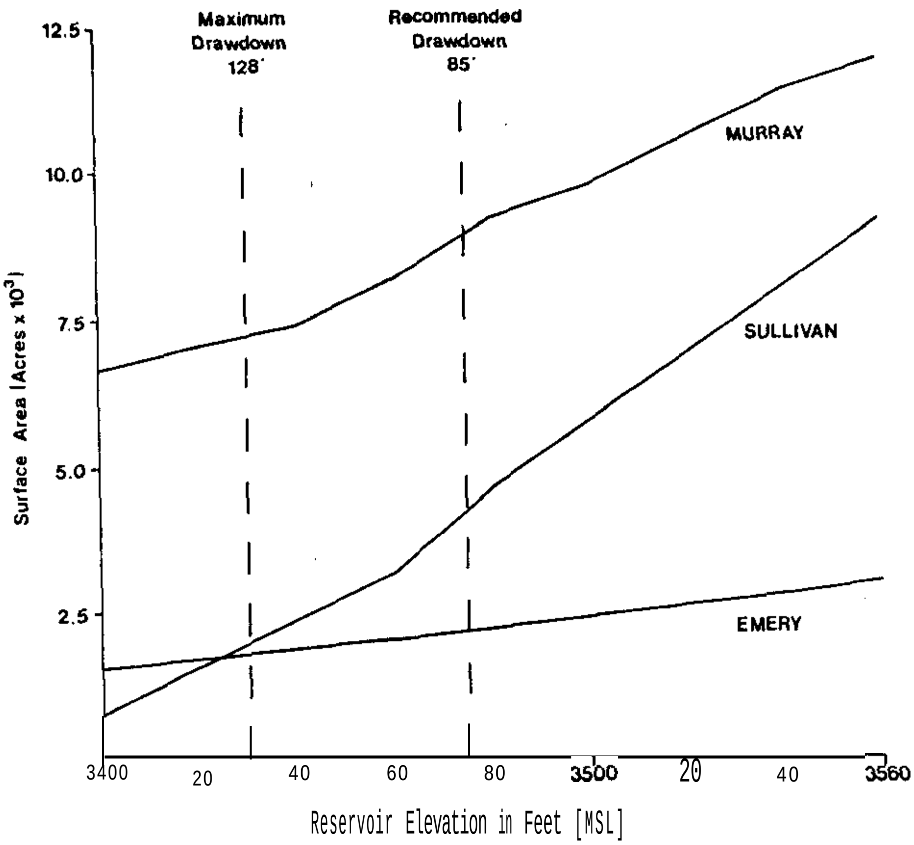

Figure 6. The relationship between surface area and reservoir elevation in the Emery, Murray and Sullivan areas of Hungry Horse Reservoir.

Table 6. Monthly lake-filling and hydraulic-residence times for low (1973) median (1980) and high (1974) water years in Hungry Horse Resevoir and for 1983 and 1984.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean	Maximum drawdown (ft)	Cumulative discharge (AF)
	Month														
	Lake-Filling Time (years)														
1973	3.02	5.75	2.97	1.26	0.33	0.47	2.05	5.29	7.28	5.24	1.65	2.13	3.12	63	1.871,000
1974	1.12	2.37	1.62	0.38	0.22	0.16	0.64	3.03	5.31	6.59	4.20	4.53	2.51	111	3,574,000
1980	5.54	5.47	3.99	0.50	0.30	0.59	1.86	4.47	3.79	5.43	3.08	1.40	3.04	69	2,351,000
1983	3.87	4.88	2.41	1.05	0.35	0.47	0.97	3.67	5.40	4.27	2.57	4.55	2.87	45	2,872,300
1984	1.98	3.50	2.31	0.73	0.37	0.34	1.34	4.60	4.61	3.89	3.58	4.38	2.64	68	2,202,900
	Hydraulic Residence-Time (years)														
1973	0.62	0.57	1.94	1.53	4.14	26.21	1.14	0.87	7.23	0.89	1.54	4.18	4.24		
1974	0.74	0.54	0.36	0.21	0.82	1.47	0.87	2.15	1.15	0.70	0.47	0.57	0.84		
1980	3.92	6.31	11.99	16.81	14.37	1.03	2.11	2.19	1.18	1.89	1.25	0.72	5.31		
1983	1.15	0.88	1.03	0.54	0.87	4.92	1.08	2.58	0.80	0.79	3.73	0.71	1.59		
1984	1.02	0.59	0.77	1.92	1.24	3.50	8.99	1.38	1.03	1.27	2.22	0.80	2.06		

decreased in a linear fashion. Annual hydraulic-residence times in Hungry Horse Reservoir are generally above one except in high water years. However, the monthly residence times vary considerably and were below one during six months in 1983 and three months in 1984.

Maps of the reservoir bottom are in the process of being digitized. Upon completion we will be able to use the GEOSCAN program to determine water surface area, water volume, dewatered reservoir bottom area and available shoreline length in each geographic area by ten foot contour intervals. The area of the littoral zone will also be determined using depth of euphotic zone and criteria discussed previously. Volumes of water in the euphotic zone and in preferred temperature ranges for zooplankton and cutthroat trout growth will also be estimated.

There appears to be little relationship between westslope cutthroat trout densities in shoreline areas and substrate and cover types (see Electrofishing Section). Distribution of cutthroat in Lake Koocanusa was determined to a large degree by temperature and food availability (McMullin 1979). Neil1 and Magnuson (1974) found that percid fishes partitioned time between an environment with preferred temperature and an environment with food, but either warmer or cooler than preferred temperature. The fish made forays for food into water with extreme temperatures, but feeding behavior did not override thermoregulatory behavior. This type of behavior pattern appears to be regulating the distribution of cutthroat trout and other fish species in Hungry Horse Reservoir. Trout in lentic environments are forced to actively seek food concentrations. Consequently there is no positive energy benefits accrued from occupying and defending a feeding station as there is in lotic habitats where most food occurs in the form of insect drift in water current. Bachman (1984) found that trout in streams use discrete energy-saving foraging sites year after year and feed mainly on insect drift.

PHYSICAL LIMNOLOGY

Water Temperature

Water temperatures in Hungry Horse Reservoir ranged from 0.0°C to 23.0°C in 1983 and 1984 with maximum temperatures occurring from late July to mid-August (Figures 7, 8, and 9). Ice formation generally begins in the upper part of the reservoir in late December and the entire reservoir is usually ice-covered by mid-January. Ice-out usually occurs sometime during the last two weeks of April. Tnermal stratification occurred about mid-June 1984 and continued through to approximately the end of September (Figures 7, 8, and 9). The reservoir was then isothermal from about mid-November to mid-May.

Seasonal water quality profiles from the Murray area are shown in Appendix C2-C6. Specific conductivity, pH and dissolved oxygen

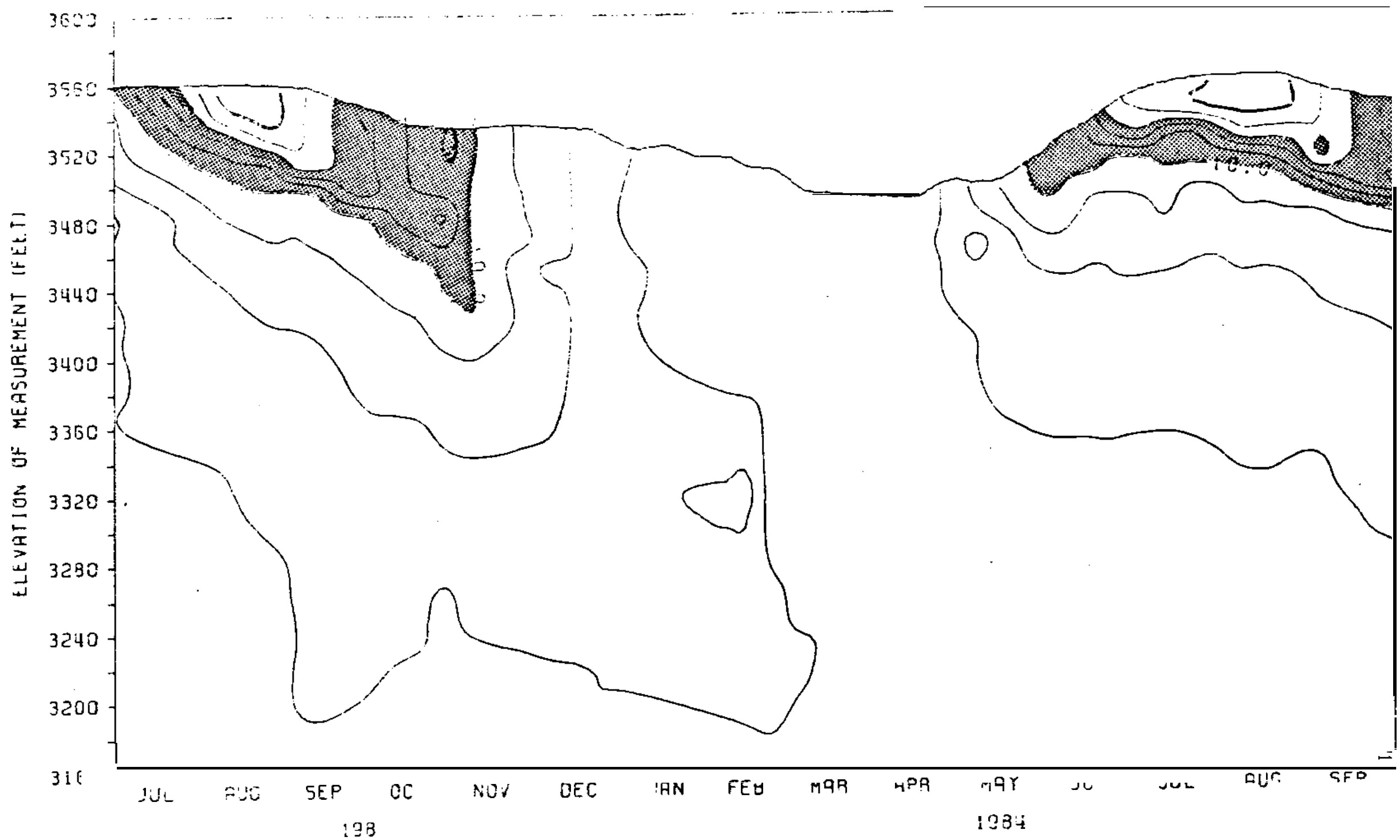

Figure 7. Isopleths of water temperatures (2°C) from the Emery Station, Hungry Horse Reservoir, 1983-1984. Shaded areas are preferred temperature strata for cutthroat trout (10°-16°C).

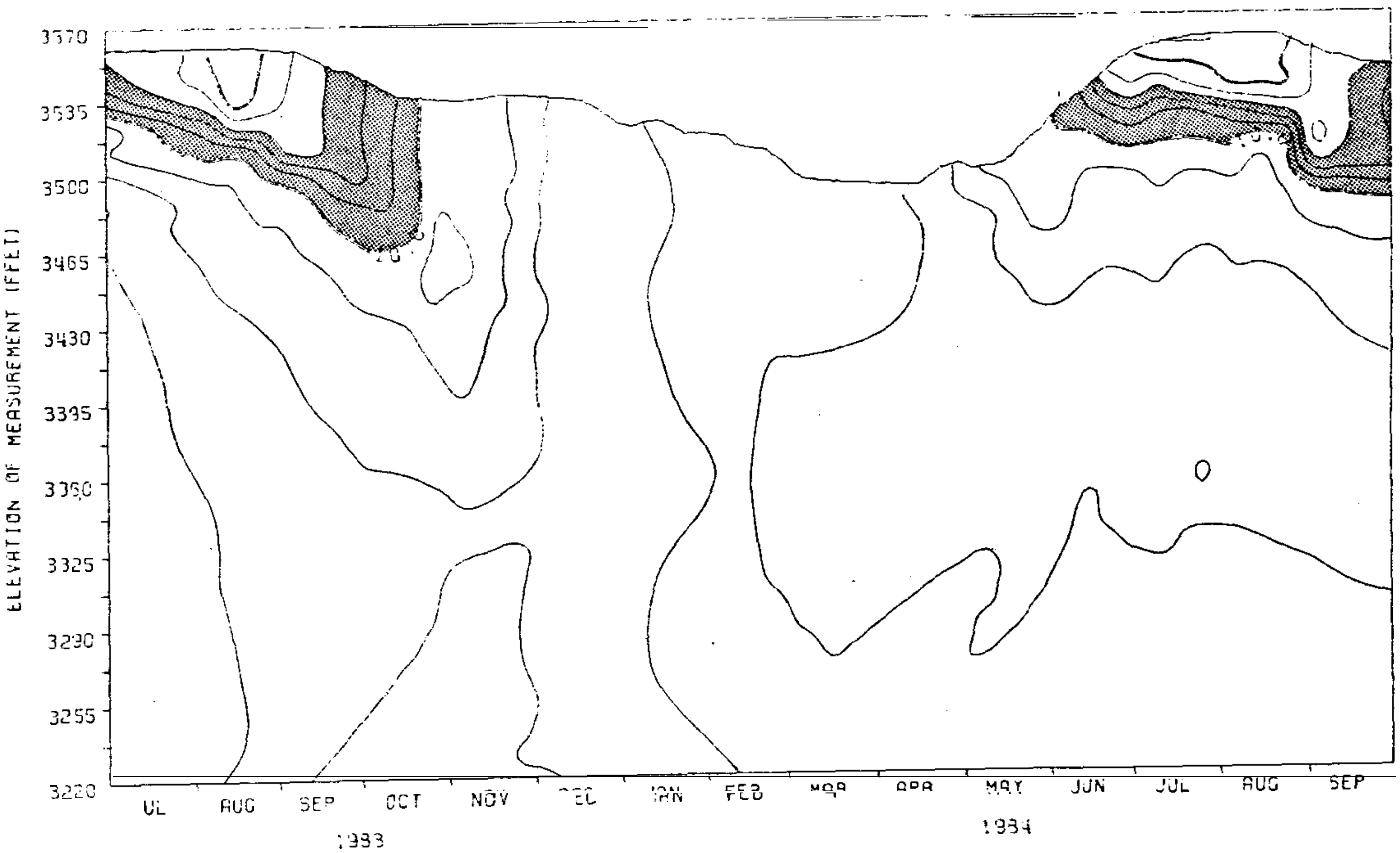

Figure 8. Isopleths of water temperatures (2°C) from the Murray Station, Hungry Horse Reservoir, 1983-1984. Shaded areas are preferred temperature strata for cutthroat trout (10° - 16°C)

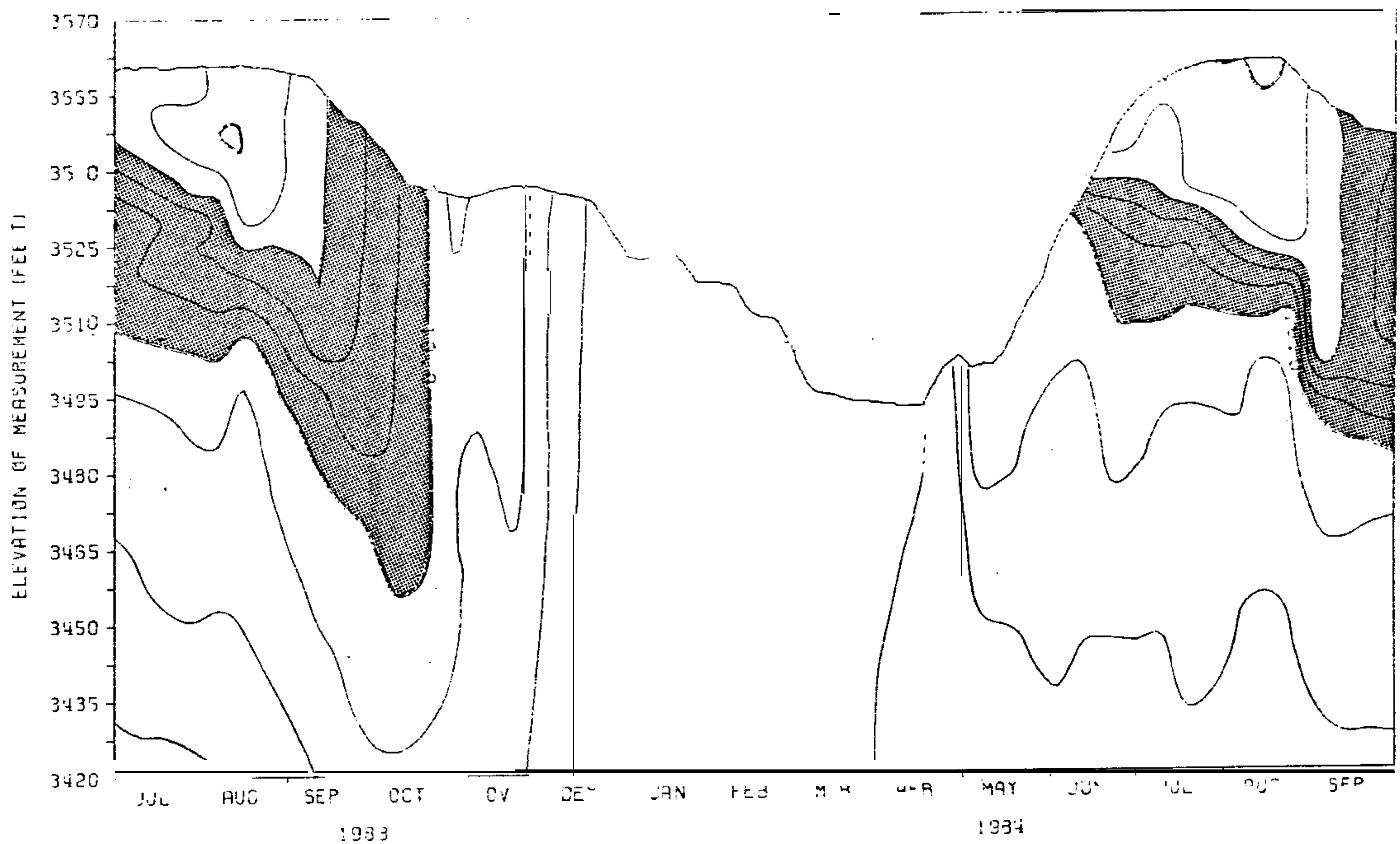

Figure 9. Isopleths of water temperatures (2°C) from the Sullivan Station, Hungry Horse Reservoir, 1983-1984. Shaded areas are preferred temperature strata for cutthorat trout (10°- 16°C)

profiles exhibited little variation from the surface down to the 50-70 m depths during the spring and fall when the reservoir was not stratified. Dissolved oxygen concentration in the summer profile ranged from 8.2 mg/liter near the surface to 9.8 mg/liter at 70 m. Specific conductivity and pH values were higher in the epilimnion than in the hypolimnion.

Westslope cutthroat trout vertical and horizontal distribution is controlled to a large degree by water temperature. Cutthroat trout prefer water temperatures from approximately 10-16°C (Hickman and Raleigh 1982). The preferred temperature range of cutthroat trout is shown in Figures 7, 8, and 9. The temperature isopleths indicate that there is more surface water in the 10-16°C range during the spring and fall than in the summer and winter.

Dissolved Oxygen

Dissolved oxygen concentrations in the upper 30-50 m of the water column have generally ranged from 8-10 mg/liter (Appendix C9-C13). These concentrations are adequate to sustain healthy aquatic life and are above the minimum required to support fish life. Davis (1975) stated that freshwater salmonids will not exhibit effects of low oxygen when concentrations are above 7.8 mg/liter and temperatures ≤15°C. Hickman and Raleigh (1982) noted that optimal oxygen levels for cutthroat trout are not well documented, but appear to be >7 mg/liter at temperatures ≤15°C. This information indicates that dissolved oxygen levels in Hungry Horse Reservoir are within the tolerance limits of the fish community inhabiting the reservoir and should have little impact on fish distribution.

pH

The pH values tend to increase during periods of high photosynthetic activity and decrease during periods of high respiration. The pH values in Hungry Horse reservoir range from about 7.4 to 8.9 with the values in the 7.8 to 8.5 range most common (Appendix C14-C18). These values are within the range recommended by the EPA Red Book (Thurston et al. 1972) for protection of aquatic life. Mckee and wolf (1963) stated that it is generally recognized that the best waters for the support of diversified aquatic life are those with pB values between 7 and 8. Most cutthroat trout poplations can probably tolerate a pH range of 5.0 to 9.5 with an optimal range of 6.5-8-O (Hickman and Raleigh 1982). Sekulich (1974) reported that pH in three reservoirs containing cutthroat trout ranged from 7.8-8.5. Thus, it appears that pH values in Hungry Horse are within the optimum range for aquatic life in general and cutthroat trout in particular.

Specific Conductance

The determination of conductivity is a quick method for measuring the ion concentration of water. Specific conductance measurements in Hungry Horse Reservoir ranged between 110-150 umhos/cm (Appndix C19-C23). Mckee and Wolf (1963) reported that studies of inland waters indicated that specific conductance of waters supporting a good mixed fish fauna ranged in general, between 150-500 umhos'cm^{-1}. The specific conductivity values in Hungry Horse Reservoir were on the lower end of the productivity scale.

Euphotic Zone

The depth of the euphotic zone in Hungry Horse Reservoir during 1984 ranged from 5.2 - 20.0 meters (Figure 10). There is considerable variation seasonally and among the geographic areas of the reservoir. Several environmental factors contribute to the wide variability in euphotic zone depths. The reflectivity of light by the water surface is dependent upon the solar height from the zenith, the greater the departure of the angle of the sun from the perpendicular, the greater the reflection (Wetzel 1975). Thus the euphotic zone will vary daily and seasonally due to changes in the amount of incident light reflected at the water surface. The proportion of light reflected is also influenced by wave action. Rapid attenuation of light transmission is caused by dense populations of algae and bacteria which vary seasonally. Similarly, sediment input during spring run-off reduces transmission particularly in the upper part of the reservoir in the Sullivan area.

Euphotic zone depths in Hungry Horse Reservoir tended to be deeper than recorded in Lake Koocanusa where the values ranged from one to 18 m (Woods and Falter 1982). The greater euphotic zone depths in Hungry Horse appear to be due primarily to lower sediment input and transport and phytoplankton standing crops.

FISH FOOD AVAILABILITY

Zooplankton

Abundance and Composition

Three groups of cladocecans and copepods dominated the crustacean zooplankton community in Hungry Horse Reservoir for the period July, 1983 to June, 1984 (Table 7). _Cyclops_ was the most abundant zooplankter found during the period and their average numbers were highest in the Graves Bay area (6.9/liter). _Diaptomus_ densities followed with a high of 2.0/liter in the Emery area with their densities generally consistent throughout the reservoir. _Daphnia_ was the most abundant cladoceran with an average of about 1.2/liter for the entire reservoir with similar densities among

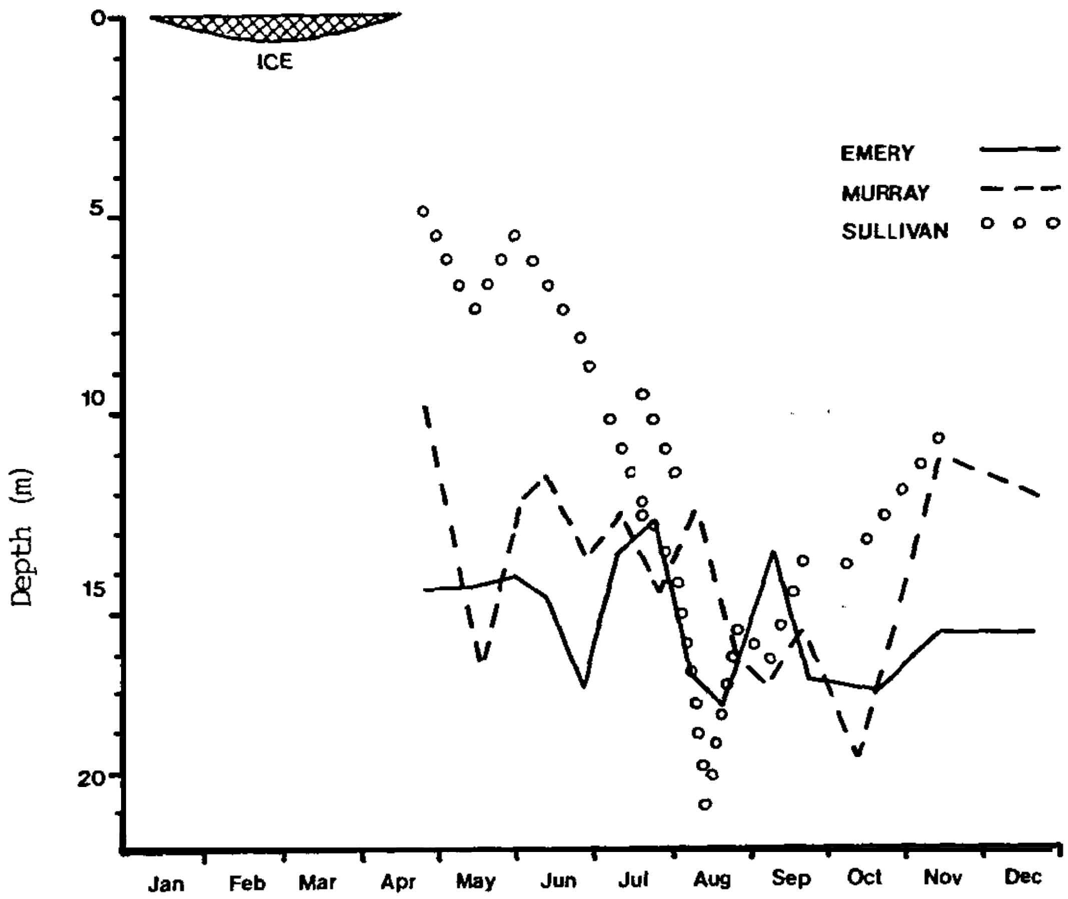

Figure 10. Euphotic zone depth in Hungry Horse Reservoir, 1984.

Table 7. Mean density ($No \cdot l^{-1}$) and range of density (in parentheses) of the principal adult crustacean zooplankton in 0-30 m Wisconsin tows collected biweekly from five stations on Hungry Horse Reservoir from July-December 1983 and April-June 1984. Epischura and Leptodora densities are $No \cdot m^{-3}$ and were calculated through December 1983.

	Emery	Murray	Sullivan	Emery Bay	Graves Bay
Cladocera					
Daphnia	1.3 (0.3-3.6)	1.2 (0.2-3.8)	1.2 (0.01-2.9)	1.2 (0.2-6.2)	1.4 (0.4-3.1)
Bosmina	0.4 (0.02-1.5)	0.6 (0.1-1.5)	1.2 (0.02-5.2)	0.8 (0.01-2.6)	2.7 (0.2-6.5)
Leptodora	0.5 (0.0-4.2)	0.1 (0.0-4.7)	0.1 (0.0-0.57)	*	*
Copepoda					
Diaptomus	2.0 (0.03-9.0)	1.4 (0.06-4.0)	1.3 (0.1-8.2)	1.3 (0.03-4.7)	1.5 (0.2-5.0)
Cyclops	2.9 (0.3-6.7)	3.1 (1.0-6.6)	4.2 (0.1-9.4)	3.2 (0.3-6.2)	6.9 (1.6-17.3)
Epischura	6.2 (0.0-25.7)	8.6 (0.5-22.7)	9.1 (1.7-35.4)	*	*

* Collected but not counted.

areas. Bosmina densities generally averaged about l.0/liter except for the Graves Bay area which was about three times higher. Epischura and Leptodora numbers were low in Hungry Horse Reservoir and averaged less than 10.0 and 0.5 /meter , respectively, at the three permanent stations during 1983. Densities of zooplankton collected at seven stations in Flathead Lake from June through December, 1980 were similar to those found at five stations in Hungry Horse Reservoir during the sample period for Daphnia, Bosmina and Epischura (Leathe 1982). Diaptomus and Leptodora were about three and fifteen times less abundant, respectively, whereas cyclops densities were about four times greater in Hungry Horse Reservoir.

In general, the mean numbers of zooplankton did not vary greatly between stations in Hungry Horse Reservoir (Appendix Dl) Leathe (1982) found no significant interstation differences in the density of the four principal crustacean zooplankton species (Daphnia thorata, Epischura, Leptodora and Diaptomus) utilized by plantivorous gamefish in Flathead Lake.

Lengths and Weights

Leptodora was the largest organism found in plankton samples and can attain lengths of up to 18 mm (Edmondson 1966). This cladoceran is predatory on other zooplankton while Daphnia and Bosmina are filter feeding herbivores. Daphnia were generally less than 2.0 mm in length and up to 350 ug in weight while Bosmina were less than 0.6 mm in length and weighed less than 40 ug (Table 8). The largest copepod found in Hungry Horse Reservoir was Epischura which is predatory on smaller zooplankton species. It was up to about 2.0 mm in length and weighed up to about 420 ug. The copepod Diaptomus is a filter feeding herbivore while Cyclops is classified as an omnivore. Largest lengths of both groups were just over 1.0 mm and they weighed up to about 75 ug.

Daphnia and Epischura were the only two groups of zooplankters longer than 1.5 mm. Our data shows that juvenile and adult cutthroat trout selectively feed on zooplankters greater than this minimum length (see below). Epischura longer than 1.5 mm comprised 73 percent of the catch compared to 19 percent over 1.5 mm for Daphnia (Table 8). The latter made up the vast majority of zooplankton available over this minimum size because they were about 1,500 times more abundant in 30 m Wisconsin tows (Table 7).

Seasonal Abundance and Composition

In the Emery and Murray areas zooplankton densities decreased from about 7/liter from July to August and then fluctuated between 5 and 10/liter during 1983 (Figures 11 & 12). Densities were increasing by late spring 1984. In contrast, zooplankton densities in the Sullivan area increased from a low of about 4 to ll/liter

Table 8. Percent of total catch, mean length (mm) and dry weight (ug) by length group for the principal crustacean zooplankton groups in Hungry Horse Reservoir collected monthly from July through December 1983.

	LENGTH GROUP														
	0.00-0.49			0.50-0.99			1.00-1.49			1.50-1.99			2.00-2.49		
Group	Percent Catch	Mean Length	man Weight	Percent catch	Mean Length	mean Weight	Percent Catch	Mean Length	Mean Weight	percent catch	Mean Length	Mean Weight	Percent Catch	Mean Length	Mean Weight
Cladocerans															
Daphnia	0.7	0.45	4.4	33.7	0.80	22.8	46.7	1.18	69.3	16.9	1.72	201.3	2.1	2.09	349.4
Bosmina	98.9	0.37	9.2	1.1	0.57	39.8	--	0.00	—	--	0.00	____	--	0.00	--
Copepods															
Diaptomus	23.6	0.44	9.6	66.5	0.73	33.6	7.0	1.04	77.4	—	0.00	—	—	0.00	- -
-	31.0	0.42	8.0	66.5	0.68	28.3	2.5	1.03	74.9	—	0.00	____	—	0.00	____
Epischura				1.6	0.90	54.7	25.6	1.13	94.5	64.4	1.72	257.4	8.4	2.09	414.0

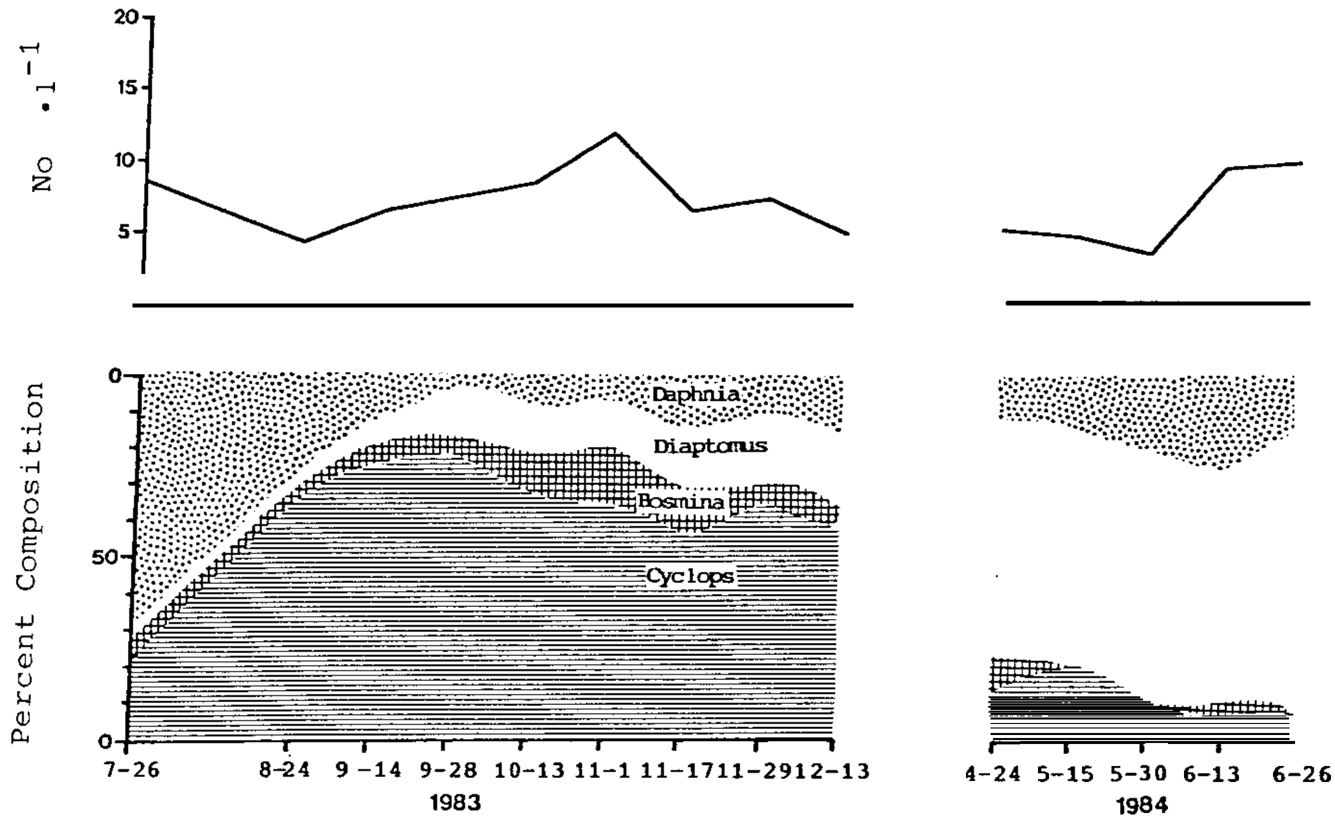

Figure 11. Seasonal flucuations in total density (No•l^{-1}; upper figure) and species composition (percent of density; lower figure) of the principal adult zooplankton found in 30 m Wisconsin tows for the Emery area of Hungry Horse Reservoir from July, 1983 through June, 1984.

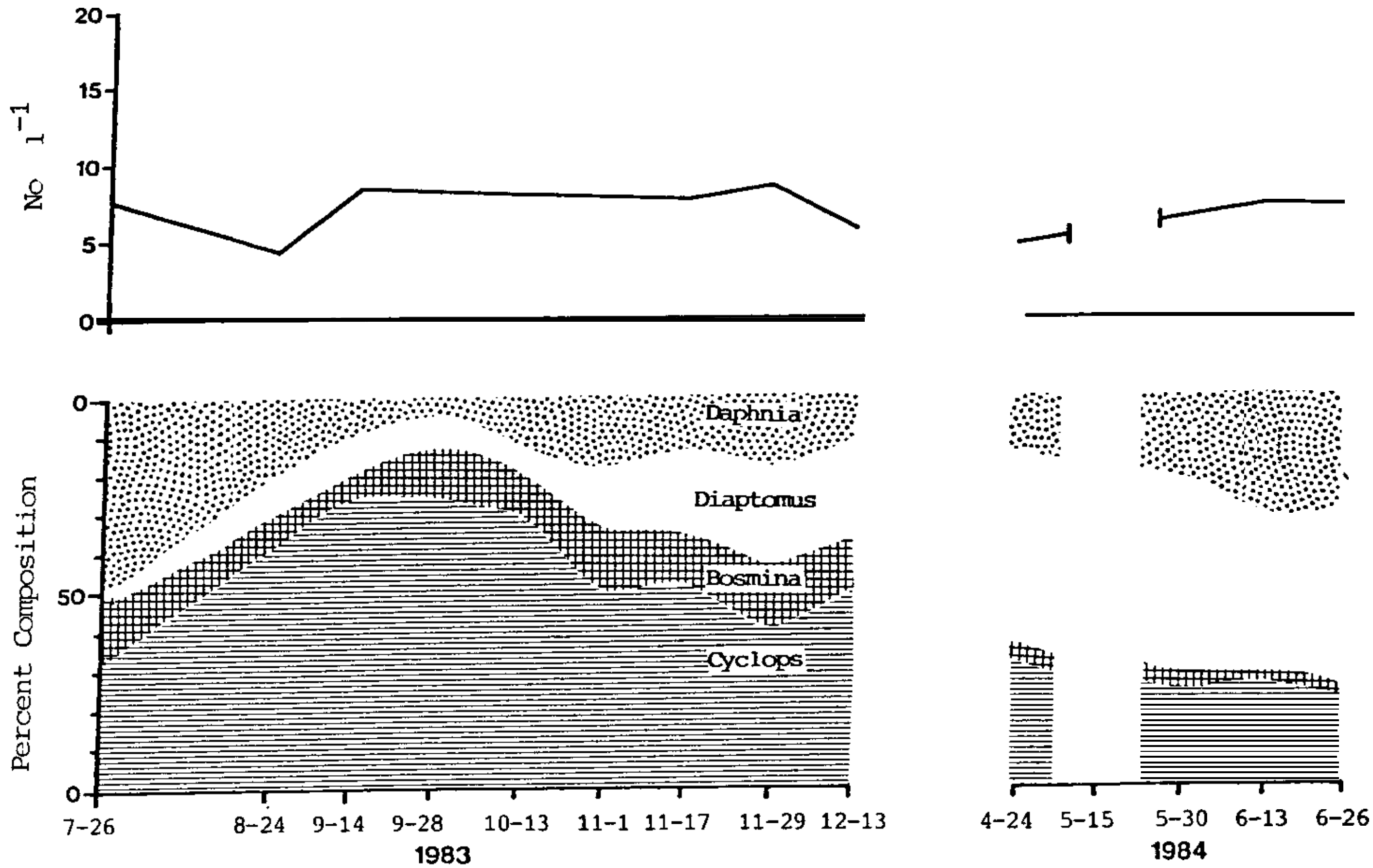

Figure 12. Seasonal fluctuations in total density (No · l^{-1}; upper figure) and species composition (percent of density; lower figure) of the principal adult zooplankton found in 30 m Wisconsin tows for the Murray area of Hungry Horse Reservoir from July, 1983 through June, 1984.

for October, decreased to 6/liter by November 1st and then increased to almost 20/liter by mid-December (Figure 13). Numbers remained low and fluctuated between 1 and 4/liter during the spring of 1984.

In all three areas Daphnia composition decreased through the summer of 1983 from a high of 50 to 70 percent of the catch down to 4 to 20 percent in the fall and winter. Daphnia composition was increasing during the spring and early summer of 1984.

Copepods dominated the zooplankton community of Hungry Horse Reservoir comprising an average of 73 percent of the catch for the three areas during the sampling period. Generally, when Cyclops concentrations were high Diaptomus was low and vice versa in all three areas. Cyclops representation was similar in the three areas and comprised the bulk of the copepods collected in 1983 with numbers peaking in September and decreasing through the end of the year. Cyclops representation was less than 30 percent during 1984 in the Emery and Murray areas while up to 70 percent in the Sullivan area. Diaptomus composition was also similar in the three areas during 1983 with numbers remaining low through the summer and increasing through the remainder of 1983. diaptomus comprised the bulk of the population in the Emery and Murray areas during the spring of 1984. They made up to 76 and 52 percent of the population, respectively, and up to 40 percent in the Sullivan area. Bosmina composition was low throughout the sample period with highest concentrations (20 percent of the community) occurring during the fall of 1983 and were almost non-existent during May of 1984.

Wisconsin Net Efficiency

The reliability of our plankton sampling method was determined by comparing results obtained using the Wisconsin tow net with those obtained using a Schindler plexiglass plankton trap. The latter sampler was considered to be one of the most efficient zooplankton sampling devices (Schindler 1969; Prepas and Rigler 1978): however, the exclusive use of this sampler on Hungry Horse Reservoir was impractical for the purpose of this study because of the large amount of time required to obtain representative samples of the entire water column.

