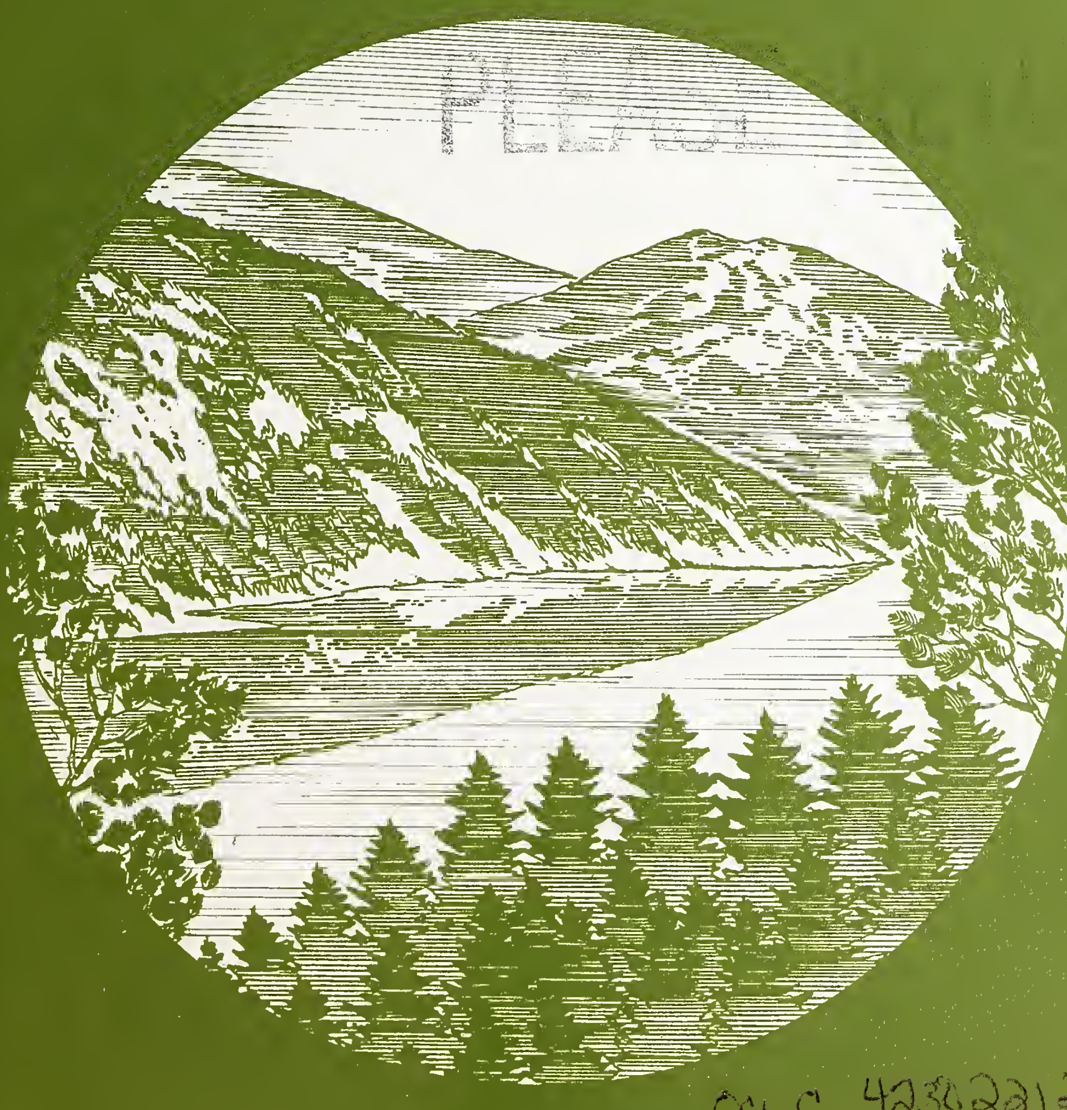
Libby Reservoir Water Levels
in or Enhance Reservoir Fisheries - Appendices

U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Montana Department of Fish, Wildlife and Parks

June 1985



Annual Report 1984

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Quantification of Libby Reservoir Levels
Needed to Maintain or Enhance Reservoir Fisheries

APPENDICES

for

Annual Report FY 1984

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APPENDIX A

Stream habitat inventory procedures

MONTANA

DEPARTMENT OF

FISH, WILDLIFE AND PARKS

STREAM HABITAT INVENTORY PROCEDURES

Fisheries Research and Special Projects Bureau

Montana Department of Fish, Wildlife and Parks
P.O. Box 67
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June 1983

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INTRODUCTION

The stream habitat inventory methodology described in this report resulted from four years of study on tributaries to the North and Middle Forks of the Flathead River. This study was funded by the Environmental Protection Agency through the Flathead River Basin Steering Committee. The methodology draws upon multidisciplinary knowledge in describing the biological and physical features interacting to form the stream environment.

The basis for this methodology was the system developed by the Resource Analysis Branch of the British Columbia Ministry of the Environment and used to survey the Canadian portion of the North Fork drainage (Chamberlin 1980a, 1980b). During the four years of study, the method was refined to fit our specific needs and to reduce individual observer bias.

The U.S. Forest Service developed a Stream Reach Inventory and Channel Stability Evaluation technique (Figure 1) to identify unstable stream channel areas and to monitor recovery rates of such areas (U.S. Forest Service 1975). The channel stability method was incorporated into our habitat evaluation technique during the 1980 field season (Fraley et al. 1981) to provide comparable data between agencies. A detailed instruction booklet describing evaluation procedures is available from the U.S. Department of Agriculture, Forest Service Northern Region.

A line transect methodology similar to that described by Herrington and Dunham (1967) was included in 1982 to provide more precise site specific information.

Annual reports (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982) should be consulted to determine exact methodologies used during each field season. Our modification of the original inventory glossary is presented in Appendix A.

METHODS

AERIAL SURVEY

The habitat evaluation process began by obtaining U.S. Geologic Survey Quadrangle maps (7.5 minute series) of the study area and color coding all tributaries to indicate stream order. Beginning at the mouth, each tributary was divided into one km sections on maps to facilitate the location of reach boundaries, survey sites and important stream features. Aerial photographs of the area were reviewed for landmark reference during aerial surveys.

Each tributary to be surveyed was flown by helicopter from its mouth to the upstream limit of suitable fish habitat. Suitable fish habitat was defined as perennial flow or adequate size to support a fish population. A definite fish barrier also marked the upstream boundary of the survey. During this upstream flight, important stream features such as slumped banks, obstructions to fish passage, beaver activity, trails and other

R-1 STREAM REACH INVENTORY and CHANNEL STABILITY EVALUATION

REACH LOCATION: Survey Date_______ Time_____ Obs.__________

Forest_______________ Rgr. Dist.__________

P.W.I.

Stream_______________ W/S No. __________

Reach Description &

Other Identification__________

	Key #	Stability Indicators by Classes (Fair and Poor on reverse side) EXCELLENT		GOOD	
Upper Banks	1	Bank slope gradient <30%.	(2)	Bank slope gradient 30-40%.	(4)
	2	No evidence of past or any potential for future mass wasting into channel.	(3)	Infrequent and/or very small. Mostly healed over. Low future potential.	(6)
	3	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	(4)
	4	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	(3)	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)
Lower Banks	5	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	(2)
	6	65%+ with large, angular boulders 12"+ numerous.	(2)	40 to 65%, mostly small boulders to cobbles 6-12".	(4)
	7	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	(2)	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)
	8	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	(6)
	9	Little or no enlargement of channel or point bars.	(4)	Some new increase in bar formation, mostly from coarse gravels.	(8)
Bottom	10	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners and edges, surfaces smooth and flat.	(2)
	11	Surfaces dull, darkened, or stained. Gen. not "bright".	(1)	Mostly dull, but may have up to 35% bright surfaces.	(2)
	12	Assorted sizes tightly packed and/or overlapping.	(2)	Moderately packed with some overlapping.	(4)
	13	No change in sizes evident. Stable materials 80-100%.	(4)	Distribution shift slight. Stable materials 50-80%.	(8)
	14	Less than 5% of the bottom affected by scouring and deposition.	(6)	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)
	15	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	(2)
		EXCELLENT COLUMN TOTAL →		GOOD COLUMN TOTAL →	

Add values in each column and record in spaces below. Add column scores.

E.___ + G.___ + F.___ + P.___ = ________ Total Reach Score.

Adjective ratings: <38=Excellent, 39-76=Good, 77-114=Fair, 115+=Poor*

*(Scores above may be locally adjusted by Forest Hydrologist)

R1-Form 2500-5A Rev.1-75 Side 1.

INVENTORY DATA: (observed or measured on this date) Side 2

Stream Width____ft.X Ave.Depth____ft.X Ave.Velocity____f/s=____Flow cfs

Reach Gradient____%. Stream Order____. Turbidity Level ______. Stream Stage______. Sinuosity Ratio ______.

Temperature °F or °C of: Air____ Water____, Others__________

	Key #	Stability Indicators by Classes FAIR		POOR	
Upper Banks	1	Bank slope gradient 40-60%.	(6)	Bank slope gradient 60%+.	(8)
	2	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)
	3	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)
	4	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)
Lower Banks	5	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.	(3)	Inadequate. Overbank flows common. W/D ratio > 25.	(4)
	6	20 to 40%, with most in the 3-6" diameter class.	(6)	< 20% rock fragments of gravel sizes, 1-3" or less.	(8)
	7	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	(8)
	8	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)
	9	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominantly fine particles. Accelerated bar development.	(16)
Bottom	10	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)
	11	Mixture, 50-50% dull and bright, ± 15% ie. 35-65%.	(3)	Predominantly bright, 65%+, exposed or scoured surfaces.	(4)
	12	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)
	13	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16)
	14	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)
	15	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	(4)
		FAIR COLUMN TOTAL →		POOR COLUMN TOTAL →	

Size Composition of Bottom Materials (Total to 100%)

1. Exposed bedrock..........____%	5. Small rubble, 3"-6".....____%
2. Large boulders, 3'+ Dia....____%	6. Coarse gravel, 1"-3"....____%
3. Small boulders, 1-3'.......____%	7. Fine gravel, 0.1-1".....____%
4. Large rubble, 6"-12".......____%	8. Sand, silt, clay, muck..____%

Figure 1. U.S. Forest Service Stream Reach Inventory and Channel Stability Evaluation Form.

crossings, were noted by the observer equipped with the topographic maps and a tape recorder. Other habitat features such as stream pattern, bank slope characteristics, streambed material, debris quantity and spawning potential for cutthroat and bull trout were noted. A general overview of geomorphically similar sections (reaches) was also gained during the upstream flight. General location of reach breaks were based largely on changes in stream gradient. A return flight downstream at greater altitude and speed allowed the observer to establish actual reach breaks and confirm locations, while keeping flying time to a minimum. A mobile fuel source provided by a backup observer and a vehicle carrying 55 gallon fuel drums also reduced fuel consumption and flying time.

Tapes were transcribed in the office and stream features and reach breaks were added to the U.S.G.S. maps. A Helicopter Stream Survey Report (Figure 2) was compiled for each reach. Recorded information included a suggested survey section typifying the reach, information on stream features, reach characteristics and general comments. Length of the recommended survey section was based on total reach length. Completed helicopter survey forms and a field copy of the U.S.G.S. maps accompanied crews conducting ground surveys.

GROUND SURVEY

Before beginning ground surveys, an intensive one or two day training session was conducted to teach survey personnel the techniques and standarize each individual's perception of what constitutes each habitat variable classification. During this training session, replicate surveys were conducted by all field personnel in two person crews so that replication of survey results could be tested. If results from replicate surveys differed significantly, more discussion and training were used to ensure results obtained from different crews in the same reach were similar. It was advisable to repeat this replicate survey with all ground crews once during the field season to test the assumption that surveys were conducted in a similar manner.

Crews of two trained observers performed the ground survey for each reach. The crew confirmed helicopter observations of obstructions to fish passage and other important features in each reach. The top of form FMD-I (Figure 3) was completed upon arrival at the survey section. Stations where observers measured and rated habitat characteristics were selected by pacing a predetermined random distance along the stream channel. These random paces were listed on the bottom portion of form FMD-I (Figure 3). The following parameters were evaluated at 20 randomly located sites per km:

(1) flow character
(2) debris presence
(3) debris stability
(4) side channel occurrence
(5) split channel occurrence
(6) habitat unit (pool, riffle, run, pocketwater, cascade)

Aquatic habitat was further quantified at a variable number of transects

HELICOPTER STREAM SURVEY REPORT

Stream: ____________ Reach No. _____________ Stream kms: ____________

Date: ______________ Time: _________________ Observer: _____________

Suggested survey section - km ____ to km ____

Reach Characteristics

Upper bank slope: _______________ Mass wasting potential: ________________

Valley flat: ___________________ Pattern: ______________________________

Flow characteristics: ___________ Channel width: ________________________

Debris - channel: _______________ Barriers - types: ______________________
floodplain: ____________ locations: ____________________

Spawning potential - Bull trout: ____
Cutthroat: ____

Portion recommended for redd counts:

Bull trout - km ________ to km ________
Cutthroat - km ________ to km ________

General comments:

Stream features:

Figure 2. Helicopter Stream Survey report.

FORM FMD-I

Length of survey section ________

Start of survey: km ____________

Stage: Dry L M H Flood

Turbidity: nil L M High

Confinement: Ent Conf Fr Oc Un N/A

Pattern: St Sin Ir IM Rm Tm

Valley flat:

Creek Name ____________________

Water Code: ________ Reach ____________

Survey personnel ________________

Agency ____________________

Date: ____________ Time: ____________

Air Temp ________ Water temp.: ______

Weather ____________________

Photos ____________________

Flow ____________ Loc ____________

OFFICE

Bank: form __________ process __________

Debris: __________ % stable __________

Side chan ____________ Split chan ________

Wet width __________ m Chan width ______ m

Floodplain Debris: N L M H

Flow char: P S R B T

SUBSTRATE		
Size Class	Streambed	Bank
Silt -detritus		
Sand (<2 mm)		
Sm. Gravel (2-6.4mm)		
Lg. Gravel (6.4-64mm)		
Cobble (64-256 mm)		
Boulder-bedrock (>256 mm)		

Reach length ________ Gradient ________

Reach location ________________

Stream Order __________

Depth: Avg ______ cm Max __________ cm

Imbeddedness: 0-25 25-50 50-75 75-100

Compaction __________ D90 __________ cm

Genetic Material: __________

HABITAT UNIT	%
Pool	
Riffle	
Run	
Pocket water	
Cascade	

Pool Class	%
I	
II	
III	

Vertical Stability - A ? D

Instream cover ________ % Type: ____________________

Overhead cover ________ % Type: ____________________

__________ m per pace

Pace No.	Transect No.	Flow Char.	DEBRIS Pres.	DEBRIS Abs.	DEBRIS Stable	DEBRIS Unstable	Side Chan.	Split Chan.	Habitat unit	Pool(I,II,III) Riffle Run	Pocket Water Cascade
30	1										
54											
177											
271	2										
428											
467											
540	3										
609											
632											
679	4										
774											
803											
858	5										
967											

Figure 3. Form FMD-I for general field and office data.

Pace No.	Transect No.	Flow Char.	DEBRIS Pres.	Abs.	Stable	Unstable	Side Chan.	Split Chan.	Feature	Pool(I,II,III) Riffle Run	Pocket Water Cascade

Significant features:

Pace No. km Description

Notes:

Figure 3. (Continued).

per km, depending on the level of precision desired. The following parameters were measured at one meter intervals or at a minimum of five equally spaced points across each transect:

(1) depth to nearest cm
(2) instream cover
(3) overhead cover
(4) two predominant substrate size classes

Visual estimates of substrate imbeddedness, compaction, D-90, percentages of each substrate size class, percentages of instream and bank cover and maximum depth were also made at each transect to attempt to quantify these subjective observations by using multiple observation points. Total wetted width and channel width were measured at each transect.

At every fifth transect the following features were noted:

(1) flood signs
(2) bank form
(3) bank process
(4) bank composition

This information along with any additional comments were recorded on field form FMD-J (Figure 4).

The Forest Service stability evaluation (Figure 1) was completed immediately following the habitat survey on each reach. When possible, stream discharge was also measured at this time. The office portion of form FMD-I (Figure 3), summarizing field measurements, was completed any convenient time after the survey.

DATA ENTRY AND ANALYSIS

Habitat data for each reach were coded on Montana Interagency Stream Fishery Resource Data Forms (Holton et al. 1981). These forms and instructions concerning their use are presented in Appendix B. Data from completed Interagency forms were keypunched and entered in the statewide data base administered through the Department of Fish, Wildlife and Parks in Helena. A dictionary was constructed enabling any physical, chemical or biological parameter available to be requested for a particular reach (Fraley et al. 1981). Use of the habitat evaluation methods and their applicability to fisheries and land management situations in the Flathead National Forest were described in Graham et al. (1982) and Fraley and Graham (1982).

Habitat survey transect data were entered into data files on the ICIS 850 computer located at the Montana Department of Fish, Wildlife and Parks Regional Headquarters, Kalispell, Montana. Computer programs (HABFST and SUMMAR) were developed to enter and summarize habitat information by survey section.

Creek: ____________ Transect No.: 1-4 Date: ______ TEMP: Air: ______ Water: ______

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth:																
Substr:																
O.H. Cover:																
Instream Cover:																

Total Wetted Width: ____ Channel Width: ____ Feature: ____ Depth (Maximum): ____ VISUAL STREAMBED: Organic: ____; Fines: ____; Small Gravel: ____

Imbededness: ____ Compaction: Nil L M H D-90: ______ cm Large Gravel: ____; Cobble: ____; Boulder ____

VISUAL COVER: Instream: ______ Bank: ______

Comments: ________________________________

____

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Creek: ____________ Transect No.: 5 Date: ______ TEMP: Air: ______ Water: ______

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth:																
Substr:																
O.H. Cover:																
Instream Cover:																

Total Wetted Width: ____ Channel Width: ____ Feature: ____ Depth (Maximum): ____ VISUAL STREAMBED: Organic: ____; Fines: ____; Small Gravel: ____

Imbededness: ____ Compaction: Nil L M H D-90: ______ cm Large Gravel: ____; Cobble: ____; Boulder ____

FLOOD SIGNS: Type: ______ BANK: Form: ______ VISUAL COVER: Instream: ______ Bank: ______

Ht.: ______ Proc.: ______

BANK MATERIAL: Organic ____% Fine: ____% Sm. grav.: ____%

L. grav: ____% Cobb: ____% Boulder: ____%

Comments: ________________________________

____

Figure 4. Field transect form FMD-J.

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APPENDIX A

Glossary of terminology used in stream habitat surveys. Adapted from British Columbia Ministry of Environment, Resource Analysis Branch.

PREFACE

This glossary is organized with definitions preceded by the year in which they were adopted. Evaluation of some parameters changed one or more times during the four years of study, therefore several definitions may be presented for certain terms.

Many of the parameters described are classified in abundance by Nil, Low, Moderate or High. Where not specifically defined (e.g. stage) these terms should have the following meanings:

Nil	the item is not present, or so seldom as to be irrelevant to any interpretation.
Low	the item is present, but only as a few scattered occurrences or in a single spot.
Moderate	the item occurs in several scattered locations or a few small concentrated zones.
High	the item is frequently present throughout the sample area (reach or point) as continuous cover or frequent zones of occurrence.

GLOSSARY

bank - (1979) the rising ground bordering a stream channel below the level of rooted vegetation and above the normal streambed; designated as right or left facing downstream. (See bank form and bank process). See also Figure 1.