The Wisconsin tow net was less efficient at collecting zooplankton compared to the Schindler trap (Table 9). In general the higher the estimated density for the Schindler trap the lower the estimate for the Wisconsin tow and vice versa. Also, these efficiencies varied greatly and ranged from 19 percent for Bosmina to 166 percent for Diaptomus. The reason or reasons for these highly variable under-estimates with the Wisconsin tow are unclear. Mesh net size should have been small enough to capture all zooplankters in these size ranges. A possible cause is that with high densities the zooplankton may be plugging the mesh which would

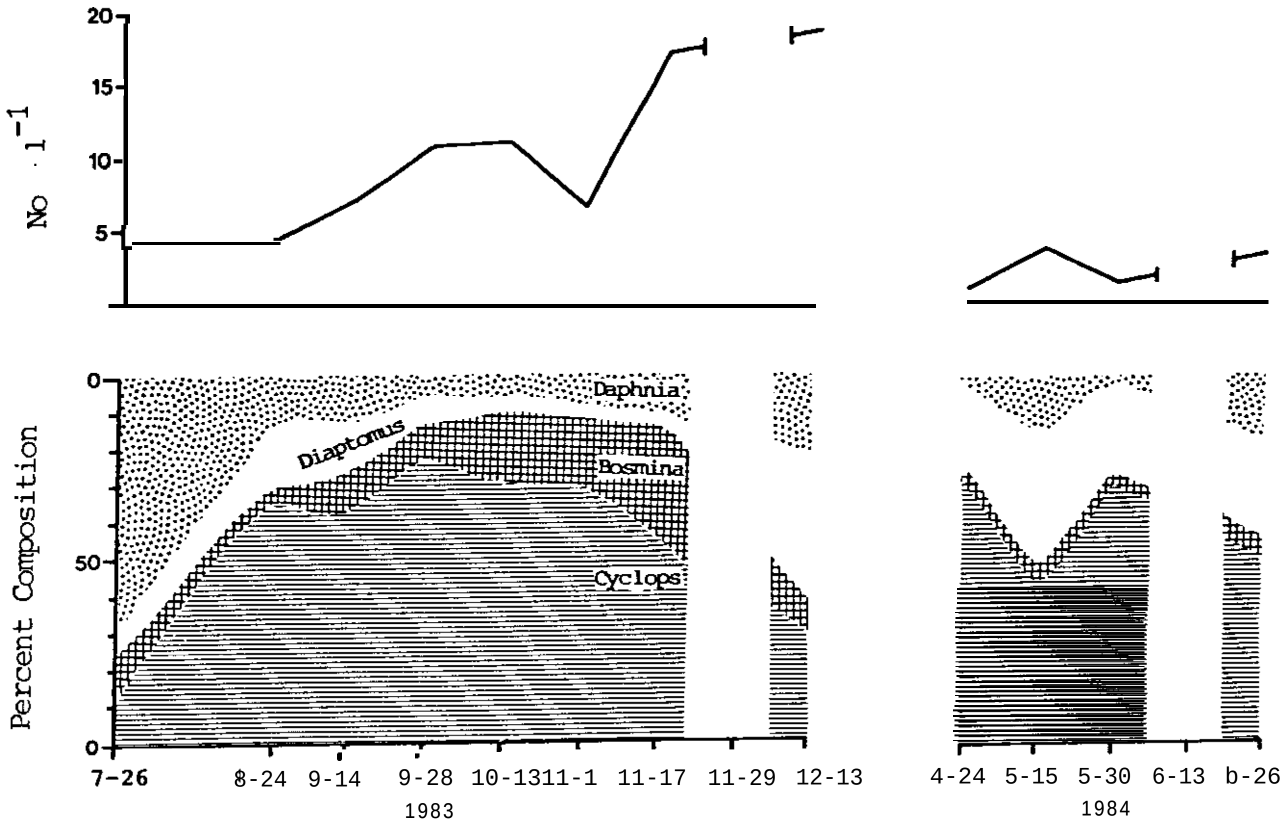

Figure 13. Seasonal fluctuations in total density (No.l^{-1}; upper figure) and species composition (percent of density; lower figure) of the principal adult zooplankton found in 30 m Wisconsin tows for the Sullivan area of Hungry Horse Reservoir from July, 1983 throuqh June, 1984.

Table 9. Percent sampling efficiency of 30 meter Wisconsin tow as compared to the Schindler plankton trap (No.l^{-1} for the trap are in parentheses) for zooplankton collected monthly at the Emery station from August-December 1983 and May-June 1984.

Date	Zooplankton Group				
	Daphnia	Bosmina	Diaptomus	Cyclops	Mean
08/18/83	36 (3.8)	25 (0.6)	44 (1.1)	51 (5.9)	39 (2.9)
09/13/83	47 (1.6)	24 (1.2)	45 (2.0)	30 (14.7)	36 (4.9)
10/12/83	34 (3.1)	23 (5.4)	43 (3.1)	49 (12.6)	37 (6.1)
11/15/83	26 (4.4)	19 (4.0)	45 (3.3)	34 (10.7)	31 (5.6)
12/12/83	73 (1.1)	31 (1.2)	79 (1.3)	89 (3.5)	68 (1.8)
05/14/84	99 (0.7)	*	166 (1.1)	92 (0.7)	119 (0.8)
06/12/84	61 (4.7)	*	128 (4.5)	72 (1.4)	87 (3.5)
Mean	54 (2.8)	25 (2.5)	78 (2.3)	60 (7.1)	

* Sample size too small to make reliable estimate.

create a backwash and therefore not collect all zooplankton in the water column. High concentrations of algae would also contribute to this problem. Another possible reason is the smaller the size and higher the density of zooplankton the greater the likelihood that the net would plug. This is a plausible explaination because Wisconsin tow efficiencies for Bosmina (the smallest zocplankters) were lowest and averaged 25 percent compared to 78 percent for Diaptomus (Table 9). Leathe (1982) obtained similar results for zooplankton groups sampled in Flathead lake except that Bosmina efficiencies were about twice that found in this study. For this report the two different sampling methods were not compared. In the future, monthly correction factors will be calculated by zooplankter group so that true density estimates can be made and conpared.

Vertical Distribution

The Schindler trap was also used to determine the seasonal depth distribution of zooplankton in Hungry Horse Reservoir. For this report, summer and fall samples were analyzed from the three permanent stations. Generally, the major concentration of all zooplankters was above the euphotic zone although dramatic fluctuations occurred at certain depths (Figures 14-16). Also, 30 m tows didn't sample the entire zooplankton population. Leathe (1982) found up to about 50 percent of zooplankton community in 60 to 30 m tows. Diaptomus and Cyclops comprised an average of 95 percent of the population in these deep water tows. During August Daphnia densities were lowest in the Sullivan area, but increased to about twice that of the other two areas in November. These high November densities may be partly due to the comparatively shallow depth in the Sullivan area which concentrates the zooplankters. The maximum depth at full pool is 35 meters and in November it was only 28 meters. For our purposes, however, 30 m tows should be sufficient to describe the zooplankton community available to cutthroat trout. Our data (see below) and the findings of McMullin (1979) show that cutthroat trout were found near the surface most of the year except in summer when surface temperatures exceeded 17oC at which time they concentrated in the metalimnion.

Daphnia

Since we found that cutthroat trout select almost exclusively for Daphnia when feeding on zooplankton (see below) we followed this group more closely than the other crustaceans. Daphnia densities were highest during July for the Emery and Murray areas peaking at about 6.0/liter for the Emery (Transect 7) and Emery Bay areas (Figure 17) and at about 3.5/liter for the Murray area (Figure 18). After mid August numbers declined rapidly and fluctuated around l.0/liter through December 1983 for the Emery and Murray areas. Numbers appeared to be increasing in the spring of 1984. In the Sullivan area numbers decreased from a high of 2.5

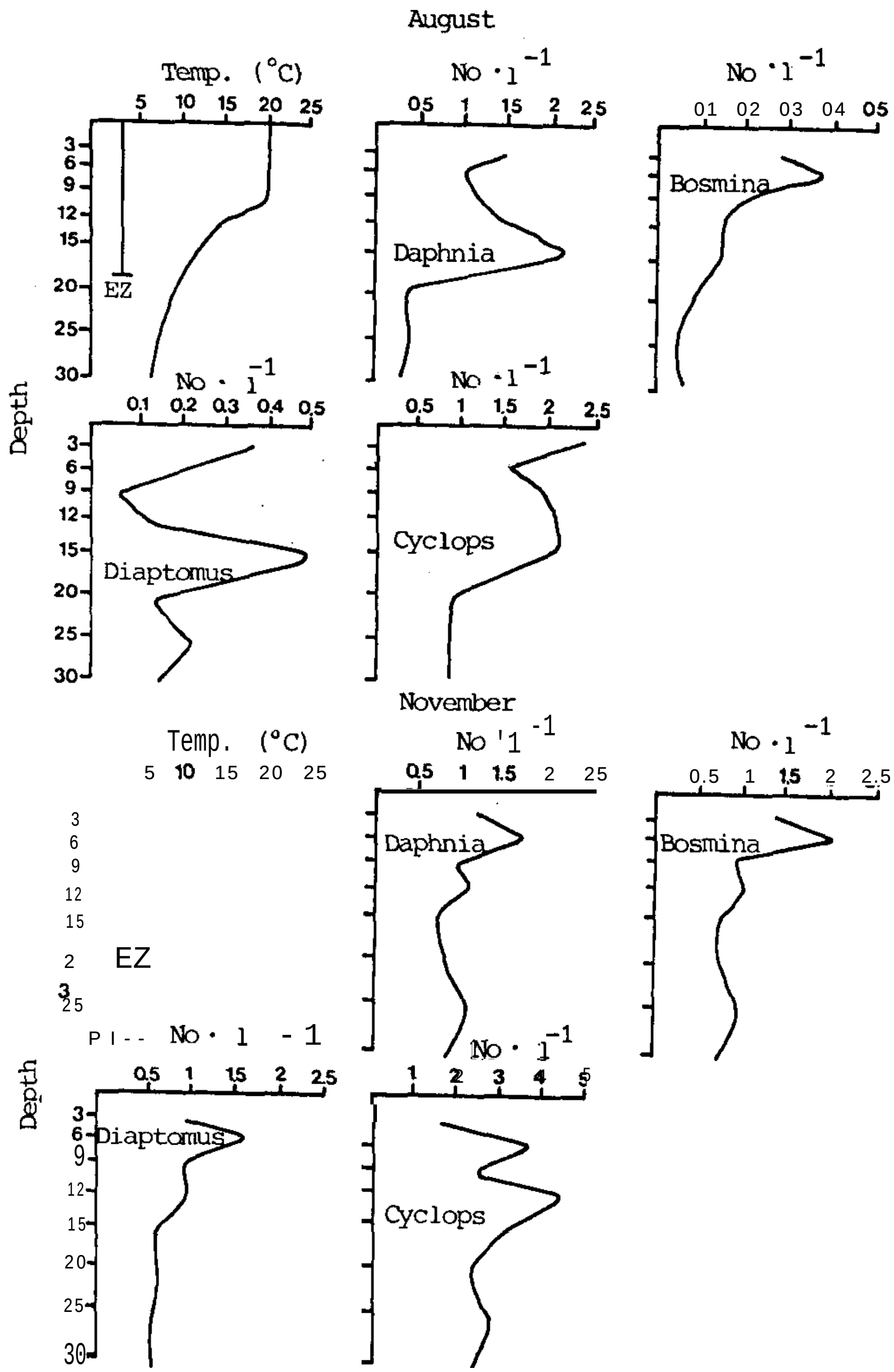

Figure 14. Temperature profile and euphotic zone (EZ) and depth distribution of the principal crustacean zooplankton at the penmnent Emery station on August8 and November 15, 1983.

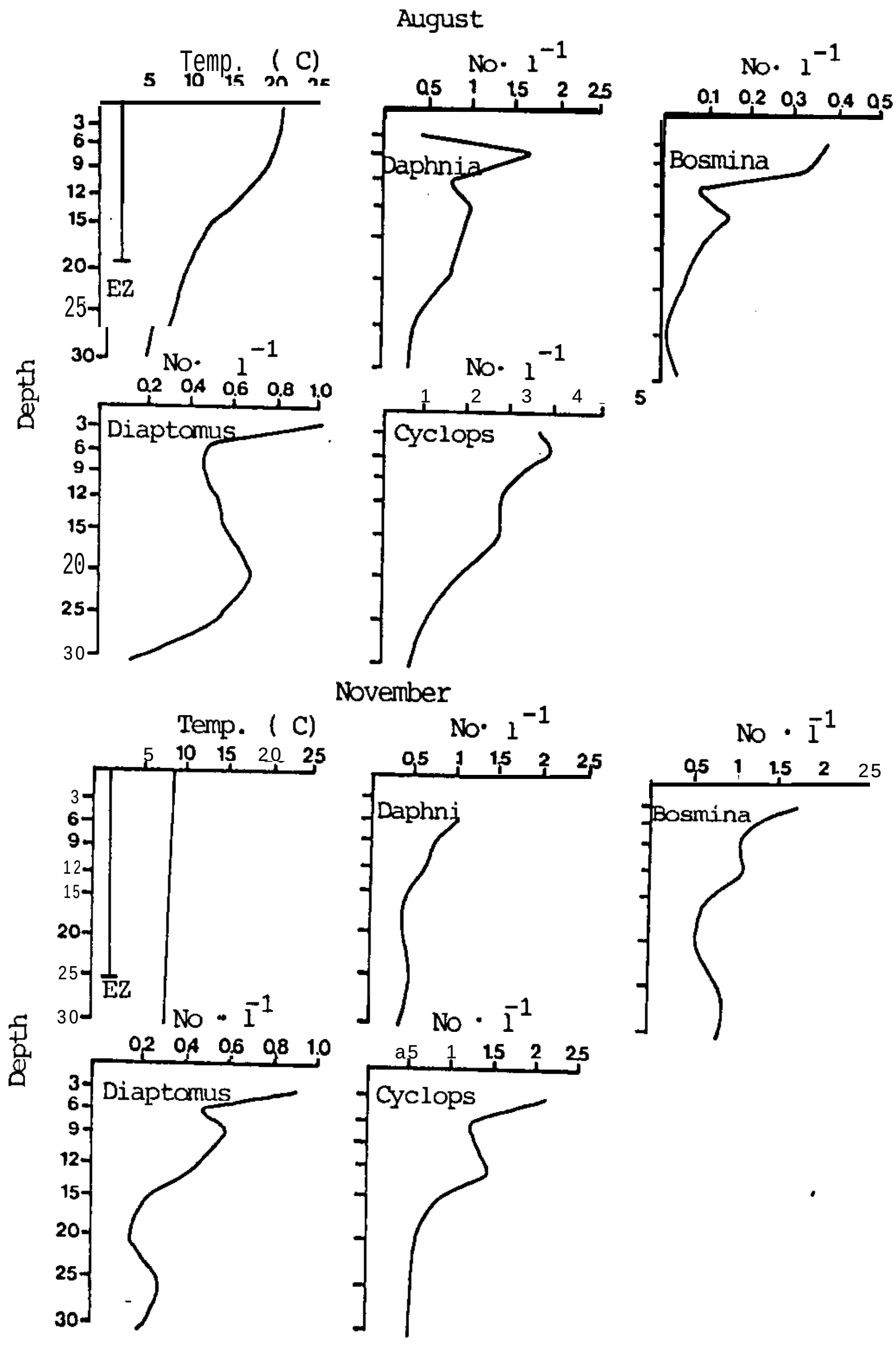

Figure 15. Temperature profile and euphotic zone (EZ) and depth distribution of the principal crustacean zppplankton at the permanent Murray station on August 23 and Ncmmber 16, 1983.

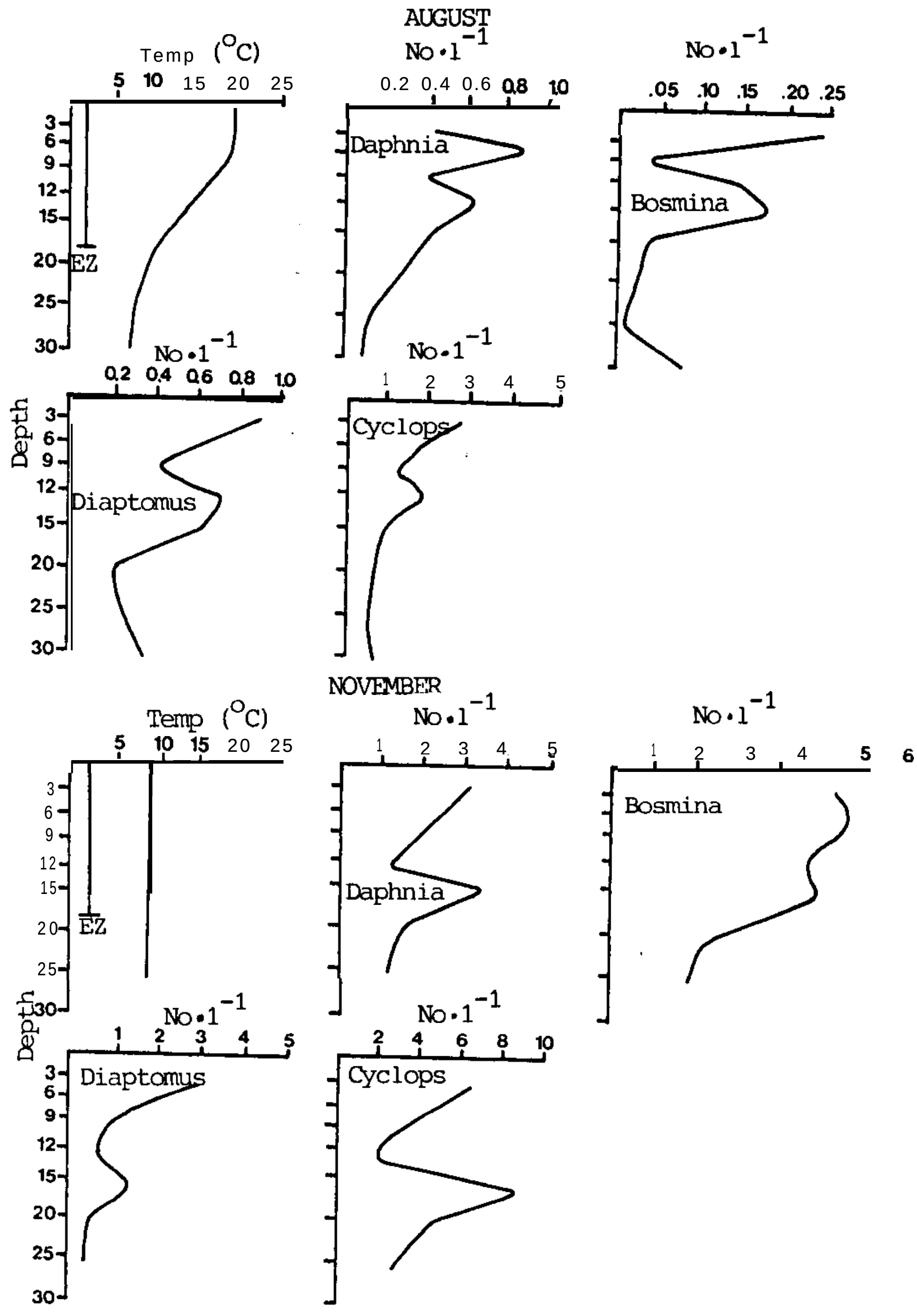

Figure 16. Temperature profile and euphotic zone (EZ) and depth distribution of the principal crustacean zooplankton at the permanent Sullivan station on August 16 and November 17, 1983.

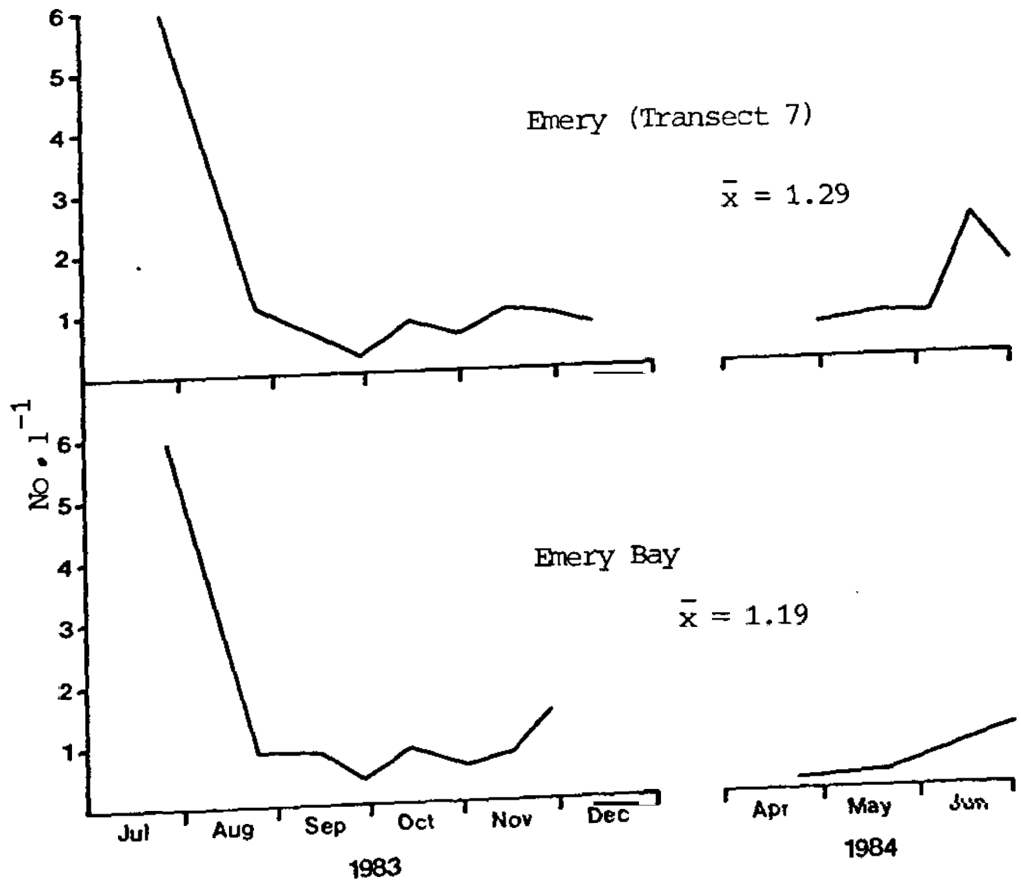

Figure 17. Number of Daphnia per liter captured in 30 m Wisconsin Tows in the Emery Area of Hungry Horse Reservoir from July through December 1983 and April through June 1984.

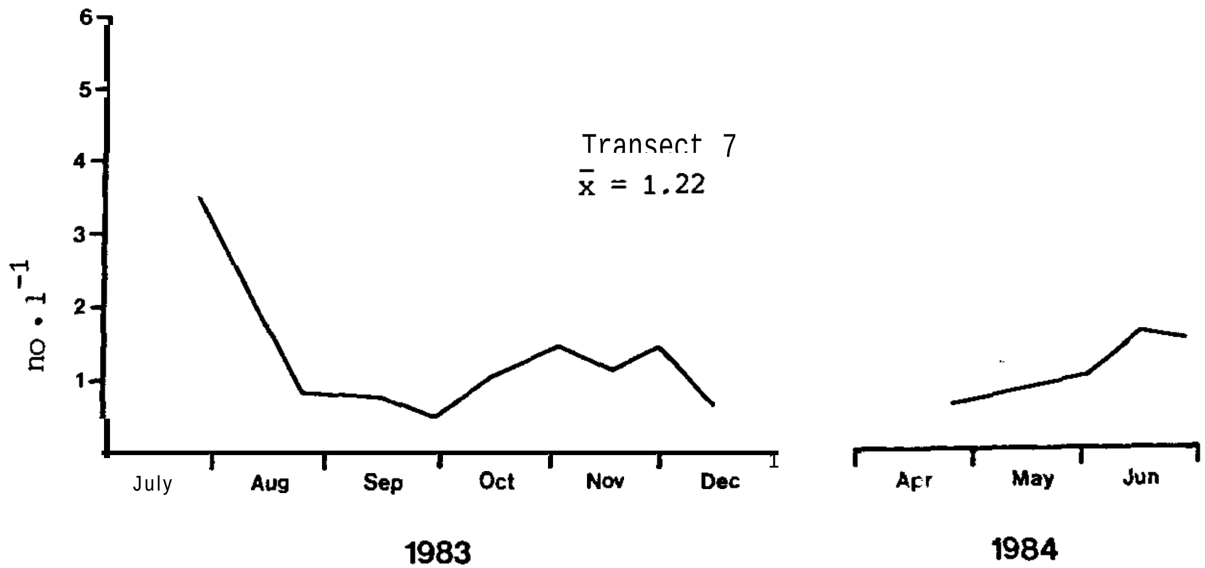

Figure 18. Number of Daphina per liter captured in 30 m Wisconsin tows in the Murray Area of Hungry Horse Reservoir from July through December 1983 and April through June 1984.

and 1.5/liter and fluctuated around 1.0 and 0.5/liter for Transect 6 and Graves Bay, respectively in a pattern similar to the Emery and Murray areas (Figure 19). In the fall of 1983, numbers increased rapidly and peaked at about 4 and 3 per liter for Transect 6 and the Graves Bay areas, respectively. Idunbars appeared to be increasing by late June 1984. Although Daphina numbers fluctuated throughout the period in the different areas the mean densities were similar and ranged from 1.2 for the Sullivan area (Transect 6) to 1.3/liter for the Emery area (Transect 7) (Figures 17-19).

Surface Insects

Terrestrial and aquatic insects were captured in surface insect tows on Hungry Horse Reservoir. In decreasing order Hymenopterans, Coleopterans, Homopterans and Hemipterans comprised the bulk of the terrestrial insects captured. Aquatic insects were represented almost entirely by Dipterans.

Aquatic insect densities on the reservoir increased during August and September, peaked in October at about 145 insects/hectare for the offshore station and declined sharply to less than 10 insects/hectare in November 1983 (Figure 20). During April through November 1984 aquatic insect densities fluctuated in a bimodal fashion. Numbers were low in April, peaked in May at about 150 per hectare, decreased through June and July, then increased again to May levels during September and October. Densities declined dramatically in November when no insects were captured.

Terrestrial insect densities increased dramatically from approximately 25 insects/hectare during August to about 5,400/hectare for the nearshore area in September. Numbers dropped just as quickly in October and terrestrial insects were almost gone on surface waters by November 1983 (Figure 21). During 1984 numbers began to increase in the spring, decreased somewhat in July, increased in August and peaked in September at about 3,600 insects/hectare, declined in October and were almost non existent by November.

True densities of terrestrial insects were probably not accurately represented during September 1983. During this collection period a total of 19,508 insects per hectare were collected both near and offshore for the three areas combined and 16,063 (96 percent) of these were captured in the Emery area alone (Appndix D2). These insects consisted almost entirely of flying ants. We felt that the Emery sample was conducted during a hatch of flying ants which was not occurring at the same time in the other areas and therefore highly inflated the average for that month. Similar situations apparently occurred during August and September of 1984 where a preponderance of flying ants in one area or station greatly inflated the mean although sampling was increased from two to three transects in July of 1984 (Appendix

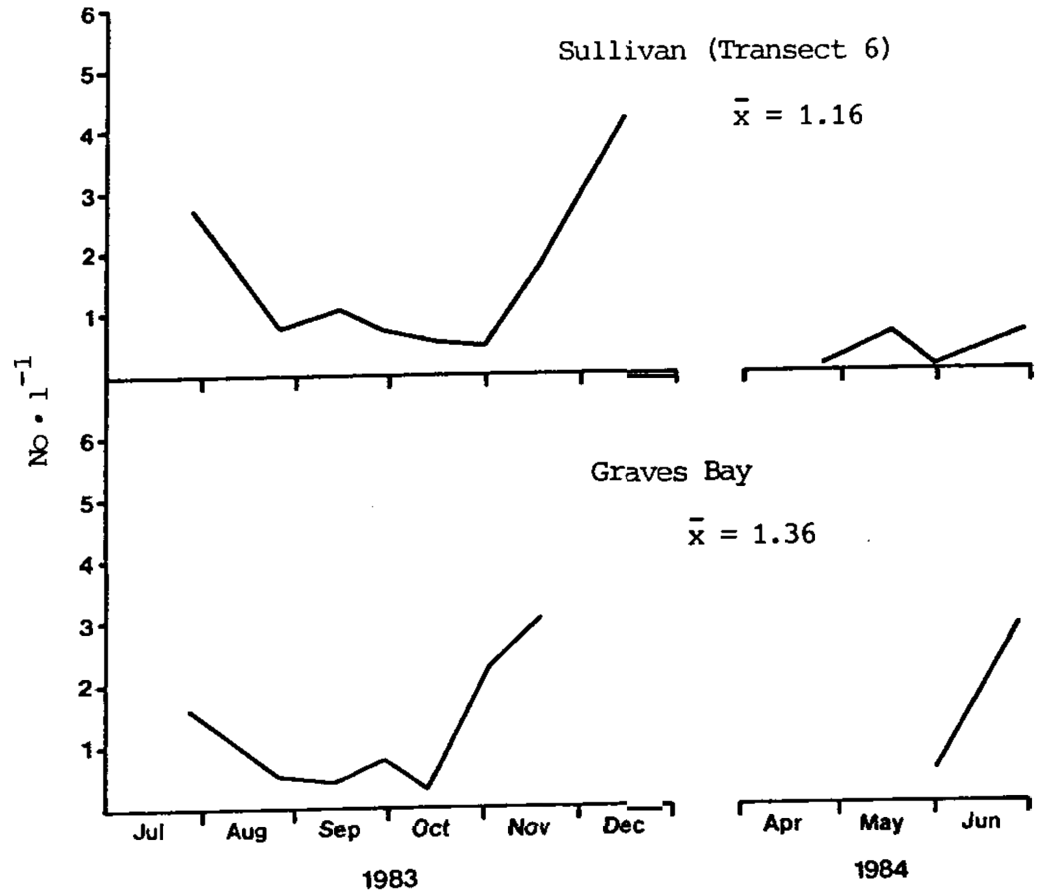

Figure 19. Number of Daphnia per liter captured in 30 m Wisconsin tows Hungry Horse Reservoir from July through December 1983 and April through June 1984.

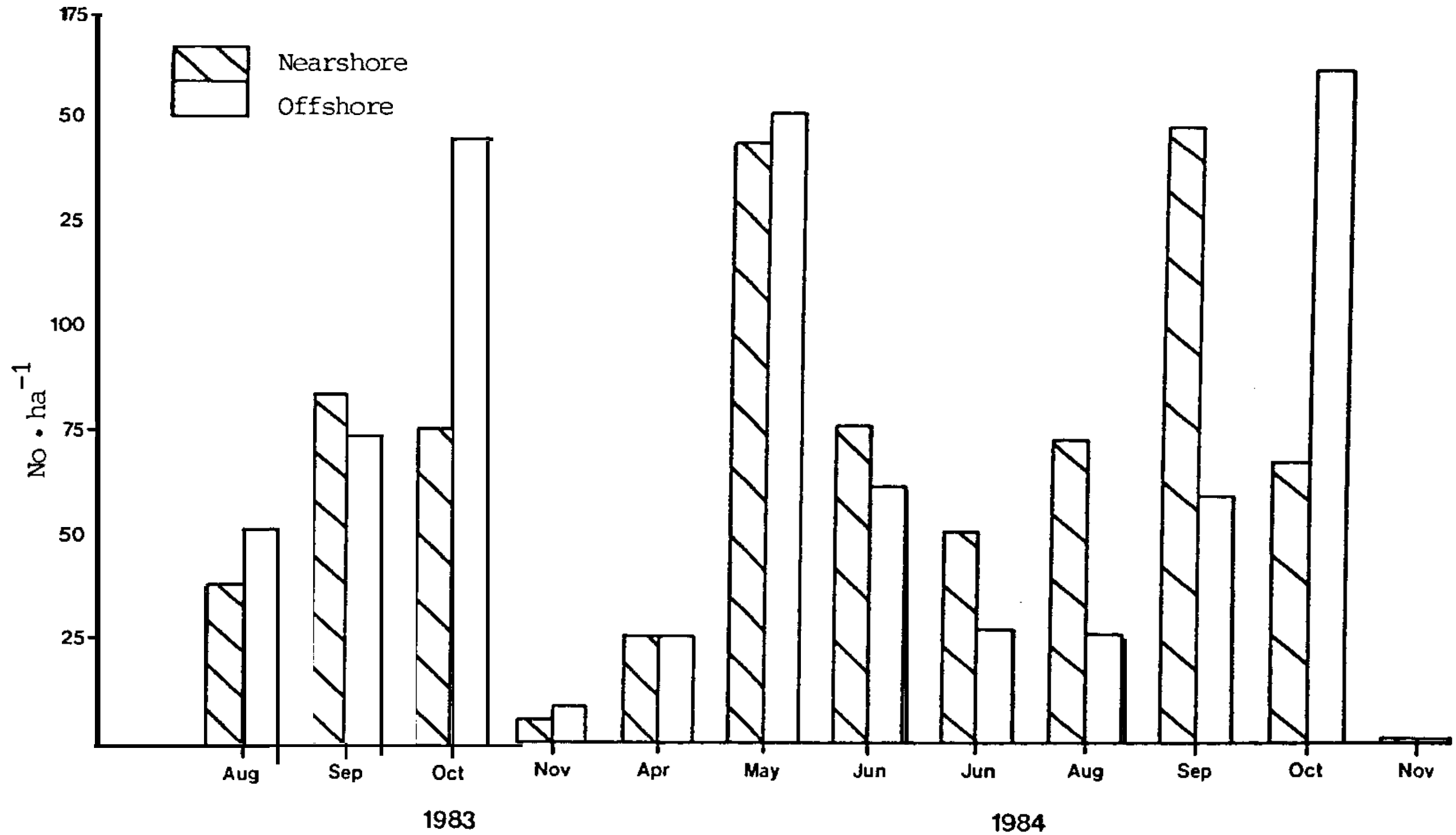

Figure 20 The monthly averages of aquatic insects captured per hectare for Emery, Murray, and Sullivan areas for near (<100 m from shore) and offshore (>100 m) samples collected at Hungry Horse Reservoir from August 1983 - November 1984.

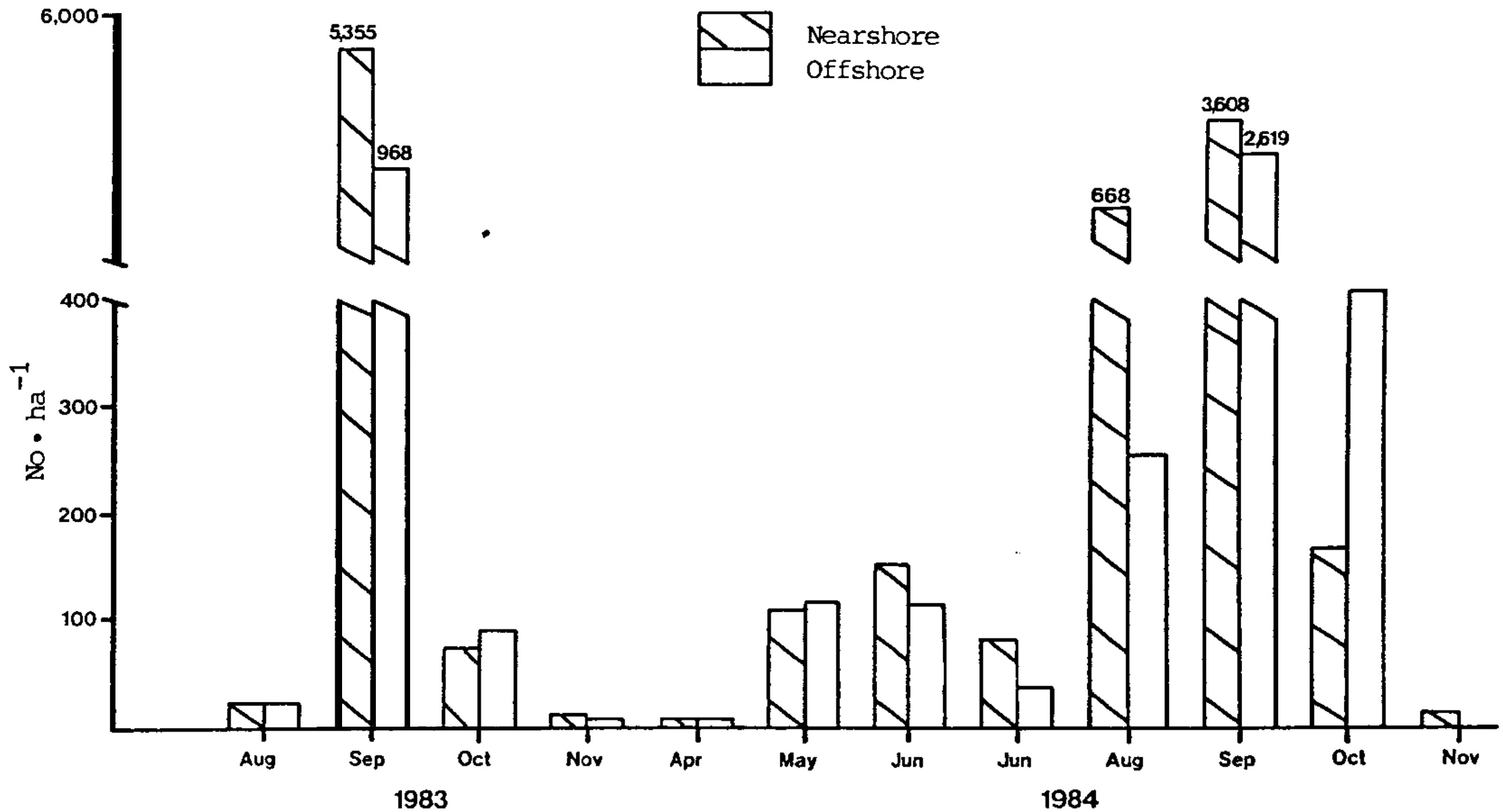

Figure 21 The monthly averages of terrestrial insects captured per hectare for the Emery, Murray, and Sullivan areas for near (<100 m from shore) and offshore (>100 m) samples collected at Hungry Horse Reservoir from August 1983 - November 1984.

D3). This information does, however, show that terrestrial insects are patchily distributed primarily temporally and secondarily spatially throughout the reservoir. Hymenopterans appear to be available in low numbers during most of the fall and at some point a major hatch occurs within a short period creating a spike in their densities. This type of pattern makes them difficult to sample effectively.

Nearshore versus Offshore

Differences between near and offshore sampling stations were difficult to interpret especially for terrestrial insects. In some months one exceeded the other by a wide margin and were similar in other months (Figure 20 & 21). Overall, the mean densities for nearshore terrestrial insects during 1983 were about five times greater than offshore (Table 10) but was probably due to the hatch of flying ants sampled in the Emery area that was mentioned above. During 1984, however, near and offshore terrestrial insect densities were similar. For aquatic insects, near and offshore densities were similar to each other in 1983 and 1984.

Area differences

Terrestrial insects appeared to be much more abundant in the Emery area versus the Murray or Sullivan area in 1983 and 1984. Once again this may be due to the patchy distribution or perhaps some type of preferred terrestrial habitat for these ants in the Emery area. More research is required to determine if there are any real differences in flying ant distribution within and between areas. Aquatic insects appearedtobe fairly evenly distributed within areas.

Benthos

When benthic sampling began in August of 1983 a Petite Ponar dredge was used. We found it to be too small and light weight to collect benthos samples on Hungry Horse Reservoir. In October 1983 we began utilizing a larger, heavier Peterson dredge and were able to collect usable substrate samples. It should be noted that only the silt/sand types of substrate could be sampled and not the larger gravels and cobble. Therefore, these benthic samples are biased towards organisms that occupy these types of habitats. Also, it took a great deal of trial and error to find the specific areas where samples could be collected. Therefore, sampling data for 1983 was incomplete. During 1984 representative samples were collected from each strata.

The benthic community of Hungry Horse Reservoir was comprised primarily of Dipteran larvae (68 percent) and oligochaetes (25 percent) for 1983 and 1984 combined (Appendix D4 & D5). In all three areas during 1984 Dipteran and Oligochaete densities were low

Table 10. The average yearly density (No $\cdot ha^{-1}$) for terrestrial and aquatic insects collected near and offshore for the Emery, Murray and Sullivan areas of Hungry Horse Reservoir during 1983 and 1984.

Year	Station	Area: Emery	Murray	Sullivan	Mean
		Terrestrial Insects			
1983	Nearshore	4,034	157	35	1,409
	Offshore	675	75	65	272
	Combined	4,709	232	100	1,681
1984	Nearshore	1,278	203	315	599
	Offshore	961	180	183	441
	Combined	2,239	383	498	1,040
		Aquatic Insects			
1983	Nearshore	68	43	40	50
	Offshore	33	112	63	69
	Combined	101	155	103	119
1984	Nearshore	56	64	98	73
	Offshore	38	68	86	64
	Combined	94	132	184	137

in June, had increased to the seasonal high by August and had decreased by November. Surface insect tow data indicated that most aquatic insects (which were primarily dipterans) had emerged by the end of October 1984 (Figure 20).

Dipteran and Oligochaete densities (Figure 22) were lowest in the strata dewatered above recommended drawdown (0-26 m). This condition is typical for reservoirs that are drawn down annually and is in direct contrast to natural Oligotrophic lakes where the littoral zone is the most productive benthic area (Wetzel 1975). Dipteran densities remained high for both the strata from recommended drawdown to maximum drawdown on record (26-39 m) and the strata below maximum drawdown on record (39 m). This was probably due to the fact that significant drawdown into these deeper strata had not occurred since 1978 (Figure 2) and therefore had been recolonized. Oligochaete densities were lowest above recommended drawdown, highest from recommended to maximum drawdown but dropped off considerably below maximum drawdown on record (Figure 22). The reasons for the different vertical distributions of these two groups are unknown but may be due to different life histories and habits, seasonal differences, recolonization, emergence times and adaptability to reservoir drawdown.

FOOD HABITS

Westslope cutthroat Trout

A total of 806 fish stomachs were collected during 1983-84 (Appendix El). The contents of 316 stomachs collected in 1983 have been analyzed and data from 119 westslope cutthroat trout stomachs are presented in this report (Table 11). Analysis of the stomachs was done separately for each season and further segregated by total length of the fish. Cutthroat <300 mm in length were classified as juveniles, whereas fish >300 mm were designated as adults. Data from the Emery, Murray and Sullivan areas were pooled since little variation in diet occurred among the areas (Appendix E2).

The food habits of juvenile cutthroat trout varied considerably from season to season (Figure 23). Aquatic Dipteran comprised 76 percent of diet by weight in the summer followed by insect parts, Hymenopterans, Homopterans, and other. The fall diet consisted almost entirely of Hymenopterans, which comprised 92 percent of the food ingested. The juvenile cutthroat switch to Daphnia in the winter when terrestrial insects and aquatic Dipteran were no longer available. The weight of Daphnia in stomachs during the winter was much less than recorded for insects in the summer and fall. The low biomass of Daphina in the winter stomachs is at least partly due to a tendency of the fish caught in gill nets to regurgitate the Daphnia more readily than other food items.

Adult westslope cutthroat trout had a diet similar to juveniles, except that Hymenopterans comprised most of the food

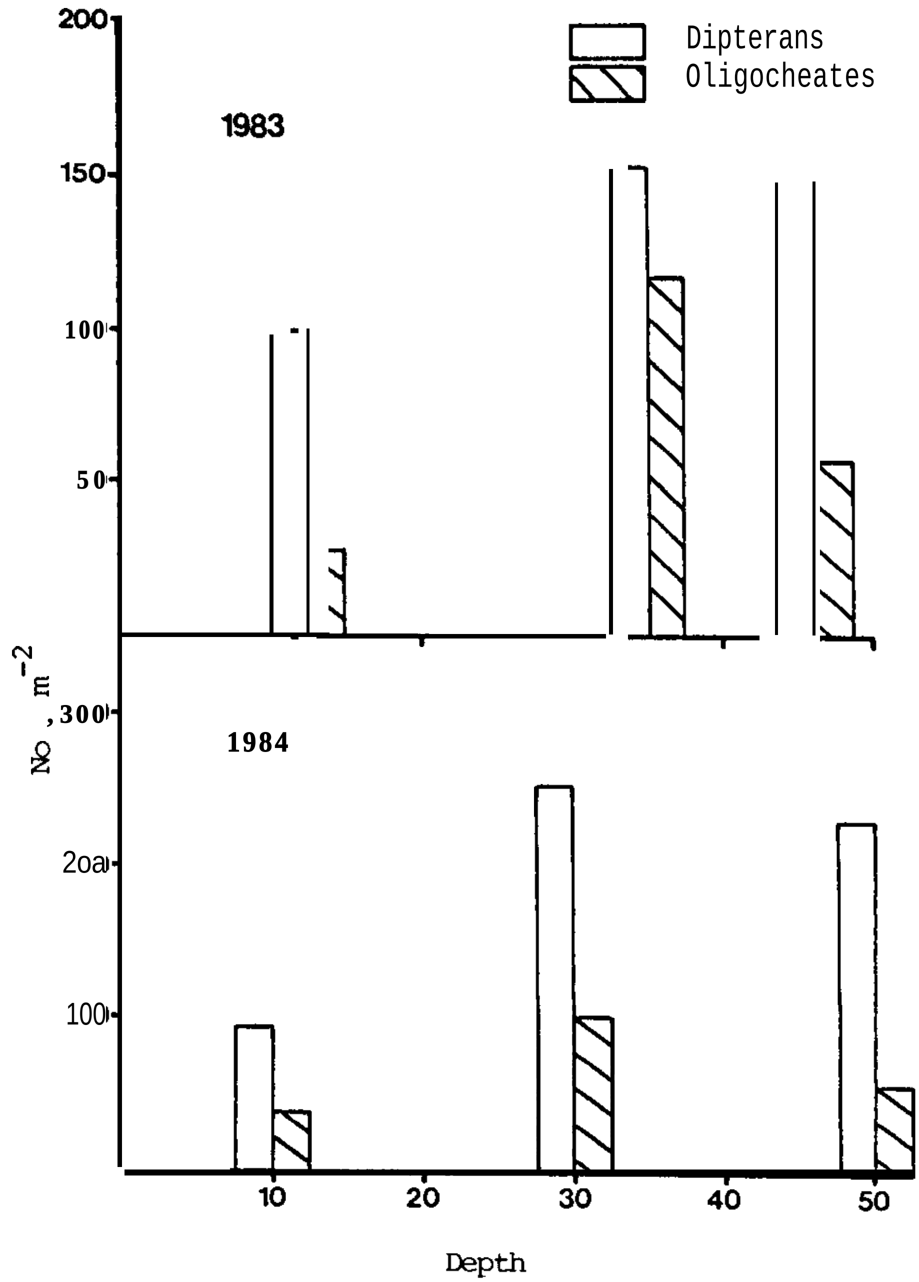

Figure 22. The mean densities (No·m^{-2}) of dipterans and oligochaetes captured in benthic sampling at depths above recommended drawdown (O-26 m) recommended to maximum drawdown (26-39 m) and below maximum drawdown on record (39 m) in the Emery Murray, and Sullivan area of Hungry Horse Reservoir from August - December 1983 and June - November 1984.

Table 11. Summary data for cutthroat trout stomachs collected from Hungry Horse Reservoir during 1983.

Month	Number of stomachs collected	Percent Empty	Number of stomachs Anlayzed	Mean Fish Length (mm)	Range (mm)	Mean Wt. Weight of stomach contents (gr)
			Cutthroat < 300 mm			
August	13	0.0	13	201	166-258	0.40
September	34	0.0	29	246	183-300	4.77
November	17	23.5	13	264	180-300	0.03
			Cutthroat > 300 mm			
August	4	0.0	4	374	355-404	11.20
September	31	0.0	28	345	303-494	14.30
Noverber	20	15.0	17	339	302-380	0.04

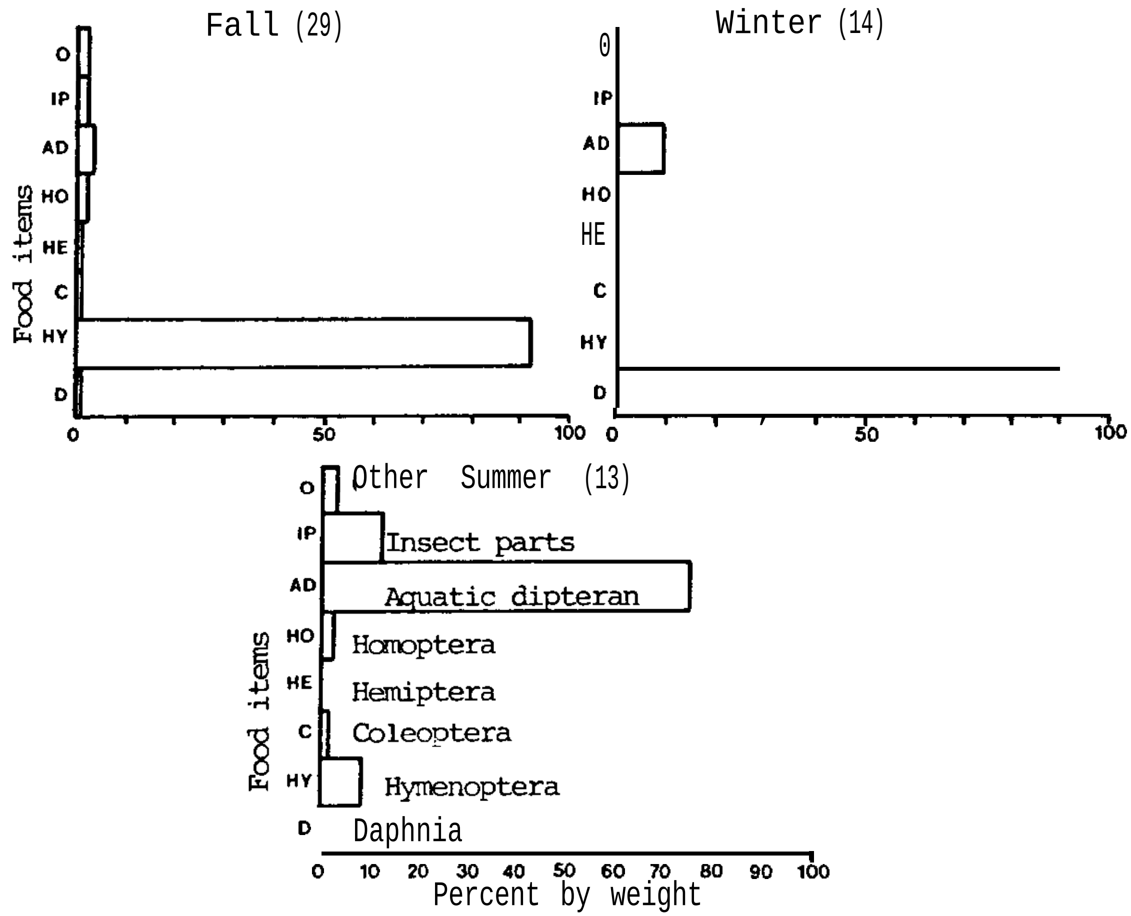

Figure 23. Principal food items in the diet of 56 westslope cutthroat trout <300 mm in length collected from Hungry Horse Reservoir, 1983. Number of stomaches analyzed is given in parenthesis.

ingested in the summer rather than aquatic Dipterans (Figure 24). Hymenopterans constituted 95 percent of the diet in the fall, while Daphnia comprised 94 percent in the winter. The biomass of Daphnia in the stomachs of adults, like juveniles, was low in the winter.

Cutthroat trout juveniles and adults selected intensively for the larger Daphnia (Table 12). Daphnia over 2.0 mm in size comprised only 3.3 percent of the population during November and December in Hungry Horse Reservoir, yet they comprised between 30-85 percent of the Daphnia ingested by cutthroat trout during the period. The mean length of Daphnia consumed by cutthroat ranged from 1.82 to 2.08 mm as compared to a mean length of 2.08 mm for Daphnia in the largest length group collected in Wisconsin tow samples (Table 8). Koening (1983) found that rainbow trout selected Daphnia over 1.5 mm in length in two lakes in southeast Alaska.

The food habits of westslope cutthroat trout in lakes and reservoirs vary considerably, probably in response to the abundance and types of food available and species composition of the fish population. Westslope cutthroat trout in Flathead Lake fed primarily upon terrestrial insects (Leathe and Graham, 1982), whereas Daphnia was the most important food item for cutthroat in Lake Koccanusa followed by terrestrial insects and aquatic diptera (McMullin 1979).

FISH ABUNDANCE AND DISTRIBUTION

Horizontal Gill Nets

Factors Influencing Gill Net Catches

Stationary gear such as gill nets are dependent on fish movement to effect capture. The number of fish caught is dependent to a large degree on their density and activity. Factors affecting activity include water temperature, water transparency, feeding patterns and spawning movements. Water temperature is generally the single most important variable influencing fish activity through its regulation of fish metabolism and spawning movements. The density of fish populations is determined by fish numbers, habitat preferences and water volume. Thus, reservoir elevation affects fish densities through its impacts on fish habitat and water volume.

Estimation of fish abundance by the relative index method requires that gill net sampling be done at similar locations and times each year. It is especially critical that water temperatures and reservoir elevation be standardized. With this sampling design, the complex interrelation of factors influencing catch are minimized and catch per unit of effort is proportional to relative species abundance. Indexes derived from catch-effort data can be

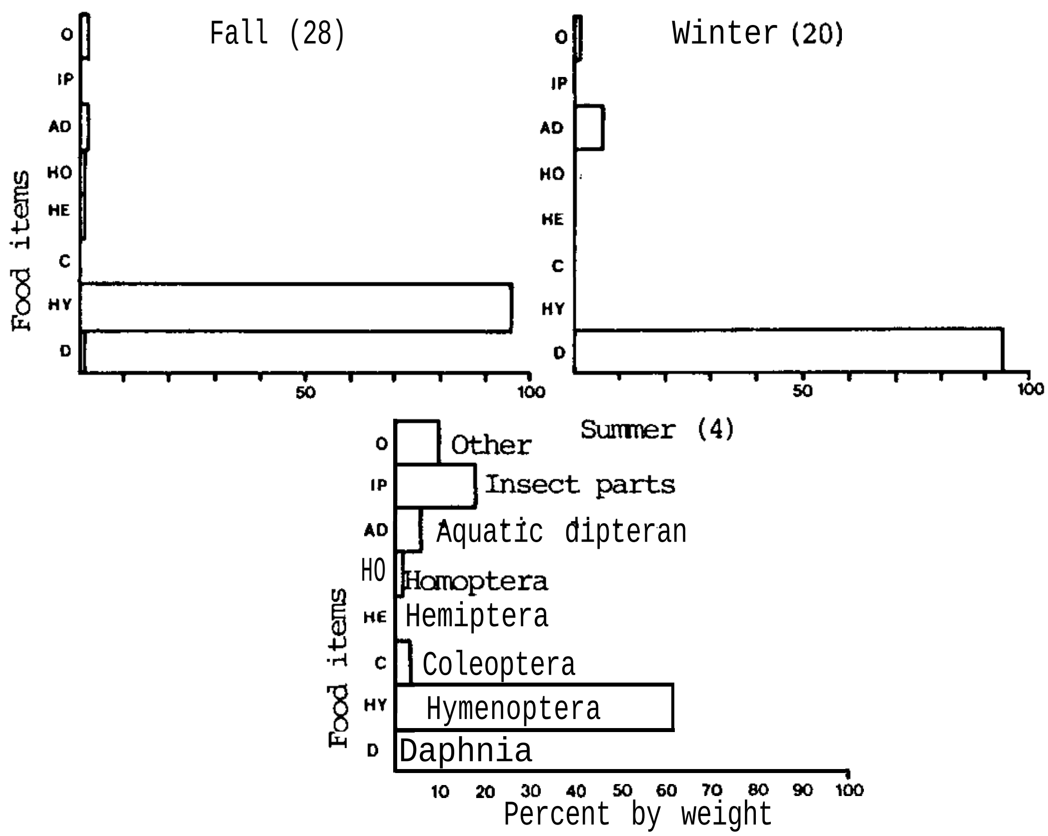

Figure 24. Principal food items in the diet of 52 westslope cutthroat trout 300 mm in length collected from Hungry Horse Reservoir, 1983. Number of stomachs analyzed is given in parenthesis.

Table 12. Length group frequencies and mean length (mm) of Daphnia from Wisconsin tow samples and consumed by westslope cutthroat trout in Hungry Horse Reservoir in November and December, 1983. Juvenile cutthroat are <300 mm in total length and adults are >300 mm.

	Emery Area		Murry Area		Sullivan Area		Areas Combined
	Juveniles	Adults	Juveniles	Adults	Juveniles	Adults	Wisconsin Tow
Length group	Percent in Length Group						
1.0-1.49 mm	------	5.0	4.0	4.0	----	4.0	46.8 (1.17#
1.5-1.99 mm	30.0	65.0	20.0	20.0	15.0	20.0	20.0 (1.74)
2.0-2.49 mm	70.0	30.0	76.0	76.0	85.0	76.0	3.3 (2.08)
Mean length (mm)	1.94	1.90	2.02	2.08	1.88	1.82	—
95% confidence inveral	±0.32	±0.43	±0.56	±0.33	±0.22	±0.34	---

a/Mean length in mm.

used to determine year to year changes in population size species composition and other vital statistics (Walburg 1969).

Catch Composition

A total of 4,932 fish were captured in 472 floating and 125 sinking gill nets in 1983 and 1984. The floating gill net catch was dominated by westslope cutthroat trout and northern squawfish which comprised 42.5 and 43.4 percent of the catch, respectively (Table 13). Mountain whitefish, northern squawfish, suckers and bull trout together comprised 98.3 percent of the sinking net catch. In addition to the species listed in Table 13, seven yellowstone cutthroat, three rainbow trout, one grayling and one pigmy whitefish were captured in the gill nets. The species composition of the sinking nets was comparable to that recorded in Hungry Horse in 1974 (Huston 1975).

The catch by net type indicates that cutthroat trout inhabit surface water when they are distributed in the littoral zone. In contrast, mountain whitefish, suckers and bull trout are closely associated with the reservoir bottom in the littoral zone. Northern squawfish appear to be dispersed throughout the water colunm in the nearshore habitat.

Weatslope Cutthroat Trout

The catch of westslope cutthroat trout in floating gill nets varied considerably with the month and season of the year (Figures 25 and 26). In general, catches were highest in the spring, lowest in the summer and intermediate in the fall, ranging from a maximum of 4.8 fish per net in April to a minimum of 0.2 in August (Appendix Fl). Water temperature and reservoir elevation differences among the sampling dates and pre-spawning movements account for most of the sampling variability (Table 14). Shoreline floating net catches in Flathead Lake varied seasonally from 0.2 cutthroat per net in the summer to 3.3 per net in the spring (Leathe and Graham, 1982). Cutthroat catches in Lake Koocanusa during the fall ranged between 1.2 to 2.5 fish per net (Huston et al. 1984).

The catch of westslope cutthroat trout varied among the Emery, Murray and Sullivan areas, although the differences were not as large as the seasonal variations in catch. The mean seasonal catch of cutthroat in 1983 and 1984 ranged from 0.7 fish per net in the Murray area to 2.1 per net in the Sullivan area (Appendix F3 and Figure 27). Floating net catches were generally highest in the Sullivan area and lowest in the Emery and Murray areas. Catch rates were especially high in the Sullivan area in April 1984 (Appendix Fl) when adult cutthroat trout stage in this area prior

Table 13. Percent composition by species and net type for gill net catches from Hungry Horse Reservoir in 1983 and 1984. number of fish collected is in parentheses

Species	Abbreviation	Percent of Catch: Floating Nets a/		Percent of Catch: Sinking Nets b/		Total catch	
westslope cutthroat	WCT	42.5	(792)	1.7	(52)	17.1	(844)
Bull trout	DV	4.9	(91)	12.6	(387)	9.7	(478)
Mountain whitefish	MWF	7.0	(130)	37.9	(1,164)	26.2	(1,294)
Northern squawfish	NSQ	43.4	(806)	22.8	(702)	30.6	(1,508)
Largescale sucker	CSU	1.9	(35)	9.4	(289)	6.6	(324)
Longnose sucker	LnSU	0.3	(5)	15.6	(479)	9.8	(484)
TOTAL CATCH		1,859		3,073		4,932	

a/ Represents catch in 472 floating gill nets

b/ Represents catch in 125 sinking gill nets

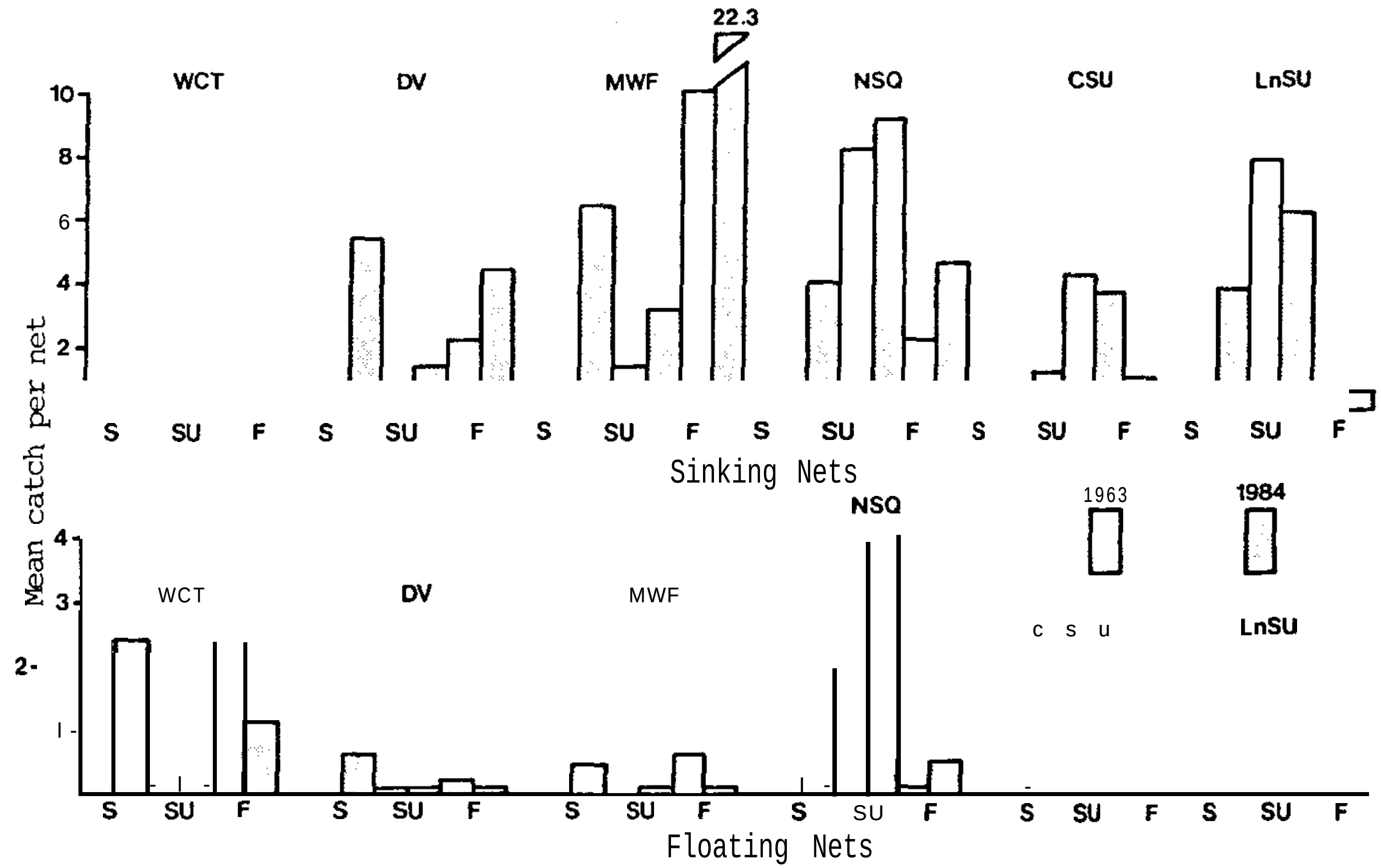

Figure 25. Mean catch of westslope cutthroat trout (WCT), bull trout (DV). mountain whitefish (MWF), northern squawfish (NSQ), largescale suckers (CSU) and longnose suckers (LnSU) in floating and sinking gill nets set in Hungry Horse Reservoir in spring (s), summer (Su), and fall (F); 1983-84. A spring sample was not collected in 1983.

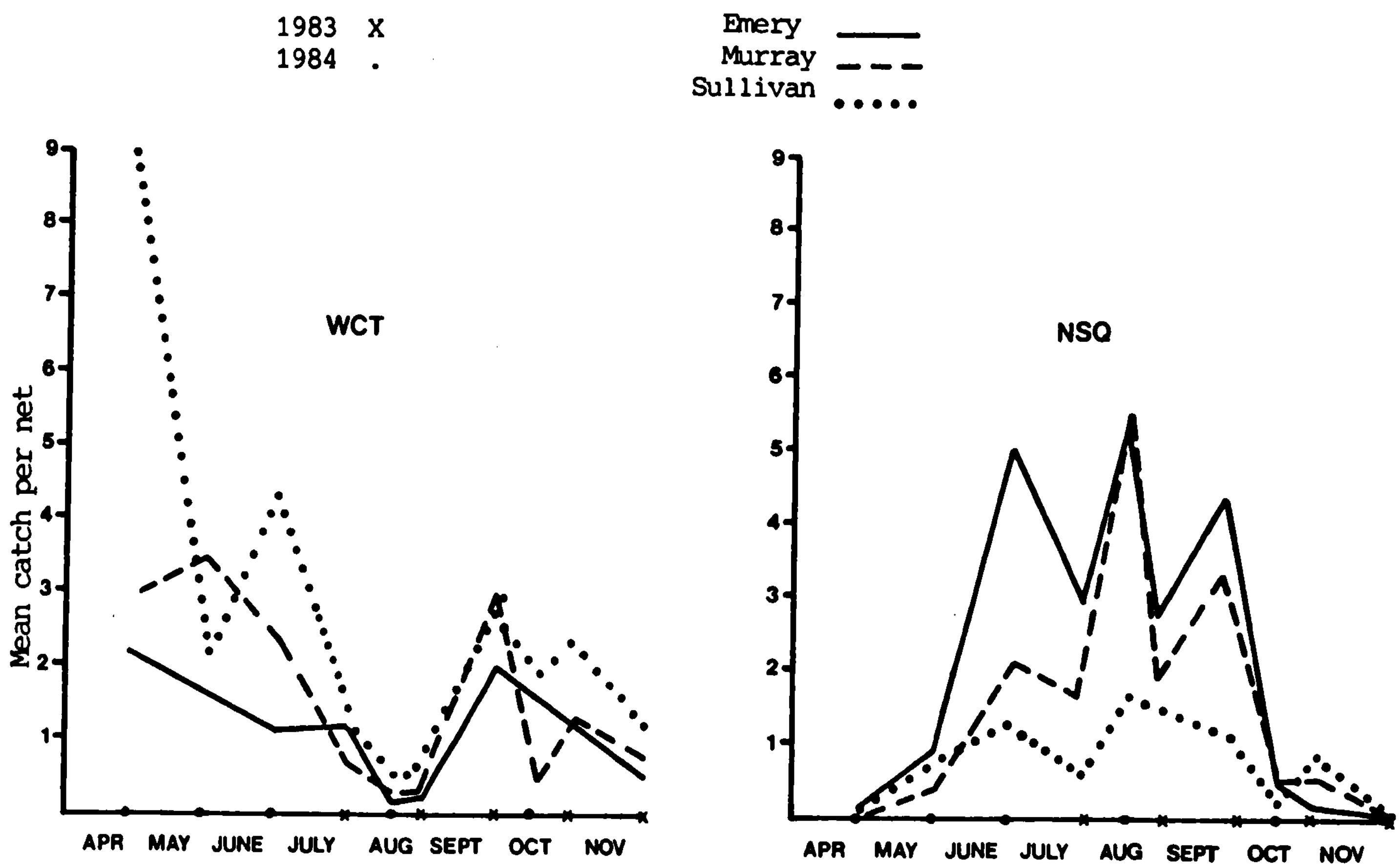

Figure 26. Mean catch per floating net of westslope cutthroat trout (WCT) and northern squawfish (NSQ) from the Emery, Murray and Sullivan areas, July, 1983 through October, 1984.

Table 14. Reservoir elevations, surface water temperatures and water transparency for gill net sampling dates in Hungry Horse Reservoir, 1983 and 1984.

Date	Reservoir elevation (ft)	Surface water temperature (°C)			Depth euphotic zone (m)		
		Emery	Murray	Sullivan	Emery	Murray	Sullivan
1983							
7/26-28	3,560	16.6	17.8	17.2	—	—	--
8/23-25	3,560	20.6	20.6	20.0	18.3	19.1	18.9
9/27-29	3,549-3,547	14.7	14.8	13.9	26.0	18.5	20.5
10/31-11/2	3,534	8.6	8.4	8.0	23.0	16.5	19.3
11/29,30	3,536	7.1	6.5	—	20.5	14.0	—
12/14-16	3,534			4.3	20.3	16.5	19.1
1984							
4/24-27	3,500	4.2	5.6	5.7	15.1	10.3	5.2
5/30-31	3519-23	10.5	9.9	8.6	14.5	13.0	5.8
6/26-6/28	3549-51	17.0	19:6	18.4	17.8	14.3	8.3
8/13-8/22	3557-59	20.0	21.0	20.0	18.3	16.7	16:3
10/11-10/15	3541-40	—	12.6	12.1	17.8	19.6	14.6

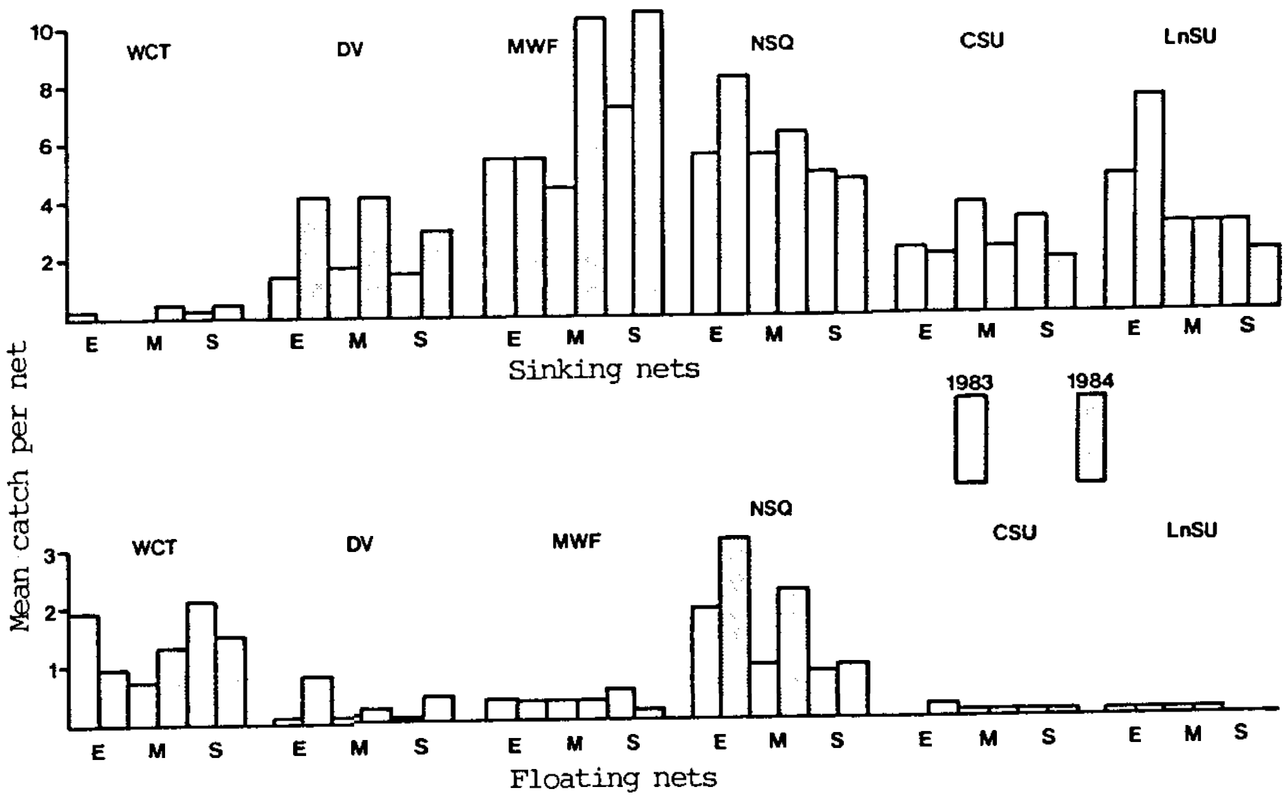

Figure 27. Mean catch of westslope cutthroat trout (WCT), bull trout (DV), mountain whitefish (MWF), northern squawfish (NSQ), largescale suckers (CSU) and longnose suckers (LnSU) in the Emery, Murray, and Sullivan areas in 1983 and 1984.

to moving into tributaries to spawn. Important spawning streams are located in the upper part of the reservoir and in the South Fork River upstream from the pool area.

The monthly catch of westslope cutthroat trout and northern squawfish in floating gill nets indicate a considerable degree of temporal and spatial separation between the two species. Cutthroat trout catches were high in the spring from April through June and in the fall from late September through November (Figure 26). In contrast northern squawfish catches were highest during the summer period from late June to late September. This difference in seasonal catch between the two species was primarily a result of dissimilar temperature preferences. cutthroat trout are a cold water species which prefer water temperatures between 10-16°C (Hickman and Raleigh 1982). Dwyer and Kramer (1975) noted that cutthroat trout scope of activity is highest at 15°C. When water temperatures in the upper part of the water column are above 17°C cutthroat trout move into deeper offshore waters. On the other hand, squawfish prefer warmer water temperatures, becoming more active and inhabiting the littoral zone when water temperatures are about 12-15°C. Squawfish become less active and move into deeper offshore waters in the fall and winter when water temperatures decline (Scott and Crossman, 1973). This habitat separation between the two species reduces potential competition for food and space and limits predation on juvenile cutthroat by northern squawfish. Indeed, initial analysis of squawfish stomachs indicated that juvenile cutthroat were seldom eaten.

The length frequency distribution of cutthroat trout from the 1983 floating gill net catch is given in Appendix Gl. The median length of cutthroat is only 272 mm in the Sullivan area as compared to 316 mm in the Murray area. The higher proportion of juvenile fish in the Sullivan area is probably due to its proximity to a comparatively large number of spawning and rearing tributaries.

The cutthroat trout catch in gill nets in 1983 consisted primarily of age two, three and four fish (Table 15). Age two fish comprised 29.6 percent of the catch as compared to only 12 percent for Flathead Lake in 1981 (Leathe and Graham, 1982). Migration class two and three fish comprised 90.5 percent of the catch. A similar migration class structure was found for cutthroat trout from Flathead Lake (Leathe, 1982) and Hungry Horse Reservoir (Huston, 1972).

Bull Trout

Bull trout catches in sinking nets varied monthly and seasonally (Figure 25 and 28) in a pattern similar to cutthroat trout. The catch was highest in the spring, intermediate in the fall and lowest in the summer. The mean catch of 5.3 bull trout per net in the spring was comparable to those obtained in Hungry Horse Reservoir in the early 1970's (Huston, 1972, 1974 and 1975).

Table 15. The percent age and migration class composition of 189 westslope cutthroat trout collected in gill nets fished in Hungry Horse Reservoir in 1983.

Age	Percent age composition of catch	migration class composition of catch
1	---	2.6
2	29.6	49.2
3	38.1	41.3
4	23.8	6.9
5	6.9	----
6	1.6	---

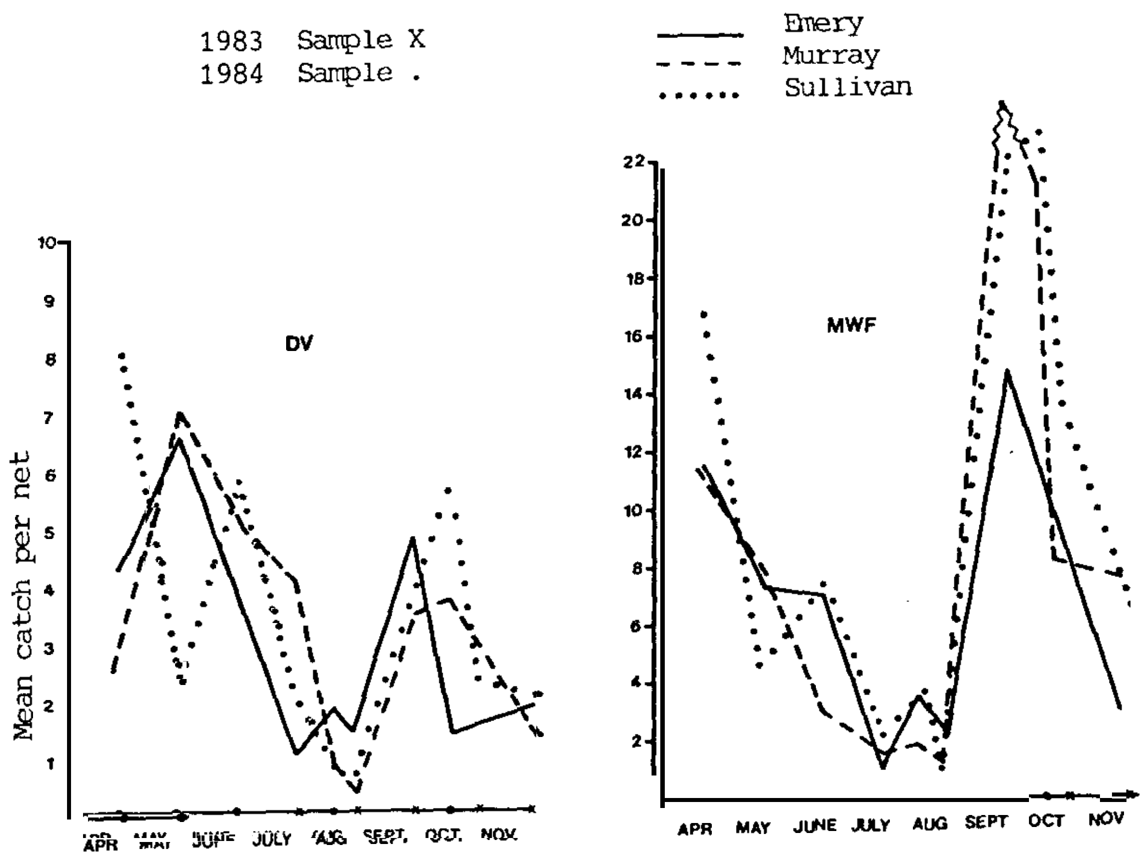

Figure 28. Mean catch per sinking net of bull trout and mountain whitefish (MWF) from the Emery, Murray and Sullivan areas; July 1983 through October 1984.

The Hungry Horse catch rates are higher than those recorded in Lake Koocanusa (Huston et al., 1984) and Flathead Lake (Leathe, 1982).

There was little difference in catch among the three areas of the reservoir (Figure 27). The highest catch of 8.0 fish per net was recorded in April in the Sullivan area with 7.0 and 6.5 fish per net collected in May in the Murray and Emery areas, respectively (Appendix F2). Bull trout appeared to be most active during the spring when surface water temperatures were increasing.

The bull trout caught in 1983 ranged in total length from 179 to 735 mm (Appendix G2). The catch in the Sullivan area was comprised more of juveniles than in the other two areas. This is probably due to the numerous spawning and rearing tributaries entering the upper end of the reservoir and in the South Fork of the Flathead River above the pool area.

Mountain Whitefish

Mountain whitefish dominated the catch in sinking nets comprising 37.9 percent of the total fish caught. The catch of whitefish varied seasonally in a pattern comparable to the cutthroat and bull trout catch. The catch was highest in the fall (22.3 fish per net) and spring with the lowest catch of 1.3 fish per net recorded in the summer (Figure 25). The high catch rate in the fall was a result of a decline in water temperatures to below 12OC which triggered spawning movements of whitefish. The 1984 fall catch of 22.3 fish per net about twice that of the catch of 10.0 fish per net in the fall, 1983. The higher catch in 1984 was probably due to the netting series occurring during the peak of the whitefish spawning movements. Mountain whitefish appear to have temperature and depth preferences which are similar to bull trout (Figure 28). This results in bull trout and whitefish inhabiting the same areas much of the time and accounts for whitefish being an important food item in the diet of bull trout.

The catch of mountain whitefish varied among the reservoir geographic areas with higher numbers of fish caught in the Sullivan and Murray areas than in the Emery area (Figure 27). The median length of the fish collected in gill nets in 1983 ranged from 291 mm in the Emery area to 302 mm in the Sullivan area (Appendix G3).