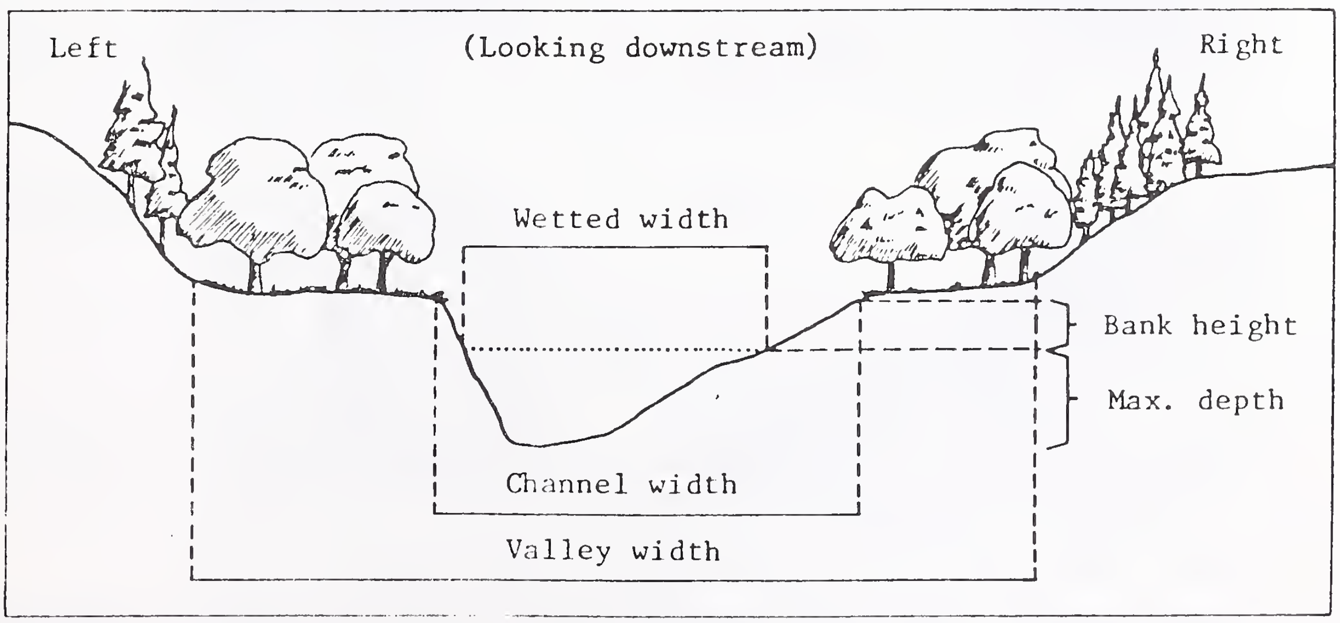


FIGURE 1. Stream Cross section

bank cover - (1982) refers only to percent overhang <1 m above water surface. Sample frequency - every transect.

bank form - (1979) the range of bank forms is arbitrarily separated into four classes which reflect the current state of river processes. Sample frequency - every fifth transect (Figure 2):

F (flat) - the river bed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.

R (repose) - the bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34° - 37°).

S (steep) - the bank is nearly vertical, due to consolidation by cementation, compaction, root structure or some other agent.

U (undercut) - the bank has an undercut structure caused by erosion. When undercut banks are stabilized by vegetation this should be indicated in the comments.

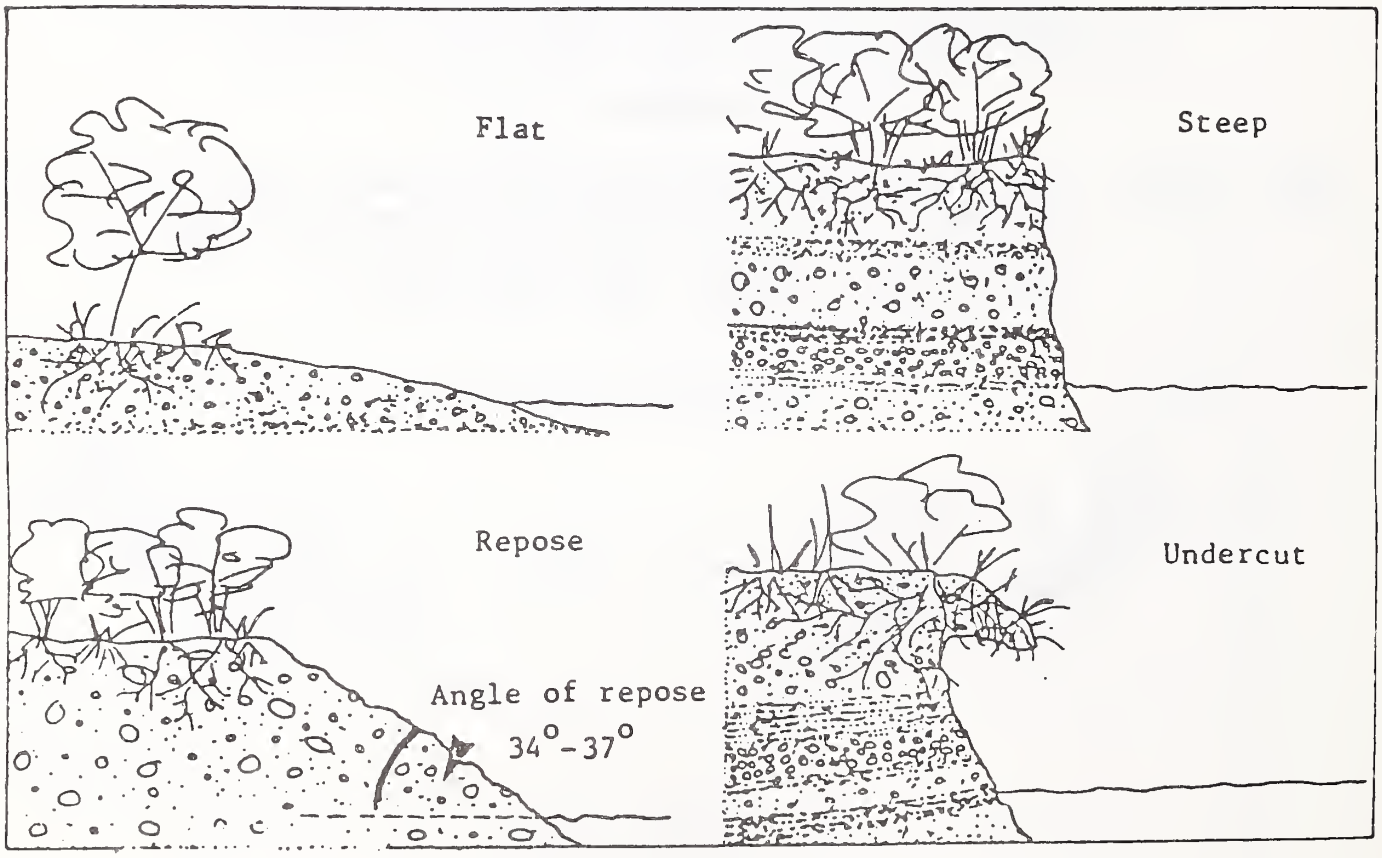


FIGURE 2. Bank Forms

bank process - (1979) the current fluvial process the bank is undergoing. Sample frequency - every fifth transect.

F (failing) - active erosion and slumping is taking place.

S (stable) - the bank is of rock, has very high root density, or is otherwise protected from erosion. Artificially stabilized banks should be noted in the comments.

A (aggrading) - continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank. Common on the inside of meander bends where it may be accompanied by the presence of a range of early to late seral vegetation.

barrier - See Obstruction.

cascade - (1982) a habitat unit consisting of a series of small steps or falls.

channel - (1979) a natural or artificial waterway of perceptible extent which periodically or continuously contains moving water. It has definite bed and banks which normally confine the water, and which display evidence of fluvial processes (See channel width and Figure 1).

channel width - (1979) the width of the channel from rooted vegetation to rooted vegetation. Mean annual high water level should be used in the absence of vegetation. If measured by tape, the width should be given to the nearest 0.1 m (See Figure 1). Sample frequency - every transect.

cover - (1979) anything which projects over the water surface at the time of survey. It is divided into two arbitrary levels; crown cover (>1 m above water surface) and overhang cover (<1 m above water surface). Described in terms of the projected area of water surface covered (% of wetted surface area). Sample frequency - visual average for reach.

(1982) sheltered areas in a wetted stream channel where a trout can rest and hide in order to avoid the impact of the elements or enemies. Instream cover types include aquatic vegetation, logs, debris, large cobbles and boulders, and man-made structures. Overhead cover would include undercut banks, overhanging vegetation 1 m or less above the water surface (bank cover), overhanging understory and overhanging overstory canopy. Sample frequency - 1 m intervals or at a minimum of five equally spaced cells across each transect. Cover types were expressed in terms of percent based on presence/absence data for all transects in the reach. Cover types were coded as follows:

Cover Codes

Instream

Type		Code No.
None		0
Aquatic vegetation		1
Logs	Below water surface	2
Debris	Below water surface	3
Boulders	Below water surface	4
Logs	Above water surface	5
Debris	Above water surface	6
Boulders	Above water surface	7
Man-made structure		8

Overhead

Type	Code No.
None	0
Undercut bank	1
Overhead (<1 m)	2
Understory (1-5 m)	3
Overstory (>5 m)	4

- (1983) turbulence was added as an instream cover type. Logs, debris, and boulders above the water surface (instream cover code numbers 5,6 & 7) were deleted from the list of instream cover types and were recorded as overhead (<1 m) or understory (1-5 m) cover. Cover was recorded as being present only if it provided cover over at least 10% of the surface area of the cell being considered.

compaction - (1979) the relative looseness of bed material with respect to fluvial processes. Caused by sedimentation, mineralization, imbrication or material size. Indicated as nil, low, moderate or high as determined by the relative ease with which a boot can be worked into streambed material. Sample frequency - every transect.

confinement - (1979) the degree to which the river channel is limited in its lateral movement by terraces or valley walls (<u>See</u> Figure 3). Sample frequency - average for reach by visual and maps. The channel is either:

Ent - entrenched - the streambank is in continuous contact (coincident with) valley walls.

Conf - confined - in continuous or repeated contact at the outside of major meander bends.

Fr - frequently confined by the valley wall.

Oc - occasionally confined by the valley wall.

Un - unconfined - not touching the valley wall.

N/A - not applicable (e.g. where no valley wall exists).

debris (channel) - (1979) organic material (primarily logs, limbs, root masses) deposited within the channel; not just in the wetted stream channel at the time of survey. Debris is recorded as being present if it could provide trout cover over at least one tenth of the channel width at bankful flow.

(1982) described as present or absent at 20 sites per km.

debris (floodplain) - (1980) organic material (primarily logs, limbs, root masses) deposited within the floodplain at time of survey. Described as Nil, Low, Moderate or High. (<u>See</u> flood sign). Sample frequency - average for reach taken from helicopter sheets.

debris stability - (1979) debris in the stream channel that has a low probability of being moved out of the area during normal spring runoff. Stable debris is usually embedded in or attached to the streambed or bank and forms a part of the stream's morphologic character.

(1982) Sample frequency - 20 sites per km.

D-90 - (1979) the diameter of bed material which is larger than 90% of the remaining material. Measured by length of intermediate axis. See Figure 4. Sample frequency - every transect.

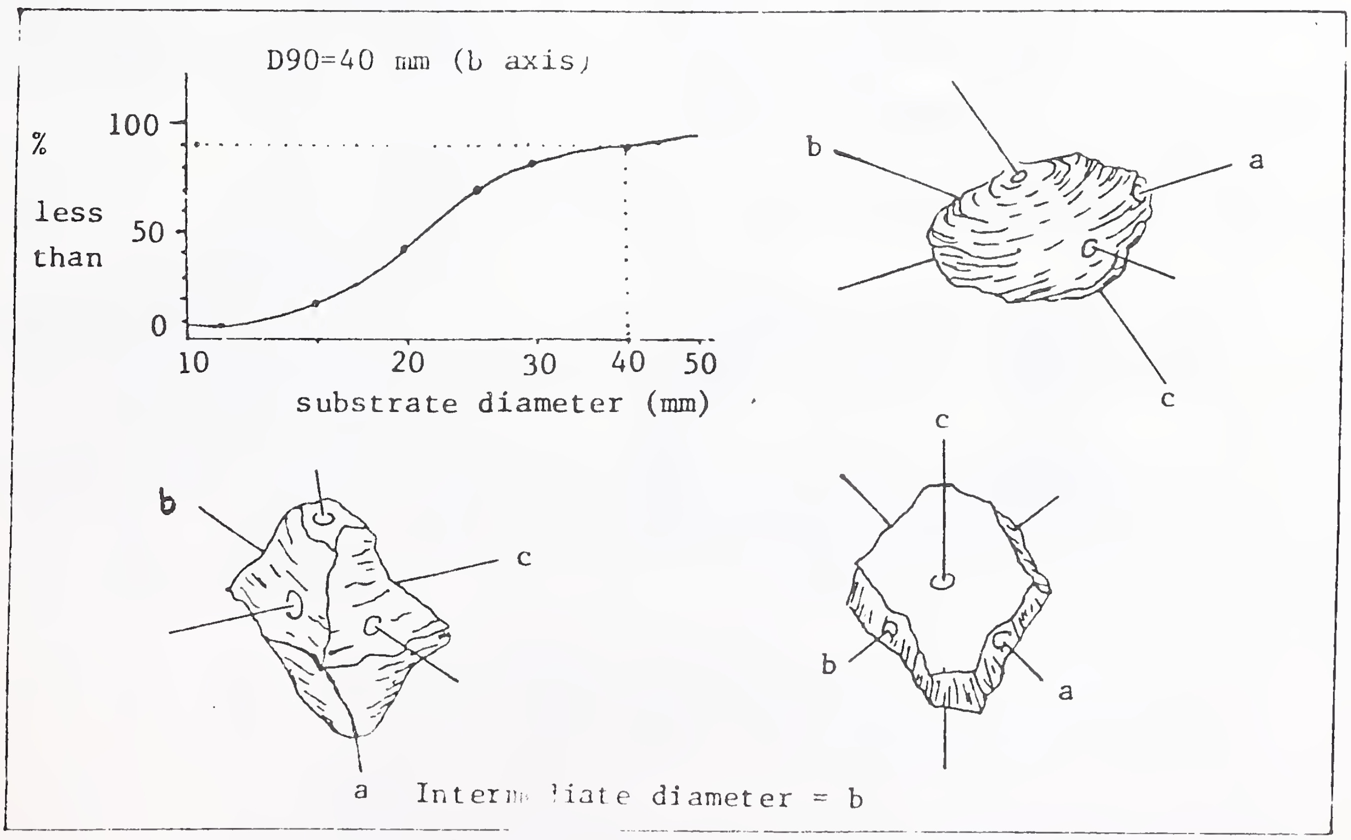


FIGURE 4. D-90 and Intermediate Axis

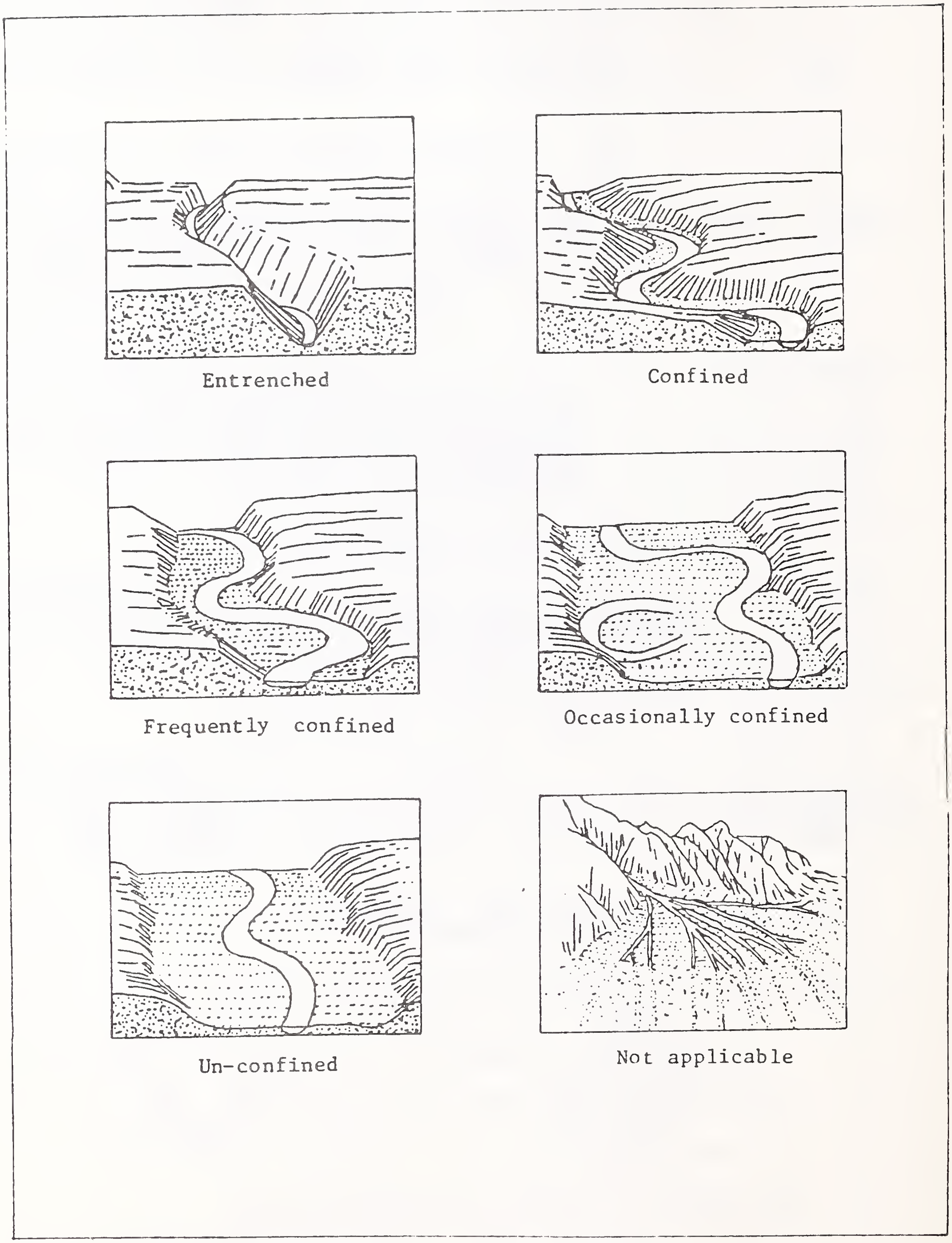


FIGURE 3: Confinement

embeddedness (imbeddedness) - (1979) the degree of filling of the interstitial spaces of a gravel or rubble stream bottom with sand or fines. Estimated as 0 to 25%, 25 to 50% , 50 to 75%, or 75 to 100% embedded. Sample frequency - every transect.

- (1983) the extent to which the predominant-sized particles in the streambed are covered by fine materials (sand & silt). Embeddedness was coded as follows:

Embeddedness	Code No.
Dominant particle size group completely embedded in fines (or nearly so).	1
Three-fourths embedded	2
One-half embedded	3
One-fourth embedded	4
Unembedded	5

entrenchment - (1979) stream channel incision resulting from current fluvial processes. This represents the extreme case of stream confinement. (*See* confinement).

feature - (1979) a specific stream attribute worthy of note. Important stream features would include slumped banks, and barriers or obstructions (such as beaver dams, log jams, chutes, falls) that could possibly hinder upstream fish movement. The location, length and height of important features should be recorded.

flood signs - (1979) evidence of the height of historic flood water levels. Recorded are the "height" above water level at the time of survey and the "type" of evidence such as debris (D), flood channels or bank scour (E), soil profiles (P), mud deposited on trees (M), or historical information (H) such as might be found in newspaper files. Sample frequency - every fifth transect.

flow - (1979) discharge in cfs or cms. Method of measurement and meter type must be indicated. Sample frequency - flow during survey or average low flow.

flow character - (1979) the surface expression of the water that is determined by water velocity and bed material. Sample frequency - 20 sites per km. It is described at the time of survey as:

p - placid - tranquil, sluggish
s - swirling - eddies, boils, swirls
r - rolling - unbroken wave forms numerous
b - broken - standing waves are broken, rapids, numerous hydraulic jumps
t - tumbling - cascades, usually over large boulders or rock outcrops.

genetic material - (1979) materials are classified according to their mode of formation. Specific processes of erosion, transportion, deposition, mass wasting and weathering produce specific types of materials that are characterized chiefly by texture and surface expression. Subsurface layers are noted in a comment. Sample frequency - visual average for reach.

Descriptive terminology:

A Anthropogenic - man-made or man-modified materials; including those associated with mineral exploitation and waste disposal, and excluding archaelogical sites.

C Colluvial- product of mass wastage; materials that have reached their present position by direct, gravity-induced movement (i.e. no agent of transportation involved). Usually angular and poorly sorted.

E Eolian - materials transported and deposited by wind action. Usually silt or fine sand with thin cross-bedding.

F Fluvial - materials transported and deposited by streams and rivers. Usually rounded, sorted into horizontal layers, and poorly compacted.

I Ice - glacier ice.

L Lacustrine - sediments that have settled from suspension of bodies of standing fresh water or that have accumulated at their margins through wave action. May be fine textured with repetitive annual layers (varves).

M Morainal - the material transported beneath, beside, or within and in front of a glacier; deposited directly from the glacier and not modified by any intermediate agent. Usually poorly sorted and angular to sub-angular. May be highly compacted and have significant clay content.

O Organic - materials resulting from vegetative growth, decay and accumulation in and around closed basins or on gentle slopes where the rate of accumulation exceeds that of decay.

R Bedrock - rock outcrop and rock covered by a thin mantle (less than 10 cm) of consolidated materials.

S Saprolite - weathered bedrock, decomposed in situ principally by processes of chemical weathering.

V Volcanic - unconsolidated pyroclastic sediments that occur extensively at the land surface.

W Marine - sediments that have settled from suspension in salt or brackish water bodies or that have accumulated at their margins through shoreline processes such as wave action and longshore drift. Found in coastal areas below 125 m above sea level.

U Undifferentiated - layered sequence of more than three types of genetic material outcropping on a steep, erosional (scarp) slope.

gradient - (1979) Difference in elevation (m) from upper to lower reach breaks divided by length of reach (m) X 100. Calculated from a topographic map. Sample frequency - for entire reach.

habitat unit - (1979a) expression of streams hydrologic nature. Sample frequency - 20 sites per km. Broken into:

pool
riffle
run
glide

(1979b) pool
riffle
run

(1980) pool
riffle
run
pocketwater

(1982) pool
riffle
run
pocketwater
cascade

instream cover - (1982) See cover.

notes - (1979) comments should be made in regards to habitat suitability for spawning westslope cutthroat trout and bull trout; land use activities (logging, grazing, etc.) in the valley flat and proximity to streambanks; uniformity of habitat within reach; etc.

obstruction - (1979) any object or formation that may block or hinder waterflow and/or fish migration identified by helicopter and confirmed by ground crew. Various types are distinguished such as falls, cascade/chutes, beaver dams, culverts, velocity and man-made dams. Height, length and location should be recorded.

(1982) obstructions or barriers are classified as:

Type A: Complete barrier to all fish passage
Type B: Barrier to spawning bull trout
Type C: Possible barrier to all fish passage
Type D: Possible barrier to spawning bull trout.

pattern - (1979) the channel pattern of a reach described in terms of its relative meander curvature (<u>See</u> Figure 5). Sample frequency - average for reach by visual and maps. Classified as follows:

St straight - very little curvature within the reach.
Sin sinuous - slight curvature within a belt of less than approximately two channel widths.
Ir irregular - no repeatable pattern.
Im irregular meander - a repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90°.
Rm regular meanders - characterized by a clearly repeated pattern.
Tm tortuous meanders - a more or less repeated pattern characterized by angles greater than 90°.

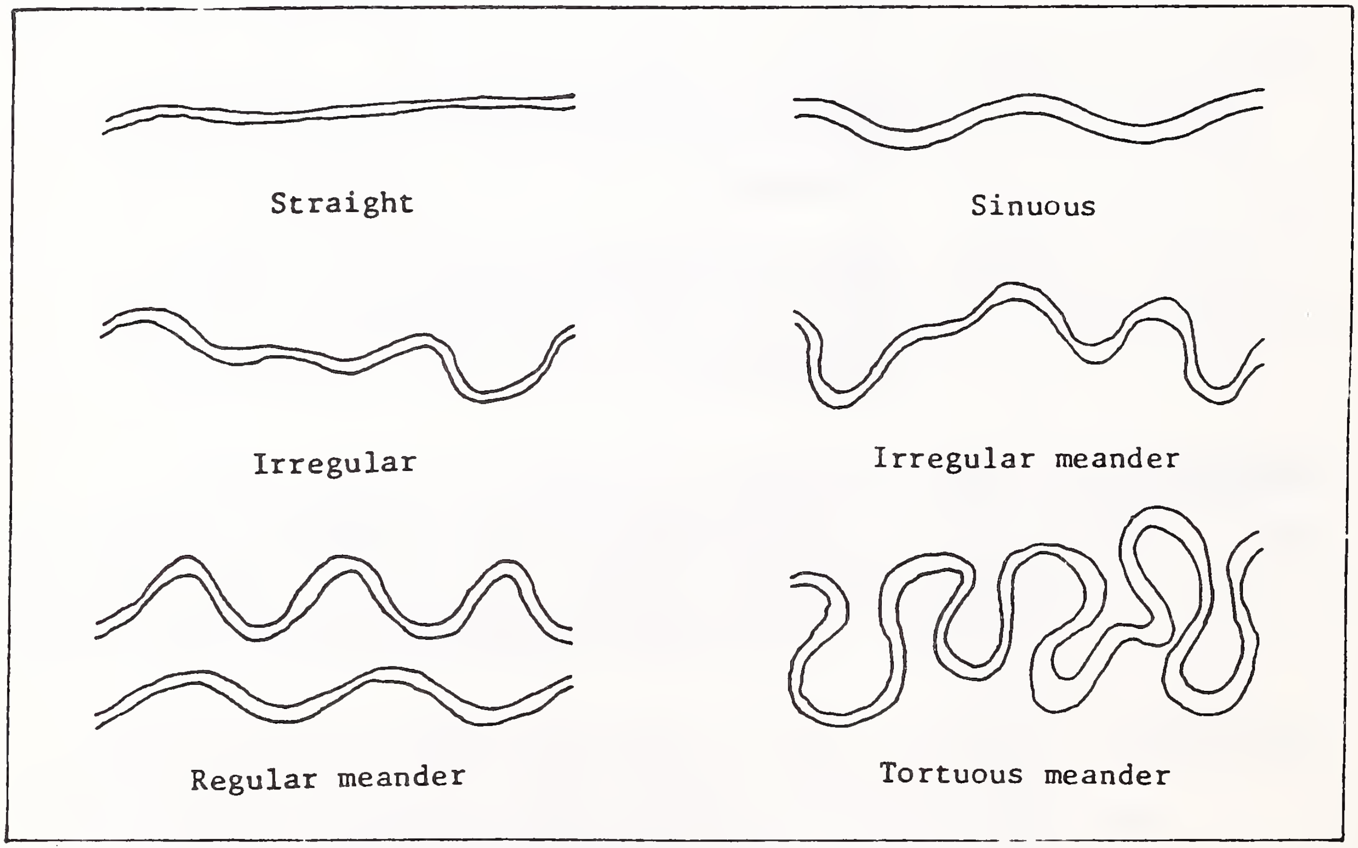


FIGURE 5. Channel Patterns

pocket water - (1980) a habitat unit - typically a run, whose flow is interrupted by boulders creating small turbulent pools or "pockets" which can provide cover for fish. Distinguished from cascade by the absence of small steps or falls.

pool - (1979) a habitat unit of low velocity and deep water relative to the main current.

pool classification - (1979) a classification scheme designed to indicate the value of a pool as fish habitat. Each pool is rated based on the size, depth, and cover. The total score is used to determine pool class. The scoring is as follows:

DEPTH RATING

Depth	Score
Over 3 feet	3
2-3 feet	2
Less than 2 feet	1

COVER RATING

Cover	Score
Abundant	3
Partial	2
Exposed	1

<u>SIZE RATING</u>
(measurement longest axis of pool)

<u>Size</u>	<u>Score</u>
Pool longer or wider than average width of stream	3
Pool as long or wide as average width of stream	2
Pool much shorter or narrower than average width of stream	1

<u>TOTAL SCORE</u>	<u>POOL CLASS</u>
8 or 9	I
7	II
5* or 6	III**

*A total score of 5 must include 2 points for depth and two points for cover.

**Pools that score less than Class III are recorded as "unclassified" or as "pocket water".

reach - (1979) a segment of a stream which has a distinct association of physical habitat characteristics. Gradient is an important factor in reach delineation. Streams are divided into reaches by aerial observer.

reach length - (1979) distance in km from lower to upper reach break. Measured on topographic map.

reach number - (1979) reaches are numbered sequentially upstream from the mouth (1,2,...n).

riffle - (1979) a habitat unit with shallow, fast moving water where the surface is turbulent and broken.

run - (1979) a habitat unit of medium velocity water with surface not turbulent to the extent of being broken. Intermediate between pool and riffle.

scour - (1979) substrate size, angularity and brightness indicate amount of scour or deposition along channel bottom. Described as Nil, Low, Moderate or High. Sample frequency - visual average for reach.

serial number - (1981) this number will be controlled by regional or state office or agency entering information.

side channel - (1979) a channel connected to the main channel that is usually less than one fourth of the average main channel width. Side channels typically have lower velocity flows (frequently placid) and smaller substrate (small gravel, fines, and detritus) than does the main channel. Described as present or absent at 20 sites per km.

split channel - (1982) channel divisions that do not differ significantly from the main channel in terms of current velocity or substrate type. Described as present or absent at 20 sites per km.

stage - (1979) the relative water level at the time of survey inferred from evidence of flow in bank and bed. Sample frequency - visual average for reach. The categories usedare dry, low, moderate, high and flood:

Dry - water not present or only as unconnected pools.
Low - water flowing as thread(s) within the channel; most bed material exposed.
Moderate - water flowing throughout the normal bed and in contact with lower portions of banks. Some bars are exposed; sand and small gravel sized bed material is in motion.
High - water flowing throughout the normal bed and in contact with middle to upper portions of banks; most bars are submerged; gravel and cobble. Sized bed material is in motion.
Flood - water bank full or over banks and into floodplain; maximum rates of bed material transport.

stability rating - (1980) nine ratings of bank stability combined with six ratings of bed stability for a stream reach. U.S. Forest Service stability evaluation field forms were used. Sample frequency - average for reach.

stream order - (1979) a number assigned to a stream based on its location in the drainage. Any unforked channel which appears on USGS maps is a first order drainage. Two first order streams meet to form a second order stream, and so on.

substrate composition - (1979) the assemblage of sizes of material in banks and bed. Sample frequency - every transect. Described according to the following:

	Code
Organic - material derived from animals or vegetation.	1
Fines - < 2.0 mm	2
Gravel - small - 2-16 mm; large - 16-64 mm	3,4
Cobble - 64-256 mm	5
Boulders - > 256 mm	6
Bedrock	

- (1982) the dominant and subdominant substrate types were recorded for each cell at 1 m intervals (or at a minimum of five equally spaced cells) across each transect. The percent composition of each substrate size class within the stream reach was calculated as the number of occurrences of a particular size class as either a dominant or subdominant type, divided by two times the number of measurement cells.

turbidity - (1979) described as Nil, Low, Moderate or High. Sample frequency - visual average for reach.

valley:channel ratio - (1979) $\frac{\text{mean valley width}}{\text{mean channel width}}$
Sample frequency - average for reach.

valley flat - (1979) the area of a valley bottom which may flood, including low terraces. Relic terraces which cannot be flooded by the present river are excluded from the valley flat. See Figure 6. Estimated mean width by aerial observer or from USGS maps.

valley wall - (1979) the remainder of the valley slope above the valley flat and relic terraces. In some cases such as on fans or deltas, there may be no valley wall. See Figure 6.

vertical stability - (1979) an indication of the net effect over a long time period of processes of deposition or scour of the streambed. Described as degrading (Deg), aggrading (Agr) or not obvious (?). Sample frequency - visual average for reach.

water chemistry - (1981) chemical parameters and ratings, optional.

water code - State of Montana Department of Fish, Wildlife and Parks code number for stream in question.

wetted width - the width of water surface at the point sample cross-section. Sample frequency - every transect.

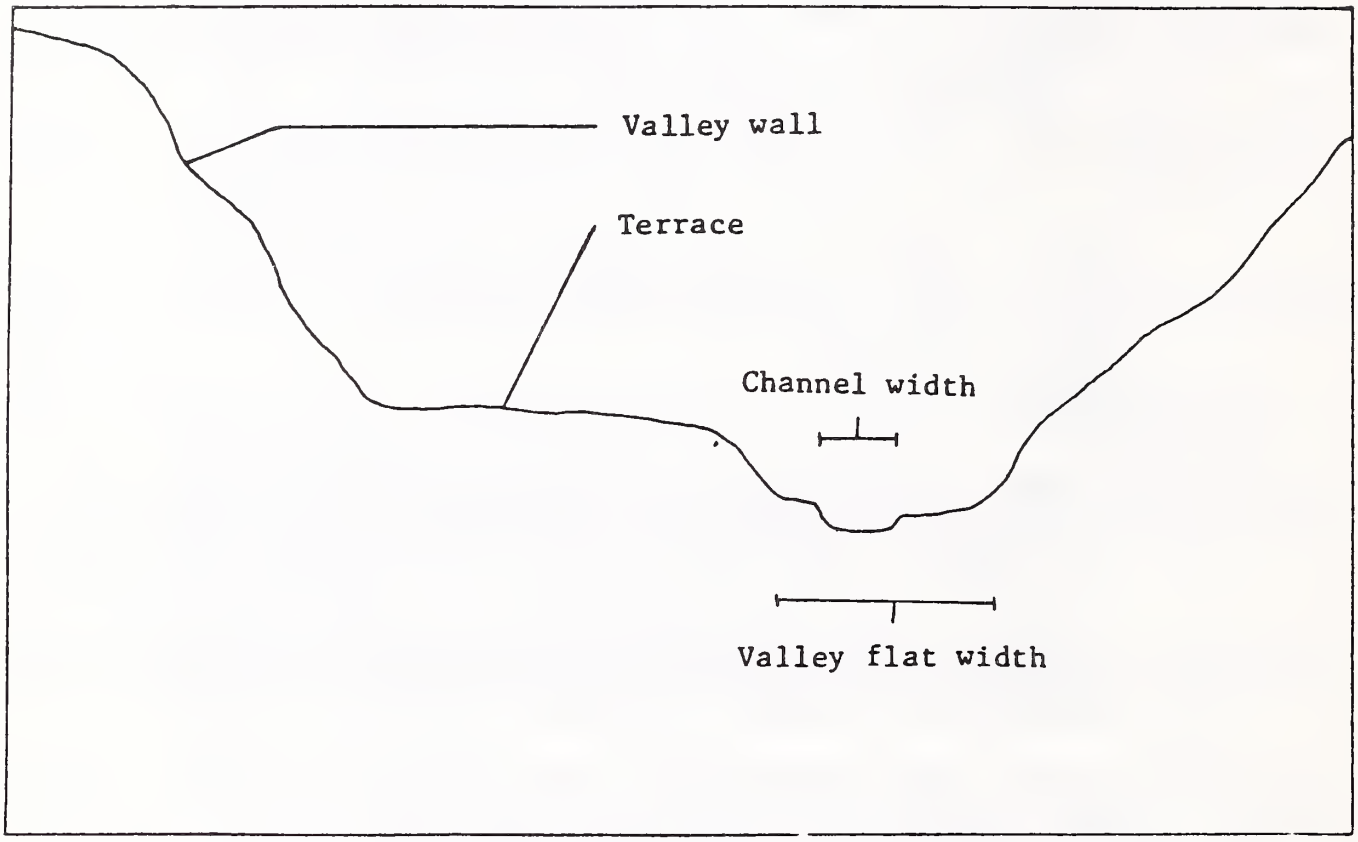


FIGURE 6. Valley Profile

APPENDIX B

Data entry format and explanation for the Interagency Stream Fishery Data Input Form (for cards 1-38 Format, instructions and example forms for additional cards 30 through 38).

INTERAGENCY STREAM FISHERY DATA INPUT
FORM INSTRUCTIONS FOR DATA ENTRY CARDS 1-22

CARD 1:

Serial Number: This number will be controlled by regional or state office or agency entering information.

State: The code for Montana is 30.

Hydrologic Unit Code: This entry designates the drainage. Regional and state office of each agency have these codes.

Stream Order: A numerical class identification assigned to a tributary based on its location in the drainage. Two first order streams meet to form a second order stream, etc.

State Water Code and Water Type: State water code and water type are obtained from a list furnished by the Montana Department of Fish, Wildlife and Parks. Stream water type codes are 01 to 19, with 19 being a stream unable to sustain a population of fish.

Reach: Portion of a stream with a distinct association of physical habitat characteristics. Gradient is the major factor in reach delineation.

Reach Number: The reaches are numbered consecutively from the mouth, up the stream.

CARD 2 AND 3:

Reach Boundaries: Brief description of upper and lower boundaries and map coordinates for these boundaries.

Elevation: Upper and lower elevation of reach boundaries in meters.

Average Wetted Width: Average of measurements from one water's edge to the other, taken at random intervals within the habitat section.

Tributary To: USGS map name of stream or river into which the study stream converges.

County: All Flathead County streams are 029.

CARD 5:

Fish and Game Region: All Flathead County streams are in Region One.

Percent Pocket Water: A series of small pools that do not classify as pools individually, but in combination create fish habitat. Pocket waters are usually found in boulder or cascade areas.

Ingress: Legal availability of public access to the stream.

CARD 8:

Flow During Survey. The instream flow (m^3/sec) during the survey and the date of observation.

Normal Low Flow: Lowest flow expected during an average year from past records or as can be estimated. Note: This is not the historic low flow.

Valley Flat: The area of a valley bottom which may flood, including low terraces. Relic terraces which cannot be flooded by the present river are excluded from the valley flat.

Channel Width: The width of the channel from rooted vegetation to rooted vegetation.

Average Maximum Pool Depth: The maximum depth measured in the deepest pool in the habitat section.

Gradient (%): $\frac{\text{Difference in elevation (meters) from upper to lower end of reach}}{\text{Length of reach (meters)}}$

This is usually measured with a clinometer or is calculated from a topographic map.

Pool-Run-Riffle Ratio: The estimated percent of each type, for a portion of the stream at low water. In combination with pocket water, equals 100%.

Pool - Usually deeper, quiet water, although pools may be at the base of falls.

Run - Moderately moving water with the surface not turbulent to the extent of being broken. Intermediate between pool and riffle.

Riffle - Shallow, fast moving water where the surface is turbulent and broken.

CARD 9 AND 10:

Bottom Type: Entered under Run. Percent make-up of bottom substrate (the bed material).

Average Peak Water Temperature: The highest water temperature measured during the summer.

Spring Creek: A spring creek or spring stream is identified by its fairly constant temperature, flow and clear water. Watercress will often be present.

Affected by Lake: When lake or impoundment significantly affects water temperature, flow pattern, fish food, or fish runs within the reach or stream.

Inundated by Beaver Ponds: The percent of the reach length presently impounded by beaver ponds is entered.

D-90: The diameter of bed material which is larger than 90 percent of the remaining material. Measured by length of intermediate axis.

Total Alkalinity and Specific Conductance: Alkalinity and conductivity values are measured at the lower end of individual drainages during the low flow period.

Floating: Recreational use by boaters.

Special Value: Importance as a trout recruitment stream.

CARD 11:

Channel Stability Rating Elements: Nine ratings of bank stability combined with six ratings of bed material for a stream reach. U.S. Forest Service stability evaluation field forms were used.

Pool Classes: The percentage of the pools in the reach in each pool class. Total = 100 percent. Pool classes are determined as follows:

Size: Measurements refer to the longest axis of the intersected pool.

3 - pool larger or wider than average width of stream
2 - pool as wide or long as average stream width
1 - pool much shorter and narrower than average stream width.

Depth Ratings	Cover Ratings
3 - Over 3 feet	3 - Abundant cover
2 - 2-3 feet	2 - Partial cover
1 - Under 2 feet	1 - Exposed

Total Ratings	Pool Class
8-9	1
7	2
5-6*	3
4-5	4
3	5

*Sum of 5 must include 2 for depth and 2 for cover.

Habitat Value for Fishes of Special Concern: A judgement value of habitat for spawning and production of westslope cutthroat.