Northern Squawfish

Northern squawfish constituted a major part of the catch in both sinking and floating gill nets (Table 13). The catch of squawfish was highest in the summer and lowest in the spring and fall (Figure 25). As noted previously, squawfish inhabit the deeper offshore waters when surface water temperatures are below approximately 10-12°C. Squawfish catches were higher in 1984 than in 1983. Surface water temperatures during the fall sampling in

1984 were approximately 4°C higher than in 1983 (Table 14) and these differences were an important factor influencing the catch rates.

The catch of northern squawfish appeared to be higher in the Emery and Murray areas than in the Sullivan area (Figure 27). The apparent lower numbers of squawfish in the Sullivan area may be related to poor spawning habitat. Northern squawfish in lakes spawn over clean talus and gravel areas (Patten and Rodman 1969). Eggs are dermersal and adhesive, attaching themselves to the substrate. A layer of silt deposited by the South Fork of the Flathead River covers most of the rubble and gravel areas in the Sullivan area, reducing their suitability as spawning habitat for squawfish.

Northern squawfish caught in gill nets in 1983 ranged in total length from 110-525 mm (Appendix 54). The median length varied from 185 mm in the Sullivan area to 198 mm in the Murray area.

Suckers

Suckers are benthic oriented species that are caught primarily in bottom net sets in the summer (Figure 25). The highest catch of 18.5 longnose suckers per net occurred in the Emery area in July, 1983 whereas the largescale sucker largest catch of 6.3 fish per net took place in the Murray area in August, 1983. Overall, there was little difference in mean catches of suckers among the three areas, except the catch of longnose suckers was higher in the Emery area than in the Murray and Sullivan areas (Figure 27). Length frequency diagrams for the two species from the 1983 net data are shown in Appendix G5 and G6.

Vertical Gill Net and Acoustical Results

The catch of fish in vertical gill nets was very low. Only 11 westslope cutthroat trout and 5 bull trout were caught in 88 vertical gill net sets (Table16). Few fish were recorded in the acoustical transects which were run in conjunction with the vertical nets. The paucity of data collected by these two methods resulted in this part of the study being discontinued. Depth distribution of fish will be determined from catches in floating and sinking gill nets, the purse seine and literature. Depth distribution in lakes and reservoirs is primarily controlled by water temperatures. This relationship between water temperature and vertical fish distribution has been well documented for westslope cutthroat in Lake Koocanusa (McMullin 1979) and Flathead Lake (Leathe 1982). Westslope cutthroat trout prefer water temperatures less than 17 or 18'C. They move into deeper and cooler waters when surface water temperatures approach 18°C in the summer. When water temperatures are below 15°C cutthroat are concentrated in the upper 7-10 meters of the water column.

Table 16. Sunmary of vertical net catches in the Emery, Murray and Sullivan areas of Hungry Horse Reservoir, October and November 1983 and May, June, July 1984.

Area	Number of nets	Number of fish caught					
		Westslope cutthroat	Bull trout	Mountain whitefish	Northern squawfish	Iargescale suckers	Longnose suckers
Emery	36	4	2	28	1	--	--
Murray	36	3	1	5		--	--
Sullivan	16	4	2	1	1	--	--
Total	88	11	5	34	2	--	--

Additional data on depth distribution of cutthroat trout is being collected in the Lake Koocanusa Study (Shepard 1984).

Electrofishing

Shoreline habitat in the Sullivan area was sampled seasonally with electrofishing gear to assess fish densities. Westslope cutthroat trout catches of 4.6 - 10.0 fish per hour were highest in the spring when surface water temperatures were about 8.5'C (Table 17). No cutthroat were collected in July when surface temperatures were around 19.4°C indicating they had moved into deeper and cooler offshore waters. Surface water temperatures in September declined to 16.1°C and a few cutthroat trout were caught in the shoreline zone. Cutthroat trout were caught in various habitats along the shoreline, but appeared to show a preference in the spring for the flat areas with gravel silt substrate and large numbers of stumps. The use of these areas in the spring may be food related.

Mountain whitefish juveniles and suckers were the most abundant fish found in the nearshore zone. Sucker densities were highest in the summer, while mountain whitefish numbers peaked in May and September when up to 39.4 fish per hour were caught. Comparatively few northern squawfish and bull trout were captured from the shoreline habitat.

Purse Seine Population Estimates

Cutthroat trout populations were sampled in May and September, 1984 using the purse seine technique. The catch in both periods was low ranging from a mean of 0.4 to 0.6 cutthroat per haul in the Sullivan area (Table 18). In addition, nineteen purse seine hauls were made in the Murray area during the fall of 1984 and no cutthroat were caught. Nine of these hauls were made after sunset. It appears that purse seining should be concentrated in the Sullivan area where cutthroat densities are higher and water depths less than in the Murray and Emery areas.

Population estimates were calculated for westslope cutthroat trout from the purse seine catches in the Sullivan area. An estimated1, 774 cutthroat (0.6 fish per acre) inhabited the limnetic zone in May and 5,429 (0.9 fish per acre) in September (Table 18). The 95 percent confidence limits for the spring and fall estimates were ±83 and ±144 percent of the point estimates, respectively. The estimate for the littoral zone in September was corrected for the differences in cutthroat densities between the limnetic and littoral zones (Table 19). A correction factor was not available for the spring estimate. The spring estimate in the littoral zone was 0.6 cutthroat per acre as compared to 1.5 per acre in the fall. The combined littoral and limnetic estimates were 0.6 and 1.2 cutthroat per acre in May and September, respectively.

Table 17. Electrofishing catch from shoreline habitat in Sullivan area of Hungry Horse Reservoir, 1984.

Date	Hours fished	Surface water Temperature (C°)	Cutthroat Trout Adults	Cutthroat Trout Juveniles	Bull Trout Adults	Bull Trout Juveniles	Mountain Whitefish Adults	Mountain Whitefish Juveniles	Northern Squawfish	Suckers
5/2	1.6	6.9	2.5	3.1	0.6	1.9	4.4	39.4	1.3	10.7
5/9	2.0	8.2	8.0	2.0	1.0	- -	6.5	10.0	—	25.0
5/10	2.6	8.4	2.1	1.9	- -	—	3.1	1.9	- -	20.4
7/17	2.1	19.4	- -	—	—	- -	- -	0.8	- -	d
7/18	1.5	19.4	—	—	—	—	—	18.5	3.1	108.5
9/11	1.8	16.1	1.1	—	- -	—	2.2	29.4	- -	d
9/12	2.2	16.1	0.5	0.5	—	0.5	3.6	26.4	—	a/

a/ Suckers not collected but they were numerous in the littoral habitat

Table 18. Population estimates for westslope cutthroat trout calculated from purse seine catches in the Sullivan area of Hungry Horse Reservoir, May and September 1984.

Reservoir Elev. (ft)	Number of purse seine hauls	Mean catch per haul	Surface area limnetic (acres)	Surface area littoral	Limnetic estimate	Littoral estimate	Total estimate	Number per acre
				May Estimate				
3,500	19	0.4	3,178	2,727	1,774(±83)[a]	1,521(+362)	3,295(±197)	0.6
				September Estimate				
3,545	30	0.6	5,972	3,227	5,429±(144)	4,781(±786)	10,210(±376)	1.2

[a] The 95% confidence limits are in parentheses as percent of the pint estimate

Table 19. Mean catch of westslope cutthroat trout in floating experimental gill nets set in the littoral and limnetic zones of the Murray and Sullivan areas, Hungry Horse Reservoir, 1984.

Date	Nmber Nets	Catch of Cutthroat Trout		Ratio of
		Littoral	Limnetic	limnetic:littoral
Murray Area				
09/21/84	10	29	22	1.0:1.4
10/11/84	6	3	4.	1.0:0.8
Sullivan Area				
09/19/84	10	44	27	1.0:1.6
10/12/84	4	13	3	1.0:4.3

The large confidence limits associated with limnetic and littoral estimates indicate that a larger sample is needed to obtain reliable estimates. Increasing the number of hauls to 60 in the Sullivan area should reduce the confidence limits markedly. The sample series in the spring should take place as soon as access to the reservoir is possible, which will be sometime in mid-April. At this time cutthroat densities are high and the adult cutthroat are staging prior to their spawning runs into tributary streams.

FISH MOVEMENT PATTERNS

Westslope Cutthroat Trout

Most juvenile and adult westslope cutthroat trout were collected and tagged when emigrating from tributary streams. A total of 3,957 juveniles and 426 adults were tagged in 1983 and 1984 (Table 20). Angler returns accounted for 40 of the 58 tags recaptured followed by 10 and 8 returns from fish trap and gill net catches, respectively. Thirty of the tag returns were from juvenile fish as compared to 28 for adult fish. Movement information was obtained from only 0.8 percent of the juvenile fish and 6.7 percent of the adult fish tagged.

Tagged fish were caught throughout the reservoir during 1983-1984 (Figure 29). Approximately 71 percent of the tagged fish were caught within 5 km of the tagging location with 36 percent of these fish recaptured near the mouth of the stream in which they were tagged. Most of the latter fish were caught by anglers in the summer soon after they were tagged and before they had a chance to migrate into the reservoir. Three fish or 5.0 percent of the tags returned moved up-reservoir distances greater than 5.0 km with 49.9 km the maximum. Approximately 24.0 percent of the returns showed down-reservoir movement of between 5.0 - 52.3 km. Huston et al. (1984) found that most we&slope cutthroat trout in bake Koocanusa exhibited downstream movement patterns.

Movement of cutthroat trout in Hungry Horse Reservoir is influenced by location of spawning and nursery tributaries and reservoir drawdown. Most of the important spawning tributaries are located in the upper part of the reservoir. Spent adults and juvenile cutthroat tagged near the mouth of these tributaries would have a tendency to move down-reservoir during the drawdown period when the upper part of the reservoir becomes dewatered. A reverse movement occurs in the spring during the spawning period when adults move up-reservoir to spawn in tributary streams. There are few tag returns from the upper part of the reservoir in the spring probably due to low angling pressure.

Table 20. Number of juvenile and spent adult westslope cutthroat trout (WCT) tagged in Hungry Horse Reservoir and its tributaries in June, July, August and September of 1983 and 1984.

	Number of juvenile WCT Tagged						Number of adult WCT Tagged					
	June 83 84	July 83 84	August 83 84	Sept. 83 84	Total 83 84	Grand Total	June 83 84	July 83 84	August 83 84	Sept 83 84	Total 83 84	Grand Total
Clark	—(—)a/	19 (64)	2(—)	47(-)	68 (64)	132	—(—)	—(—)	-(-|	-(—)	—(—)	—
Emery	257(23)	191(246)	— (1)	72(1)	520(270)	790	3 (6)	—(18)	—(-)	-(—)	3 (24)	27
Forest	—(—)	—(153)	— (7)	—(-)	-(160)	160	—(—)	—(10)	—(-)	-(—)	— (10)	10
Hungry Horse	71 (9)	89(523)	— (56)	48(-)	208(588)	796	21(20)	10 (159)	—(1)	-(—)	31(180)	211
Logan, N.F.	68 (-)	38(--)	—(—)	—(-)	106(—)	106	12(—)	1(—)	—(-)	-(—)	13(—)	13
Logan, S.F.	—(—)	4(---)	—(—)	—(-)	4(—)	4	—(—)	—(—)	—(-)	-(—)	—(—)	—
McInerrie	99(—)	34(--)	—(—)	35(-)	168(—)	168	5(—)	2(—)	—(-)	-(—)	7(—)	7
Murray	22(--)	—(—)	—(—)	—(-)	22(—)	22	8(—)	—(—)	—(-)	-(—)	8(—)	8
Quintonkon	—(—)	— (76)	—(140)	11(-)	11(216)	227	—(—)	— (12)	—(2)	-(—)	— (14)	14
Spotted Bear R.	—(—)	— (12)	—(—)	—(-)	— (12)	12	—(—)	— (3)	—(-)	-(—)	— (3)	3
Sullivan	—(—)	156(169)	338(—)	43(-)	537(169)	706	—(—)	10 (2)	2(-)	-(—)	12 (2)	14
Tent	33(—)	38(--)	—(—)	31(-)	102(—)	102	21(—)	1(—)	—(-)	-(—)	22(—)	22
Tin	—(—)	6(—)	—(—)	—(-)	6(—)	6	—(—)	—(—)	—(-)	-(—)	—(—)	—
Twin, lower	—(—)	129(—)	237(—)	—(-)	366(—)	366	—(—)	9 (3)	18(-)	-(—)	27 (3)	30
Twin, upper	—(—)	2(—)	—(—)	—(-)	2(—)	2	—(—)	—(—)	—(-)	-(—)	—(—)	—
upper Reservoir	—(—)	—(—)	—(—)	—(2)	— (2)	2	—(34)b/	—(—)	—(-)	-(23)	— (57)	57
Wheeler	—(—)	7(309)	13(—)	—(-)	20(309)	329	—(—)	— (10)	—(-)	-(—)	— (10)	10
Wounded Buck	—(—)	—(—)	—(—)	27(-)	27(—)	27	—(—)	—(—)	—(-)	-(—)	—(—)	—
Total	550(32)	713(1552)	590(204)	314(2)	2167(1790)	3957	70(60)	33(217)	20(3)	-(23)	123(303)	426

a/ 1984 totals in parentheses

b/ These fish were tagged in May

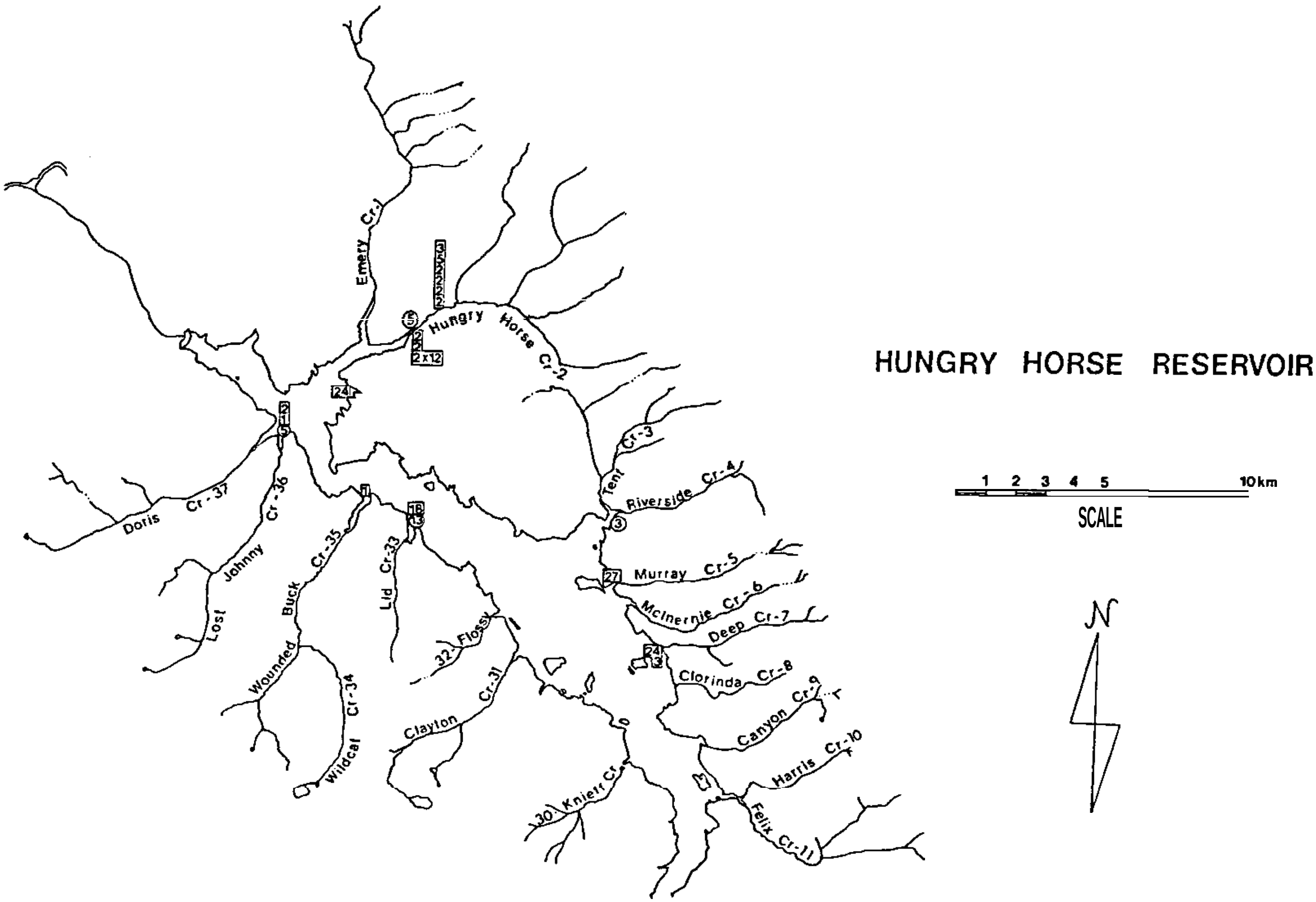

Figure 29. Map of Hungry Horse Reservoir showing locations of westslope cutthroat trout tag returns with the number indicating the stream in which the fish was tagged. Circled numbers are returns from 1983 and squares for 1984.

GAMEFISH GROWTH

Scales were taken from all westslope cutthroat and bull trout and most mountain whitefish caught in gill nets and purse seine hauls. Scales were also collected from cutthroat trout collected in the Hungry Horse and Emery Creek fish traps. Plastic impressions of the scales are in the process of being aged. The data is being entered into the computer and initial growth information will be included in the 1985-86 annual report.

Otoliths were taken from cutthroat trout collected in gill nets and will be aged through a contract with Dr. Ed Brothers. He will able to determine monthly growth from the otoliths which will us to relate the effects of reservoir operation to monthly and seasonal growth increments.

IMPACTS OF RESERVOIR OPERATION

Habitat

Operation of Hungry Horse Dam has large impacts upon the morphometrics and thermal stability of the reservoir. Annual drawdown for flood control and power production causes reductions in surface area, volume, shoreline length, area in littoral zone, volume in euphotic zone and volumes in preferred temperature strata for trout. In addition, large outflow volumes reduce hydraulic residence times and weaken thermal structure. These changes in reservoir morphometrics and thermal stability translate into a reduction of habitat for fish food organisms and gamefish populations. The loss of the productive littoral zones in the upstream part of the reservoir may be especially detrimental to fish populations.

The GEOSCAN program will be used to estimate the changes in reservoir morphometrics at ten foot contour intervals as well as volumes in the euphotic zone and in selected temperature ranges.

Fish food Organisms

Benthos

The adverse effects of reservoir drawdown upon benthic macroinvertebrates has been well documented in the literature (Benson and Hudson 1975, Baxter 1977, Fillion 1965 and Kaster and Jacobi 1978). Paterson and Fernando (1969) noted that approximately 90-95 percent of the Dipteran larvae died after exposure to freezing conditions in a dewatered reservoir area. Dipteran standing crops in areas not dewatered by drawdown in Hungry Horse Reservoir were much larger than in the littoral zones which were annually dessicated and exposed to freezing conditions. Dipterans are an important food item of westslope cutthroat trout in the spring and summer. Consequently, large drawdowns should have an adverse impact upon the growth and condition factors of cutthroat trout. These impacts should be especially severe in the spring when dipterans are the primary food source of cutthroat trout.

Zooplankton

Reservoir operation may have negative impacts upon zooplankton populations through its influence on the thermal structure of the reservoir and downstream losses of zooplankton in reservoir outflow. Woods (1982) found that weak thermal stability caused by large volumes of inflow and outflow currents was a major factor in limiting primary productivity in Lake Koocanusa. Reduced primary productivity results in lower zooplankton production since phytoplankton is the primary food source for the zooplankton community. Decreased hydraulic residence times were also found to lower productivity and zooplankton densities in Midwest reservoirs by changing thermal structure (Mayhew 1977). Temperature plays an important role in zooplankton production through its influence on metabolism and egg development (Bottrell et al. 1976) and filtering rates (Burns 1969). Seasonal progression of major zooplankton taxonomic groups in Missouri River Reservoirs was found to be dependent on water temperatures (Martin et al. 1981).

The impacts of reservoir operation upon zooplankton populations in Hungry Horse Reservoir is not known due to the short period of data collection. Lake filling and hydraulic residence times for Hungry Horse are comparatively high when compared to Lake Koocanusa indicating thermal structure may be less impacted in Hungry Horse. However, residence times during drawdown periods still appear low enough to impact thermal structure and zooplankton populations.

The relationship between monthly residence times and zooplankton populations will be determined. Since residence times are usually lowest in winter and early spring we will need to collect zooplankton data during this period when the reservoir is ice covered.

The relationship between zooplankton populations and volume of water in euphotic zone and volumes in selected temperature ranges will also be evaluated as more data is collected and analyzed. Low zooplankton populations may be reflected in the growth rates and condition factors of cutthroat trout and mountain whitefish in the winter and early spring. Both of these species appear to utilize primarily zooplankton (Daphnia) during the winter and early spring period.

Surface Insects

Insects on the surface film are the primary food of cutthroat trout in Hungry Horse Reservoir. Reservoir drawdown has a drastic effect on dipteran densities in areas dewatered by drawdown. A reduction in dipteran production in dewatered areas should result in lower densities of Dipterans on the surface film, especially during the spring and early summer period when dipteran are emerging and much of the littoral zone is still dewatered. Years of extreme drawdown may result in slower growth rates and lower condition factors for cutthroat trout than in years of lesser drawdowns.

Terrestrial insects are the most important food item of westslope cutthroat trout in Hungry Horse Reservoir during the summer and fall. Unfortunately, there is a paucity of data in the literature concerning the effects of drawdown on terrestrial insects densities on the surface film. Intuitively, it appears that drawdown would not effect terrestrial insect density, but rather would cause a reduction in the total number of insects available in the epineuston due to less surface area. A large reduction in total numbers of terrestrial insects may be reflected in low summer and fall growth rates and condition factors of westslope cutthroat trout. The relationship between drawdown and surface insect densities will be evaluated and estimates of numbers and biomass of insects not available due to reduction in surface area calculated.

Gamefish Species

Westslope Cutthroat trout

Reservoir operation impacts cutthroat trout populations through influencing fish food availability and living space or habitat quality and quantity. The relationship between drawdown, aquatic Dipteran densities, zooplankton standing crops and availability of terrestrial insects on the surface film are in the process of being developed. The next step is to determine the relationship between food availability and seasonal growth rates and condition factors. This will be accomplished as more data on these parameters are collected during the study. Initial analysis of the data indicates that large reservoir drawdowns may adversely affect fish food availability and may reduce seasonal growth rates and condition factors of trout. Timing of drawdown may also be important especially in the fall. Food resources were high during September and October and drawdown during this period may adversely effect cutthroat trout growth.

Reductions in quantity and quality of living space negatively effects cutthroat trout populations by increasing intraspecific and interspecific competition for food and space. Competition for limited resources usually causes an increase in mortality coupled with a decrease in growth. Large annual drawdowns probably expose juvenile cutthroat to increased predation rates by concentrating them into a smaller volume with less escape cover. Stevens and Miller (1983) found that predation on salmon smolts increased in low flow years because the young are concentrated in smaller river volumes where they are more readily caught by predators. Slower growth resulting from a large drawdown would increase mortality of juvenile cutthroat because they would be vulnerable to predation for a longer period of time. Mills and Foring (1983) found that slow growth rates of yellow perch prolonged the period of vulnerability to predation by walleye.

Annual mortality rates will be calculated from three sources: 1) Purse seine population estimates, 2) age structure of gill net and angler catches (catch curves) and 3) rate of adult returns from tagged juvenile and adult cutthroat emigrants from Hungry Horse Creek. These parameters will be correlated with reservoir operation to determine if there is a relationship between operation and cutthroat trout mortality rates.

Westslope cutthroat trout mortality due to angling should be determined in 1985. This will entail running a creel survey to determine catch rates. Total harvest will be calculated from these catch rates and fishing pressure from a mail survey conducted by Montana Department of Fish, Wildlife and Parks in 1985.

Bull Trout and Mountain Whitefish

Reservoir operation also affects bull trout and mountain whitefish populations through its impacts on fish food availability and quantity of available habitat. Reduction in zooplankton populations (<u>Daphnia</u>) would lower the food supply of mountain whitefish and may result in a decline in growth rates and condition factors. Large drawdowns would probably adversely affect the growth and survival of small bull trout due to reduced food supply and living space. In contrast drawdowns are probably beneficial to the piscivorous larger bull trout. Drawdown reduces living space which concentrates fish and makes them more susceptible to predation by bull trout.

RECOMMENDATIONS

Continue the study with the following modifications:

1. Complete stream habitat surveys including Graves Creek above the barrier chute.

2. Obtain population estimates for cutthroat trout in major spawning tributaries in order to develop a model relating habitat to standing crops of juvenile trout.

3. Evaluate westslope cutthroat trout use of structure in shoreline habitats during the spring and fall.

4. Drop the Emery Day and Graves Ray Wisconsin tows and pick up an additional random tow in each area for a total of three samples in each geographic area per sampling date.

5. Increase frequency of surface insect tows during the spring, summer and fall. This should help reduce bias caused by large temporal variations in their abundance.

6. Collect and analyze stomachs using present methodology through 1985. Continue to collect stomachs after this date but pool them for analysis.

7. Delete vertical gill net and acoustical sampling, because of low fish catches in nets and few fish recorded during acoustical runs.

8. Sample fish populations in the reservoir seasonally with gill nets using a more intensive effort.

9. Estimate total harvest of major game species in 1985 by conducting a creel survey to determine catch rates. Total harvest will be calculated from these catch rates and fishing pressure obtained from a fishing pressure survey conducted by the Montana Department of Fish, Wildlife and Parks.

10. Run a downstream trap in Hungry Horse Creek through September and determine trap efficiency by two week periods.

11. Collect Wisconsin zooplankton tows during February and March in the Emery and Murray areas.

12. Conduct intensive purse seining in the Sullivan area in spring and fall.

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Appendix A

Stream Habitat Survey Data

BED MATERIAL						FLOOD SIGNS	AVERAGE DEPTH	MAXIMUM DEPTH	CHANNEL WIDTH	DEBRIS	WETTED WIDTH	COVER			D_{90}	COMPACTION	IMBEDDEDNESS	FEATURE RIF, PL, RN	SIDE CHANNEL	TRANSECT
O	F	SG	LG	C	B							INSTR	OVERH <1 m	OVERH >1 m						
																				1
																				2
																				3
																				4
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POOLS		
I	II	III

STREAM PATTERN:
FLOW CHARACTER:
VALLEY FLAT :
TURBIDITY :
STAGE :

UNUSUAL FEATURES AND COMMENTS	
PACE:	FEATURE OR COMMENT

Appendix Al. Stream habitat survey field data form.

Appendix A2. stream survey data foe east-side tributaries of Hungry Horse Reservoir collected during 1983 and 1984.

Stream Name	Reach No.	Stream order	Drainage Area (km^2) a/	Barrier location km from stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent: Instream cover	Percent: overhead cover	Percent: Pool	Percent: Run
Emery	1	3 3	52.8		Y	5.2	2.1	33.5	21.3	1.3	14.7	6.1	70.0
	2				Y	4.9	2.4	70.4	10.3	25.5	22.5	20.0	53.3
Oliver	1	1			Y	0.7	5.5		Too small				
	2	1			N	1.4	22.1		Too steep				
Remington	1	1			Y	0.7	4.2		Too small				
	2	1			N	1.3	27.1		Too steep				
Royal	1	1 1			Y	0.8	10.8		Too small				
	2				N	0.7	34.3		Too steep				
Strife	1	2			Y	0.4	9.9		Too small				
	2	1			N	1.5	24.3		Too steel,				
Emery Loop	1	2			Y	1.3	2.0		Too small				

Appendix A2. Continued

Stream Name	Reach No.	Stream Order	Drainage Area (km²)[a]	Barrier location km from stream origin	Accessible[b] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent: Instream cover	Overhead cover	Pool	Run
Hungry	**2**	3	39.8		Y	3.1	2.0	32.2	21.6	19.0	16.5	10.0	43.3
Horse	**3**	2		7.0	Y	3.6	4.3	96.0	10.3	17.8	29.2	36.7	60.0
		2			N	0.8	14.6		Barrier				
Margaret	1	2			Y	2.7	4.1	27.4	34.4	11.2	13.3	20.0	50.0
Tiger	**1**	2			Y	2.8	3.5	59.3	33.5	17.8	12.2	36.7	43.3
Turmoil	1	2			Y	0.9	9.0		Too small				
Lost	**1**	2			**Y**	**1.2**	5.1	68.3	43.3	5.7	13.2	13.3	50.0
Mare	**2**	2			**N**	**2.1**	18.3		Too steep				
Tent	1	3	48.9		Y	1.3	3.6	43.1	41.9	48.5	13.5	20.0	11.0
							3.5						
Dudley A	1	**2**			**Y**	**1.8**	**7.4**	39.4	28.4	6.8	8.0	13.3	36.7
	2	**2**			**N**	**2.0**			Dry				
							9.7						
Dudley B	**1**	1		0.1	N	0.4	**25.4**		Barrier				
	2	2			N	1.3			Barrier				
							8.4						
Dudley C	1	1			**Y**	**0.7**	**30.9**		Too small				
	2	1			**N**	**1.1**			Too steep				
Ryle	1	2			Y	**1.0**	8.4		Too small				
	2	2			N	**1.2**	17.2		Too steep				

Appendix A2. Continued

Stream Name	Reach No.	Stream Order	Drainage[a] Area (km^2)	Barrier location km from stream origin	Accessible[b] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Percent pool	Percent Run
Lost Hair	1	1			N	1.4	24.8		Too steep				
Seagrid A	1	1			N	0.7	12.0		Too steep				
	2	1			N	1.6	23.6		Too steep				
Seagrid B	1	1			N	0.5	10.8		Too steep				
	2	1			N	1.3	29.9		Too steep				
Riverside	1	3	15.8		Y	0.9	5.3	24.4	67.9	5.8	2.5	33.3	16.7
	2	3		C-1.3[c]	P	3.2	9.8		Too small				
Murray	1	2	8.3	C-0.2	P	1.1	6.8	7.3	48.8	28.3	19.5	0	13.3
	2				N	2.6	21.1		Too steep				
	3	2,2			N	1.7	6.3		Too small				
		2											
McInernie	1	2	6.4	C-0.5	P	1.2	4.0	58.3	11.2	9.1	18.4	17.2	34.5
	2				P	1.0	6.1	18.0	36.3	23.5	38.3	5.0	40.0
	3	2		2.3	N	2.0	23.5		Barrier				
		2											
Deep	1	1	1.5		Y	1.4	9.6	30.7	Needs survey				
	2				N	1.8	23.5		Too steep				

Appendix A2. Continued

Stream Name	Reach No.	Stream order	Drainage Area[a/] (km^2)	Barrier location km from stream origin	Accessible[b/] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Percent Pool	Percent Run
clorinda	1	1	3.7	c-o.2	N	1.0	13.1		Barrier				
	2	1			N	2.1	20.3		Barrier				
Canyon	1	2	10.0		Y	1.1	8.8	36.4	53.2	41.7	13.7	0	16.7
	2	2			N	2.0	15.0		Too Steep				
Harris	1		1.2	c-o.3	P	1.8	8.2	35.6	48.8	31.8	13.2	3.3	20.0
	2	ll			N	2.5	21.4		Too steep				
Felix	1		23.0	c-O.2	N	2.5	2.9	32.8	40.8'	5.3	3.5	13.4	40.0
	2	3			N	1.3	2.1	18.5	52.1	14.7	12.0	13.3	33.3
	3	3			N	2.1	18.1		Too steep				
		2											
Unawan	1	2			Y	1.3	1.4	7.7	Too small				
	2	2			N	1.9	20.4		Too steep				
Paint	1	1	6.4	c-o.2	N	1.5	9.0		Barrier				
	2	1			N	3.2	3.9		Barrier				
	3	1			N	1.6	33.3		Barrier				
Logan	1	2	15.6	c-O.5	P	2.8	4.8	9.6	42.6	15.7	8.3	20.0	10.0
	2	2			N	2.8	12.1		Too steep				

Appendix A2. Continued

Stream Name	Reach NO.	Stream Order	Drainage Area (km²)[a/]	Barrier location km from stream origin	Accessible[b/] (Y/N/P)	Length (km)	Gradient (%)	spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Percent Pool	Percent Run
S.F. Logan	1	2	21.4		Y	2.9	6.3	4.1	23.0	5.7	14.3	16.7	23.3
	2	2			N	2.0	21.3		Too steep				
Devil's Corkscrew	1	2	4.5		N	2.1	ll.3		Too steep				
Hoke	1	2	30.9		Y	1.9	6.3		Too small				
	2	2			N	2.6	23.0		Too steep				
Baptiste	1	2			N	1.4	5.4		Dry				
	2	2			N	2.4	22.5		Dry				
Deadhorse	1	2			N	1.2	5.9		Dry				
	2	2			N	2.1	9.1		Dry				
Peters	1	2			Y	2.7	10.2		Too small				
	2	2			Y	1.2	5.2		Too small				
	3	2			Y	1.8	29.9		Too small				
Brush	1	2			N	2.5	26.4		Too steep				
Dry Park	1	2			N	1.9	23.2		Too steep				

Appendix A2. Continued

Stream Name	Reach No.	Stream Order	Area (km^2)	Barrier location km from stream origin	Accessible[b/] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Pool	Run
So. Fork Dry Park	1	1			N	1.7	41.8		Too steep				
							2.6						
Lower Twin	1	3			Y	4.5	1.5	22.9	68.9	18.7	1.2	10.0	10.0
	2	3		7.0	Y	4.9	[illegible]	3.5	59.9	17.8	1.8	6.7	6.1
	3	2			N	2.5	4.8		Dry				
	4	2			N		3.1		Dry				
	5	1			N	2.1/3.4	3.4		Dry				
Rib. A	1	2			N	4.8	14.5		Dry				
Trib. B	1	1			N	1.4	41.5		Dry				
Trib. C	1	1			N	0.9	36.0		Dry				
Trib. D	1	1			N	0.8	31.1		Dry				
Trib.E	1	1			N	1.5	14.5		Dry				
Trib. F	1	1			N	2.5	15.3		Dry				
Trib. G	1	1			N	2.5	23.2		Dry				

Appendix A2. Continued

Stream Name	Reach NO.	Stream Order	Drainage Area (km²) a/	Barrier location km from stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m²/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Pool	Run
Rib. H	1	2			N	2.3	23.9		Dry				
Trib. I	1	1			N	1.6	31.7		Dry				
Tanner	1	2			Y	1.1	8.7		Too small				
Upper Twin	1	4			Y	5.0	1.3	0	Canyon				
	2	4		1.8	Y	6.8	2.0	0	Canyon				
	3	4			N	7.0	1.6		Barrier				
	4	3			N	4.2	2.9		Barrier				
	5	2			N	1:5	6:1		Barrier				
North	1	3			Y	2.6	7.4		Canyon				
	2	1			Y	3.1	6.3		Canyon				
	3	1			Y	1.1	15.1		Canyon				
South	1	2			N	2.6	3.6		Barrier				
	2	2			N	3.0	1.4		Barrier				
Nanny	1	3			N	1.7	4.0		Barrier				
	2	2			N	1.6	10.6		Barrier				

Appendix A2. Continued

Stream Name	Reach No.	Stream Order	Drainage Area (km^2) a/	Barrier location km from stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent: Instream cover	Overhead cover	Pool	Run
Grouse	1	2			N	1.8	6.8			Barrier			
	2	2			N	0.6	10.2			Barrier			
Head	1	3			N	2.6	2.9			Barrier			
	2	2			N	1.4	6.0			Barrier			
Spy	1	1			N	3.0	13.7			Barrier			

a/ Drainage areas are given for entire stream and include drainage areas of subordinant tributaries

b/ y = Yes; N = No; P = Passage possible during early and late parts of spawning period

c/ C = Culvert

Appendix A3. Stream survey data for west-side tributaries to Hungry Horse Reservoir collected during 1983 and 1984.