Fish Population: List of game fish species present, their abundance and dominant use.

CARD 19:

Imbeddedness: The filling of the interstitial spaces of a gravel or rubble stream bottom with sand or fines.

Habitat Trend: All man-caused activities in or adjacent to the stream as well as dynamic natural processes.

Esthetic: Description of the pristine qualities of the reach.

CARD 20:

Channel Alterations: Cause, type, and length of artificial and natural changes occurring in the stream channel.

Bank Encroachment: Description of structure or activities that interfere with natural stream or floodplain hydraulics.

CARD 21:

Data Source: Month, year, field person, and agency to be contacted concerning data and agency.

CARD 22:

Information on the reach not contained on other cards.

ADDITIONAL INFORMATION:

Parameters were rated based on the following criteria:

1-3 means the data rated were based on judgement estimates.

4-6 means the data rated were based on limited measurements.

7-9 means the data rated were based on extensive measurements.

INTERAGENCY STREAM FISHERY DATA INPUT
FORM INSTRUCTIONS FOR DATA ENTRY CARDS 30-38

Cards 30-35 are optional, but any module that has entries must be complete, i.e., species (codes) and densities must be filled out.

CARD 30 - POOLS

Column 6-7: Method of estimating (see code sheets on page B8 for method abbreviations)

Column 8: Rating, enter 1-9

Column 9-11: Enter species code (enter 3 digit number) (012)

Columns 12-27: Enter density (0-999.9) per 100 m^2 for each age class

Columns 28-30: Enter species code (005)

Columns 31-46: Enter densities (0-999.9) per 100 m^2 for each age class

Columns 47-49: Species code (085)

Columns 50-57: Densities (0-999.9) per 100 m^2

If a species is not present, leave species code and density columns blank.

CARD 31 - 34 - RUNS, RIFFLES, POCKET WATER, COMBINED FEATURES

Same as Card 30

CARD 35

Same as Card 30 except enter Biomass (g/100 m^2) (0-999.9) instead of density.

CARD 36

Option, but any module that has entries must be complete, i.e., number, density, year and rating must be filled out.

Columns 6-8: Number of bull trout redds in reach, enter 0-999

Columns 9-11: Density of redds (no/km) (0-99.9)

Columns 12-13: Year of redd survey (1950 to 1980)

Columns 14: Rating 1-9

Sequence repeated through column 41.

CARD 37 - ADDITIONAL PHYSICAL HABITAT DATA

Columns 6-8: Average depth (0-999 cm)

Column 9: Rating (1-9)

Columns 10-11: Percent cover, overhang (0-99 or blank)

Columns 12-13: Percent canopy (0-99 or blank)

Column 14: Rating (1-9)

Columns 15-17: Wetted cross sectional area (m^2) .1-99.9

Column 18: Rating (1-9)

Columns 12-25: Drainage area (1-999999.9 or blank)

Column 26: Rating (1-9)

Column 27: Barrier Type (see code sheet for abbreviations)

Columns 28-31: Barriers (0-999.9 or blank)

Column 32: Rating (1-9)

Columns 33-42: Percent cover in features (0-99, or blank)

Column 43: Rating (1-9)

Columns 44-46: Blank

Columns 47-48: Flow characteristics (see code sheet for abbreviations, Alpha code - dominant in Col. 48)

Column 49: Blank

Columns 50-51: Valley - channel ratio (1-99)

Column 52: Rating (1-9)

Column 53: Confinement (see code abbreviations)

Column 54: Pattern (see code abbreviations)

Column 55: Floodplain debris - N L M H

Column 56: Channel debris - N L M H

Columns 57-59: Percent of stable debris (0-100)

Column 60: Rating (1-9)

Column 61: Bank Form (see code abbreviations)

Column 62: Bank Process (see code abbreviations)

Column 63: Type of Genetic Material (see code abbreviations)

Column 64: Rating (1-9)

CARD 38 - OPTIONAL

Chemical parameters and ratings, optional, all can be blank

Lines 6-9: Total Carbon (.01-9.99) Rating 1-9

Lines 10-13: Total Phosphorous (.001-.999) Rating 1-9

Lines 14-17: No_3 - (.01-9.99) Rating 1-9

Lines 18-21: SO_4 - 2 (.1-99.9) Rating 1-9

Lines 22-25: Na^+ (.1-99.9) Rating 1-9

Lines 26-29: K^+ (.01-9.99) Rating 1-9

Lines 30-33: Ca^{+2} (.1-99.9) Rating 1-9

Lines 34-37: Mg^{+2} (.1-99.9) Rating 1-9

Line 38: Turbidity - N L M H, (Nil, Low, Moderate, High)

CODE ABBREVIATIONS

METHOD OF OBTAINING FISH ABUNDANCE INFORMATION

A two letter code was used to identify the method for obtaining fish information. The first letter identifies the Method used to collect the information and the second letter identifies the Estimator used.

METHOD

1st Letter	Electrofishing
B:	Boat electrofishing with boom
M:	Boat electrofishing with mobile anode
S:	Bank electrofishing
P:	Backpack electrofishing
	Observation
U:	Underwater observation (snorkel)
I:	Above water observation
	Nets
W:	Weirs
J:	Trammel net
L:	Trap-type net without leads
N:	Trap-type net with leads
O:	Purse seine
Q:	Beach seine
T:	Trawl
V:	Vertical gill net
F:	Floating gill net
G:	Sinking gill net
D:	Drift net
	Other
K:	Creel
H:	Hydroacoustic
C:	Chemical
E:	Explosives
R:	Dewatering
Z:	Hand capture
A:	Angling

ESTIMATOR

2nd Letter	
T:	Two-pass
P:	Peterson mark-recapture
Z:	Zippin
S:	Schnable mark-recapture
C:	Catch per unit effort
N:	Total catch
U:	Unknown
D:	Density

FLOW CHARACTERISTICS

P: Placid - Tranquil, Sluggish
S: Swirling - Eddies, Boils, Swirls
R: Rolling - Unbroken wave forms numerous
B: Broken - Standing waves are broken, rapids, numerous hydraulic jumps
T: Tumbling - Cascades, usually over large boulders or rock outcrops

BARRIER TYPES

A: Complete barrier to all fish passage
B: Barrier to spawning bulls
C: Possible barrier to all fish passage
D: Possible barrier to spawning bulls

CONFINEMENT

Confinement (R) - the degree to which the river channel is limited in its lateral movement by terraces or valley walls. The channel is either:

E:	Ent	Entrenched - The streambank is in continuous contact (coincident with) valley walls.
C:	Conf	Confined - In continuous or repeated contact at the outside of major meander bends.
F:	Fr	Frequently confined by the valley wall.
X:	Oc	Occasionally confined by the valley wall.
U:	Un	Unconfined - not touching the valley wall.
N:	N/A	Not applicable (e.g. where no valley wall exists).

Confinement Classification

Entrenched

Confined

PATTERN

Pattern (R) - The channel pattern for the reach is described in terms of curvature. The channel is either:

S:	St	Straight - Very little curvature within the reach.
N:	Sin	Sinuous - Slight curvature within a belt of less than approximately two channel widths.

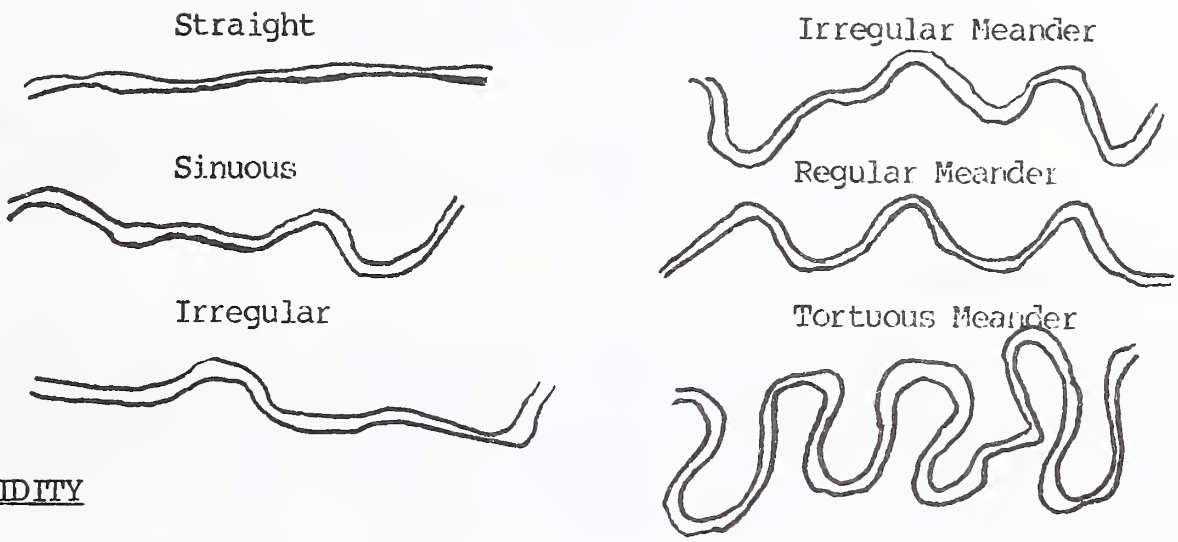
P: Ir — Irregular - No repeatable pattern.

C: Im — Irregular Meander - A repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90°.

R: Rm — Regular Meanders - Characterized by a clearly repeated pattern.

T: Tm — Tortuous Meanders - A more or less repeated pattern characterized by angles greater than 90°.

<u>Typical Meander Patterns</u>



TURBIDITY

H: High
L: Low
M: Moderate
N: Nil

BANK PROCESS (P)

The current fluvial process the bank is undergoing.

F: Failing - Active erosion and slumping is taking place.

S: Stable - The bank is composed of rock and has a very high root density, or is otherwise protected from erosion. Artificially stabilized banks should be noted in the comments.

A: Aggrading - Continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank. Common on the inside of meander bends where it may be accompanied by the presence of a range of early to late seral vegetation.

BANK FORM

The range of bank forms is arbitrarily separated into four classes which reflect the current state of river processes. These are:

F: Flat - The riverbed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.

R: Repose - The bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34° - 37°).

S: Steep - The bank is nearly vertical, due to consolidation by cementation, compaction, root structure, or some other agent.

U: Undercut - The bank has an undercut structure caused by erosion. When undercut banks are stabilized by vegetation this should be indicated in the comments.

GENETIC MATERIALS (P)

Materials are classified according to their mode of formation. Specific processes of erosion, transportation, deposition, mass wasting and weathering produce specific types of materials that are characterized chiefly by texture and surface expression. For added detail, consult the Terrain Classification Manual (ELUC - Sec. 1976). Subsurface layers are noted in a comment. Descriptive terminology:

A: Anthropogenic - Man-made or man-modified materials; including those associated with mineral exploitation and waste disposal, and excluding archaeological sites.

C: Colluvial - Product of mass wastage; minerals that have reached their present position by direct, gravity-induced movement (i.e. no agent of transportation involved). Usually angular and poorly sorted.

E: Eolian - Materials transported and deposited by wind action. Usually silt or fine sand with thin cross-bedding.

F: Fluvial - Materials transported and deposited by streams and rivers. Usually rounded, sorted into horizontal layers, and poorly compacted.

K: Ice - Glacier ice.

L: Lacustrine - Sediments that have settled from suspension in bodies of standing fresh water or that have accumulated at their margins through wave action. May be fine textured with repetitive annual layers (varves).

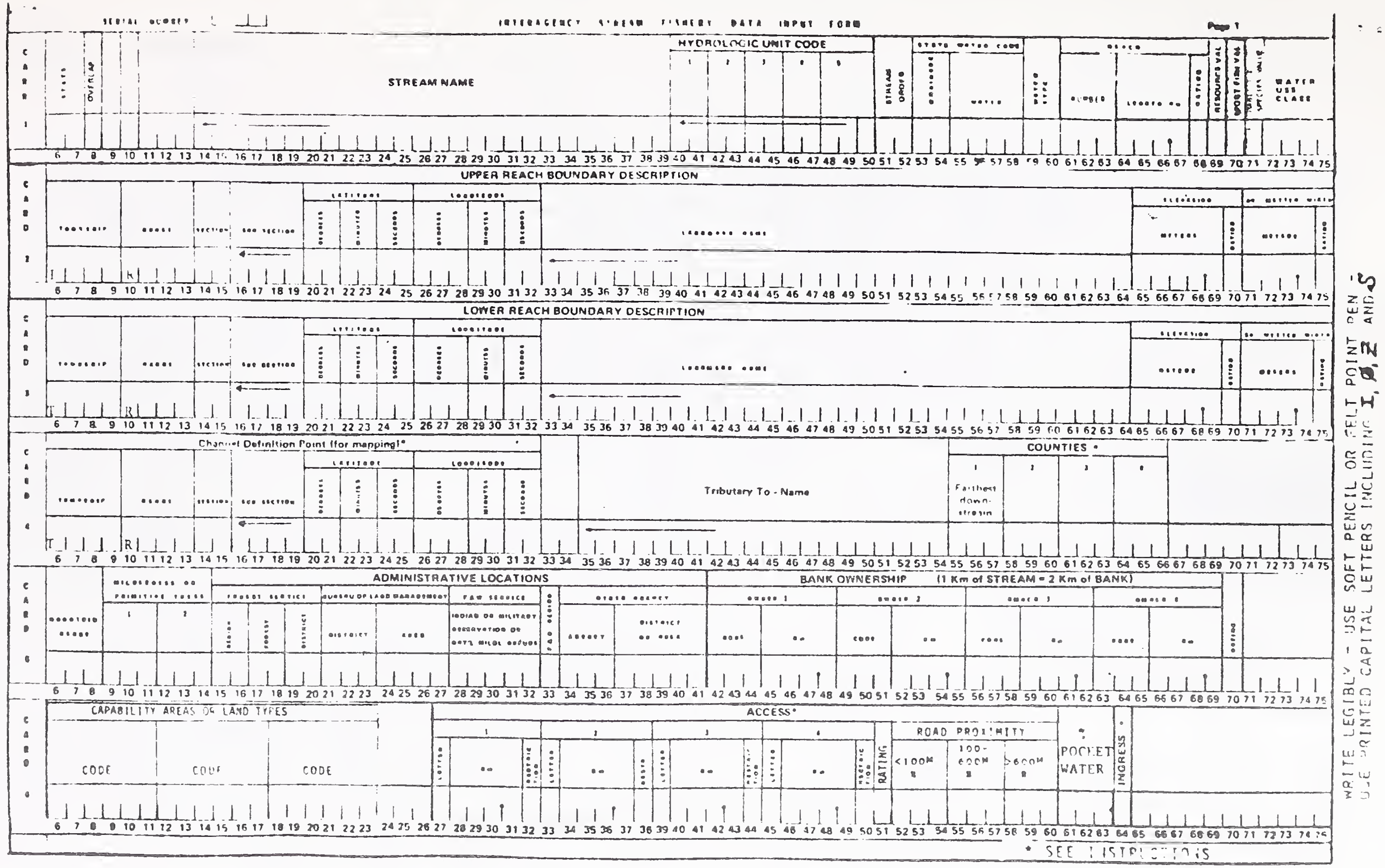


Figure 1. Interagency Stream Fishery Input Data Form.

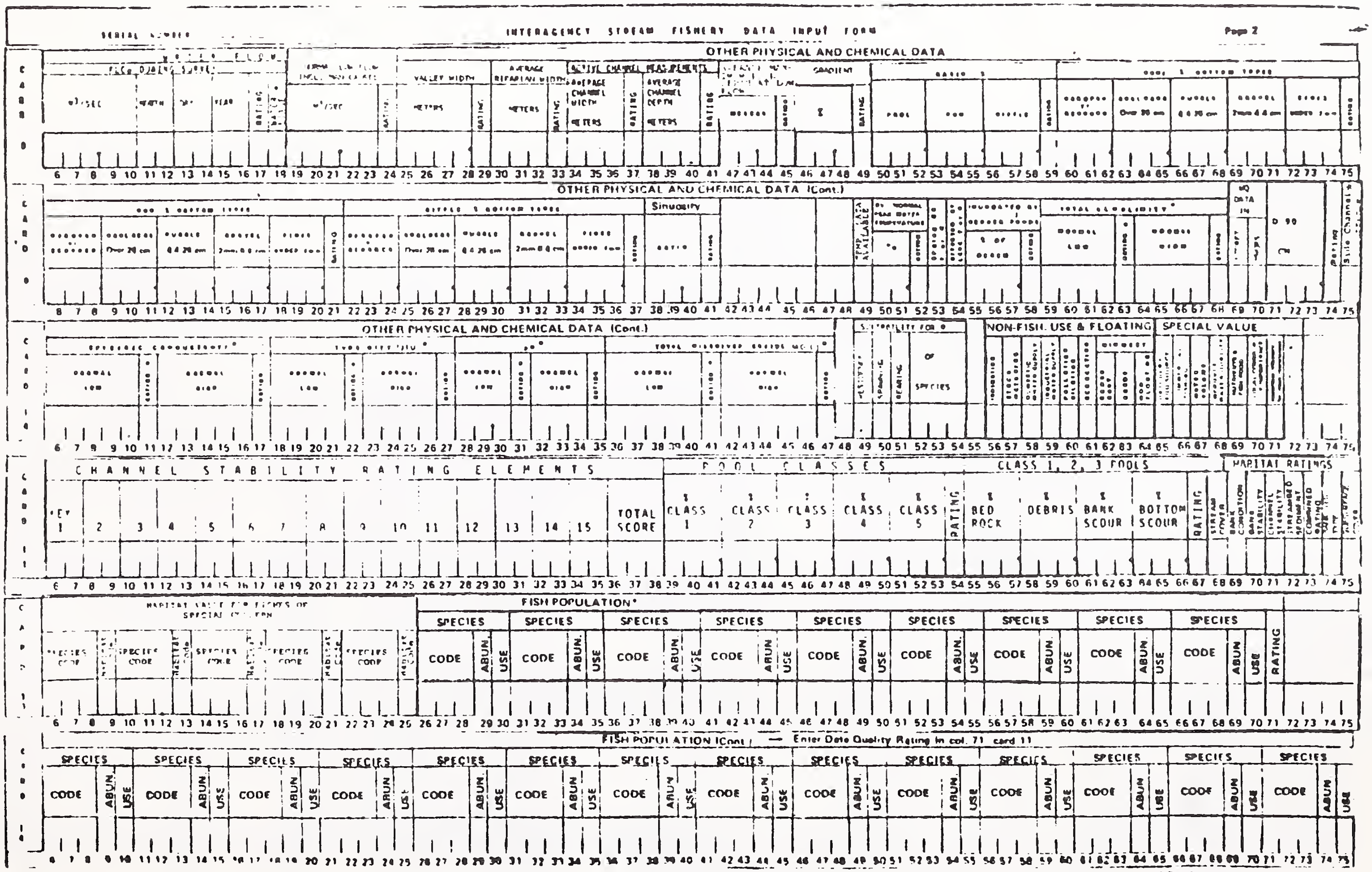


Figure 1. (Continued).