Stream Name	Reach No.	Stream Order	Drainage Area (km^2)[a/]	Barrier location km from stream origin	Accessible[b/] (Y/N/P)	Length (km)	Gradient (%)	spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Percent Pool	Percent Run
Alpha	1	1	3.2		N	2.4	25.6			Too steep			
Beta	1	2	3.1		N	3.0	23.8			Too steep			
Doris	1	3	35.1	5.5	Y	2.1	3.5	12.4	38.5	25.2	9.2	10.0	36.7
	2	3				3.4	5.8	18.8	64.6	25.2	13.7	13.3	36.7
	3	3			N	2.3	12.4			Barrier			
cove	1	1			N	2.2	20.6			Barrier			
Silver	1	2			N	1.7	13.9			Barrier			
Lost Johnny	2	3	24.4	2.0	Y	1.0	4.1	61.0	56.5	37.1	10.9	17.8	28.6
	3	2			N	3.8	6.4						
					N	3.5	4.7			Barrier			
Otila	1	2			N	3.8	11.8			Barrier			
Wounded Buck	1	3	41.5		Y	3.6	2.0	29.7	42.6	20.0	5.0	0	73.3
	[illegible]	3	5.6		Y	2.3	4.5	42.5	20.5	14.0	12.8	10.0	80.0
						1.3	13.8	5.2	31.9	12.0	6.1	13.6	45.4
	4	2			N					Barrier			

Appendix A3. Continued

Stream Name	Reach NO.	Stream Order	Drainage Area (km^2)[a/]	Barrier location km from Stream origin	Accessible[b/] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent: Instream cover	Percent: Overhead cover	Percent: Pool	Percent: Run
Clayton	1	3	17.2	0.1	N	2.6	5.1			Barrier			
	2	2			N	3.7	11.6			Barrier			
Goldie	1	2	9.6	c-0.1	N	1.5	8.0			Barrier			
Natrona	1	1	0.9		N	1.4	12.6			Too steep			
Fannora	1	1	2.2		N	2.5	10.4			Cascades			
Knieff	1	3	11.8	0.4	N	1.2	8.1			Barrier			
	2	3			N	1.2	8.6			Barrier			
John	1	2			N	2.1	16.1			Barrier			
Emma	1	1	1.8		Y	0.9	15.5			Dry			
Pearl	1	1	2.8		N	2.3	20.1			Too steep			
Anna	1	1			N	1.4	22.8			Too steep			
Ben	1	1	4.2		N	3.3	18.4			Too steep			
Mazie	1	1	3.8		N	3.2	17.5			Too steep			

Appendix A3. continued

Stream Name	Reach No.	Stream Order	Drainage Area (km^2)[a]	Barrier location km from stream origin	Accessible[b] (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Pool	Run
						6.9							
wildcat	1	2		0.3	N	2.7	1.9			Barrier			
	2	2			N		4.4			Berrier			
Lid	1	2	7.1	C-0.3[c]	N	1.5	12.7			Barrier			
	2	2			N	2.7	15.3			Barrier			
Flossy	1	3	4.5		N	2.3	14.0			Too steep			
	2	2			N	1.3	25.0			Too steep			
						1.3							
Elya	1	2	2.0		N	1.2	15.1			Too steep			
	2	1			N		25.8			Too steep			

Appendix A3. Continued

Stream Name	Reach NO.	Stream Order	Drainage Area (km²) a/	Barrier location km from stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	spawning gravel (m²/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover	Percent Pool	Percent Run
Graves	1	3	75.6	0.0	N	2.1	3.9			Needs survey			
	2	2			N	5.1	4.0			Needs survey			
	3	2			N	2.0	7.6			Needs survey			
						3.3							
Aeneas	1	2			N	2.4	6.6			Needs survey			
	2	2			N		3.2			Needs survey			
Jones	1	2			N	3.3	14.4			Too steep			
Baker	1	1	5.0		Y	3.3	18.4			Cascades			
		3				4.2	8.3						
Forest	1	2	12.6		Y	1.7	15.4	23.3	33.7	20.8	10.5	13.3	0
	2				N					Too steep			
	1												
Wheeler	2	3	57.3		Y	1.7	2.8	24.1	44.9	40.2	4.7	33.4	23.3
		3		10.0	Y	8.3	2.6	112.8	32.7	38.2	5.8	26.7	33.3
	3	2			N	4.9	12.1			Barrier			
Martin	1	1			N	2.9	24.3			Too steep			
Mink	1	1			N	1.8	32.2			Too steep			
Trapper	1	2			N	4.2	11.9			Too steep			

Appendix A3. Continued

Stream Name	Reach NO.	Stream Order	Drainage Area (km²) a/	Barrier location km from Stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	spawning gravel (m²/km)	D-90 (cm)	Percent Instream cover	Percent Overhead cover.	Percent Pool	Percent Run
Bigelow	1	1			N	3.3	19.5			Too steep			
Kate	1	2			N	2.3	8.9			Barrier			
	2	1			N	1.4	26.7			Barrier			
Heinrude	1	1	3.6		N	3.0	16.4			Too steep			
Battery	1	2			Y	1.9	13.7	7.4	24.1	11.3	13.7	13.3	53.3
Sullivan	1	4			Y	3.2	1.1	6.8	34.3	12.3	0.2	3.3	6.1
	2	4			Y	7.6	1.6	63.0	24.5	9.8	3.2	0	23.3
	3	3			Y	4.5	2.1		34.0	12.2	3.5	3.3	10.0
	4	2			Y	5.6	3.0	9:::	16.2	22.0	19.3	16.7	30.0
Ball	1	3			Y	1.8	6.2	34.4	33.9	22.0	9.2	10.0	16.7
	2	3			Y	4.0	4.5			Too small			
Branch	1	3		1.5	Y	3.5	6.1	10.6	40.0	21.8	7.0	13.3	23.4
	2	3			N	2.8	4.8			Barrier			
Conner	1	3			N	4.8	3.3			Too small			
Slide		2			N	2.1	5.5			Dry			
	:	2			N	1.6	8.4			Dry			

Appendix A3. Continued

Stream Name	Reach No.	Stream Order	Drainage Area (km^2) a/	Barrier location km from stream origin	Accessible b/ (Y/N/P)	Length (km)	Gradient (%)	Spawning gravel (m^2/km)	D-90 (cm)	Percent: Instream cover	Percent: Overhead cover	Percent: Pool	Percent: Run
Quin-	1	3			Y	4.3	2.3	40.9	34.2	18.8	4.3	6.7	20.0
Tonken	2	3		5.2	N	4.0	2.5			Barrier			
	3	3			N	7.2	7.6			Barrier			
Posy	1	2			N	3.2	11.2			Barrier			
Red owl	1	2			N	2.0	16.2			Barrier			
Clark	1	2			Y	2.5	3.9	82.4	26.9	13.8	16.5	10.0	40.0
	2	2			Y	3.0	6.8	36.7	19.8	14.0	15.7	16.7	50.0
Taylor	1	1			N	2.4	19.4			Too steep			
Soldier	1	2			Y	2.6	7.3	53.1	39.7	22.3	23.0	16.7	23.3
	2	1			Y	2.7	5.2	92.6			Needs survey		
Tin	1	3			Y	1.5	4.3	18.7	30.2	22.2	9.0	10.0	26.7
	2	3			Y	3.0	7.5	5.3	34.5	17.3	3.4	14.3	10.7

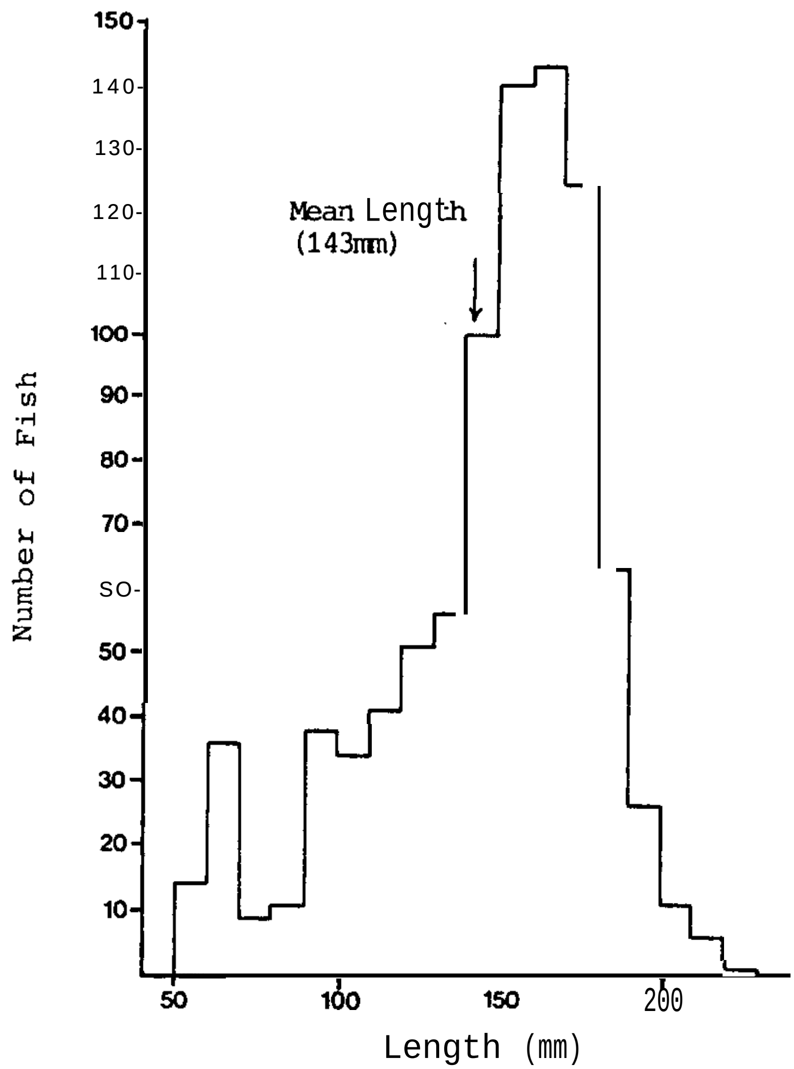
a/ Drainage areas are given for entire stream and include drainage areas of subordinat tributaries

b/ Y= Yes; N = No: P = Passage Possible during early and late parts of spawning period

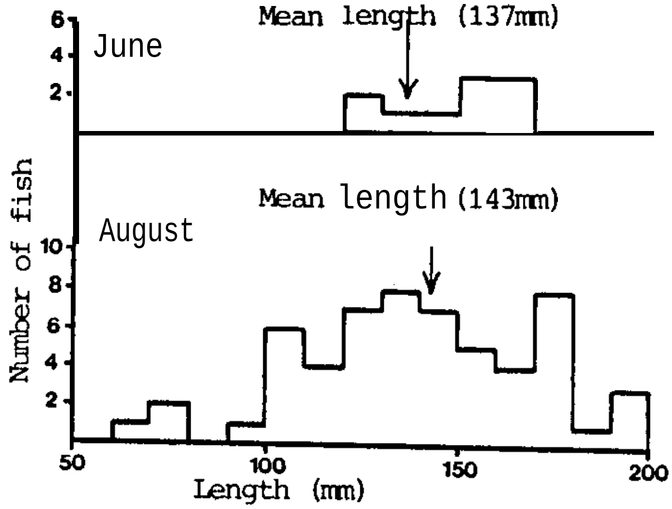
c/ C = Culvert

APPENDIX B

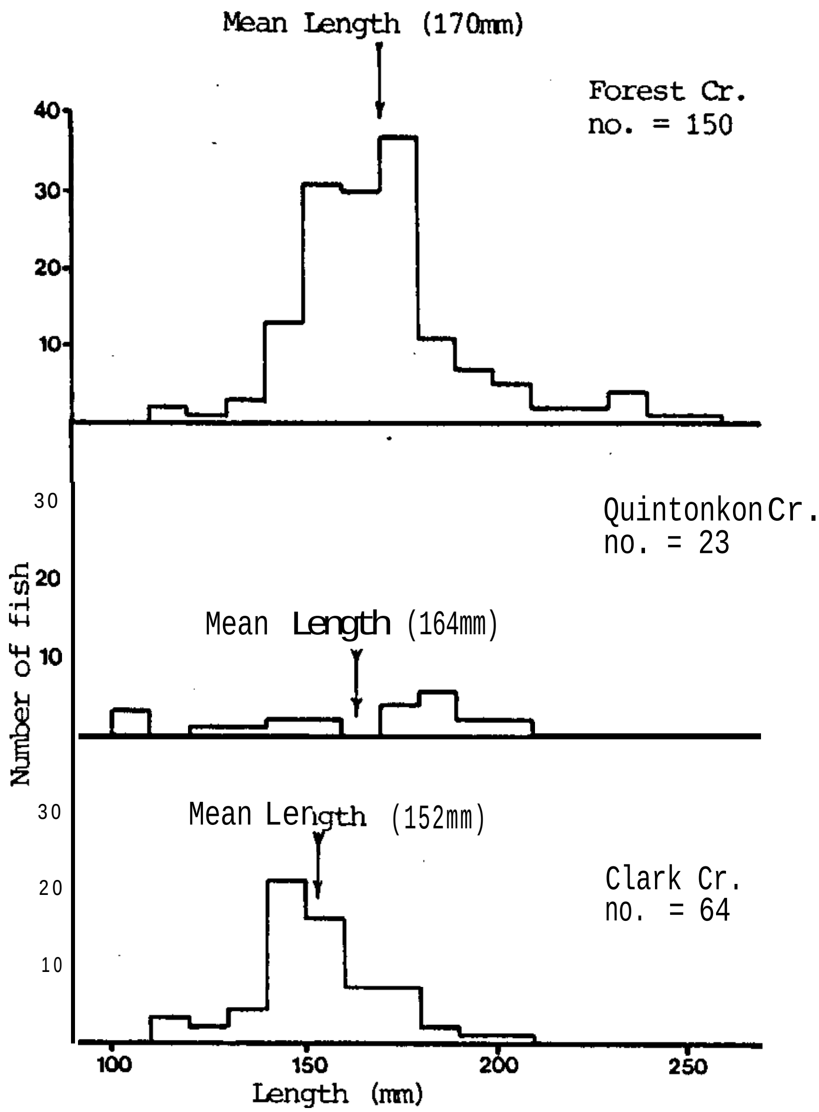
Length Frequency Distributions of Westslope Cutthroat Trout Caught in Fish Trap



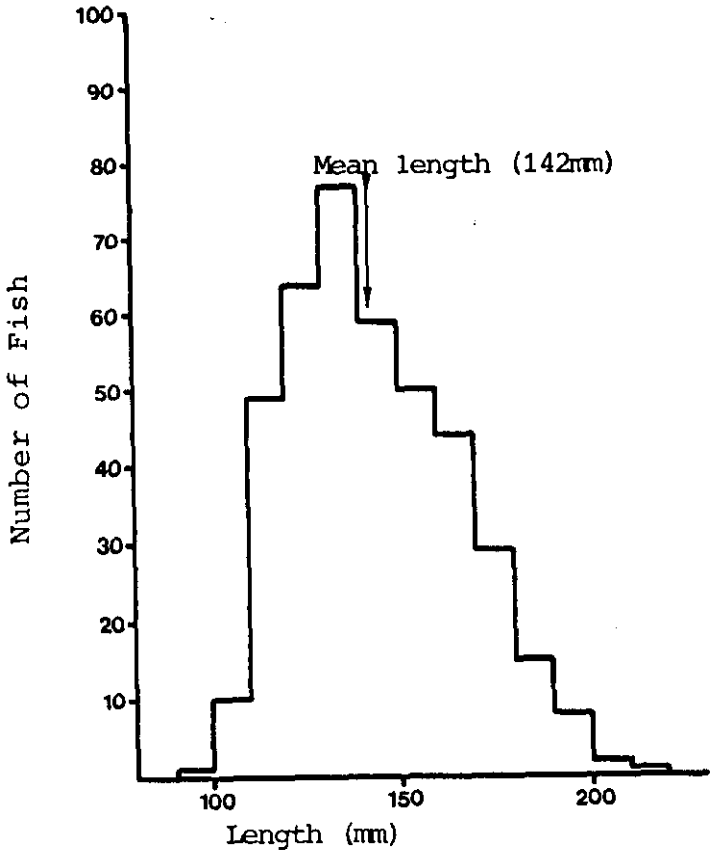
Appendix Bl. Length frequency distribution of 904 juvenile westslope cutthroat trout caught in downstream trap in Hungry Horse Creek. July 1984.



Appendix B2. Length frequency distribution of juvenile cutthroat trout caught in downstream trap in Hungry Horse Creek June and August 1984.



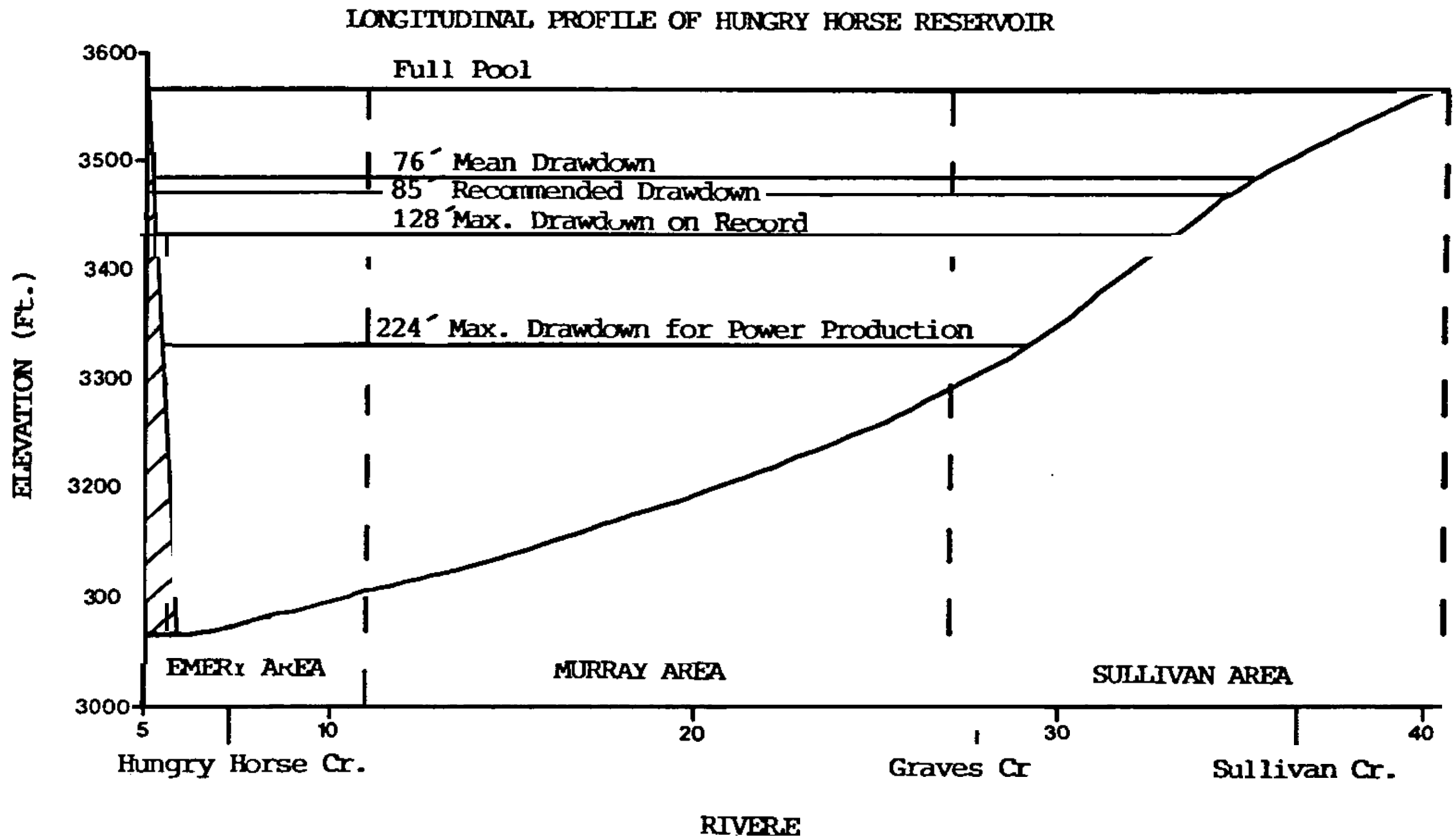
Appendix B3. Length frequency distribution of westslope cutthroat trout caught in downstream fish traps, 1984.



Appendix B4. Length frequency distribution of 409 juvenile westslope cutthroat trout caught in downstream fish trap in Emery Creek, 1984.

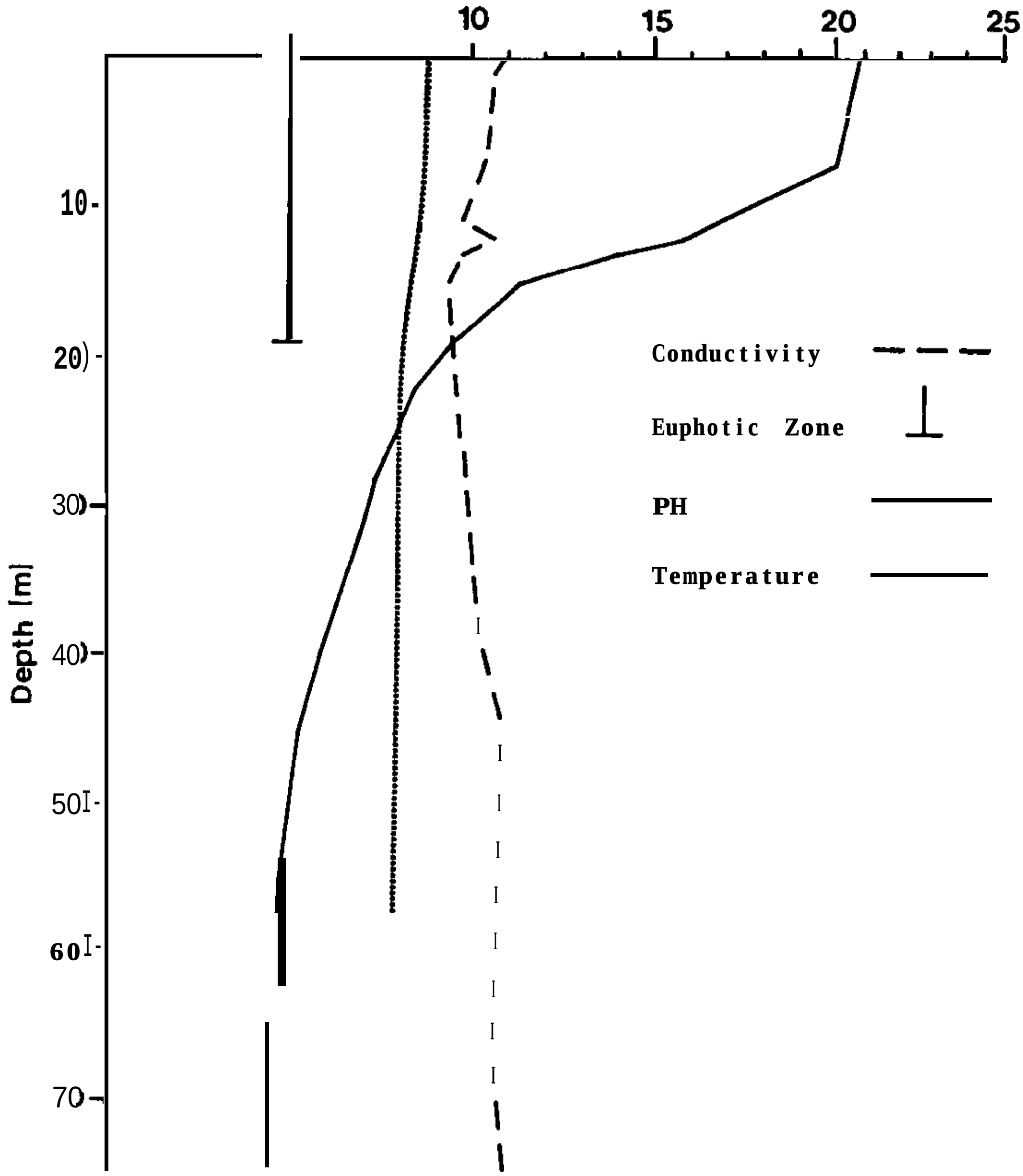
APPENDIX C

Morphometric and Water Quality Data

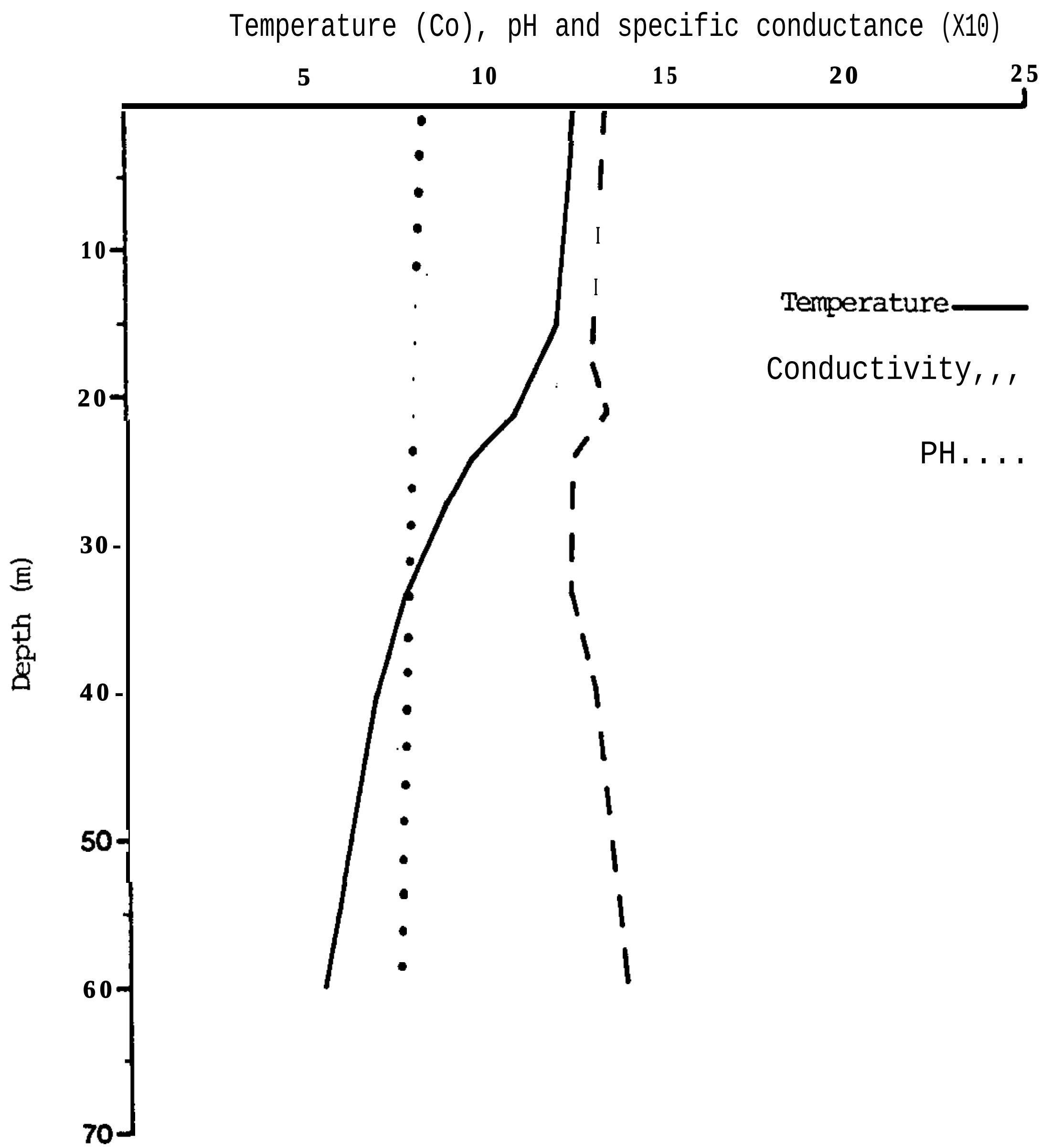


Appendix C1. Longitudinal cross-sectional profile of Hungry Horse Reservoir at water surface elevations of 3,560 (full pool), 3,484; 3,475; 3,432 and 3,336.

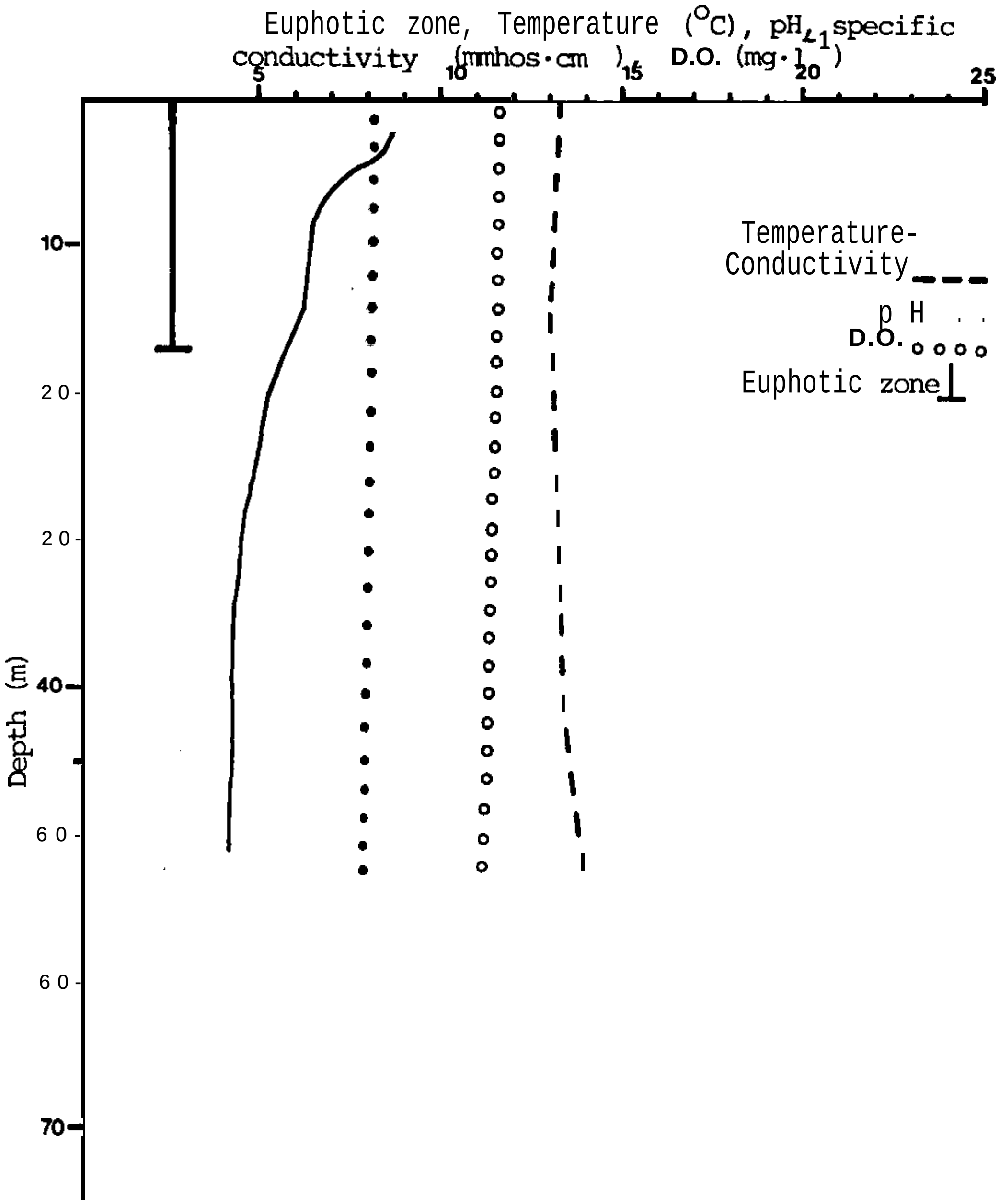
Euphotic zone, temperature (°C), pH and specific conductance (x10)



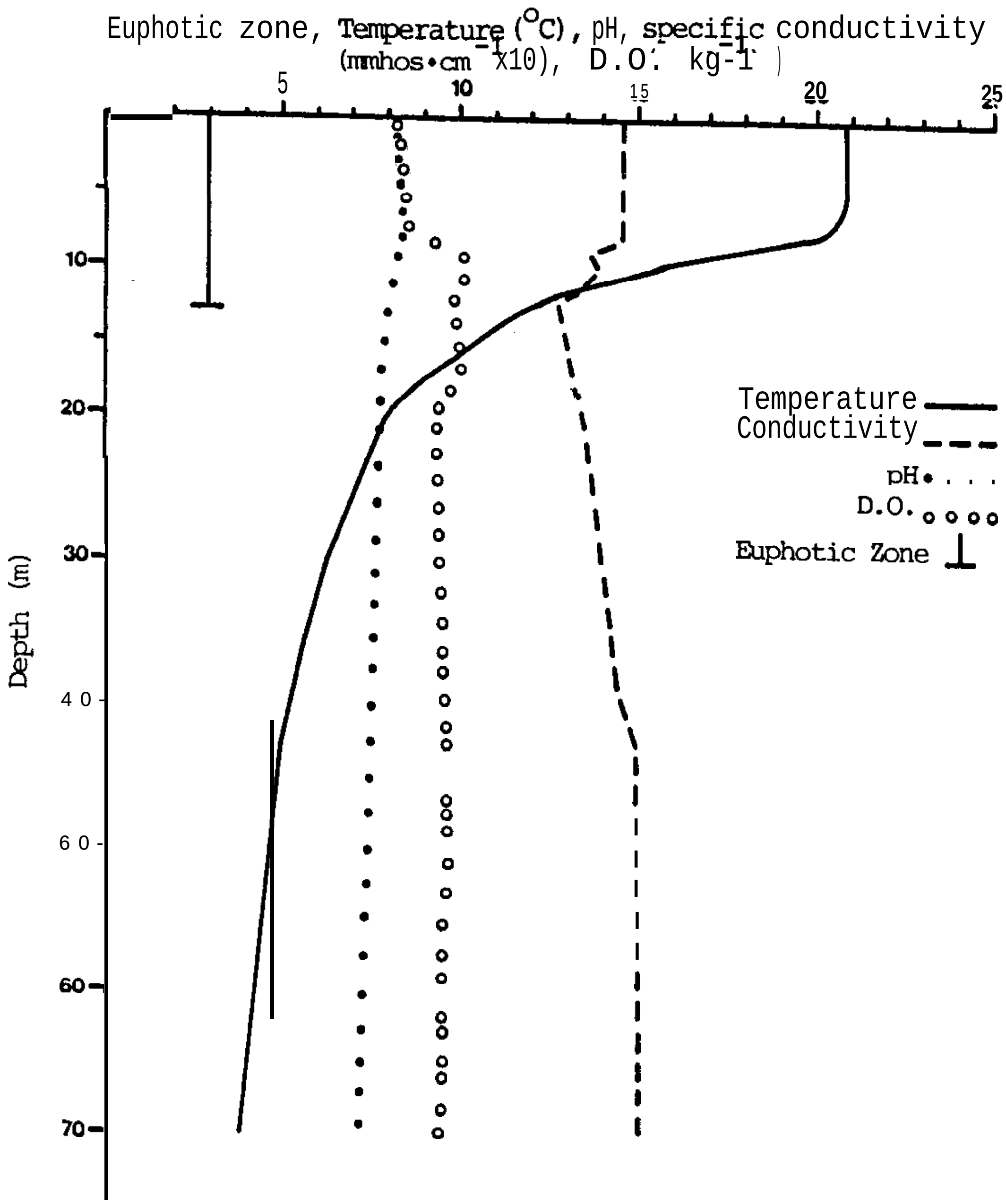
Appendix C2. Euphotic zone, temperature, pH and specific conductance profiles from the Murray area of Hungry Horse Reservoir; 8/23/83.



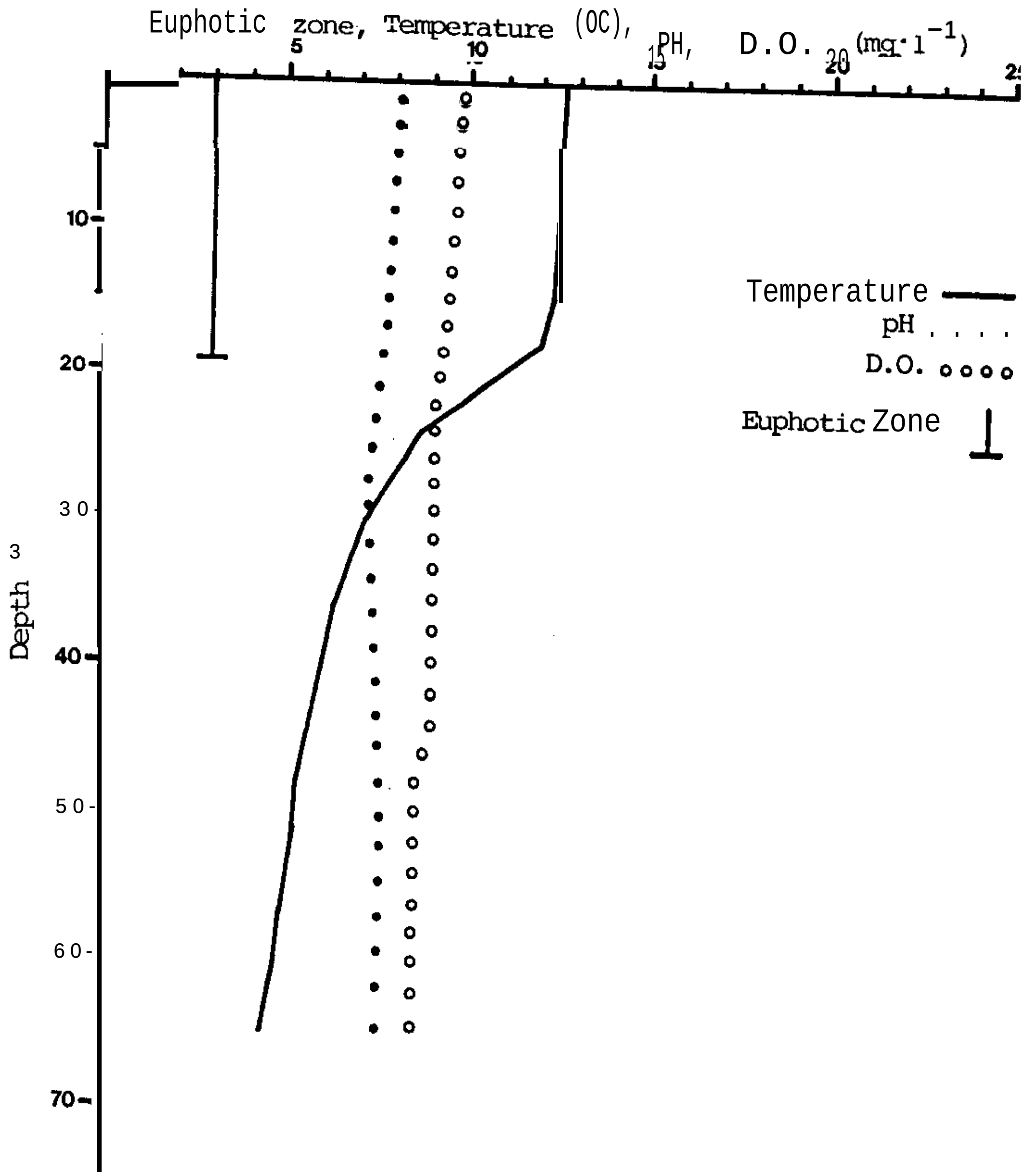
Appendix C3. Temperature, pH and specific conductance profiles from the Murray area of Hungry Horse Reservoir, 10/12/83.



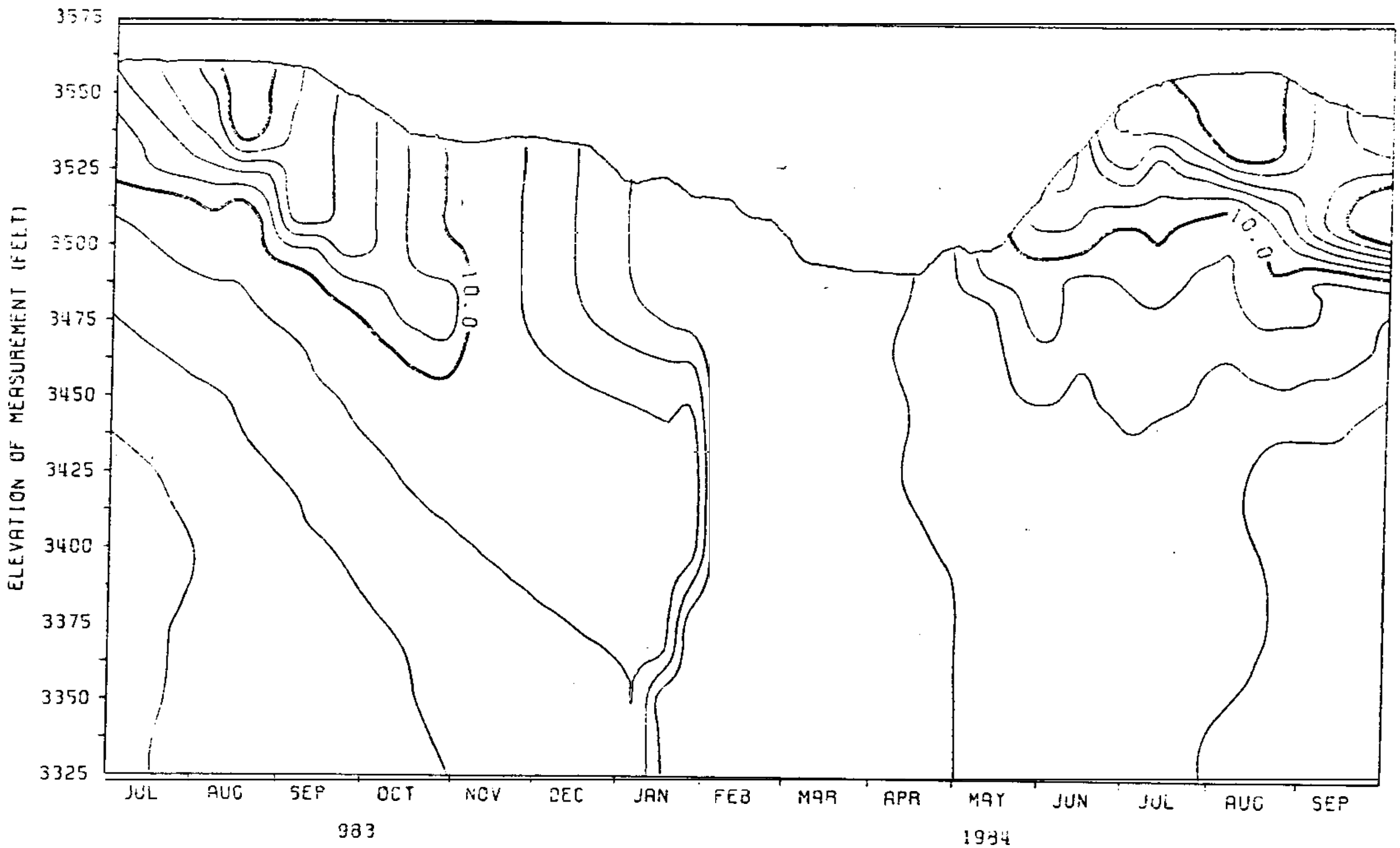
Appendix C4. Euphotic zone, temperature, pH, specific conductivity and D.O. profiles frm the Murray area of Hungry Horse Reservoir, May 15, 1984.