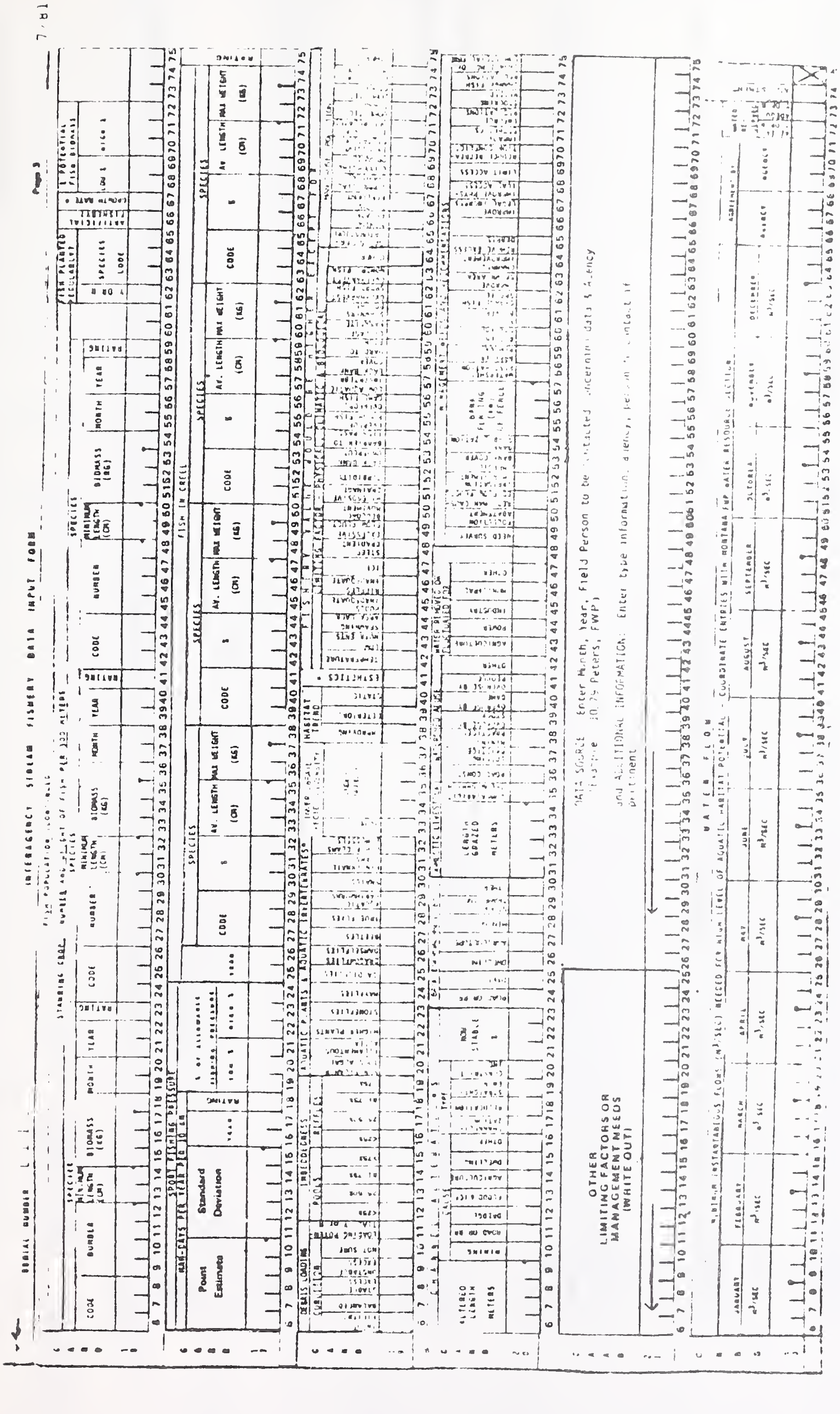


Figure 1. (Continued).

CARD 1

This card need be filled out ONLY if card 22(s) below are submitted at a different time than the first three pages of the input form.

IDENTIFYING NUMBER

STATE WATER CODE

DRAINAGE | WATER

REACH NUMBER

CARD NO. 22 — ADDITIONAL INFORMATION

CARD NO. 22 — ADDITIONAL INFORMATION

CARD NO. 22 — ADDITIONAL INFORMATION

CARD NO. 22 — ADDITIONAL INFORMATION

CARD NO. 22 — ADDITIONAL INFORMATION

Figure 1. (Continued).

Card 30 — Fish Densities (No./100M^2) (Pools)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	<150mm	>150mm	
6	7	8	9 10 11	12 13 14 15	16 17 18 19	20 21 22 23	24 25 26 27	28 29 30 31	32 33 34	35 36 37 38	39 40 41 42	43 44 45 46	47 48 49	50 51 52 53	54 55 56 57	58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

Card 31 — (Runs)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	<150mm	>150mm	

Card 32 — (Riffles)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	<150mm	>150mm	

Card 33 — (Pocket Water)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	<150mm	>150mm	

Card 34 — (All Features Combined) (Density)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	< 150mm	> 150mm	

Card 35 — (g/100M2) (Fish Biomass, All Features Comb.)

Method	Rating	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	Age 0	Age I	Age II	Age+ III	Species Code	<150mm	>150mm	

Card column numbers (each card): 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

Figure 1. (Continued).

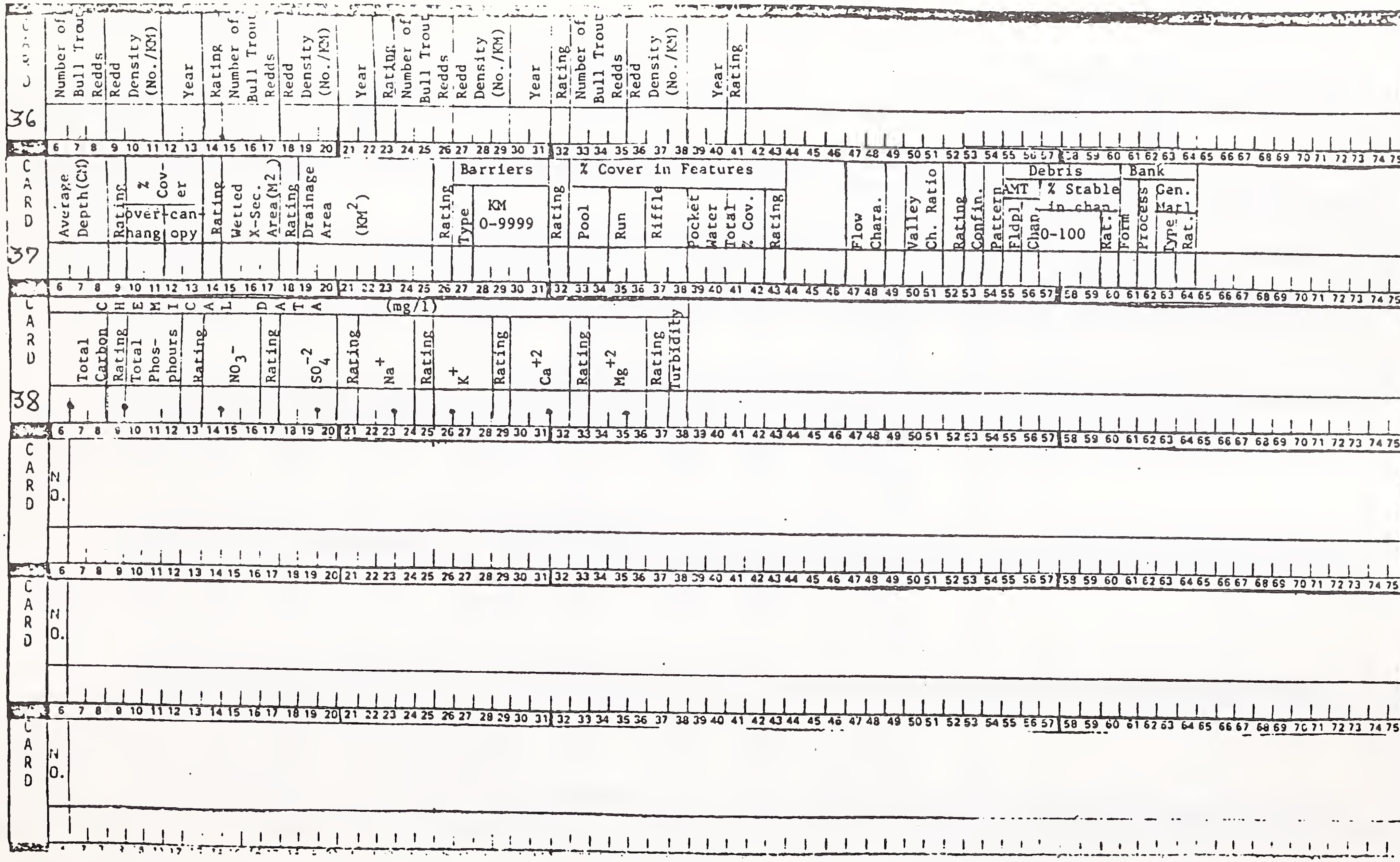


Figure 1. (Continued).

APPENDIX B

Lengths of hydroacoustic sample transects, cross-sectional area of each depth strata covered by the 10^{o} cone width, and volume of water sampled by depth strata for hydroacoustic transects sampled in Libby Reservoir during August, 1984.

Appendix B1. Lengths and volumes across 38 hydroacoustic transects in Libby Reservoir sampled during August 1984.

Area Transect	Length[1/] (m)	Total Volume (Area x length) by depth interval (m^3 x 100) 0-10	10-20	20-30	30-40	40-50	50-60	60-70
Tenmile								
	area(M^2)	8.75	26.25	43.75	61.25	78.75	96.25	113.75
1	2024	177.1	531.3	885.5	1239.7	1593.9	1948.1	2302.3
2	1982	173.4	520.3	867.1	1214.0	1560.8	1907.7	2254.5
3	1966	172.0	516.1	860.1	1214.2	1548.2	1892.3	2236.3
4	2016	176.4	529.2	882.0	1234.8	1587.6	1940.4	2293.2
5	2212	193.5	580.6	967.7	1354.8	1741.9	2129.0	2516.1
6	2358	206.3	619.0	1031.6	1444.3	1856.9	2269.6	2682.2
7	2200	192.5	577.5	962.5	1347.5	1732.5	2117.5	2502.5
8	2205	192.9	578.8	964.7	1350.6	1736.4	2122.3	2508.2
9	2913	254.9	764.7	1274.4	1784.2	2294.0	2803.8	3313.5
10	1846	161.5	484.6	807.6	1130.7	1453.7	1776.8	2099.8
Peck Gulch								
11	1495	130.8	392.4	654.1	915.7	1177.3	1438.9	1700.6
12	1768	154.7	464.1	773.5	1082.9	1392.3	1701.7	2011.1
13	1457	127.5	382.5	637.4	892.4	1147.4	1402.4	1657.3
14	1724	150.8	452.5	754.2	1055.9	1357.6	1659.3	1961.0
15	2180	190.7	572.2	953.7	1335.2	1716.7	2098.2	2479.7
16	1888	165.2	495.6	826.0	1156.4	1486.8	1817.2	2147.6
17	1489	130.3	390.9	651.4	912.0	1172.6	1433.2	1693.7
18	754	66.0	197.9	329.9	461.8	593.8	725.7	857.7
19	1161	101.6	304.8	507.9	711.1	914.3	1117.5	1320.6
20	554	48.5	145.4	242.4	339.3	436.3	533.2	630.2
Rexford								
21	1850	161.9	485.6	809.4	1133.1	1456.9	1780.6	2104.4
22	728	63.7	191.1	318.5	445.9	573.3	700.7	828.1
23	2207	193.1	579.3	965.6	1351.8	1738.0	2124.2	2510.5
24	1518	132.8	398.5	664.1	929.8	1195.4	1461.1	1726.7
25	3056	267.4	802.2	1337.0	1871.8	2406.6	2941.4	3476.2
26	1943	170.0	510.0	850.1	1190.1	1530.1	1870.1	2210.2
27	1947	170.4	511.1	851.8	1192.5	1533.3	1874.0	2214.7
28	1619	141.7	425.0	708.3	991.6	1275.0	1558.3	1841.6
29	3315	290.1	870.2	1450.3	2030.4	2610.6	3190.7	3770.8
30	3441	301.1	903.3	1505.4	2107.6	2709.8	3311.9	3914.1
Canada								
31	1023	89.5	268.5	447.6	626.6			
32	1159	101.4	304.2	507.1	709.9			
33	2541	222.3	667.0	1111.7	1556.4			
34	3439	300.9	902.7	1504.6	2106.4			
35	909	79.5	238.6	397.7	556.8			
36	3661	320.3	961.0	1601.7	2242.4			
37	3203	280.3	840.8	1401.3	1961.8			
38	2094	183.2	549.7	916.1	1282.6			
TOTAL	76.1 km							

1/ Based on boat speed & time corrected using known distance transects.

APPENDIX C

Temperature, pH, dissolved oxygen, and conductivity profiles in Libby Reservoir during 1983 and 1984.

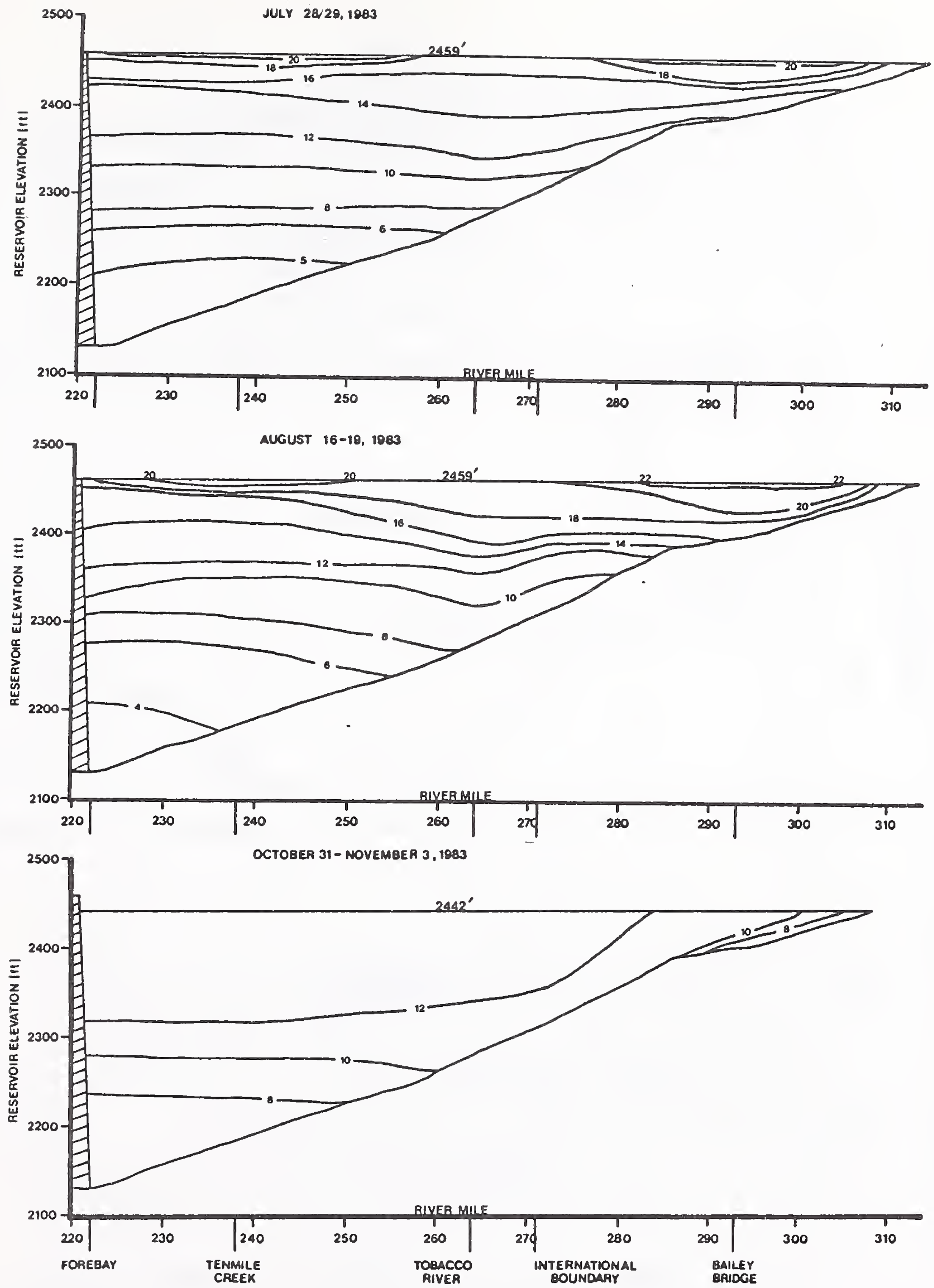


Figure C1. Temperature isopleths in Libby Reservoir in July, August, and October-November, 1984.

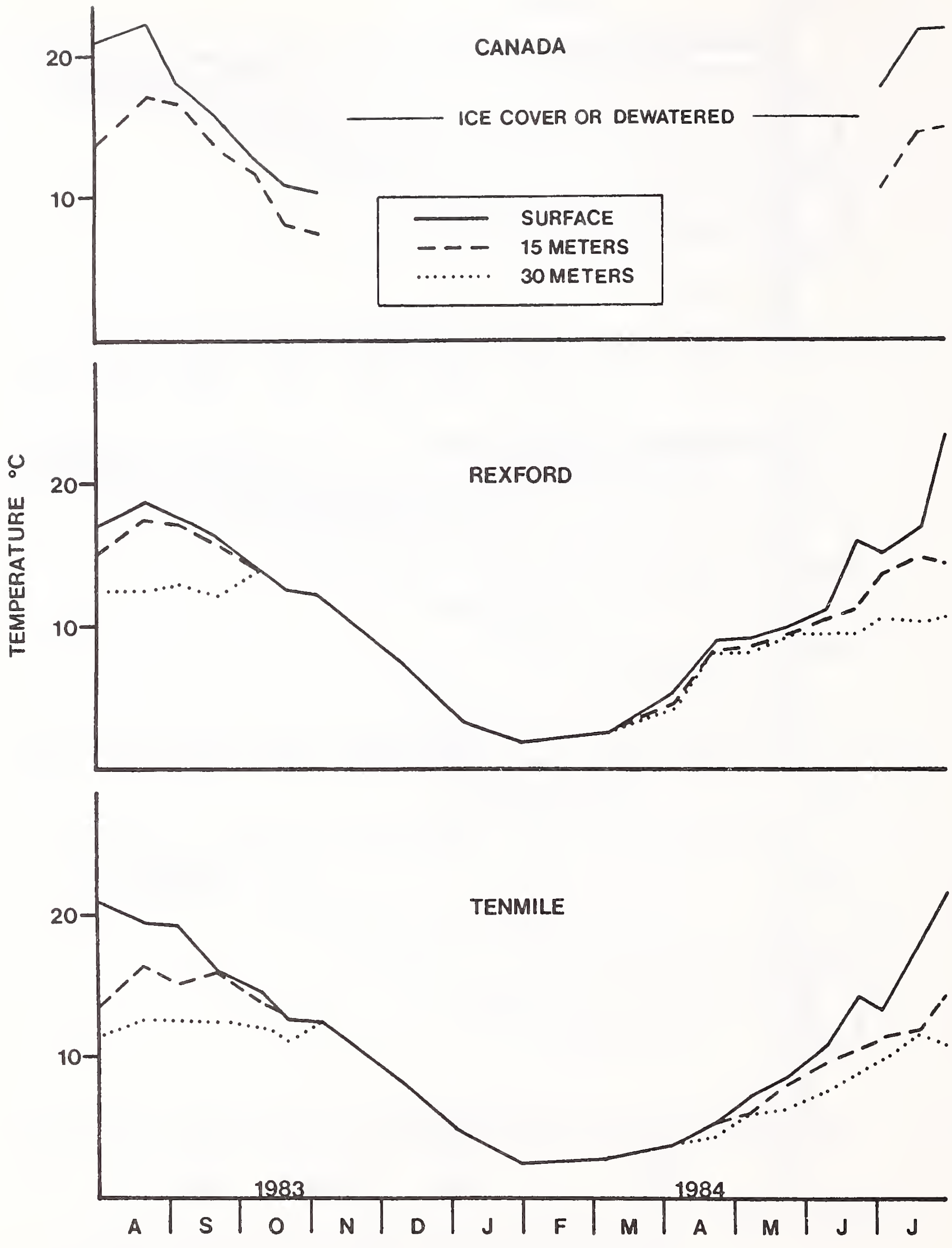


Figure C2. Temperatures measured at the surface, 15 m, and 30 m depths of three areas of Libby Reservoir during 1983 and 1984.