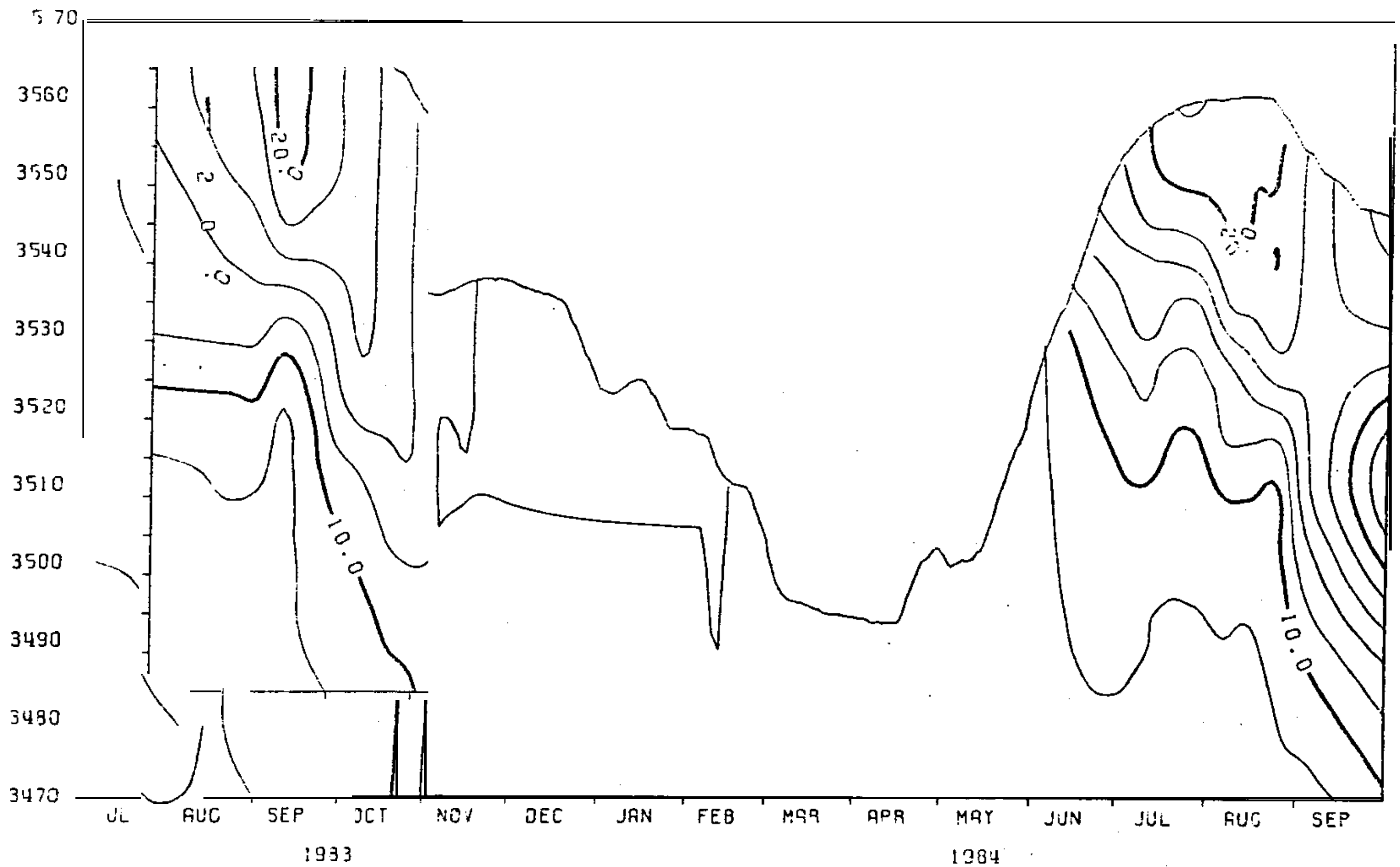
Appendix C5. Euphotic zone, temperature, pH, specific conductivity, and D.O. profiles for the Murray area of Hungry Horse Reaervoir; August 7, 1984.



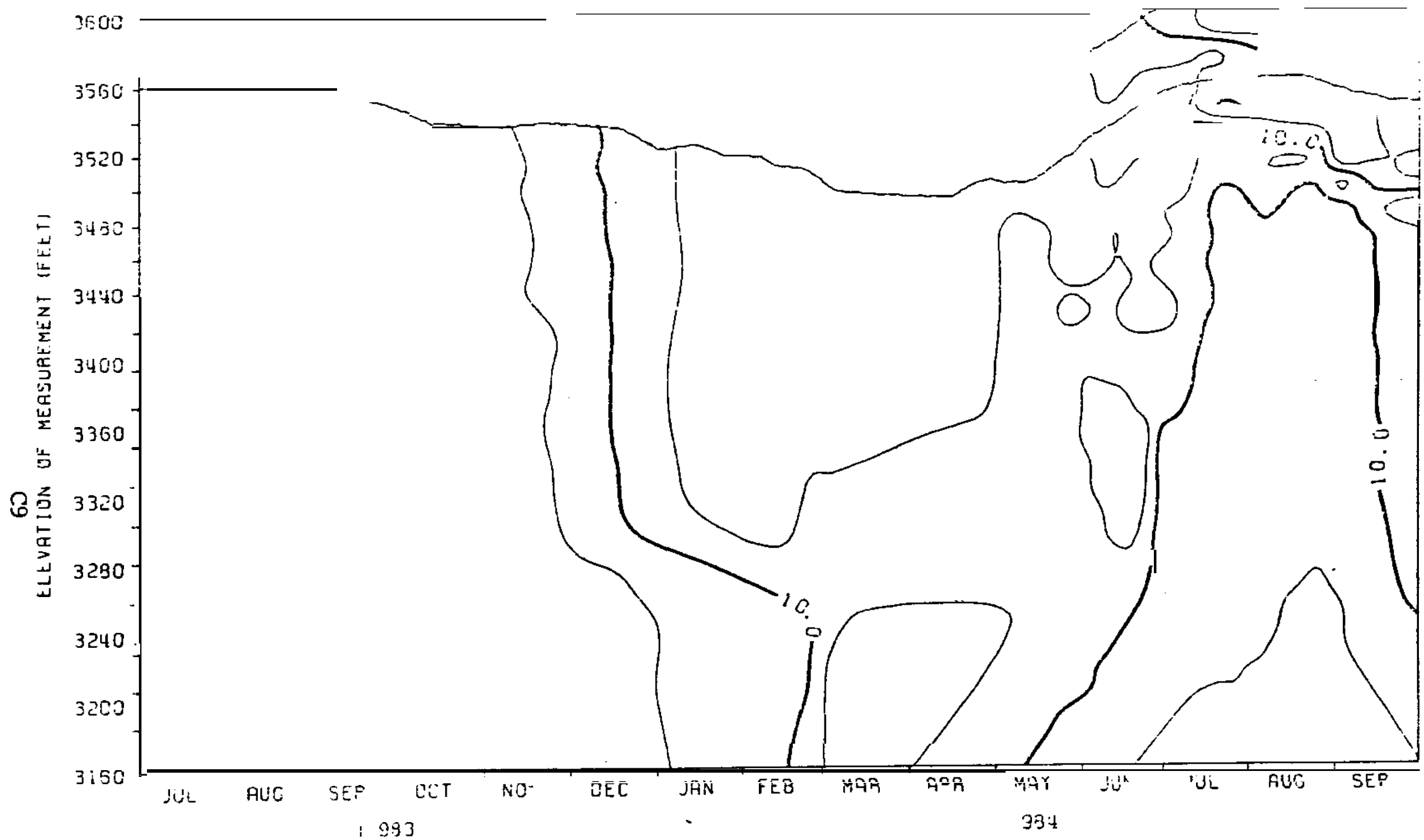
Appendix C6. Euphotic zone, temperature, pH and D.O. profiles for the Murray Area of Hungry Horse Reservoir; October 11, 1984. Conductivity meter was not fuctioning properly due to low air temperature.



Appendix C7 Isopleths of water temperatures (2°C) from the Emery Bay Station, Hungry Horse Reservoir, 1983-84.

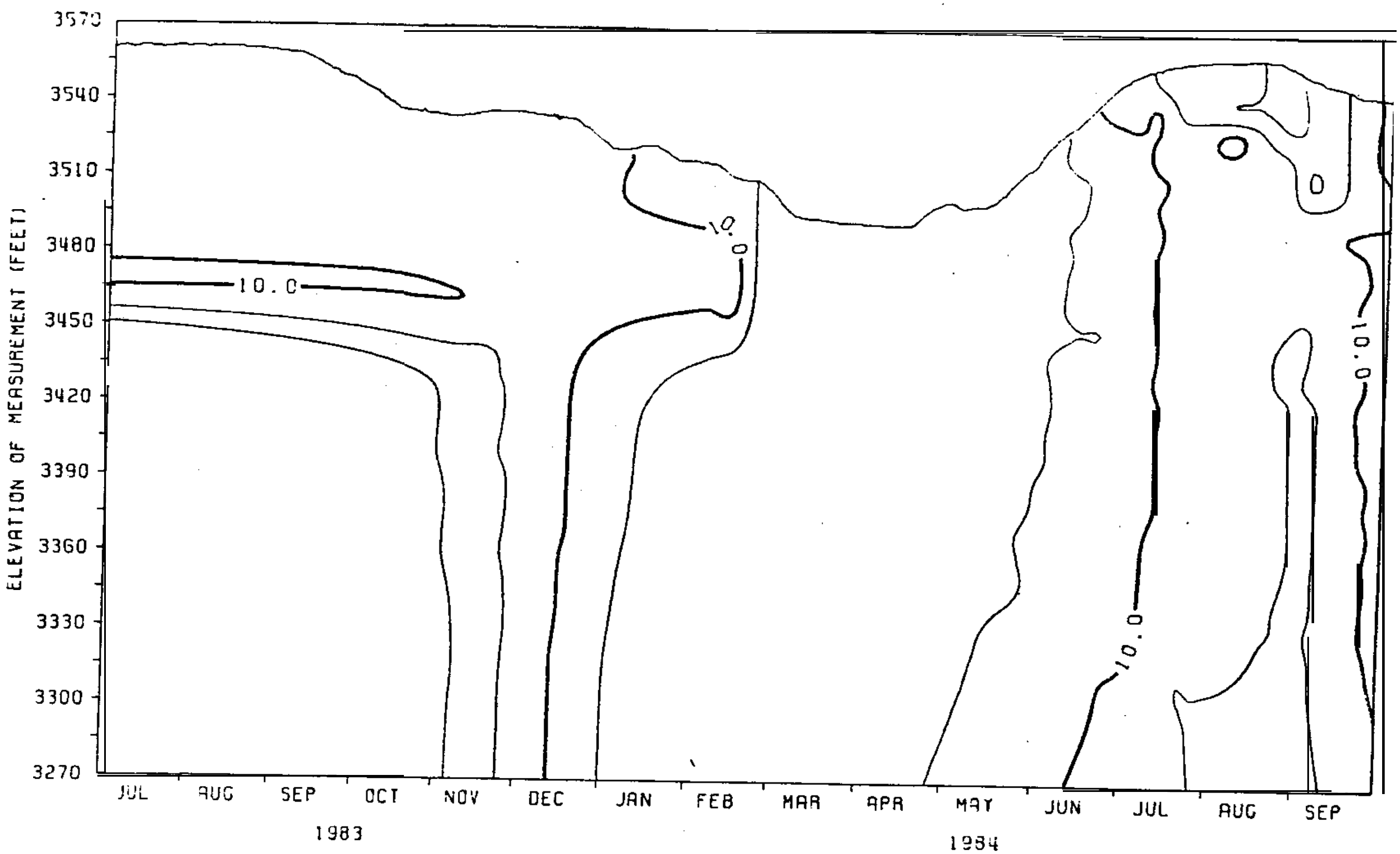


Appendix C8 Isopleths of water temperatures (2°C) from the Graves Bay Station, Hungry Horse Reservoir, 1983-84

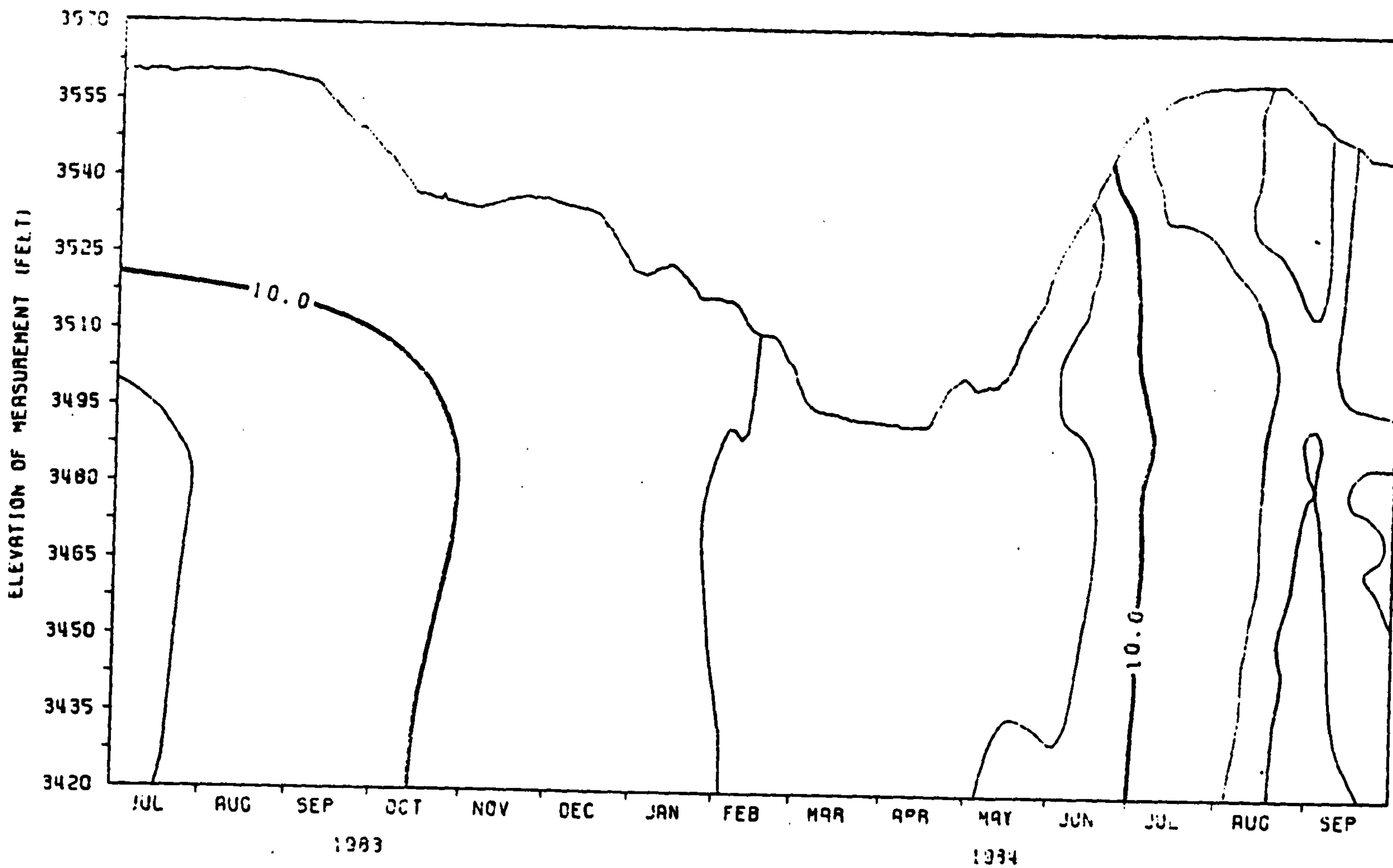


C9

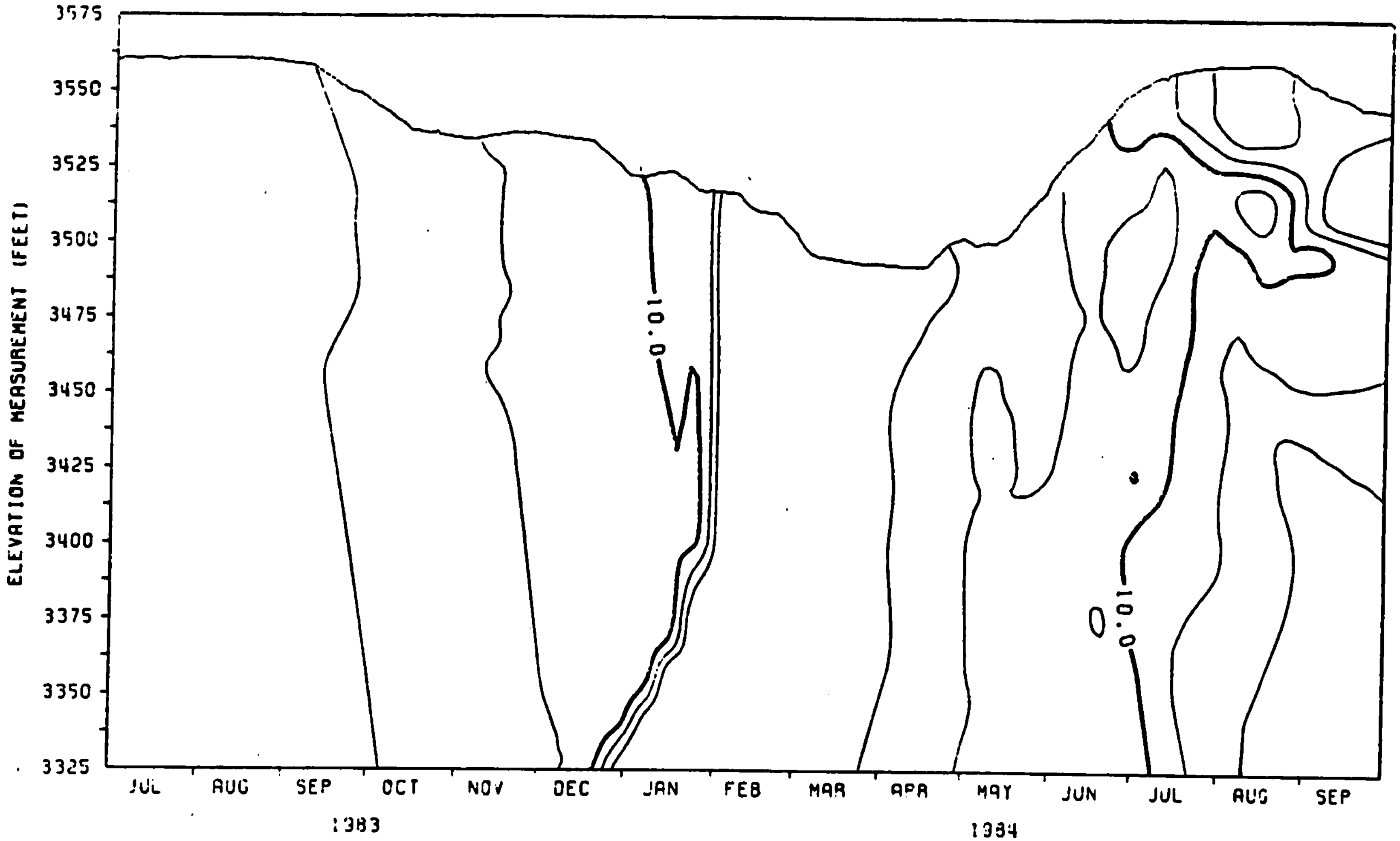
Appendix C9 Isopleths of dissolved oxygen ($1mg \cdot l^{-1}$) from the Emery Station, Hungry Horse Reservoir, 1983-84.



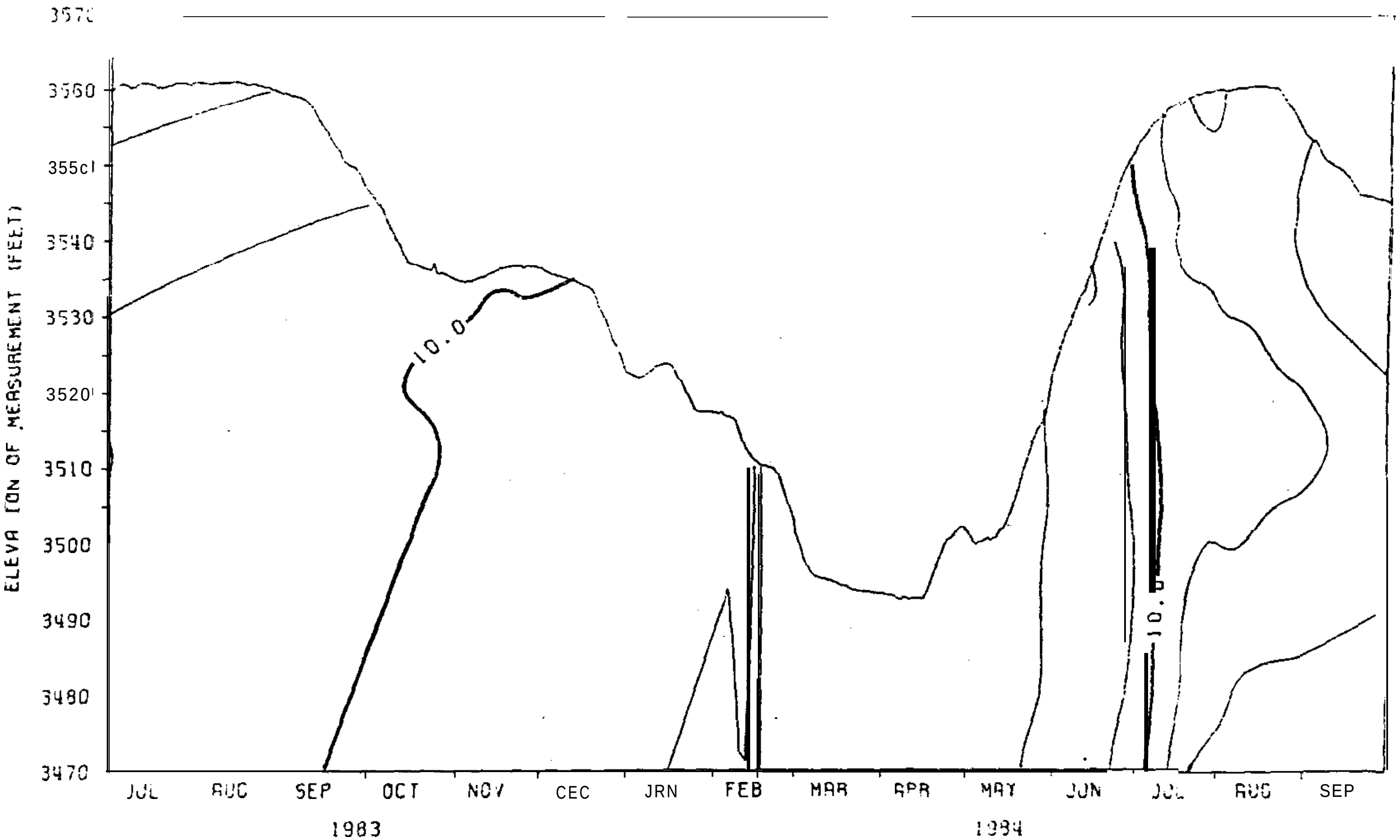
Appendix C10. Isopleths of dissolved oxygen ($1mg \cdot l^{-1}$) from the Murray Station, Hungry Horse Reservoir, 1983-84.



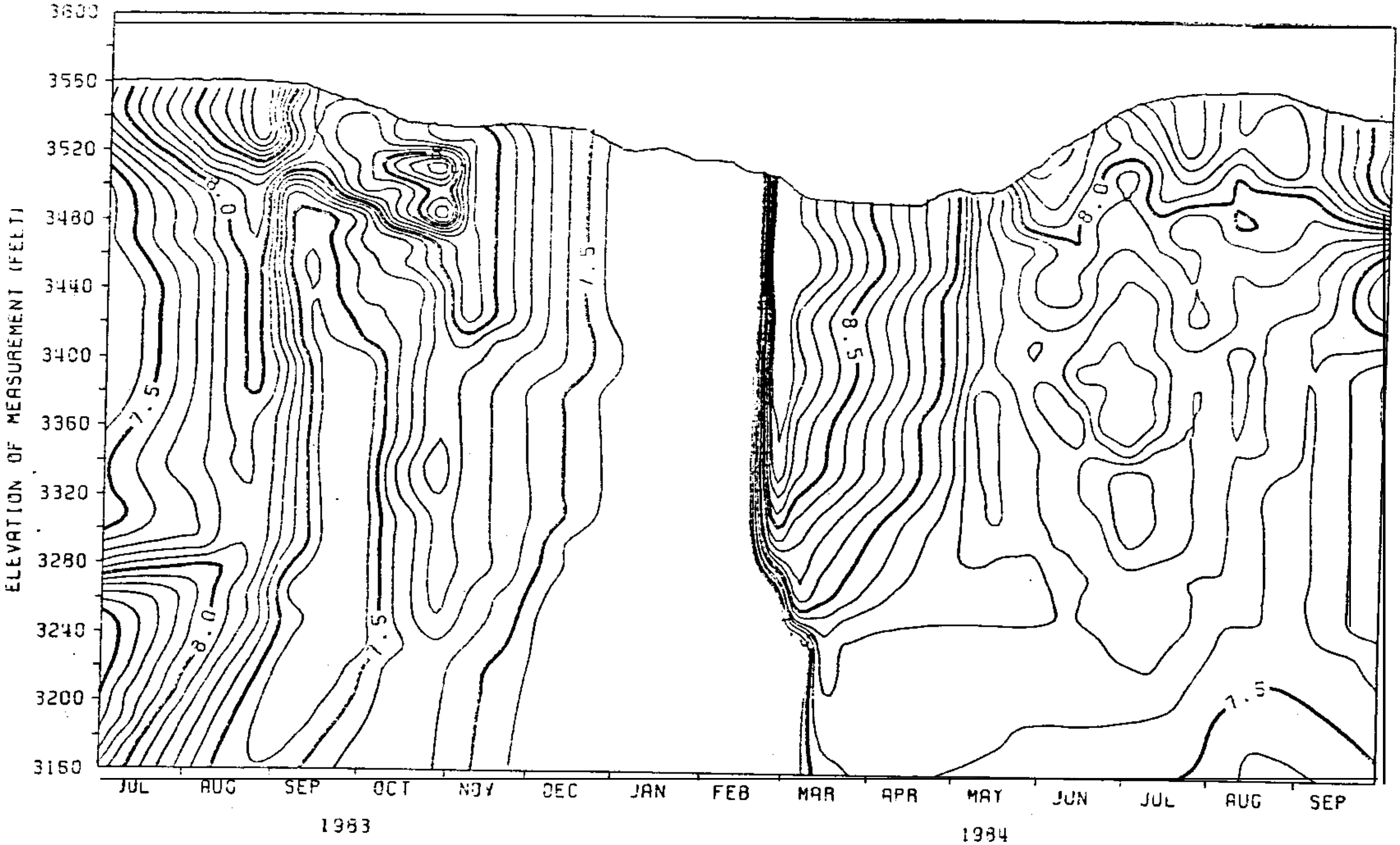
Appendix C11. Isopleths of dissolved oxygen ($1 mg \cdot l^{-1}$) from the Sullivan Station, Hungry Horse Reservoir, 1983-84.



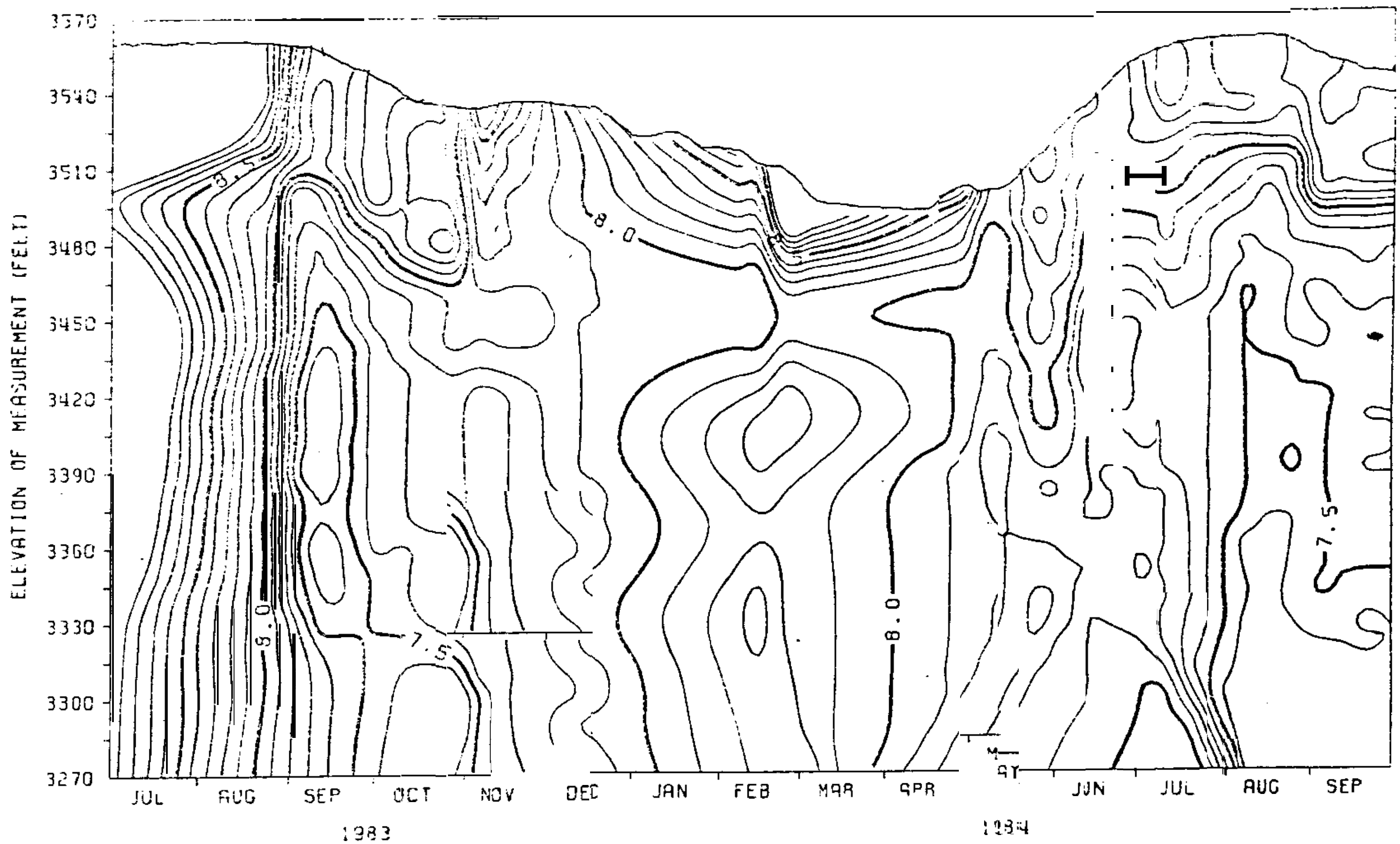
Appendix C12. Isopleths of dissolved oxygen ($1mg \cdot l^{-1}$) from the Emery Bay Station, Hungry Horse Reservoir, 1983-84.



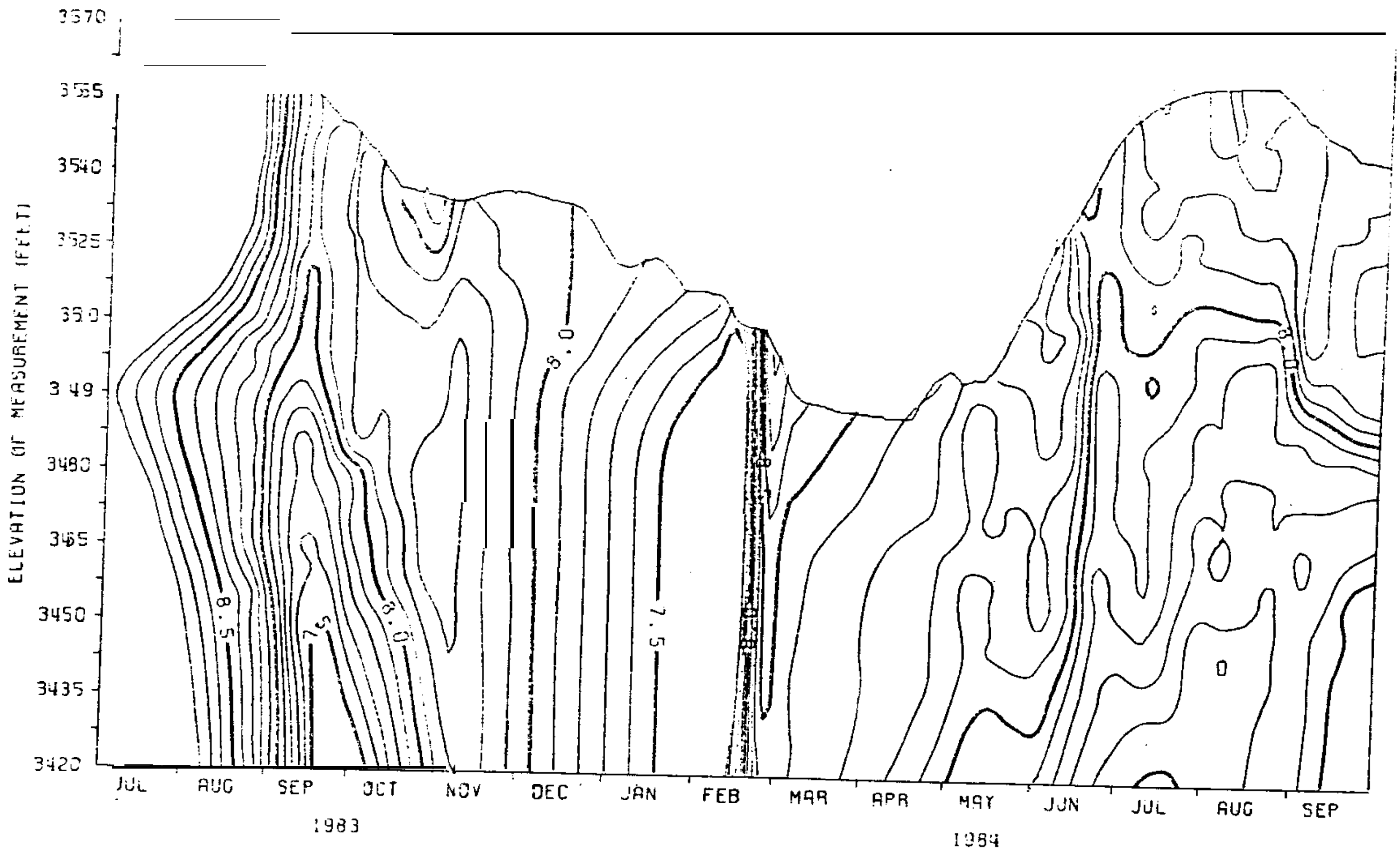
Appendix C13 Isopleths of dissolved oxygen (1mg·l^{-1}) from the Graves Bey Station, Hungry Horse Reservoir, 1983-84.



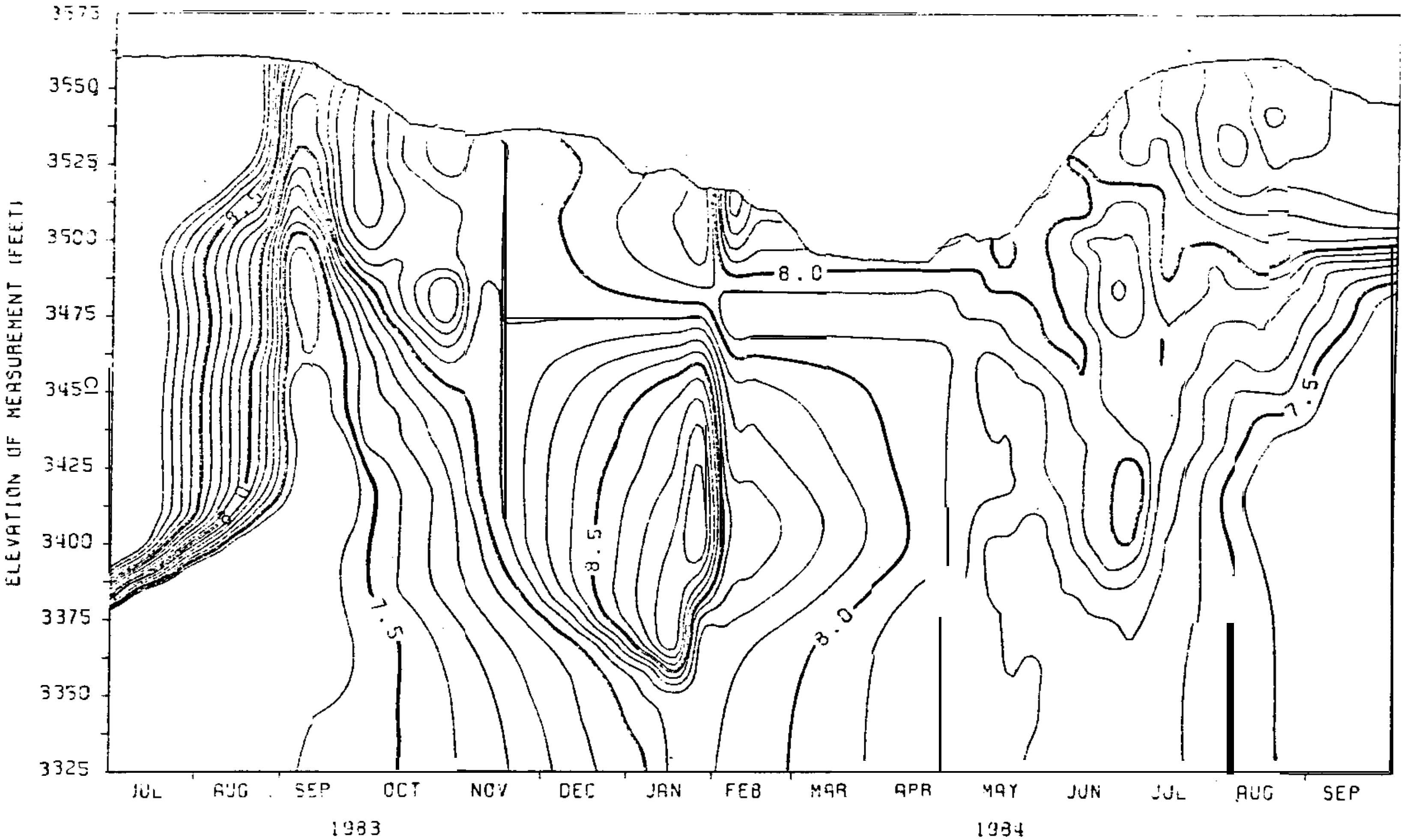
Appendix C14. Isopleths of pH standard units (0.1) from the Emery Station, Hungry Horse Reservoir, 1983-84.



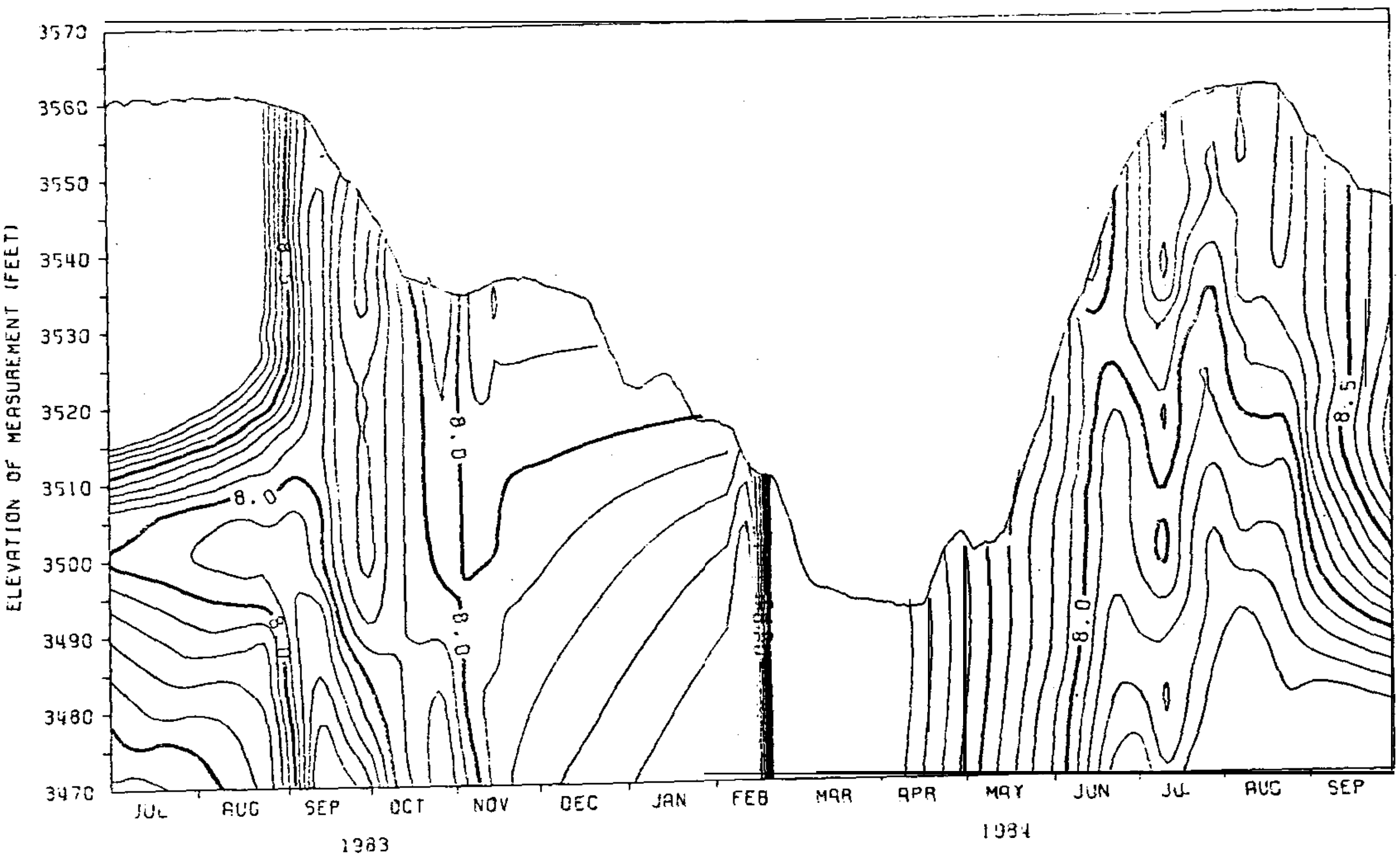
Appendix C15. Isopleths of pH standard units (0.1) from the Murray Station, Hungry Horse Reservoir, 1983-84.