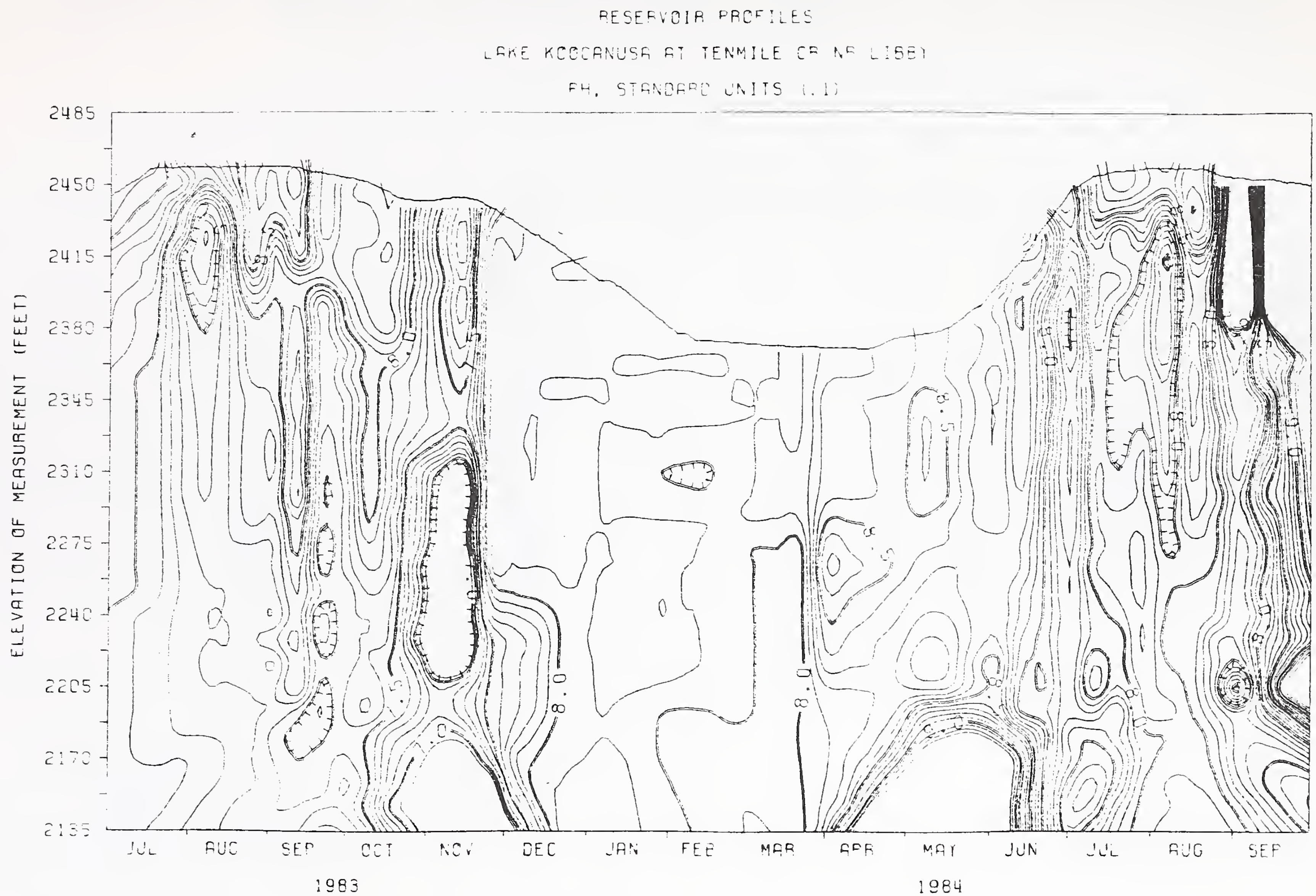


Figure C3. Isopleths of pH measured in the Tenmile area of Libby Reservoir during 1983 and 1984.

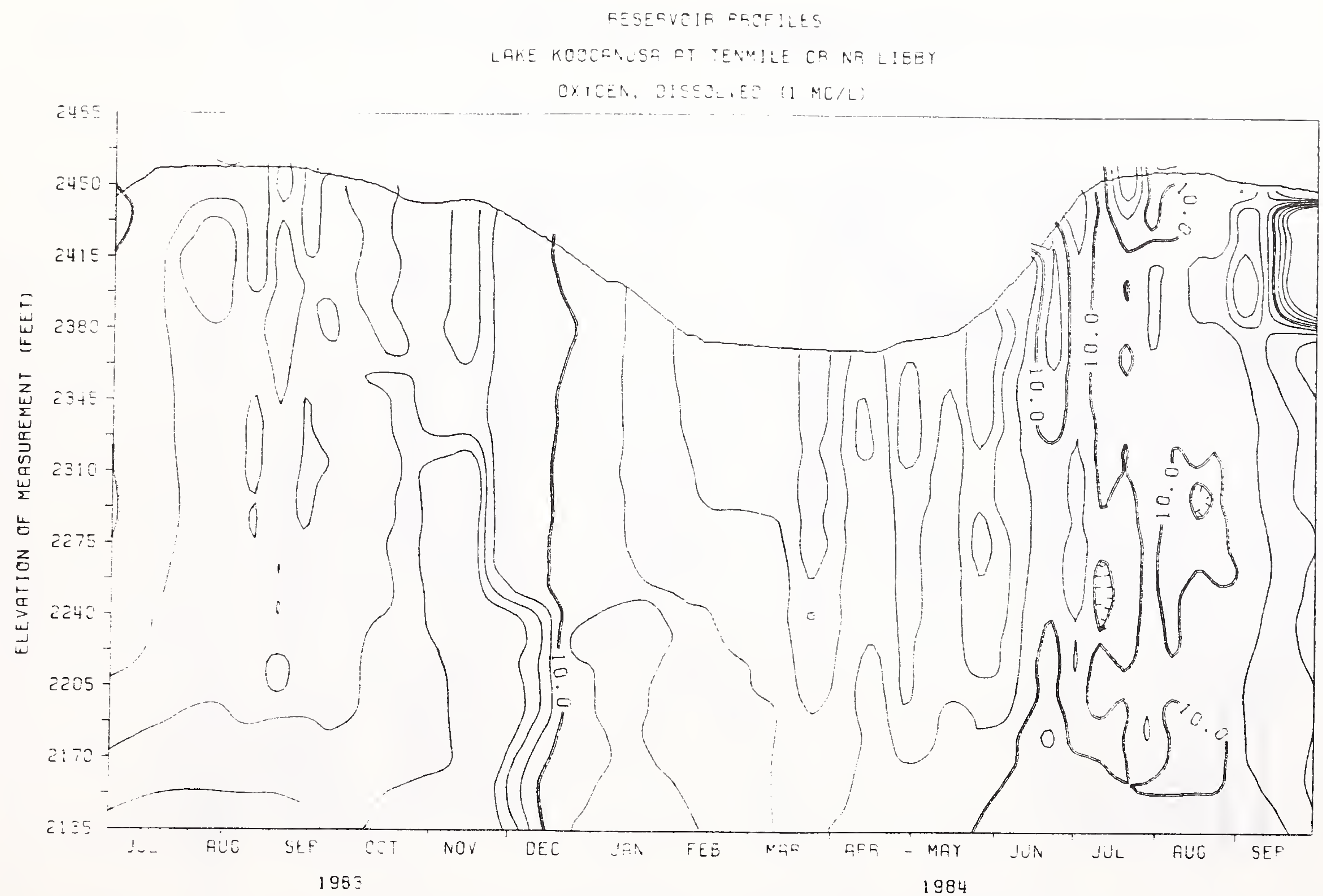


Figure C4. Isopleths of dissolved oxygen measured in the Tenmile area of Libby Reservoir during 1983 and 1984.

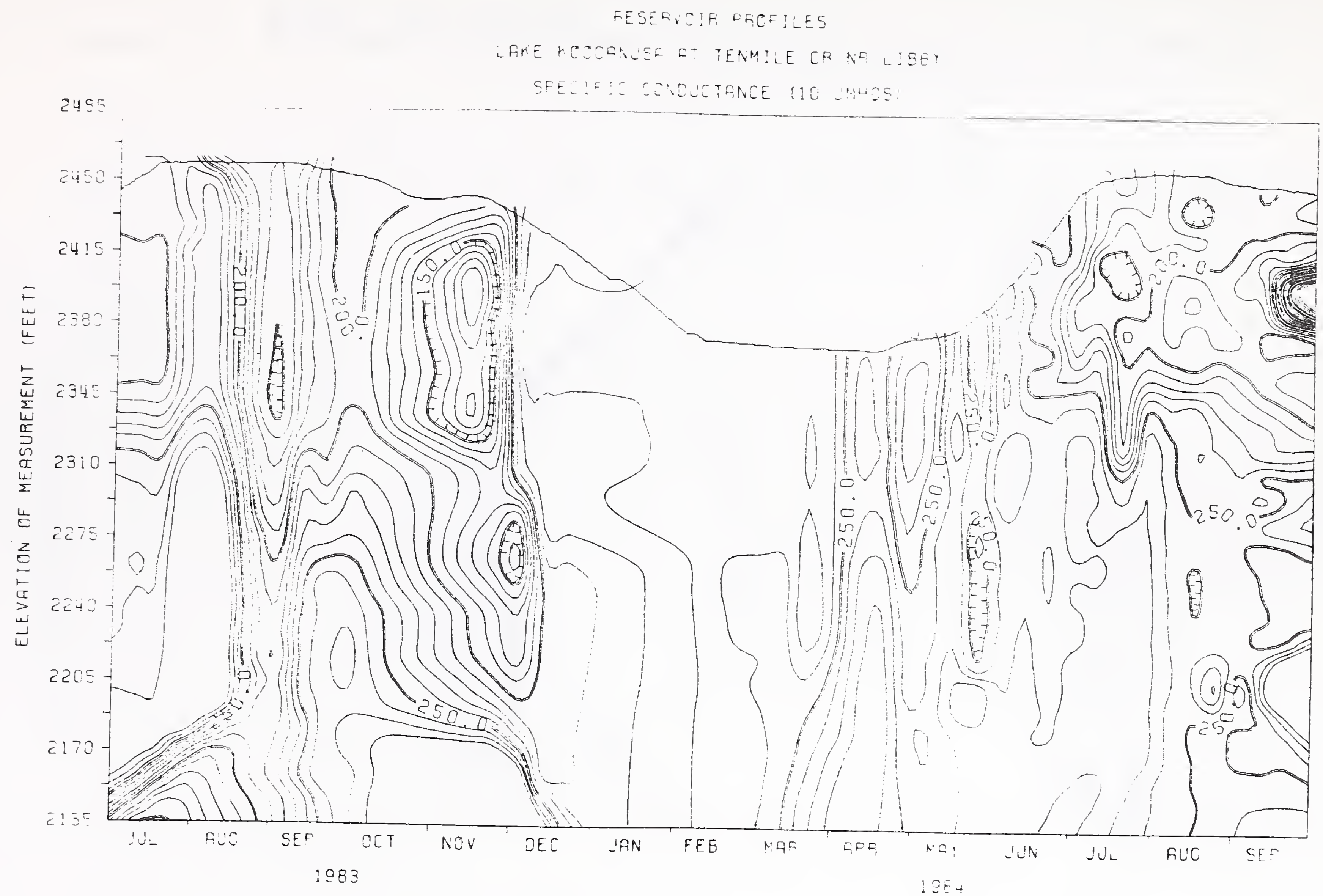


Figure C5. Isopleths of specific conductance measured in the Tenmile area of Libby Reservoir during 1983 and 1984.

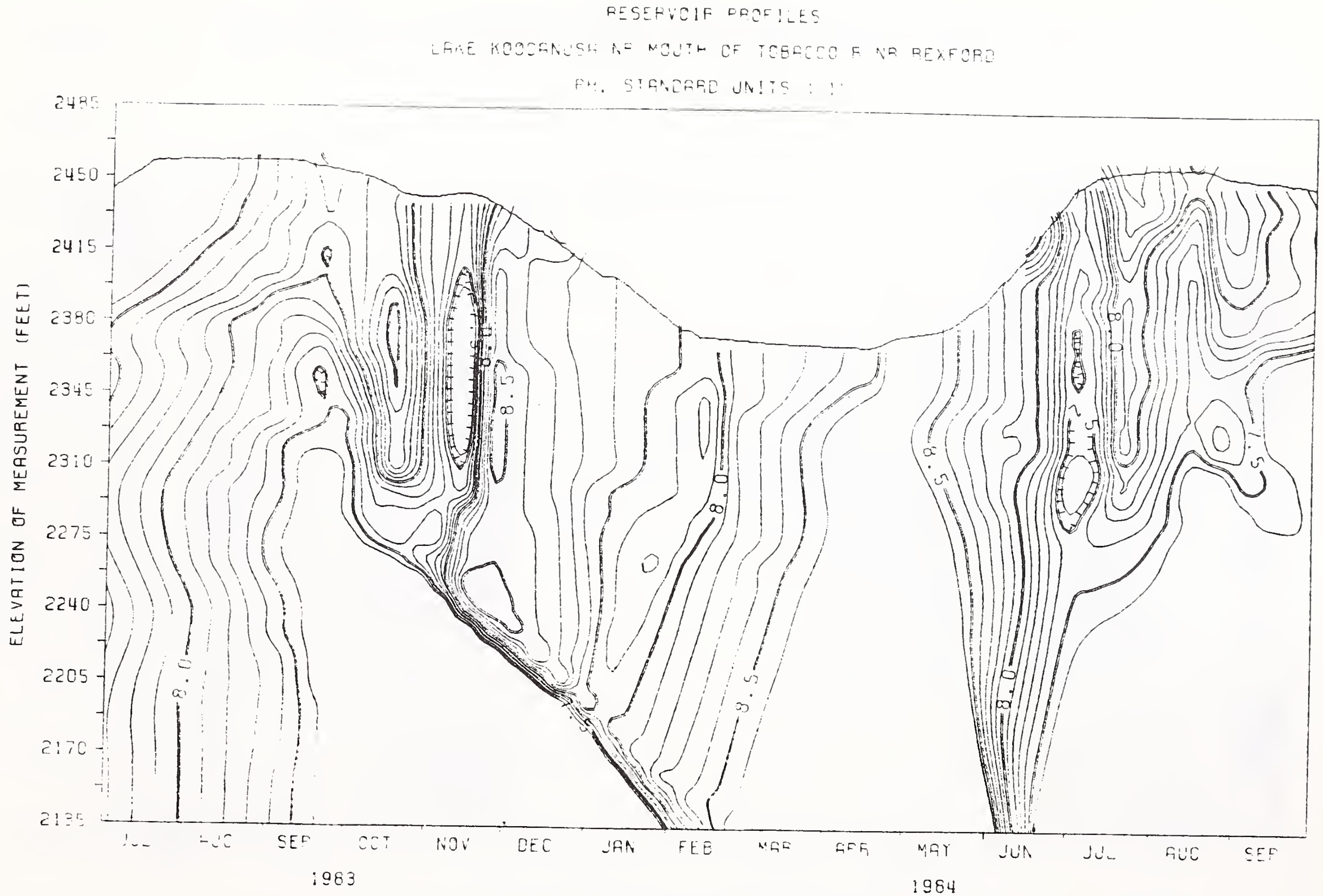


Figure C6. Isopleths of pH measured in the Rexford area of Libby Reservoir during 1983 and 1984.

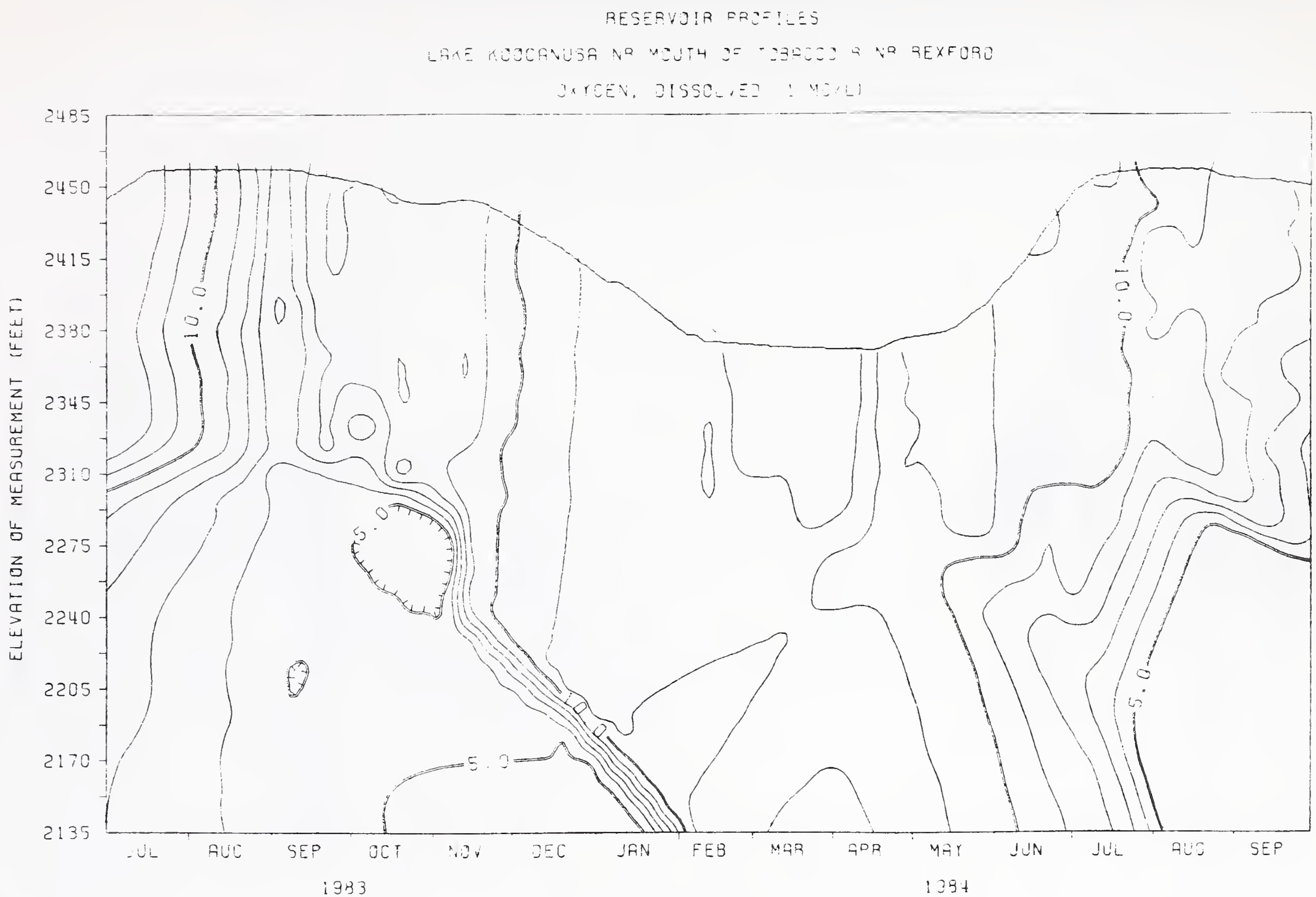


Figure C7. Isopleths of dissolved oxygen measured in the Rexford area of Libby Reservoir during 1983 and 1984.

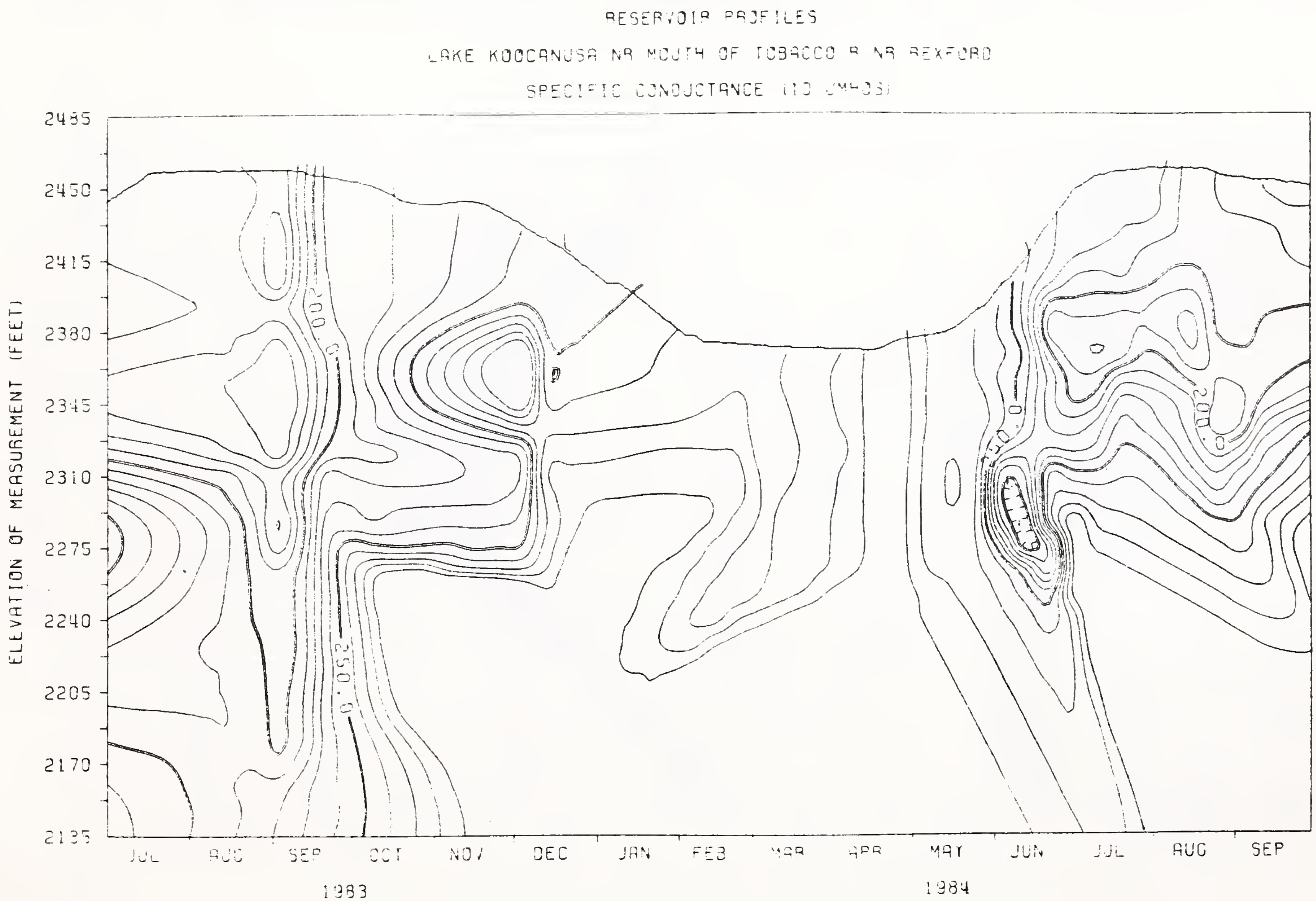


Figure C8. Isopleths of specific conductance measured in the Rexford area of Libby Reservoir during 1983 and 1984.

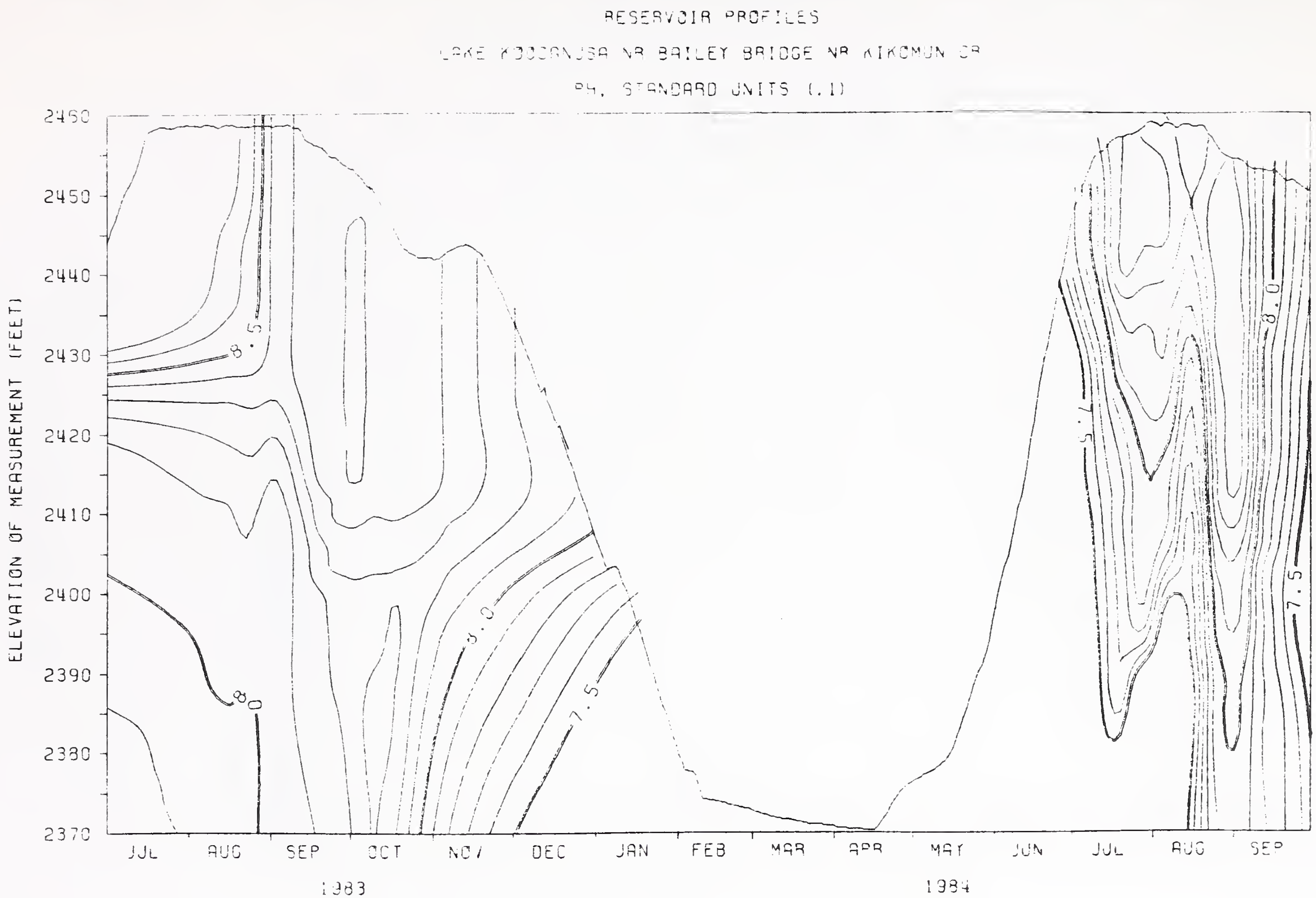


Figure C9. Isopleths of pH measured in the Canada area of Libby Reservoir during 1983 and 1984.

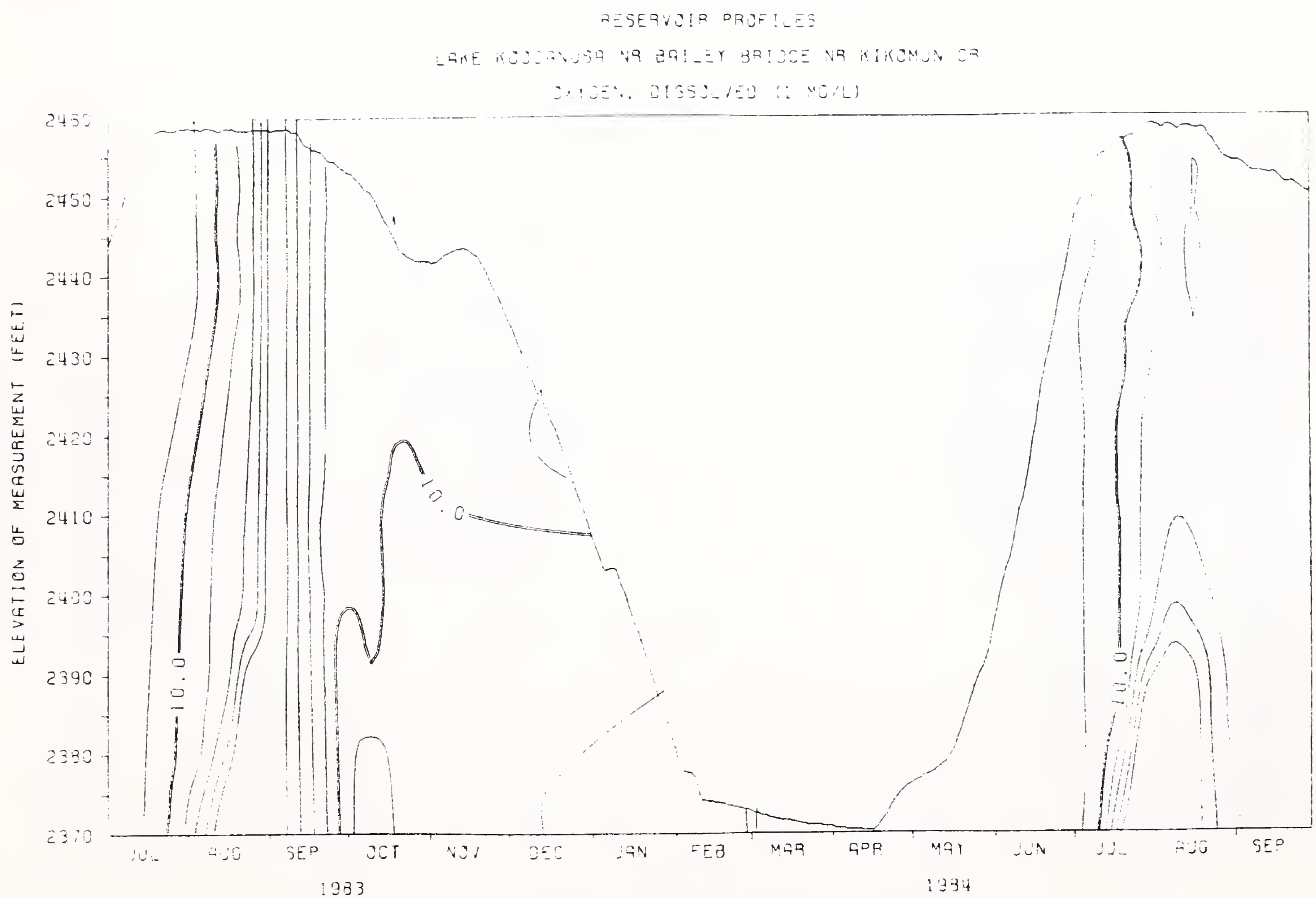


Figure C10. Isopleths of dissolved oxygen measured in the Canada area of Libby Reservoir during 1983 and 1984.

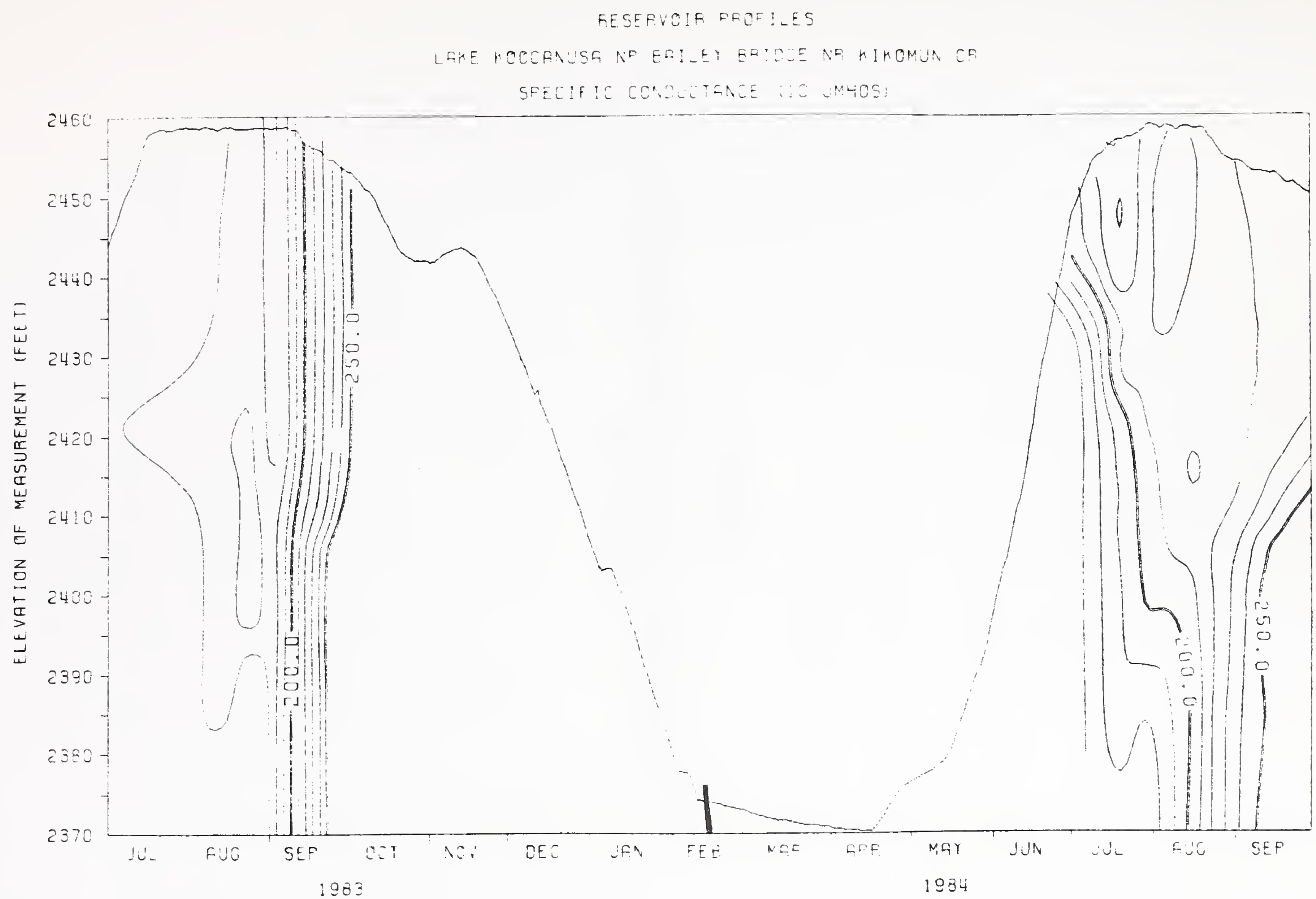


Figure C11. Isopleths of specific conductance measured in the Canada area of Libby Reservoir during 1983 and 1984.

APPENDIX D

Summary of tributary habitat survey information by reach for tributaries surveyed during 1983 and 1984.

Table D1. Summary of tributary habitat survey information by reach for East-side tributaries to Libby Reservoir surveyed during 1983 and 1984.

Tributary	Reach	Reach length (km)	Stream order	Drainage area (km^2)	Gradient (%)	Average depth (cm)	Channel width (m)	Wetted width (m)	Cover (%) Instream	Cover (%) Overhead[a/]	D_{90} (cm)	Spawning Gravel (m^2/km)
Little Jackson[b/] Cr.	1	1.0	2	6.7	16.5	—	—	—	—	—	—	—
Jackson Cr.	1	3.0	3	9.3	3.5	19.5	6.1	3.5	74	39/81	44	25.3
No. Fork[b/]	1	7.3	3	8.9	1.7	—	—	—	—	—	—	—
So. Fork[b/]	1	3.0	2	4.0	6.5	—	—	—	—	—	—	—
Barron Cr.	1	6.3	3	21.6	2.6	26.3	6.8	4.5	36	36/37	7	425.7
---	2	2.9	3	11.7	5.0	14.3	4.5	2.2	35	73/75	15	295.3
Bristow Cr.	1	4.9	3	27.3	3.2	28.7	9.6	7.1	54	63/67	40	233.3
---	2	55	3	21.7	5.2	14.8	7.6	3.8	30	45/73	24	12.6
No. Fork	1	1.7	2	2.7	5.0	10.9	5.4	3.3	35	65/80	30	29.3
So. Fork	1	1.0	2	1.4	5.0	16.0	5.0	3.3	35	60/63	27	2.3
Ural Cr. [b/]	1	2.2	2	8.8	6.2	—	—	—	—	—	—	—
--- [b/]	2	1.8	2	2.5	7.2	—	—	—	—	—	—	—
Geibler Cr.[b/]	1	2.0	2	3.7	18.4	—	—	—	—	—	—	—
Parsnip Cr.	1	2.7	3	8.0	4.6	20.5	9.7	6.2	56	37/77	27	5.5
---[b/]	2	2.7	3	18.1	8.7	—	—	—	—	—	—	—
Middle Fork [b/]	1	3.1	3	3.5	9.6	—	—	—	—	—	—	—
No. Fork [b/]	1	3.4	2	3.6	16.3	—	—	—	—	—	—	—
Big Cr.	1	12.3	4	194.0	15.8	37.8	23.2	15.6	31	19/18	40	65.2
Steep Cr.	1	1.6	2	19.0	11.4	10.9	5.9	3.0	42	17/65	43	59.5
Good Cr.	1	5.0	2	8.8	6.2	11.6	11.1	6.2	44	19/59	46	5.4
No. Fork	1	5.2	3	18.5	3.8	25.9	9.0	5.1	51	40/64	33	106.0
---	2	3.5	3	11.3	4.5	18.2	9.0	4.4	18	30/41	25	36.5
So. Fork	1	12.0	4	86.2	2.4	39.1	16.1	12.1	45	31/31	47	54.3
---	2	12.1	4	33.9	0.9	40.6	11.7	10.0	33	15/19	31	23.3
Drop Cr.	1	3.0	3	9.8	5.6	23.9	10.2	3.7	55	58/55	29	153.5
East Branch	1	5.4	3	23.9	2.2	31.4	6.6	5.2	49	51/34	29	114.9
---	2	4.1	2	9.3	2.1	34.5	9.0	4.5	42	28/45	27	47.9
West Branch	1	4.0	3	11.6	1.2	38.4	6.1	4.9	33	12/3	19	26.1
Boulder Cr.[b/]	1	3.5	4	9.7	12.3	—	—	—	—	—	—	—
--- [b/]	2	4.8	3	19.7	4.2	—	—	—	—	—	—	—
Sullivan Cr.	1	5.2	3	46.1	7.6	25.4	6.1	4.1	31	17/60	55	31.1
Poverty Cr.[b/]	1	1.9	2	1.4	7.4	—	—	—	—	—	—	—
--- [b/]	2	3.1	2	3.5	1.0	—	—	—	—	—	—	—
Dodge Cr.	1	1.5	3	2.1	2.9	22.9	10.0	4.8	23	37/79	11	461.8
---	2	3.4	3	4.4	3.0	30.5	7.1	5.9	42	42/68	13	81.9
---	3	2.3	3	6.5	4.5	19.2	5.1	4.0	20	15/57	31	69.9
---	4	3.6	3	12.3	6.9	24.2	6.1	3.6	21	7/85	27	51.5
So. Fork [b/]	1	3.0	2	5.6	12.6	--	---	---	--	—	--	—
No. Fork	1	2.4	2	6.7	10.0	15.8	2.6	2.0	13	18/48	20	17.4
Young Cr.	1	1.5	4	1.6	2.5	38.1	12.5	6.0	11	8/73	22	150.6
---	2	1.6	4	5.1	1.9	20.5	5.7	4.7	41	32/64	21	34.2
---	3a	2.8	4	16.6	1.0	48.0	4.7	4.3	8	8/9	47	437.8
---	3b	2.8	4	16.6	1.0	24.1	9.7	5.7	6	3/29	17	558.2
---	4	6.8	4	23.6	4.2	24.4	9.0	5.3	6	7/76	29	346.9
---	5	3.1	4	17.5	8.2	19.2	7.8	4.9	7	17/71	31	52.5
So. Fork	1	2.3	3	16.3	8.3	18.6	3.8	3.3	9	14/85	30	54.5

a/ First number is percent of streambank with overhead cover less than or equal to 1 m above the water's surface/and the second number is the percent of streambank with overhead cover further than 1 m above the water's surface.

b/ Cursory survey identified reach as having limited fish production potential.

Table D2. Summary of tributary habitat survey information by reach for Westside tributaries to Libby Reservoir surveyed during 1983 and 1984.