Appendix C16 Isopleths of pH standard units (0 1) from the Sullivan Station, Hungry Horse Reservoir, 1983-84.

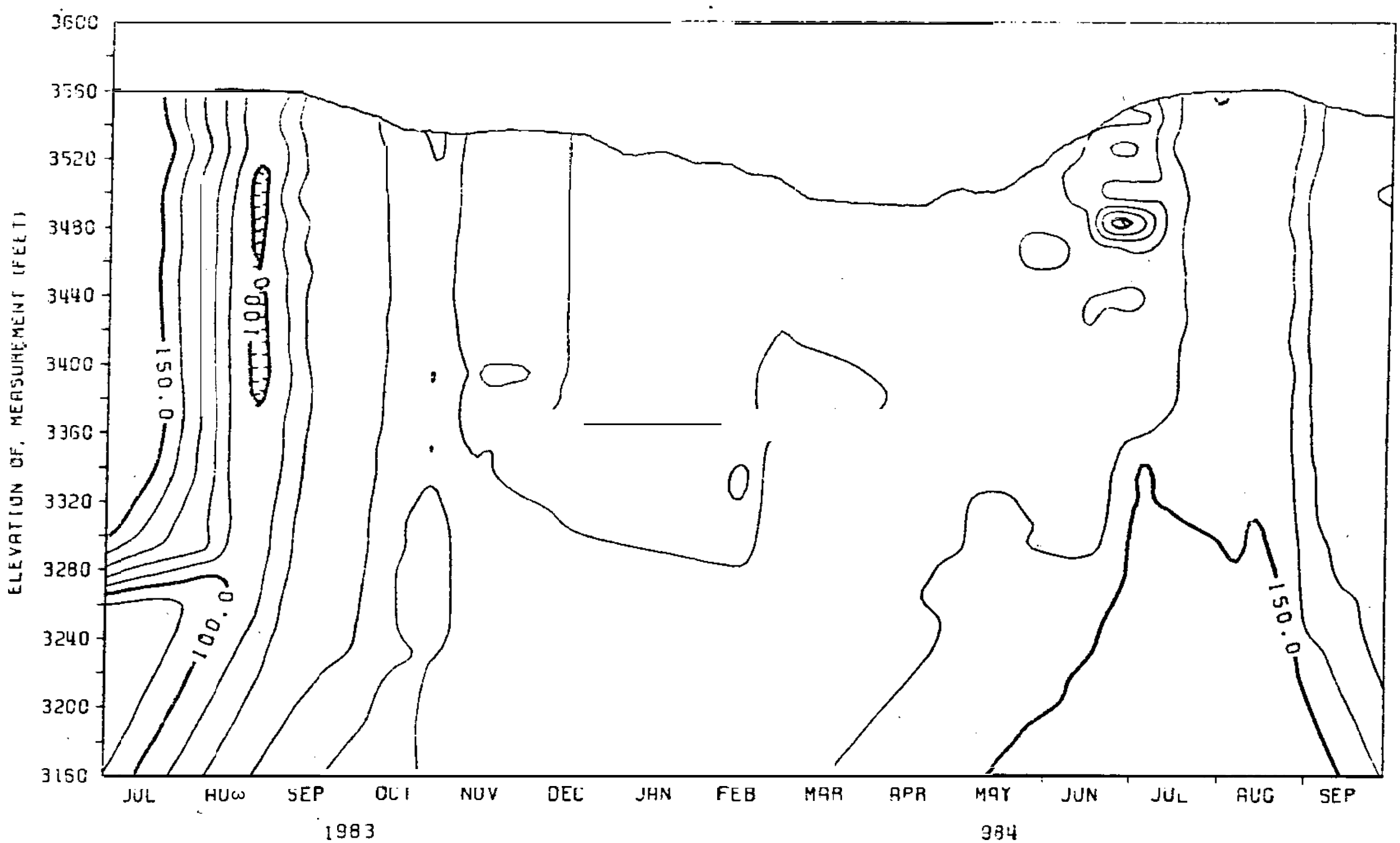


Appendix C17. Isopleths of pH standard units (0.1) from the Emery Bay Station, Hungry Horse Reservoir, 1983-84.

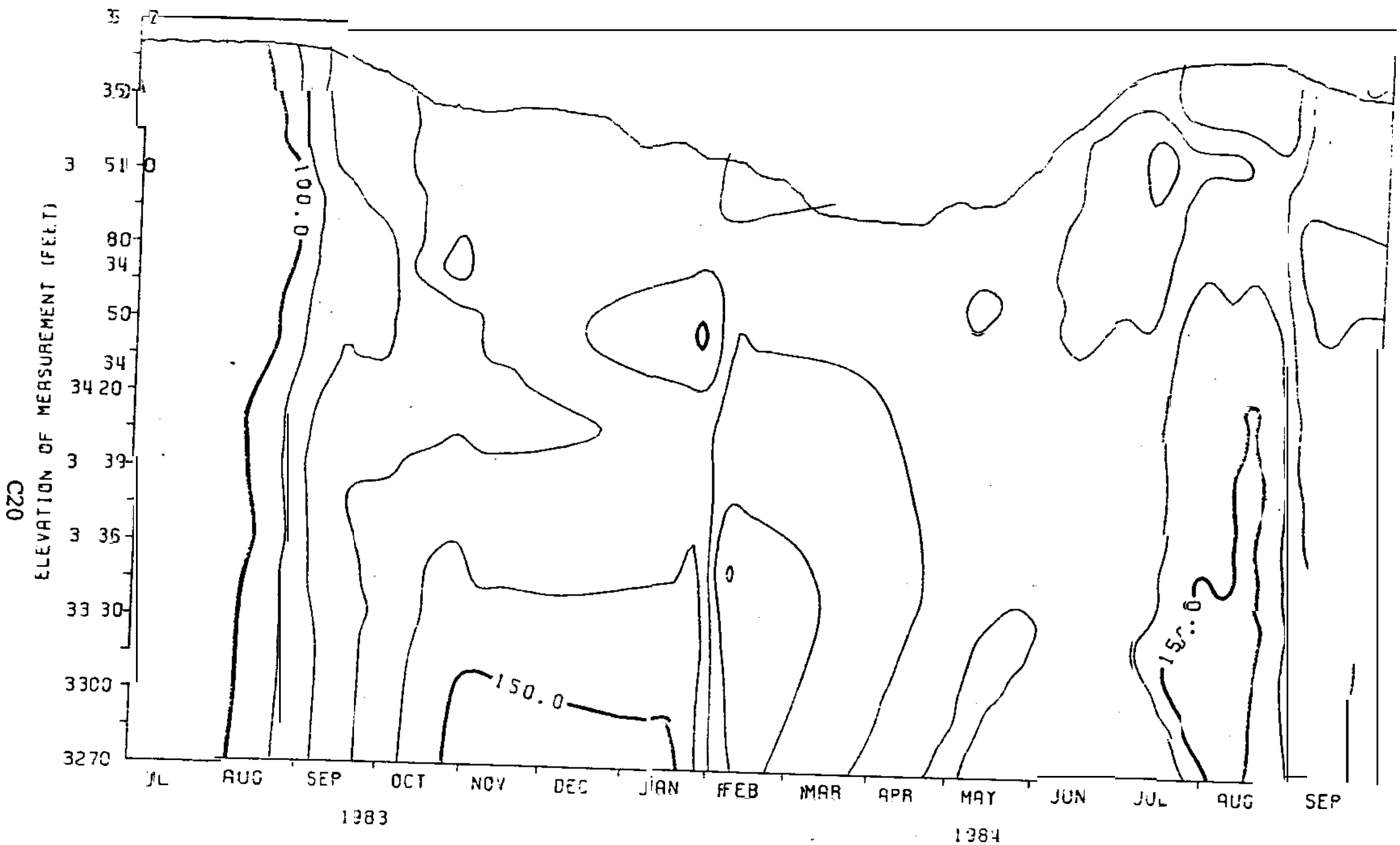


C18

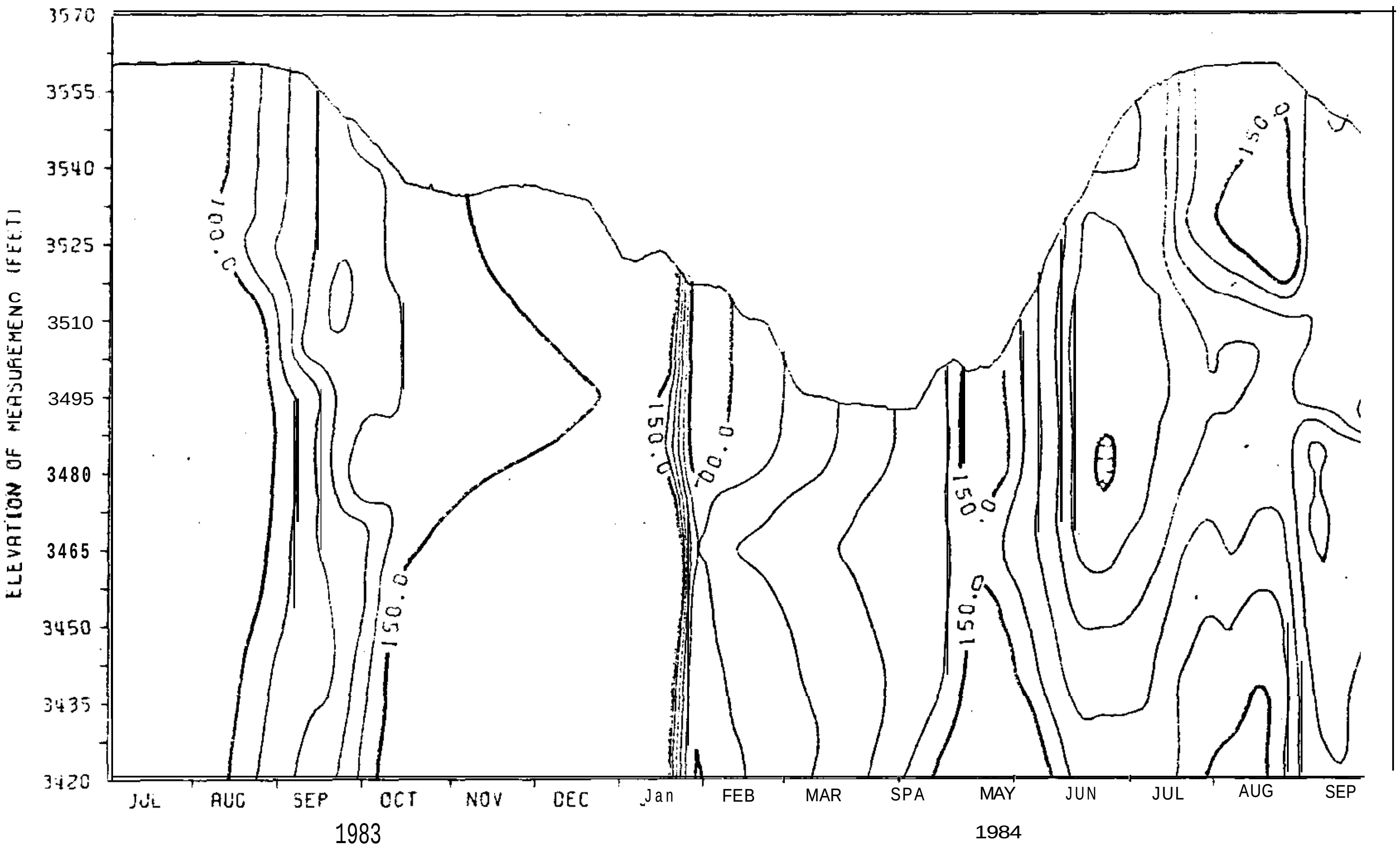
Appendix C18. Isopleths of pH standard units (0.1) from the Graves Bay Station, Hungry Horse Reservoir, 1983-84.



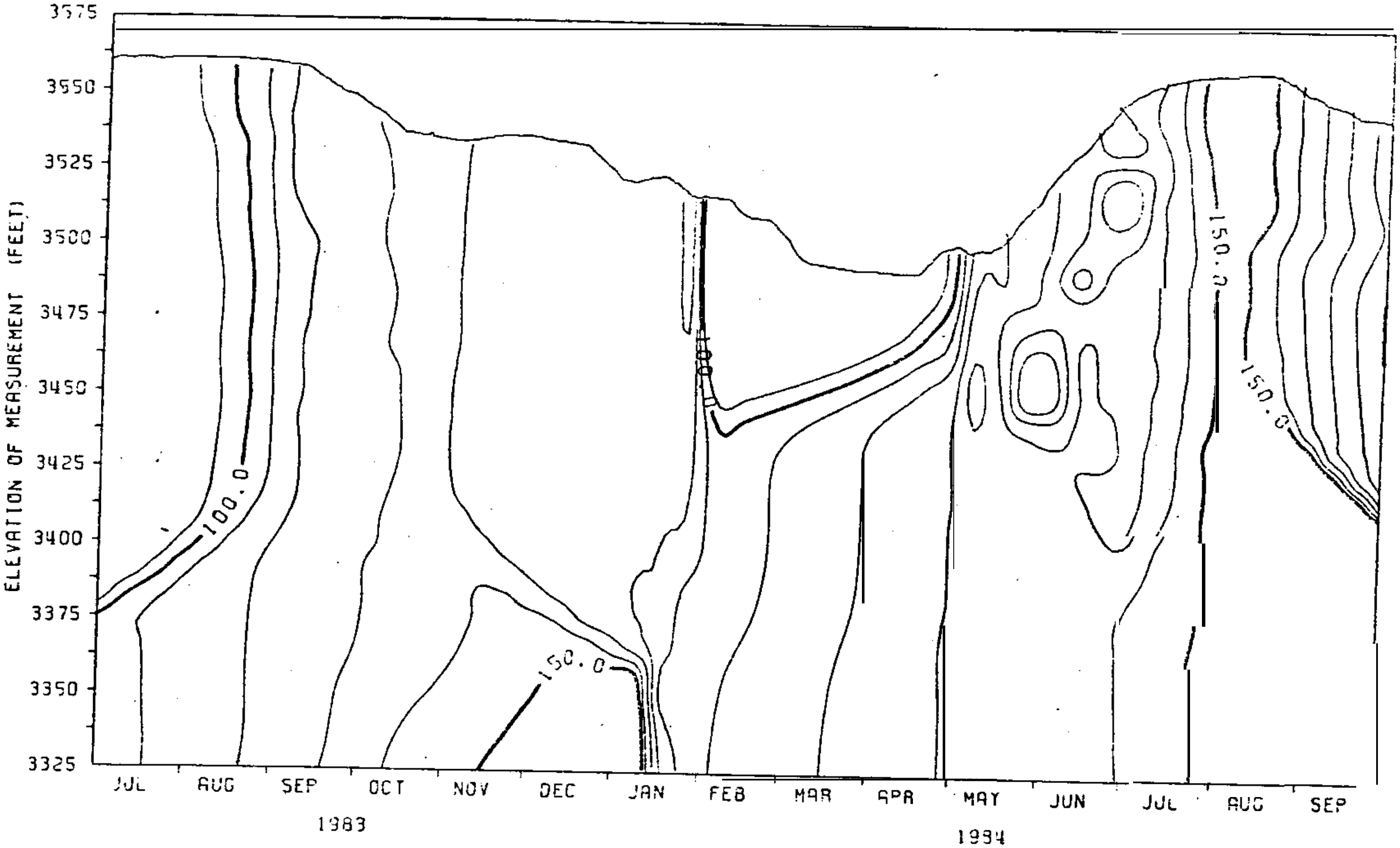
Appendix C19. Isopleths of specific conductance (10 mmhos) from the Emery Station, Hungry Horse Reservoir, 1983-84.



Appendix C20. Isopleths of specific conductance (10 mmhos) from the Murray Station, Hungry Horse Reservoir, 1983-84.

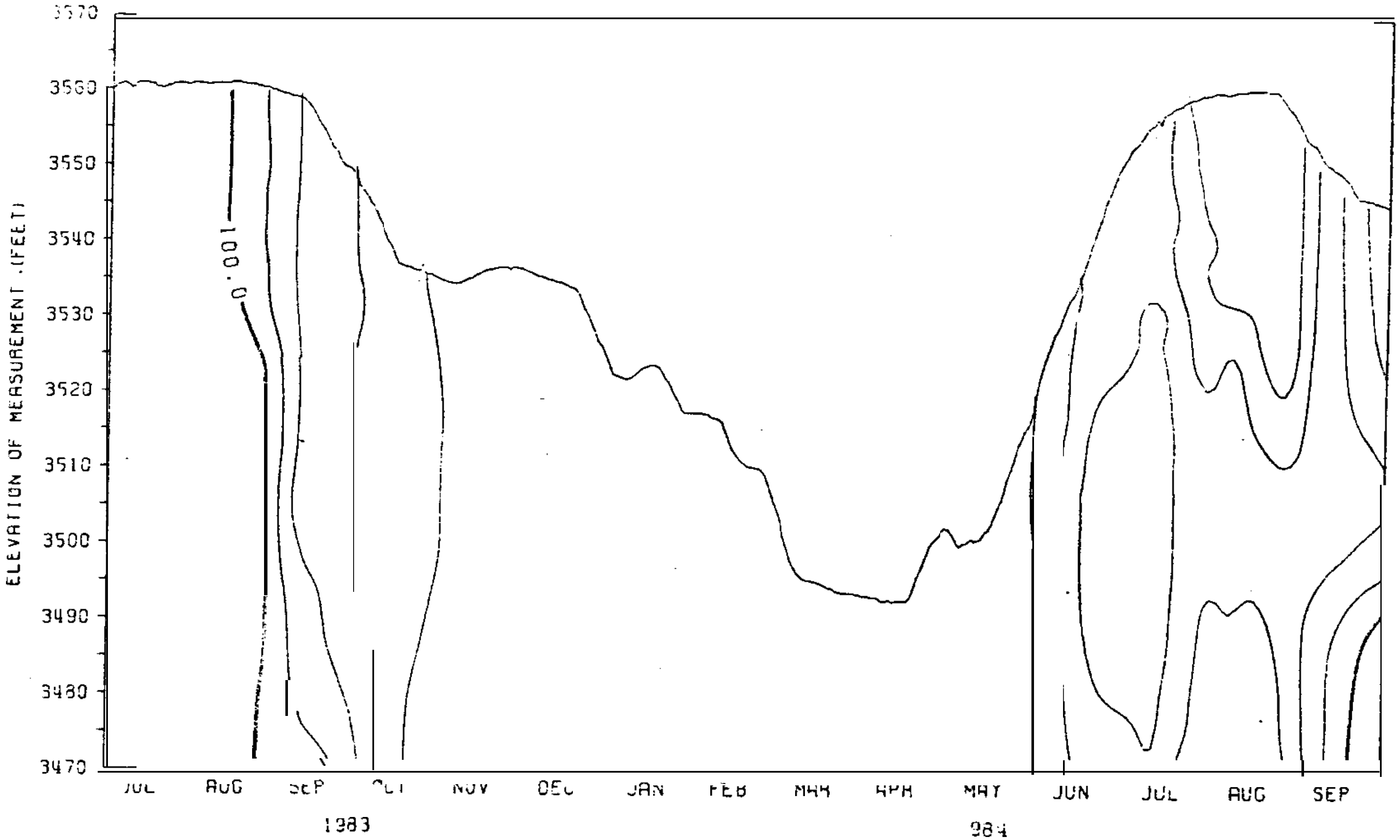


Appendix C21 Isopleths of specific conductance (10 mmhos) from the Sullivan Station, Hungry Horse Reservoir, 1983-84.



C22

Appendix C22 Isopleths of spec ic conductance 10 mmhos) ƃm the Emery Bay Station, Hungry Horse Reservoir, 1983-84.



Appendix C23. Isopleths of specific conductance (10 mmhos) from the Graves Bay Station, Hungry Horse Reservoir, 1983-84.

APPENDIX D

Fish Food Organisms Data

Appendix D1. The mean density and yearly average of adult zooplankton captured bi-monthly in 30 m Wisconsin tows for the permanent, random, and bay stations At the Emery Murray and Sullican areas of Hungry Horse Reaervoir from July-December 1983 and April-June 1984.

Date	Emery				Murray			Sullivan			
	Perm.	Random	Mean	Bay	Perm.	Random	Mean	Perm.	Random	Mean	Bay
					DAPHNIA						
7/25/83	3.56	8.23	5.90	5.21	3.14	3.00	3.47	2.87	2.41	2.54	1.55
8/24/83	1.35	0.96	1.16	0.91	0.80	0.73	0.77	0.65	0.80	0.73	0.43
9/14/83	0.68	0.74	0.71	0.84	0.62	0.77	0.70	1.15	1.17	1.16	0.42
9/28/83	0.10	0.36	0.33	0.42	0.29	0.60	0.44	1.21	0.30	0.76	0.75
10/13/83	1.06	0.64	0.85	0.91	1.21	0.79	1.00	0.64	0.31	0.49	0.20
11/1/83	0.71	0.53	0.62	0.62	1.76	1.10	1.43	0.33	0.52	0.43	2.25
11/17/83	1.13	0.07	1.00	0.82	1.34	0.79	1.07	1.49	2.06	1.78	3.06
11/29/83	0.66	1.18	0.92	1.49	1.87	0.93	1.40	--	----	----	----
12/13/83	0.82	0.64	0.73	--	0.94	0.17	0.56	2.22	3.74	4.09	---
4/24/84	0.88	0.25	0.50	0.21	1.03	0.36	0.70	0.12	0.68	3.03	----
5/15/84	0.57	0.86	0.72	0.20	--	----	--	0.45	0.01	0.57	----
5/30/84	0.44	0.95	0.70	0.52	1.27	0.88	1.09	0.01		0.01	0.53
6/13/84	2.86	1.65	2.25	----	0.60	2.67	1.68	----	----	----	----
6/26/84	2.03	1.63	1.53	1.00	1.83	1.31	1.57	____	0.60	----	2.71
Mean			1.29	1.19			1.22			1.16	1.36
					BOSMINA						
7/26/83	0.45	0.67	0.56	0.93	0.67	1.20	0.94	0.58	0.54	0.55	0.35
8/24/83	0.16	0.06	0.11	0.05	0.18	0.22	0.20	0.10	0.16	0.13	0.22
9/14/83	0.34	0.30	0.32	0.26	0.40	0.13	0.27	1.09	0.53	0.81	1.95
9/28/83	0.49	0.41	0.45	0.64	0.49	1.23	0.86	1.33	1.15	1.24	0.98
10/13/83	1.23	0.79	1.01	2.62	1.05	0.38	0.72	2.04	2.80	2.42	2.13
11/01/83	1.50	0.92	1.21	1.97	1.39	1.22	1.31	1.17	1.29	1.23	6.53
11/17/83	0.77	0.56	0.67	1.45	1.26	0.81	1.04	3.44	5.23	4.34	9.35
11/29/83	0.64	0.57	0.61	1.91	1.52	0.96	1.24	----	----	----	----
12/13/83	0.38	0.40	0.39	----	0.92	0.34	0.63	2.53	1.35	1.97	----
5/15/84	0.01	0.04	0.02	0.01	---	----	----	0.10	0.12	0.11	---
6/13/84	0.31	0.02	0.17	----	0.07	0.25	0.16	----	----	----	----
6/26/84	0.06	0.0	0.03	0.07	0.08	0.04	0.06	----	0.13	---	0.72
Mean			0.43	0.83			0.59			1.17	2.65

Appendix D1. (Continued)

Date	Emery Perm.	Emery Random	Emery Mean	Emery Bay	Murray Perm.	Murray Random	Murray Bay	Sullivan Perm.	Sullivan Random	Sullivan Mean	Sullivan Bay
						CYCLOPS					
7/26/83	1.79	2.70	2.20	2.56	2.01	2.9	2.46	0.58	0.32	0.45	2.51
8/24/83	3.04	2.50	2.77	2.99	3.12	1.70	2.41	2.50	3.40	2.35	3.80
9/14/83	5.00	4.33	4.69	5.32	7.17	4.74	5.96	3.21	5.15	4.48	7.02
9/28/83	6.66	4.85	5.76	5.36	6.58	4.62	5.60	6.83	3.44	8.14	7.30
10/13/83	6.22	S.49	5.86	6.20	4.62	5.94	5.28	7.04	8.37	7.71	6.39
11/1/83	5.45	4.20	4.83	4.83	4.02	3.31	3.67	4.74	4.02	4.38	10.83
11/17/83	3.50	3.78	3.73	3.50	3.37	3.21	3.53	7.41	11.51	9.46	17.26
11/29/83	4.13	5.73	4.93	5.70	3.26	2.56	2.91	---	---	---	5.70
12/13/83	3.14	2.73	2.94	----	3.22	1.84	2.53	6.47	4.34	5.41	---
4/24/84	0.05	0.48	0.67	0.20	1.74	1.00	1.37	1.30	0.59	0.95	---
5/15/84	0.52	1.22	0.92	0.44	- -	---	---	1.41	1.80	1.61	----
5/30/84	0.39	0.30	0.35	0.22	1.35	1.35	1.35	0.10	0.09	0.35	1.52
6/13/84	0.99	0.40	0.70	---	0.95	2.53	1.74	---	---	----	----
6/26/84	0.88	0.66	0.77	0.45	1.60	1.89	1.45	---	1.69	----	5.71
Mean			2.94	3.15			3.10			4.23	6.36
						DIAPTOMUS					
7/26/83	0.03	0.06	0.05	0.03	0.06	0.06	0.06	0.10	0.20	0.15	0.21
9/14/83	0.57	0.86	0.72	0.85	0.89	0.76	0.83	0.57	0.85	0.71	0.72
9/28/83	0.94	0.72	0.83	0.75	0.47	0.54	0.56	0.53	0.63	0.63	0.27
10/13/83	1.26	0.75	1.01	1.09	0.51	0.52	0.52	0.50	0.54	0.52	0.24
11/1/83	1.00	0.62	0.81	1.30	1.35	0.64	1.00	0.24	0.43	0.34	2.20
11/17/83	1.49	0.96	1.23	1.41	1.60	0.83	1.22	0.97	2.63	1.83	3.68
11/29/83	1.34	1.11	1.23	2.10	2.01	1.47	1.74	----	----	----	----
12/13/83	0.99	0.98	0.39	----	1.68	0.01	1.25	7.33	a.22	7.80	---
4/24/84	3.31	1.05	2.18	0.66	3.04	1.03	2.04	0.27	0.27	0.27	----
5/15/84	1.74	4.35	3.05	0.66	- -	---	---	1.33	1.52	1:,3	---
5/30/84	3.06	1.66	2.36	1.44	2.99	2.28	2.64	0.36	0.39	0.3a	0.43
6/13/84	5.74	6.40	6.07	----	1.68	4.15	2.92	----	----	---	----
6/26/84	5.49	9.00	7.25	4.73	4.02	2.64	3.33	----	0.81	---	5.04
Mean			2.00	1.28			1.44			1.33	1.50

* ---- = sample not usable or not collected

Appendix D2. The mean Number of surface insects captured per hectare for Emery, Murray, and Sullivan areas and the total of these averages for "ear (<100 m from shore) and offshore (>100 m) Samples collected at Hungry Horse Reservoir area from August - November 1983.

Month	Insect group	Area: Emery		Murray		Sullivan		Grand Mean	
		Nearshore	Offshore	Nearshore	Offshore	Nearshore	Offshore	Nearshore	Offshore
Aug.	Terrestrial	21	0	35	42	14	28	23	23
	Aquatic	14	0	63	83	35	70	37	51
	TOTAL	35	0	98	125	49	98	60	74
Sept.	Terrestrial	16,063	2,608	446	117	96	179	5,535	968
	Aquatic	146	36	25	37	79	146	83	73
	TOTAL	16,209	2,644	471	154	175	325	5,618	1,041
Oct.	Terrestrial	54	92	142	138	13	46	70	92
	Aquatic	96	79	83	325	46	29	76	144
	TOTAL	150	171	225	463	58	75	146	236
NW.	Terrestrial	0	0	4	4	17	8	7	4
	Aquatic	17	17	0	0	0	8	6	8
	TOTAL	17	17	4	4	17	16	13	12
Mean	Terrestrial	4,034	675	157	75	35	65	1,409	272
	Aquatic	68	33	43	112	40	63	50	69
	TOTAL	4,102	708	200	187	75	128	1,459	341

Appendix D3. The mean number of surface insects captured per hectare for Emery, Murray, and Sullivan areas and the total of these averages for near (<100 m from shore) and offshore (>100 m) samples collected at Hungry Horse Reservoir area from April - November 1984.

Month	Insect group	Area: Emery Nearshore	Emery Offshore	Murray Nearshore	Murray Offshore	Sullivan Nearshore	Sullivan Offshore	Grand Mean Nearshore	Grand Mean Offshore
April	Terrestrial	8	8	0	0	8	8	6	6
	Aquatic	17	8	17	33	42	33	25	25
	TOTAL	25	16	17	33	50	41	31	31
May	Terrestrial	250	233	63	88	17	17	110	113
	Aquatic	146	125	142	146	142	184	143	151
	TOTAL	396	358	205	234	159	201	253	264
June	Terrestrial	221	142	213	188	13	17	149	115
	Aquatic	83	13	33	17	108	156	75	62
	TOTAL	304	155	246	205	121	173	224	177
July	Terrestrial	161	25	53	44	25	47	80	39
	Aquatic	53	8	39	17	58	61	50	29
	TOTAL	214	33	92	61	83	108	130	68
Aug.	Terrestrial	17	28	175	106	1,809	633	667	256
	Aquatic	47	22	119	17	53	39	7[illegible]	26
	TOTAL	64	50	294	123	1,862	672	739	282
Sept.	Terrestrial	9,560	7,243	861	525	403	89	3,608	2,619
	Aquatic	72	22	64	31	303	119	146	57
	TOTAL	9,632	7,265	925	556	706	208	3,754	2,676
Oct.	Terrestrial	6	6	261	489	245	656	170	383
	Aquatic	28	106	94	283	78	94	67	161
	TOTAL	34	112	355	772	323	750	237	544
Nov.	Terrestrial	0	0	0	0	0	0	0	0
	Aquatic	6	0	0	0	0	0	2	0
	TOTAL	6	0	0	0	0	0	2	0
Mean	Terrestrial	1,278	961	203	180	315	183	599	441
	Aquatic	56	38	64	68	98	86	73	64
	TOTAL	1,334	999	267	248	413	269	672	505

Appendix D4. **The number and weight (g) of aquatic macroinvertebrates.m2 in benthos** samples from Emery, Murray and Sullivan areas of Hungry Horse Reservoir August through November, 1983.

Date	Mean Depth	Dipteran Larvae No.	Larvae Wt.	Pupae No.	Pupae Wt.	Total No.	Total Wt.	Oligochaeta No.	Oligochaeta Wt.	Other No.	Other Wt.
Emery Area 1983											
October 14	8.2	3.6	0.001	—	- -	3.6	0.001	32.3	0.037	68.1	0.050
	30.0	53.8	0.023	- -	—	53.8	0.023	14.3	0.219	17.9	0.008
December 12	18.5	154.1	0.082	—	- - -	154.1	0.082	7.2	0.013	—	----
	49.2	139.8	0.587	- -	----	139.8	0.587	10.8	0.006	—	- -
Summary	13.4	78.9	0.041	—	- - -	78.9	0.041	19.7	0.025	34.1	0.025
	30.0	53.8	0.023	- -	- - -	53.8	0.023	14.3	0.219	17.9	0.008
	49.2	139.8	0.587			139.8	0.587	10.8	0.006	- -	----
Murray Area 1983											
October 14	13.1	43.0	0.019	3.6	0.002	46.6	0.021	25.1	0.033	20.7	0.021
	30.2	121.8	0.481	3.6	0.003	125.4	0.484	18.0	0.039	---	---
	40.7	10.6	0.008	- -	- - -	10.0	0.008	10.8	0.015	--	----
December 12	17.4	172.0	0.079	---	----	172.0	0.079	21.5	0.021	----	--
	38.7	204.3	1.439	- -	- - -	204.3	1.439	35.8	0.054	3.6	0.013
	53.9	64.5	0.221	---	----	64.5	0.221	14.4	0.039	---	---
Summary	15.3	107.5	0.049	1.8	0.001	109.3	0.050	23.3	0.027	14.4	0.011
	34.5	163.1	0.960	1.8	0.002	164.9	0.962	26.9	0.047	1.6	0.006
	41.3	37.7	0.115	—	----	37.7	0.115	12.6	0.027	--	----
Sullivan Area 1983											
October 14	8.7	25.1	0.013	--	---	25.1	0.013	7.2	0.001	10.8	0.003
	28.7	190.0	0.298	---	-----	190.0	0.298	107.5	0.036	1.2	0.227
	39.2	103.9	0.150	3.6	0.081	107.5	0.231	39.4	0.072	- -	----
December 12	17.9	283.1	0.805	---	- -	263.1	0.805	50.2	0.052	----	---__
	44.3	154.1	0.542	—	- - -	154.1	0.542	82.5	0.071	- - -	-__--
Summary	13.3	154.1	0.409	- - -	----	154.1	0.409	28.7	0.027	5.4	0.002
	28.7	190.0	0.298	- -	- - - -	190.0	0.298	107.5	0.036	7.2	0.227
	41.2	129.0	0.346	1.8	0.041	130.8	0.387	61.0	0.072	-:-	--_-_
1983 Areas Combined Mean											
1983	14.0	113.5	0.166	0.6	0.001	114.1	0.167	23.9	0.026	17.9	0.027
						1125.11 a/		[32.9]		137.81	
	31.9	142.5	0.560	0.9	0.001	143.4	0.561	43.9	0.087	7.2	0.062
						[83.5]		[63.3]		[16.1]	
	45.9	102.2	0.349	0.6	0.013	102.8	0.363	28.1	0.035	----	--__-
						[93.3]		[43.2]			

a/ Standard deviation in brackets.

Appendix D5. The number and weight (g) of aquatic macroinvertebrates·m^2 in benthos samples from Emery, Murray and Sullivan areas of Hungry Horse Reservoir June through November 1984.

Date	Mean Depth(m)	Dipteran Larvae No.	Dipteran Larvae Wt.	Dipteran Pupae No.	Dipteran Pupae wt.	Dipteran Total No.	Dipteran Total Wt.	Oligochaeta No.	Oligochaeta Wt.	other NO.	other wt.
					Emery Area 1983						
June 6	11.7	--	--	--	--	--		--	--	--	--
	27.3	46.6	0.147	--	--	46.6	0.147	7.2	0.002	--	--
	48.3	10.6	0.047	--	--	10.8	0.047	14.3	0.005	--	--
August 10	8.3	43.0	0.079	3.6	0.037	46.6	0.116	107.5	0.043	--	--
	28.0	663.1	1.078	--	--	663.1	1.018	308.3	0.242	--	--
	53:o	236.5	0.575	--	--	236.5	0.575	186.4	0.223	--	--
November 7	14.8	57.3	0.075	--	--	57.3	0.075	--	--	--	--
	31.8	50.2	0.120	--	--	50.2	0.120	3.6	<0.001	--	--
	51.5	186.4	0.967	--	--	186.4	0.967	7.2	0.013		--
Summary	11.6	33.4	0.052	1.2	0.012	34.6	0.064	35.8	0.014	--	--
	29.1	253.3	0.448	--	--	253.3	0.448	106.4	0.061	--	--
	50.9	144.6	0.530	--	--	144.6	0.530	69.3	0.081	--	--
					Murray Area 1984						
June 20	19.3	8.1	0.006	2.7	0.002	10.8	0.008	5.4	0.002	--	--
	28.3	83.3	0.135	--	--	83.3	0.135	51.1	0.033	--	--
	60.3	430.1	0.315	14.3	0.104	444.4	0.419	28.7	0.007		
August 9	3.0	154.1	0.171	--	--	154.1	0.171	17.9	0.012	3.6	0.005
	25.8	559.1	1.960	--	--	559.1	1.960	207.9	0.173	--	--
	50:5	455.2	0.351	--	--	455.2	0.351	147.0	0.459	--	--
November 8	10.8	14.4	<0.001	--	--	14.4	<.001	--	--	--	--
	30.2	211.5	0.839	--	--	211.5	0.839	14.3	0.14	--	--
	50.8	75.3	0.505	--	--	75.3	0.505	--	--	--	--
summary	11.9	53.8	0.054	1.1	0.001	54.9	0.055	7.5	0.004	3.2	0.007
	28.1	264.5	0.894	--	--	264.5	0.894	87.1	0.069	--	--
	53.9	320.2	0.391	4.8	0.035	325.0	0.426	58.5	0.155	--	--
					Sullivan Area						
June 21	8.3	28.7	0.068	--	--	28.7	0.068	17.9	0.071	--	--
	37.7	172.1	0.423	3.6	0.005	175.6	0.428	89.6	0.047	--	--
August 8	3.8	168.4	0.125	--	--	168.4	0.125	35.9	0.043	7.2	0.057
	34.2	440.9	0.545	--	--	440.9	0.545	240.1	0.312	--	--
November 8	10.2	333.4	0.305	--	--	333.4	0.305	20.7	0.133	--	--
	33.5	50.2	0.136	--	--	50.2	0.136	--		--	--
	44.5	125.5	0.701	--	--	125.5	0.701	14.4	0.008	--	--
Summary	7.4	176.8	0.166	--	--	176.8	0.166	27.5	0.082	2.4	0.019
	35.1	221.0	0.368	1.2	0.002	222.2	0.370	109.9	0.370	--	--
	4415	125.5	0.701	--	--	125.5	0.701	14.4	0.008	--	--
					Areas Combined						
	10.4	86.8	0.089	0.8	0.004	87.6 [144.4][a/]	0.093	23.1 [42.3]	0.033	1.9	0.008
	30.7	246.9	0.582	0.4	0.001	241.3 [296.1]	0.583	100.6 [154.9]	0.089	--	--
	51.3	217.1	0.495	2.1	0.015	219.1 [218.1]	0.510	41.6 [60.7]	0.102	--	--

a/ Standard deviation in brackets.

APPENDIX E

Food Habits Data

Appendix E1. Numder of fish stomachs collected in Hungry Horse Reservoir during 1983 and 1984.

Date	Wests1op cutthroat trout	Bull trout	Mountain whitefish	Northern squawfish	Longnose sucker	Largescale sucker	Total
			Emery Area				
08/23/83	3	5	5	7	5	4	29
09/27/83	21	17	11	6	--	--	55
11/29/83	11	6	10	2	--	--	29
06/26/84	16	20	8	21	--	--	65
08/14/84	2	16	7	16	--	--	41
			Murray Area				
08/24/83	3	2	4	8	6	5	29
09/28/83	23	9	5	6	--	--	43
11/30/83	14	4	11	--	--	--	29
06/27/84	21	21	6	23	--	--	71
08/16/84	5	14	6	20	--	--	45
10/12/84	12	20	7	7	--	--	46
12/22/84	48	--	--	--	--	--	48
			Sullivan Area				
08/25/83	12		2	7	5	4	32
09/29/83	21	2	5	6	--	--	38
12/15/83	11		15	--	--	--	33
06/28/84	23	1:	6	14	--	--	60
08/22/84	16	6	8	19	--	--	49
10/10/84	20	21	11	13	--	--	65
Totals	282	193	127	175	16	13	806

Appendix E2. Number and weight in grams of food items ingested by westslope cutthroat trout in Hungry Horse Reservoir, 1983. The percent that each item comprised of the total food for each season is given in parenthesis. Empty stomachs were not included in the analyses.

Season	Number Stomachs	Daphnia No.	Daphnia Wt.	Epischura No.	Epischura Wt.	Hymenoptera No.	Hymenoptera Wt.	Coleoptera No.	Coleoptera Wt.	Hemiptera No.	Hemiptera Wt.	Homoptera No.	Homoptera Wt.	Lepedoptera No.	Lepedoptera Wt.	Arachnids No.	Arachnids Wt.	Diptera No.	Diptera Wt.	Insect Parts No.	Insect Parts Wt.	Misc. No.	Misc. Wt.
Westslope Cutthroat <300mm																							
Summer	13	-	-	1 (<0.1)	-	48 (2.5)	0.374 (7.8)	15 (0.8)	.060 (1.3)	-	-	57 (3.0)	.095 (1.8)	-	-	3 (0.2)	0.020 (0.4)	1,758 (93.5)	4.040 (75.5)	- -	0.625 (11.7)	-	0.280 (2.5)
Fall	29	344 (5.0)	0.114 (1.0)	21 (0.3)	0.008 (<.1)	5464 (79.0)	129.100 (92.0)	142 (2.1)	0.986 (0.7)	99 (1.4)	0.581 (0.4)	169 (2.4)	2.050 (1.5)	23 (0.3)	0.838 (0.6)	67 (1.0)	0.499 (0.4)	585 (8.5)	3.050 (2.2)	- -	1.630 (1.2)	- -	0.030 (<.1)
Winter	13	1479 (98.6)	0.601 (90.5)	1	0.001 (<.1)	-	-	-	-	-	-	-	-	-	-	-	-	21 (1.3)	0.610 (9.2)	-	-	-	0.010 (0.3)
Total	55	1823 (17.7)	0.715 (0.5)	23 (0.2)	0.009 (<.1)	5512 (535)	129.474 (88.9)	157 (1.5)	1.046 (0.7)	99 (1.0)	0.581 (0.4)	226 (2.2)	2.145 (1.5)	23 (0.2)	0.838 (0.6)	70 (0.7)	0.519 (0.4)	2364 (23.0)	7.700 (5.3)	-	2.255 (1.5)	-	0.320 (0.2)
Westslope Cutthroat >300 mm																							
Summer	4	-	-	1 (<0.1)	0.004	1072 (85.2)	29.800 (61.8)	12 (0.9)	1.550 (3.3)	8 (0.6)	0.001 (<.1)	74 (5.9)	0.709 (1.5)	-	-	20 (1.6)	0.425 (0.9)	67 (5.5)	3.250 (6.7)	- -	8.940 (18.3)	- -	4.700 (8.5)
Fall	28	194 (0.7)	0.054 (<.1)	325 (1.2)	0.125 (<.1)	23,791 (90.9)	392.100 (95.4)	279 (1.1)	2.450 (0.6)	2.38 (0.9)	3.130 (0.8)	259 (1.0)	1.860 (0.5)	78 (0.3)	3.650 (0.9)	107 (0.4)	0.654 (0.2)	842 (3.2)	5.590 (1.4)	- -	0.554 (0.1)		5.300 (0.1)
Winter	17	2538 (98.6)	1.010 (93.8)	1 (<0.1)	tr. (<0.1)	-	-	-	-	-	-	-	-	-	-	-	-	24 (0.9)	0.064 (6.0)	-	.001 (0.1)		0.010 (0.1)
Total	49	2732 (9.1)	1.064 (0.2)	327 (1.1)	0.129 (<0.1)	24,863 (83.1)	421.900 (90.5)	291 (1.0)	4.000 (0.9)	246 (0.8)	3.131 (0.7)	333 (1.1)	2.569 (0.5)	78 (0.3)	3.65 (0.8)	127 (0.4)	1.079 (0.2)	933 (3.1)	8.904 (1.9)		9.495 (2.0)		10.010 (2.2)

APPENDIX F

Horizontal Gill Net Data

Appendix F1. Mean catch by month for fish species captured in floating gill nets from Hungry Horse Reservoir, 1983-84.

Date	Number of nets per area	Emery						Murray						Sullivan					
		WCT	DV	MWF	MSQ	CSU	LNSU	WCT	DV	MWF	MSQ	CSU	LNSU	WCT	DV	MWF	MSQ	CSU	LNSU
4/84	14	2.2	0.0	0.1	0.1	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	9.1	1.2	0.1	0.1	0.0	0.0
5/84	14	1.6	1.4	0.5	0.9	0.4	0.1	3.4	0.6	0.3	0.4	0.1	0.1	2.1	1.0	0.3	0.8	0.1	0.0
6/84	14	1.1	0.7	0.2	5.0	0.3	0.0	2.3	0.2	0.2	2.2	0.2	0.1	4.3	0.6	0.1	1.3	0.2	0.0
7/83	14	1.2	0.1	0.1	2.9	0.0	0.0	0.7	0.1	0.0	1.7	0.0.	0.0	1.1	0.1	<0.1	0.6	0.1	0.0
8/83	14	0.1	0.1	0.0	2.7	0.0		0.2	0.1	0.0	1.9	0.1	0.1	0.4	0.1	0.0	1.5	0.1	0.1
8/84	28	2.0	0.1	0.1	5.3	0.0	0.0	0.2	0.0	0.1	5.4	0.1	0.0	0.5	0.0	0.1	1.7	0.0	0.0
9/83	14		0.2	1.7	4.4	0.0	0.0	3:0	0.1	1.9	3.3	0.3	0.0	2.8	0.2	1.3	1.1	0.0	0.0
10/83	14	2.6	0.2	0.5	0.1	0.0	0.0	1.2	0.0	0.4	0.0	0.0	0.0	2.4	0.2	0.6	0.1	0.1	0.0
10/84	28/26[a]	—	—	—	—	—	—	0.4	0.1	0.6	0.8	0.2	0.0	1.8	0.1	0.0	0.2	0.0	0.0
11/83	14	0.5	0.1	0.1	0.0	0.0	0.0	0.8	0.1	0.1	0.0	0.0	0.0	0.7	0.1	0.4	0.0	0.0	0.0

[a] Twenty-eight nets were set in the Murray and 26 in the Sullivan area.

Appendix F2. Mean catch by Month For fish species captures in sinking gill nets from Hungry Horse Reservoir 1983-84

Date	Number of nets per area	Emery						Murray						Sullivan					
		WCT	DV	MWF	NSQ	CSU	LNSU	WCT	DV	MWF	NSQ	CSU	LNSU	WCT	DV	MWF	NSQ	CSU	LNSU
4/84	4	1.5	4.3	11.5	1.3	1.0	0.3	1.5	2.5	11.0	0.3	0.3	0.3	0.0	8.0	16.8	2.0	1.5	2.5
5/84	4	0.0	6.5	7.3	3.5	1.0	6.8	1.0	7.0	7.5	4.0	1.5	2.8	0.3	2 3	4.5	4.3	0.8	1.8
6/84	4	0.8	3.5	7.0	7.5	4.8	6.8	0.3	5.0	3.0	5.5	2.5	7:0	0.3	2:0 5'8	2.0 7.5	4.0 3.0	3.8 4.0	10.0 9.0
7/83	2	0.0	l:0	1.0	13.5	3.5	18.5	0.0	4.0	1.5	7.5	4.0	7.5						
8/83	3	0.3	1.3	2.0	8.7	3.3	11.3	0.0	0.3	1.3	10.3	6.3	6.0	0.0	0.7	0.7	6.0	5.7	6.0
8/84	10	0.0	1.7	3.6	12.8	2.8	8.0	0.1	1.8	1.9	10.8	4.6	5.9	0.2	0.7	3.7	3.8	3.7	4.3
9/83	3	0.0	4.7	15.0	14.7	4.7	0.3	1.0	3.3	38.0	5.3	1.3	0.0	2.3	3.7	22.0	3.3	0.3	0.0
10/83	10 (7)a/	03	13	9.0	23	10	03	0.0	3.0	7.3	0.7	1.0	0.0	0.3	2.3	13.7	3.7	0.7	0.0
10/34								0.0	3.6	21.6	3.8	0.5	0.3	0.7					
11/83	3	1.3	1.7	3.0	0.7	0.3	0.0	1.3	1.3	7.7	1.3	0.0	0.0	0.3	5 2:0 6	23.3 6.7	5.9 0.3	1.1 0.0	0.3 0.0

a/ Seven nets were set in Sullivan and none in Emery do to Mechanical problems with boat.

Appendix F3. Average catch per net of fish species in floating and sinking gill nets from the Emery Murray and Sullivan areas of Hungry Horse, August and October 1983 and May, August and October 1984. Number of net sets is given in parenthesis.

	Area					
	Emery		Murray		Sullivan	
Species	1983(28)	1984[a] (42)	1983(28)	1984(70)	1983(28)	1984(66)
Floating Nets						
Westelope cutthroat	1.9	0.9	0.7	1.3	2.1	1.5
Bull trout	0.1	0.8	0.1	0.2	<0.1	0.4
Mountian whitefish	0.3	0.3	0.2	0.3	0.5	0.1
Northern squawfish	1.9	0.2	0.9	2.2	0.8	0.9
Largescale sucker	0.0	0.2	<0.1	0.1	0.1	<0.1
Longnose sucker	0.0	<0.1	<0.1	<0.1	0.1	0.0
Sinking Nets						
	1983(6)	1984(14)	1983(6)	1984(24)	1983(6)	1984(21)
Westslope cutthroat	0.2	0.0	0.0	4.1	0.2	0.4
Bull trout	1.3	4.1	1.7	10.3	1.5	2.9
Mountain whitefish	5.5	5.5	4.3	[illegible]	7.2	10.5
Northern squawfish	5.5	8.2	5.5	6.2	4.9 3.2	4:7
Largescale sucker	2.2		3.7			1.9
Longnose sucker	5.7	7.4	3.0	3.0	3.0	2.1

[a] Emery area was not sampled in October, 1984 due to mechanical problems with boat.

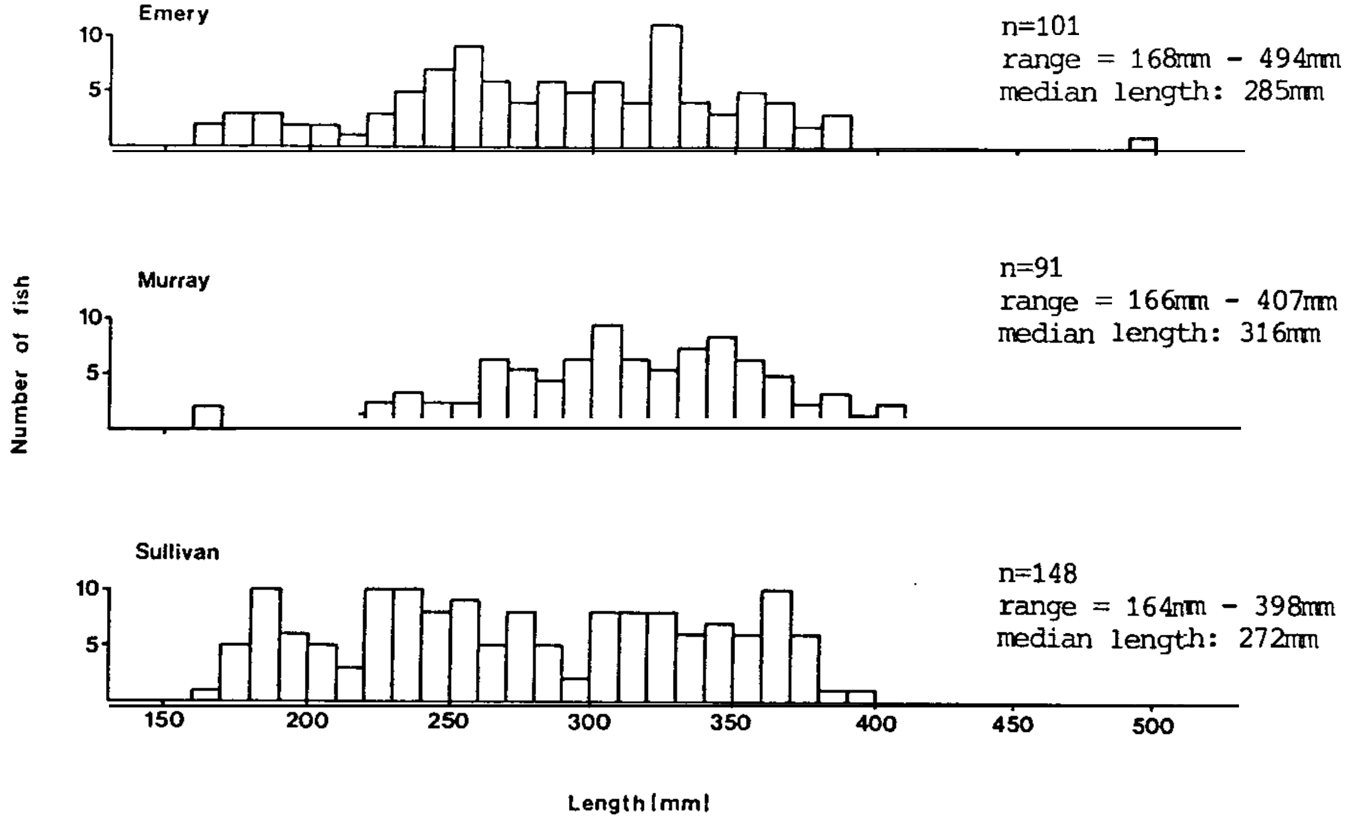
Appendix F4. Mean catch by season for fish species captured in floating and sinking gill nets from Hungry Horse Reservoir, 1983-84. The number of nets is given in parenthesis.

Species	Spring (May) 1983	Spring (May) 1984 (40)	Summer (August) 1983(42)	Summer (August) 1984 (84)	Fall (October) 1983(42)	Fall (October) 1984(54)[a]
Floating Nets						
Weatslope cutthroat		2.4	0.4	0.2	2.4	1.1
Bull trout		0.6	0.1	0.1	0.2	0.1
Mountain whitefish	–	0.4	0.0	0.1	0.6	0.3
Northern squawfish	--	0.7	2.0	4.1	0.1	0.5
Largescale sucker	–	0.2	0.1	0.1	0.0	0.1
Longnose sucker		0.1	0.1	0.0	0.0	0.0
Sinking Nets						
	1983	1984(12)	1983(9)	1984(30)	1983(9)	1984(17)
Westslope cutthroat	--	0.4	0.1	0.1	0.3	0.3
Bull trout		5:3	0:8	1.4	2.2	4.4
			1.3	3.1	10.0	22.3
Northern whitefish	--	6.9	8.3	9.1	2.2	4.6
Largescale sucker		1.1	4.1	3.7	0.9	0.8
Longnose sucker		3.8	7.8	6.1	0.1	0.3

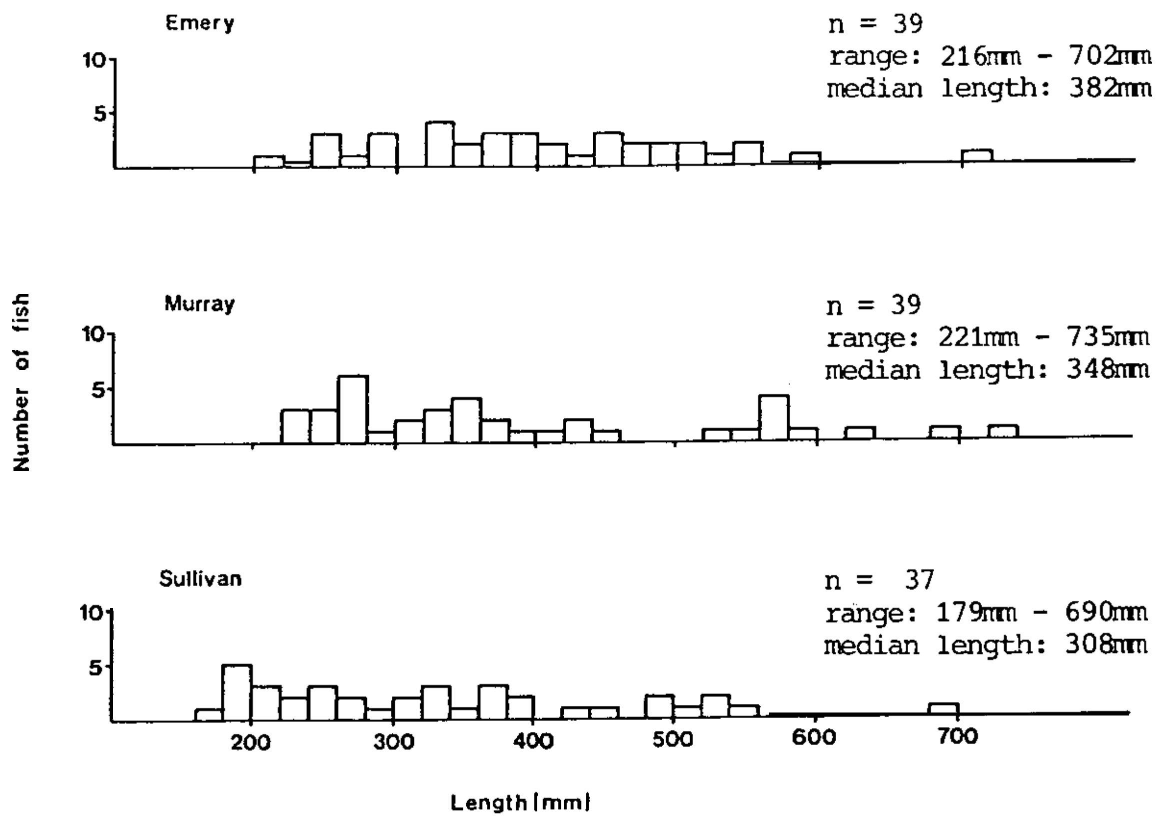
[a] Emery area was not sampled in fall, 1984 due to mechanical problems with boat.

APPENDIX G

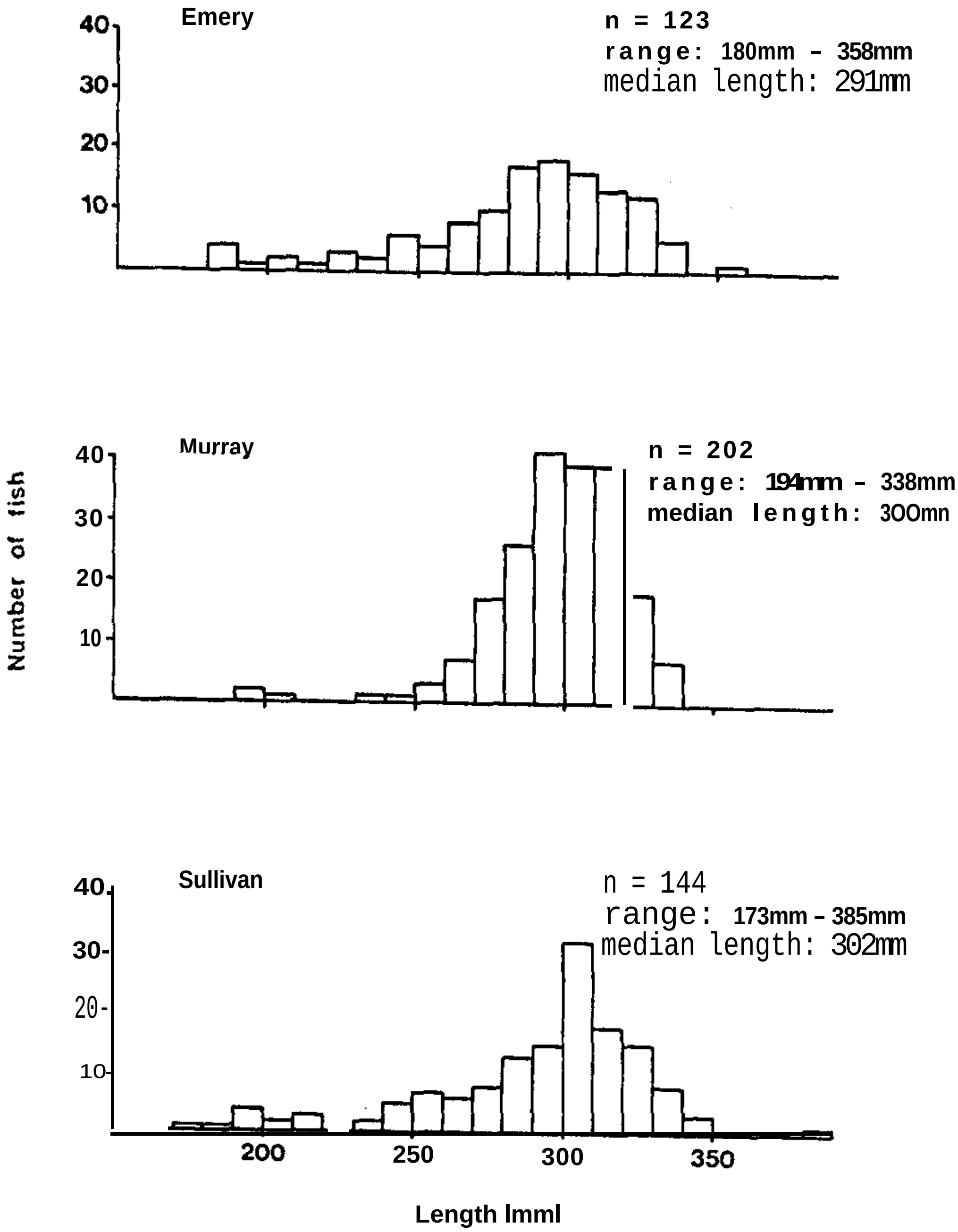
Length Frequency Distributions of Fish Caught in Horizontal Gill Nets in 1983.



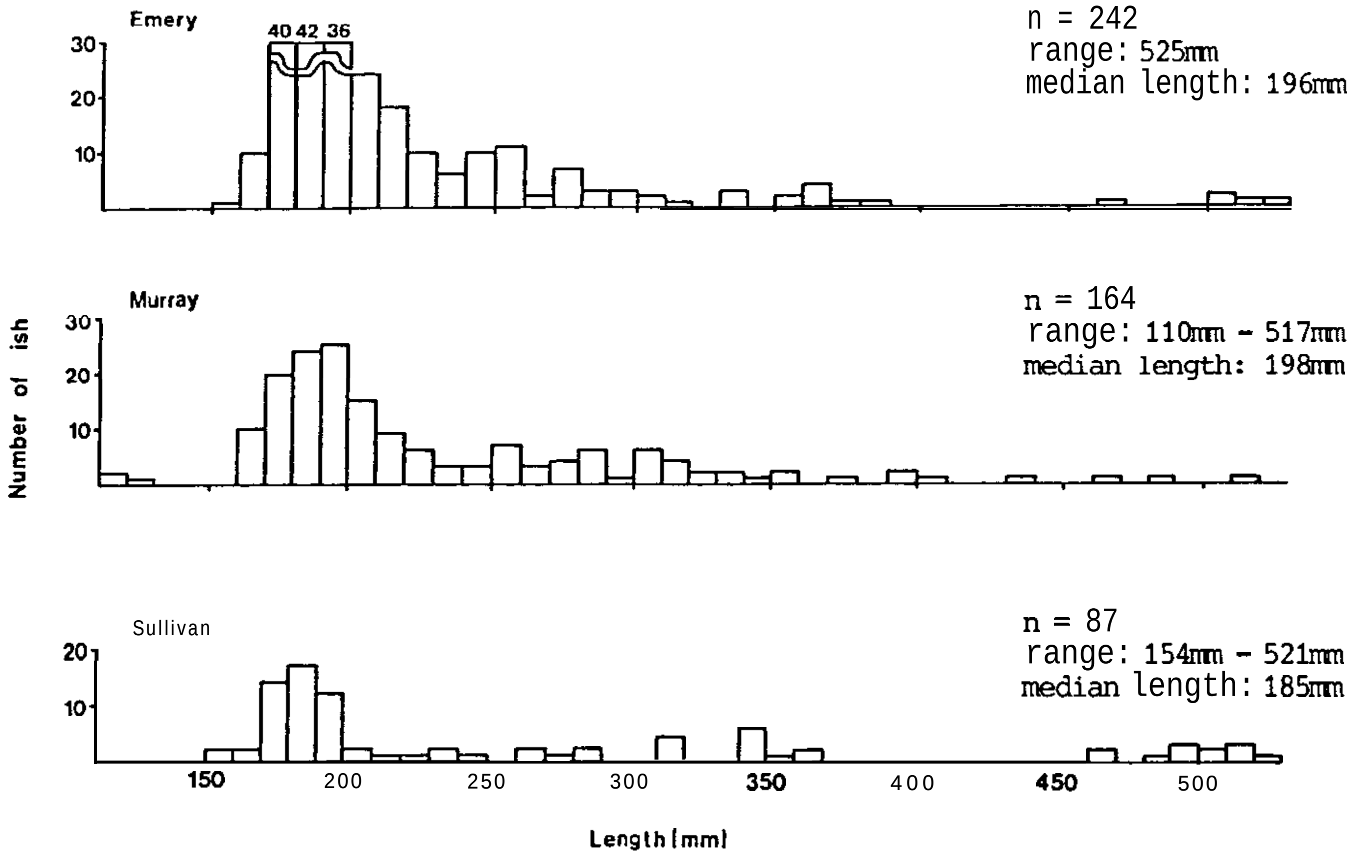
G1. Length frequency diagrams for westslope cutthroat captured in floating and sinking gill nets set in Emery area, Murray area, and Sullivan area of Hungry Horse Reservoir, 1983.



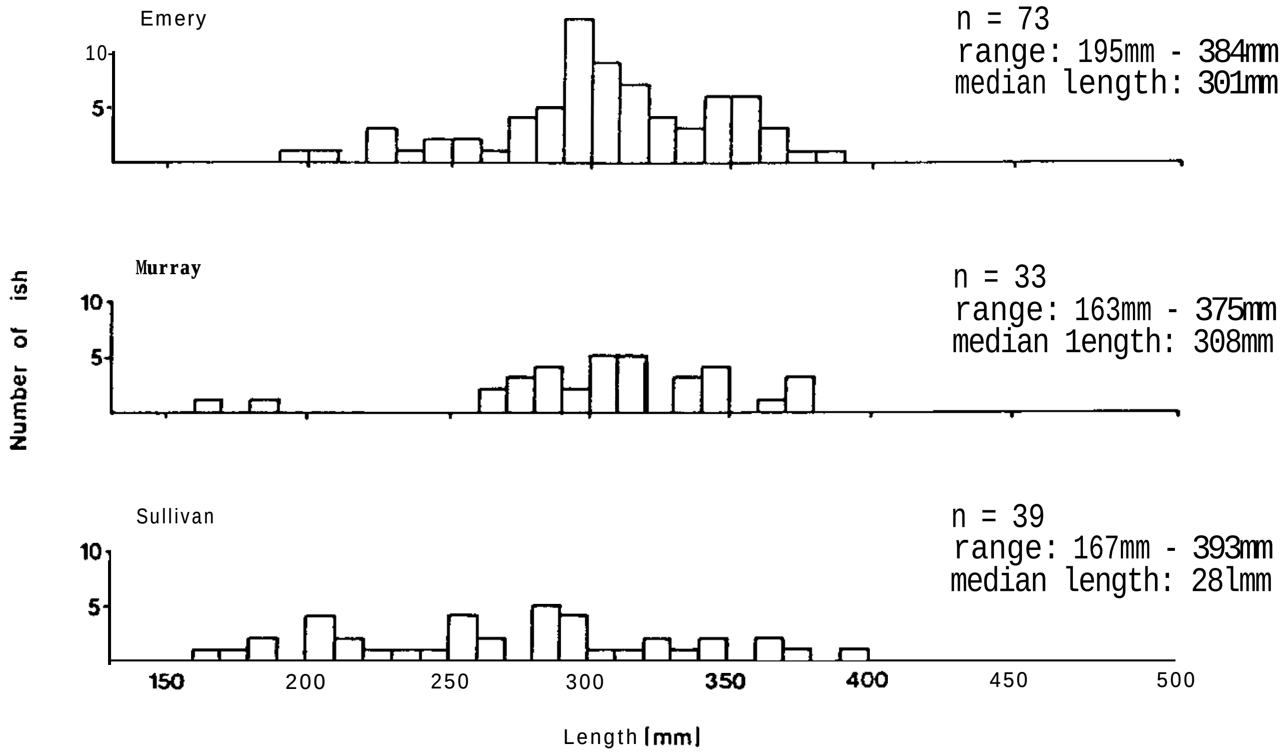
Appendix G2. Length frequency diagrams for bull trout captured in floating and sinking gill nets set in Emery area, Murray area, and Sullivan area of Hungry Horse Reservoir, 1983.



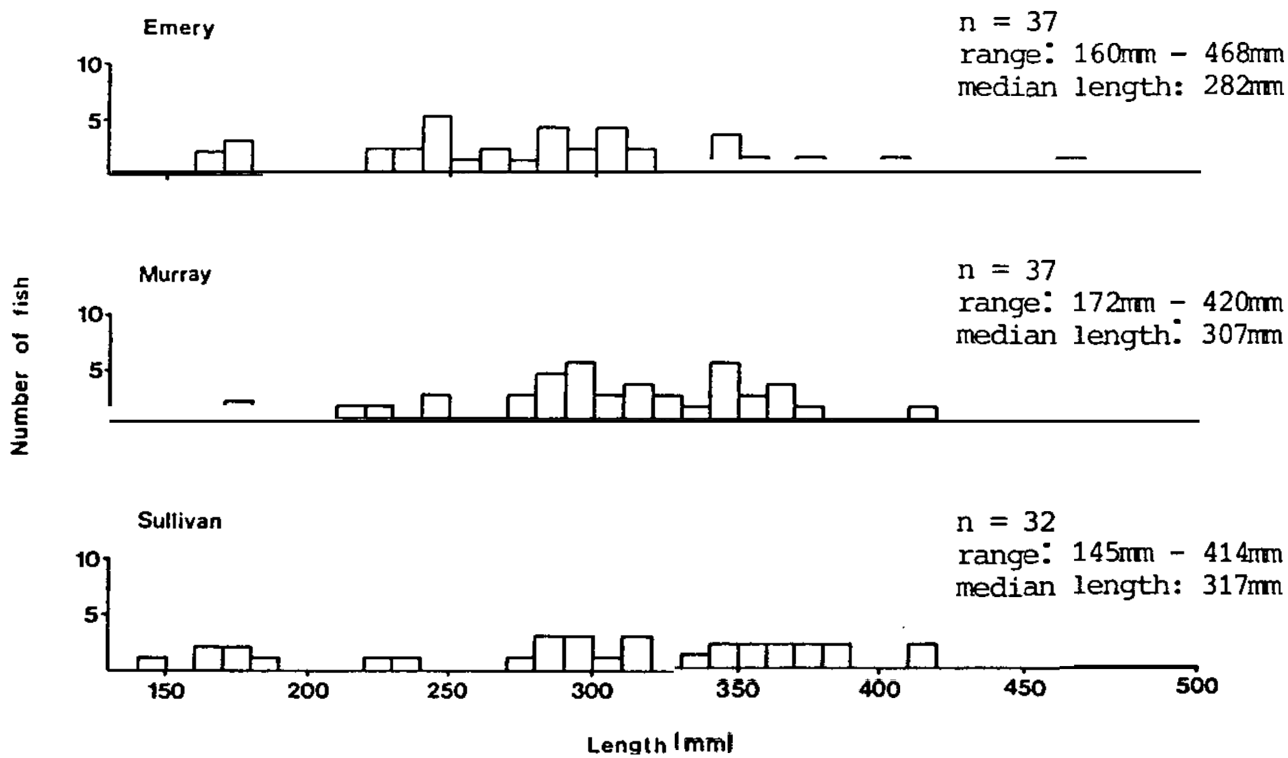
Appendix G3. Length frequency diagram for mountain whitefish captured in floating and sinking gill nets set in Emery area, Murray area and Sullivan area of Hungry Horse Reservoir, 1983.



AppendixG4. Length frequency diagrams of northern squawfish captured in floating and sinking gill nets set in Emery area, Murray area, and Sullivan area of Hungry Horse Reservoir, 1983.



Appendix G5. Length frequency diagrams of long-nose suckers captured in floating and sinking gill nets set in Emery area, Murray area, and Sullivan area of Hungry Horse Reservoir, 1983.



Appendix G6. Length frequency diagrams of large scaled suckers captured in floating and sinking gill nets set in Emery area, Murray area, and Sullivan area of Hungry Horse Reservoir, 1983.

APPENDIX H

Tag Return Data

Appendix Hl. Tagging and return information for westslope cutthroat and bull trout tagged in trioutaries to Hungry Horse Reservoir and south Fork River 1983.

Tagging Data				Retuen Date				
Date	Location	Length (mm)		Date	Location	Length (mm)	Method of Recapture	Distance Moved (km)
				Westslope Cutthroat				
6-16-83	Emery cr.	170	J[a]	6-?-83	Emery cr.	-150	Angling	—
6-24-83	Emery cr.	135	J	7-20-83	Hungry Horse Res.--Emery Bay	169	Gill Net	—
6-28-83	Emery cr.	146	J	11-29-83	Hungry Horse Res.--Emery Bay	266	Gill Net	—
7-3-83	Emery cr.	142	J	P-3-83	Emery cr.	-178	Angling	—
6-28-83	Hungry Horse cr.	348	A	12-15-83	Mouth of Clark Cr.	-368	Gill Net	+49.9[b]
7-4-83	Hungry Horse cr.	368	A	7-23-83	Hungry Horse Res.	—	Angling	—
7-19-83	Lower Twin Cr.	380	A	7-26-83	Mouth Of Lower Twin cr.	-368	Angling	0.5
7-19-83	Lower Twin Cr.	200	J	8-31-83	Inlet of S. Fork River	-203	Angling	-8.4
7-24-83	Lower Twin Cr.	255	J	7-26-83	Mouth Of Lower Twin cr.	-252	Angling	0.5
7-28-83	Lower Twin cr.	234	J	8-2-83	Mouth of Lower Twin Cr.	-229	Angling	0.5
8-2-83	Lower Twin cr.	232	J	9-21-83	Inlet of S. Fork River	-254	Angling	-8.4
6-15-83	Murray cr.	106	J	6-29-83	Mouth of Hungry Horse cr.	—	Angling	-18:8
6-16-83	Murray cr.	340	A	6-29-83	Mouth of Lost Johnny cr.	—	Angling	+14.5
6-23-83	North Fork Logan Cr.	172	J	8-30-133	Mouth of Sullivan Cr.	203-229	Angling	-9.3
6-24-83	North Fork Logan Cr.	145	J	U-24-83	Mouth of Lid Cr.	-178	Angling	-28.2
7-28-83	sullivan Cr.	200	J	8-21-83	Sullivan Cr.	—	Angling	—
7-30-83	Sullivan Cr.	163	J	P-29-83	Hurqry Horse Res.--Devils corkscrew Area	208	Gill Net	—
6-16-83	Tent cr.	333	A	6-25-83	Riverside Boat Landing	- -	Angling	+3.7
6-21-83	Tent cr.	367	A		Hungry Horse Res.--Devils Corkscrew Area	-373	Gill Net	+28.5
				Bull Trout				
8-l-03	Sullivan Cr.	194	J	—	Hungry Horse Res.--Devils Corkscrew Area	-203	Gill Net	+5.2

a/ J-Juvenile fish: A-Adult fish

b/ + is up-reservoir movement; - is dam-reservoir movement

Appendix H2. Tagging and return information of juvenile westslope cutthroat tagged in trebutaries to Hungry Horse Reservoir (HHR) and South Fork River, 1984.

Tagging Data			Return Date				
Date	Location	Length (mm)	Date	Location	Length (mm)	Method Of Recapture	Distance Moved (km)
7-9-04	Emery cr.	135	8-?-84	HHR-Mouth Of Lost Johnny	--	Angling	+2.2a/
7-25-84	Emery cr.	170	8-30-84	Wounded Buck Cr.	—	Angling	+4.9
7-20-84	Forest cr.	165	8-27-84	Sullivan Cr.	-190	Angling	+4.0
7-23-04	Forest Cr.	170	8-8-84	HHR--Mouth of Graves Cr.	—	Angling	-4.0
9-7-83	Hungry Horse cr.	148	7-21-84	Hungry Horse Cr. Trap	206	Trap	—
7-5-84	Hungry Horse cr.	152	7-21-84	HHR-Mouth Of Lost Johnny Cr.	-153	Angling	+2.3
7-11-84	Hungry Horse cr.	175	7-15-84	HHR--Mouth Of Hungry Horse cr.	- -	Angling	0.5
7-12-84	Hungry Horse cr.	182	7-15-84	HHR--Mouth Of Hungry Horse cr.	—	Angling	0.5
7-31-83	Lower Twin cr.	210	6-28-84	HHR-Sullivan Area	283	Gill Net	-5.2
8-1-83	Lower Twin cr.	181	4-26-04	HHR-Sullivan Area	239	Gill Net	-12.9
7-14-84	Lower Twin cr.	227	7-14-84	Lower Twin Cr.	227	Angling	—
7-31-83	Sullivan Cr.	180	6-20-84	HHR--Sullivan Area	262	Gill Net	4.0
8-8-83	Sullivan Cr.	202	5-31-84	HHR--Murray Area	290	Gill Net	-24.1
7-23-84	Wheeler cr.	155	3-5-84	Sullivan Cr.	—	Angling	+4.0
7-23-84	Wheeler cc.	152	9-5-84	Sullivan cr.	—	Angling	+4.0

a/ + is up-reservoir movement - is down-river reservoir movement

Appendix H3. Tagging and return information of adult westslope cutthroat **and bull** trout tagged in tributaries to Hungry Horse Reservoir (HHR) and South Fork River, 1984.

Tagging Date				Return Date				
Date	Location	Length (mm)		Date	Location	Length (mm)	Method Of Recapture	Distance Moved (km)
7-11-84	Forest Cr.	388		9-2-84	Murray Bay	- -	Angling	-22.7[a]
6-24-83	Hungry Horse cr.	378		5-20-84	Hungry Horse Cr. Trap	390	Trap	—
7-3-83	Hungry Horse cr.	386		5-23-84	Hungry Horse Bay	—	Angling	0.5
6-28-84	Hungry Horse Cr.	390		10-23-84	Hungry Horse Bay	-430	Angling	0.5
7-7-84	Hungry Horse Cr.	391		7-18-84	Hungry Horse Bay	- -	Angling	0.5
7-2-04	Hungry Horse Cr.	368		7-5-84	Hungry Horse Bay	- -	Angling	0.5
7-3-84	Hungry Horse Cr.	369		7-8-84	Hungry Horse Bay	- -	Angling	0.5
7-7-84	Hungry Horse cr.	319		7-15-84	Hungry Horse Bay	—	Angling	0.5
7-4-04	Hungry Horse cr.	391		7-15-84	Hungry Horse Bay	—	Angling	0.5
7-4-84	Hungry Horse Cr.	284		7-27-84	Hungry Horse Cr. Trap	204	Trap	—
7-6-84	Hungry Horse Cr.	371		7-12-84	Hungry Horse Bay	—	Angling	0.5
7-11-84	Hungry Horse Cr.	357		7-15-84	Hungry Horse Bay	—	Angling	0.5
7-13-84	Hungry Horse cr.	355		7-21-84	Hungry Horse Bay	—	Angling	0.5
7-13-84	Hungry Horse cr.	351		7-15-84	Hungry Horse Bay	- -	Angling	0.5
7-17-84	Hungry Horse Cr.	373		7-21-84	Hungry Horse Bay	—	Angling	0.5
8-9-83	Lower Twin cr.	297		7-1-84	H.H.R.-Lid Cr. Area	—	Angling	-52:3
6-15-83	Murray cr.	351		7-9-84	Hungry Horse Cr. Trap	367	Trap	-18.8
6-17-83	North Fork Logan Cr.	340		5-19-84	North Fork Logan Cr.	—	Angling	
7-12-84	Quintonkon Cr.	378		7-15-84	Sullivan Cr.	-390	Angling	-1.0
5-9-84	Reservoir--Mouth of Sullivan Cr.	370		5-31-84	H.H.R.-Emery Area	-365	Gill Net	-48.0
5-2-84	Reservoir--Upper end	255		7-?-84	S.Fork River-Log Landing	-340	Angling	+3.0
8-8-83	Sullivan Cr.	387		6-16-84		-390	Angling	
6-18-83	Tent cr.	360		6-25-84	Hungry Horse Cr. Trap	380	Trap	-14.0
6-22-83	Tent Cr.	392		7-8-84	H.H.R.--Mouth Of Deep Cr.	-415	Angling	-5.6
5-9-04	Reservoir-Mouth of Sullivan Cr.	559	*DV*	8-29-84	Quintonkon Cr.	—	Angling	-6.0

a/ + is up-reservoir Movement - is darn-reservoir movement