Tributary	Reach	Reach Length (km)	Stream Order	Drainage Area (km^2)	Gradient (%)	Average Depth (cm)	Channel Width (m)	Wetted Width (m)	Instream	Overhead	D_{90} (cm)	Spawning Gravel (Sq. m^2/km)
Tobacco												
Pinkham Cr.[b/]	1	8.7	4	33.0	1.9							
Sutton Cr/[b/]	1	4.2	4	45.7	5.0							
—	2	3.6	3	12.0	8.5							
—	3	3.0	3	20.6	4.3							
Flat Cr.	1	4.8	2	22.5	12.2							
McGuire Cr.	1	8.2	4	33.9	8.4	30.7	10.5	5.7	52	41/76	64	3.4
Tenmile Cr.	1	3.0	3	11.5	7.1	27.9	10.6	7.9	17	24/51	66	8.8
Fivemile Cr.	1	10.6	3	38.0	1.1	25.8	7.0	5.4	30	25/65	15	584.3
—	2	3.0	3	11.1	9.1							
So. Fork	1	2.0	2	28.2	11.5	8.5	5.0	2.7	41	24/67	39	13.3
Warland Cr.	1	7.6	2	19.4	3.9	12.0	6.9	3.3	70	43/76	41	41.2
Cripple Horse Cr.	1	3.6	4	18.2	4.0	21.1	14.1	5.7	67	24/58	55	183.8
—	2	11.7	4	50.9	3.0	19.0	10.0	6.3	60	19/43	48	34.6
So. Fork[c/]	1	3.0	4	4.7	4.0	—	—	—	—	—	—	—
Canyon Cr.	1	6.4	4	23.1	4.0	17.7	10.0	3.5	49	35/66	36	109.8
—	1	6.4	4	23.1	4.0	9.9	6.5	3.9	19	25/47	58	36.3
— [c/]	2	2.5	4	20.9	6.0	—	—	—	—	—	—	—
No. Fork [c/]	1	3.7	4	8.5	3.7	—	—	—	—	—	—	—

a/ First number is percent of streambank with overhead cover less or equal to 1 m above the water's surface/ and the second number is the percent of streambank with overhead cover further than 1 m above the water's surface.

b/ These streams will be surveyed during 1985.

c/ Cursory survey identified reach as having limited fish production potential.

APPENDIX E

Near-shore floating and sinking gill net catches (number of fish per net night) by species in the three areas of Libby Reservoir during 1983 and 1984.

Table E1. Floating gill net catches (# fish/net) in the Tenmile area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	MWF	PM	NSQ	RSS	CSU	FSU
July 1983	(12)	2.7	0.9	0.6	4.2	—	—	—	38.7	2.9	1.2	4.3	—
Aug. 1983	(14)	0.5	0.1	0.1	0.7	—	—	0.1	47.1	5.8	1.0	6.1	—
Sept. 1983	(14)	1.9	0.9	1.7	4.5	—	—	0.3	12.2	1.3	0.1	0.1	—
Oct. 1983	(10)	2.9	1.1	2.6	6.6	0.2	—	0.4	2.1	1.1	0.2	0.3	—
Nov. 1983	(10)	2.7	1.5	3.5	7.7	0.1	0.1	—	2.4	0.5	0.1	0.4	—
Dec. 1983	(10)	1.1	1.8	1.7	4.6	0.2	—	—	0.2	0.1	—	—	—
Jan. 1984	(10)	0.3	0.5	0.7	1.5	—	—	—	0.1	—	—	—	—
Feb. 1984	(10)	1.0	0.8	0.4	2.2	0.1	0.1	—	0.1	—	—	0.1	—
March 1984	(14)	1.3	0.6	0.6	2.5	0.1	0.1	—	—	—	—	—	—
April 1984	(10)	4.9	5.7	2.1	12.7	5.8	0.3	0.4	2.8	0.4	—	0.9	—
May 1984	(4)	15.5	19.8	2.5	37.8	1.9	1.9	0.1	30.3	1.6	0.3	1.6	—
June 1984	(10)	6.9	2.9	2.0	11.8	0.4	0.6	0.1	107.4	6.4	2.0	2.4	—
Aug. 1984	(24)	1.5	0.3	0.9	2.7	<0.1	—	<0.1	38.0	4.1	1.9	2.3	—
Sept. 1984	(14)	2.5	0.8	0.4	3.7	2.8	0.1	0.7	9.1	1.1	0.1	—	—
Nov. 1984	(20)	1.9	0.7	0.7	3.3	0.8	0.5	—	6.8	0.1	—	<0.1	—

Table E2. Floating gill net catches (# fish/net) in the Rexford area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	MWF	PM	NSQ	RSS	CSU	FSU
July 27, 1983	(10)	2.6	0.3	1.7	4.6	---	0.1	---	70.1	5.3	2.8	6.7	---
Aug. 16, 1983	(14)	9.0	2.2	1.1	12.3	---	---	0.1	42.7	6.2	2.2	4.3	0.1
Sept. 20, 1983	(10)	2.0	0.4	1.5	3.9	0.6	---	0.5	13.2	2.8	1.5	0.7	---
Oct. 18, 1983	(10)	2.5	0.8	1.8	5.1	0.1	0.1	0.8	4.1	1.3	0.2	---	---
Nov. 15, 1983	(10)	3.7	4.4	3.3	11.4	0.1	0.2	---	1.9	0.7	---	0.3	---
Dec. 1983		FROZEN											
Jan. 2, 1984	(8)	4.7	5.0	4.7	14.4	2.2	---	0.2	0.1	---	---	0.2	---
Feb. 23, 1984	(8)	1.5	0.7	0.5	2.7	0.1	---	0.1	0.2	---	---	---	---
March 21, 1984	(10)	7.0	4.0	3.8	14.8	1.4	---	0.2	1.1	0.4	---	2.6	---
April 24, 1984	(6)	12.2	11.0	6.5	29.7	9.1	2.3	2.1	93.0	5.0	0.1	1.7	---
May 23, 1984	(4)	15.5	19.8	2.5	37.8	1.9	1.9	0.1	30.3	1.6	0.3	1.6	---
June 12, 1984	(2)	6.5	3.5	1.5	11.5	---	---	---	72.0	6.5	3.0	1.5	---
Aug. 13, 1984	(24)	1.5	0.3	0.9	2.7	<0.1	---	<0.1	38.0	4.1	1.9	2.3	---
Sept. 25, 1984	(14)	0.6	0.6	0.5	1.7	10.1	0.1	0.9	12.9	1.4	0.4	0.4	---
Nov. 8, 1984	(20)	1.3	0.9	1.1	3.3	1.3	1.0	0.3	2.9	0.4	---	---	---

Table E3. Floating gill net catches (# fish/net) in the Canada area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	MWF	PM	NSQ	RSS	CSU	FSU
July 28, 1983	(10)	1.4	0.6	---	2.0	---	---	---	32.4	4.8	---	7.3	---
Aug. 18, 1983	(14)	0.4	---	---	0.4	0.1	---	---	17.1	10.6	0.9	4.4	---
Sept. 22, 1983	(14)	1.6	0.6	0.3	2.5	0.2	---	0.2	21.4	4.6	0.3	1.6	---
Oct. 20, 1983	(14)	1.7	1.7	1.8	5.2	0.2	0.2	0.3	0.8	1.0	---	2.0	---
Nov. 16, 1983	(8)	3.1	3.9	1.6	8.6	0.5	---	0.6	0.6	0.6	---	3.5	---
Dec. 1983		FROZEN OR DEWATERED THROUGH JUNE											
Aug. 16, 1984	(28)	0.3	---	0.1	0.4	---	---	0.1	30.4	8.2	0.5	2.2	<0.1
Sept. 22, 1984	(14)	2.0	1.5	1.8	5.3	19.3	0.2	0.3	18.6	2.6	0.3	0.4	---
Nov. 14, 1984	(20)	2.1	2.1	1.3	5.5	5.6	0.2	0.3	1.4	0.4	---	3.3	---

Table E4. Sinking gill net catches (# fish/net) in the Tenmile area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	Ling	MWF	PM	NSQ	RSS	CSU	FSU
July 25, 1983	(2)	1.0	---	---	1.0	---	---	1.0	7.5	19.0	6.5	1.0	8.0	3.5
Aug. 15, 1983	(2)	5.5	0.5	0.5	6.5	---	---	---	4.5	7.5	1.0	0.5	19.5	3.0
Sept. 19, 1983	(2)	5.0	0.5	---	5.5	---	---	---	3.0	50.5	20.0	2.0	30.5	---
Oct. 17, 1983	(2)	1.5	---	---	1.5	---	0.5	1.0	4.0	13.5	11.0	---	17.5	---
Nov. 14, 1983	(2)	1.0	---	---	1.0	---	1.0	0.5	---	34.0	6.0	---	8.0	---
Dec. 19, 1983	(1)	1.0	1.0	---	2.0	---	---	---	3.0	19.0	9.0	---	6.0	---
Jan. 16, 1984	(2)	1.5	---	0.5	2.0	---	0.5	0.5	2.0	4.5	0.5	---	1.5	1.5
Feb. 21, 1984	(2)	2.0	---	---	2.0	---	0.5	3.0	2.0	2.0	---	---	5.0	0.5
March 18, 1984	(2)	1.0	---	0.5	1.5	---	1.5	---	1.0	5.0	2.0	---	8.0	1.0
April 23, 1984	(2)	0.5	---	---	0.5	0.5	1.0	---	4.5	14.0	1.0	---	4.0	---
May 21, 1984	(2)	---	---	---	0	---	0.5	0.5	5.5	24.5	9.5	1.5	10.5	1.5
June 14, 1984	(2)	0.5	---	---	0.5	---	0	---	---	46.0	3.5	0.5	16.5	10.0
August 13, 1984	(4)	0.7	---	---	0.7	---	0.2	0.5	2.0	19.0	3.2	---	9.5	1.2
Nov. 7, 1984	(4)	0.5	---	---	0.5	0.5	1.0	1.0	1.0	12.0	2.7	---	6.3	1.0

Table E5. Sinking gill net catches (# fish/net) in the Rexford area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	Ling	MWF	PM	NSQ	RSS	CSU	FSU
July 26, 1983	(2)	2.0	—	1.0	3.0	—	1.0	0.5	1.0	26.5	4.5	—	11.0	1.5
Aug. 16, 1983	(2)	3.0	—	0.5	3.5	—	—	—	—	24.0	1.5	—	25.5	0.5
Sept. 20, 1983	(2)	—	—	1.0	1.0	0.5	0.5	—	3.5	57.5	9.0	1.0	24.5	1.5
Oct. 18, 1983	(2)	2.5	—	—	2.5	—	1.0	—	6.0	55.5	8.5	—	13.0	0.5
Nov. 15, 1983	(2)	1.0	0.5	1.0	2.5	—	1.0	—	0.5	50.0	14.0	—	6.5	0.5
Dec.	ICE COVER													
Feb. 2, 1983	(2)	3.0	1.0	1.5	5.5	—	1.0	1.0	5.5	2.0	—	—	3.5	0.5
Feb. 23, 1983	(2)	4.0	—	3.0	7.0	—	2.5	0.5	9.0	6.5	0.5	—	5.5	1.0
March 21, 1983	(2)	1.5	—	—	1.5	—	1.5	—	14.0	17.0	3.0	—	11.5	1.0
April 24, 1984	(2)	1.5	0.5	—	2.0	3.0	3.0	1.0	19.0	32.5	7.5	1.0	10.0	—
May 23, 1984	(2)	4.5	2.0	9.5	16.0	—	2.5	1.5	5.0	20.0	2.0	0.5	6.0	0.5
June 12, 1984	(20)	2.5	0.1	0.6	3.2	—	1.8	0.4	2.9	59.2	8.0	2.5	63.2	5.6
Aug. 14, 1984	(4)	1.0	0.7	—	1.7	0.5	0.2	—	2.0	32.7	6.2	0.2	5.6	1.2
Nov. 12, 1984	(4)	1.7	—	0.3	2.0	—	1.7	—	1.5	43.3	3.5	0.2	7.0	—

Table E6. Sinking gill net catches (# fish/net) in the Canada area of Libby Reservoir by date.

Date	(n)	RB	WCT	HB	Total Salmo sp.	KOK	DV	Ling	MWF	PM	NSQ	RSS	CSU	FSU
July 28, 1983	(2)	---	---	---	0	---	0.5	---	0.5	9.5	1.0	---	7.5	---
Aug. 18, 1983	(2)	1.0	1.0	---	2.0	---	---	---	2.0	9.5	5.5	0.5	19.5	0.5
Sept. 22, 1983	(2)	0.5	---	0.5	1.0	1.5	0.5	---	7.0	17.5	3.5	0.5	12.5	1.0
Oct. 20, 1983	(2)	1.5	---	1.0	2.5	0.5	0.5	---	5.5	2.5	3.0	0.5	8.0	0.5
Nov. 16, 1983	(2)	2.0	---	---	2.0	---	1.5	---	11.5	5.0	2.0	---	1.5	---
Dec.	ICE													
Aug. 16, 1984	(4)	0.5	0.5	---	1.0	1.5	0.5	---	4.0	13.2	2.7	0.2	7.2	---
Nov. 14, 1984	(4)	0.5	1.0	0.7	2.2	1.5	---	0.3	11.3	0.7	1.0	---	1.7	0.3

APPENDIX F

Annual catches (number of fish per net night) of fish in floating gill nets set during the fall and sinking gill nets set during the spring in Libby Reservoir 1975-1984.

Table F1. Average catch per net night in floating gill nets set during the fall in the Tenmile and Rexford areas of Libby Reservoir in 1975, 1976, 1978, 1979, 1980, 1982, and 1984.[a]

Parameter	Year								
	1975	1976	1978	1979	1980	1982	1983	1984	1977
Surface temperature(°C)	16.1	17.2	15.6	16.7	15.6	16.7	16.3	15.6	range 7.6 to 17
Number of nets	129	91	78	73	79	70	24	28	24
Average catch of:[b]									
RB	2.8	3.6	6.3	4.9	4.8	2.4	1.9	1.5	5.4
WCT	2.0	2.5	2.0	1.4	1.2	1.2	0.7	0.7	3.5
RB x WCT[c]	0.0	0.0	0.1	<0.1	<0.1	<0.1	1.6	0.4	
Total Salmo	4.8	6.1	8.4	6.3	6.0	3.6	4.2	2.6	
MWF	2.0	2.3	1.2	1.4	0.6	1.0	0.4	0.8	
CRC	4.0	4.2	3.0	6.5	8.8	15.1	12.6	11.0	
SQ	4.2	4.7	4.2	2.1	1.9	3.5	1.9	1.3	
RSS	3.3	7.9	7.3	2.0	0.5	0.2	0.7	0.2	
DV	<0.1	<0.1	<0.1	0.1	0.2	<0.1	0.0	0.1	
CSU	1.9	2.4	0.9	1.1	1.2	1.2	0.4	0.2	
KOK	0.0	0.0	0.0	0.2	0.0	7.1	0.3	6.5	
Total	20.2	27.6	25.0	19.7	19.2	31.7	20.5	22.7	

a/ Catches prior to 1983 reported by Huston et al. (1984)

b/ Abbreviations explained in "Methods" section under "Fish Abundance..."

c/ Prior to 1983 very few hybrids were identified as such, although they were probably present in the samples.

Table F2. Average catch per net night in sinking gill nets set during the spring in the Rexford area of Libby Reservoir in 1975, 1976, 1978, 1980, 1982, and 1984.[a]

Parameter	Year					
	1975	1976	1978	1980	1982	1984
Surface tempertaure (°C)	12.8	12.2	11.1	11.1	11.7	12.7
Number of nets	111	41	41	38	36	20
Average catch of:[b]						
RB	0.8	0.3	1.4	0.7	1.4	2.5
CT	0.2	0.4	0.4	0.2	0.4	<0.1
RB x WCT[c]	0.0	0.0	0.0	0.0	<0.1	0.6
MWF	6.6	6.4	7.2	1.0	2.1	2.9
CRC	0.3	1.0	0.7	7.2	24.3	59.2
NSQ	2.3	1.2	5.8	2.8	4.3	8.0
RSS	[d]	1.4	2.8	0.7	1.9	2.5
DV	1.4	1.9	2.2	0.8	1.5	1.8
LING	<0.1	0.2	0.3	0.6	0.5	0.4
CSU	37.3	26.1	23.5	36.3	18.6	63.2
FSU	7.9	11.1	9.1	5.8	10.9	5.6
YP	0.0	0.0	0.0	0.0	0.2	0.8
Total	56.8	50.0	53.4	56.1	66.0	147.5

[a] Catches prior to 1984 reported by Huston et al. (1984)

[b] Abbreviations explained in "Methods".

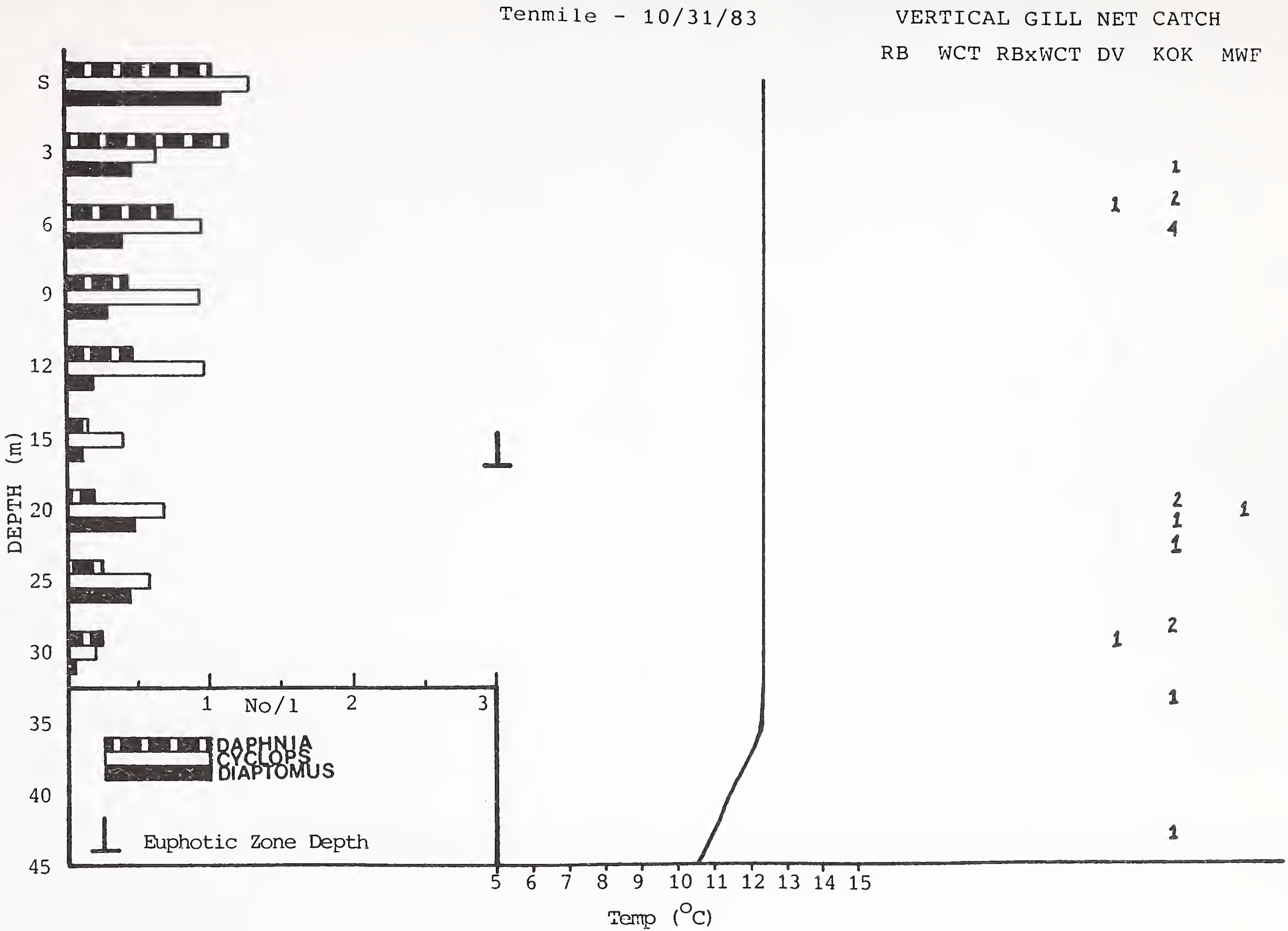
[c] Prior to 1984 very few hybrids were identified as such, although they were probably present in the samples

[d] Numbers of redside shinres were not recorded in 1975, although several hundred were caught

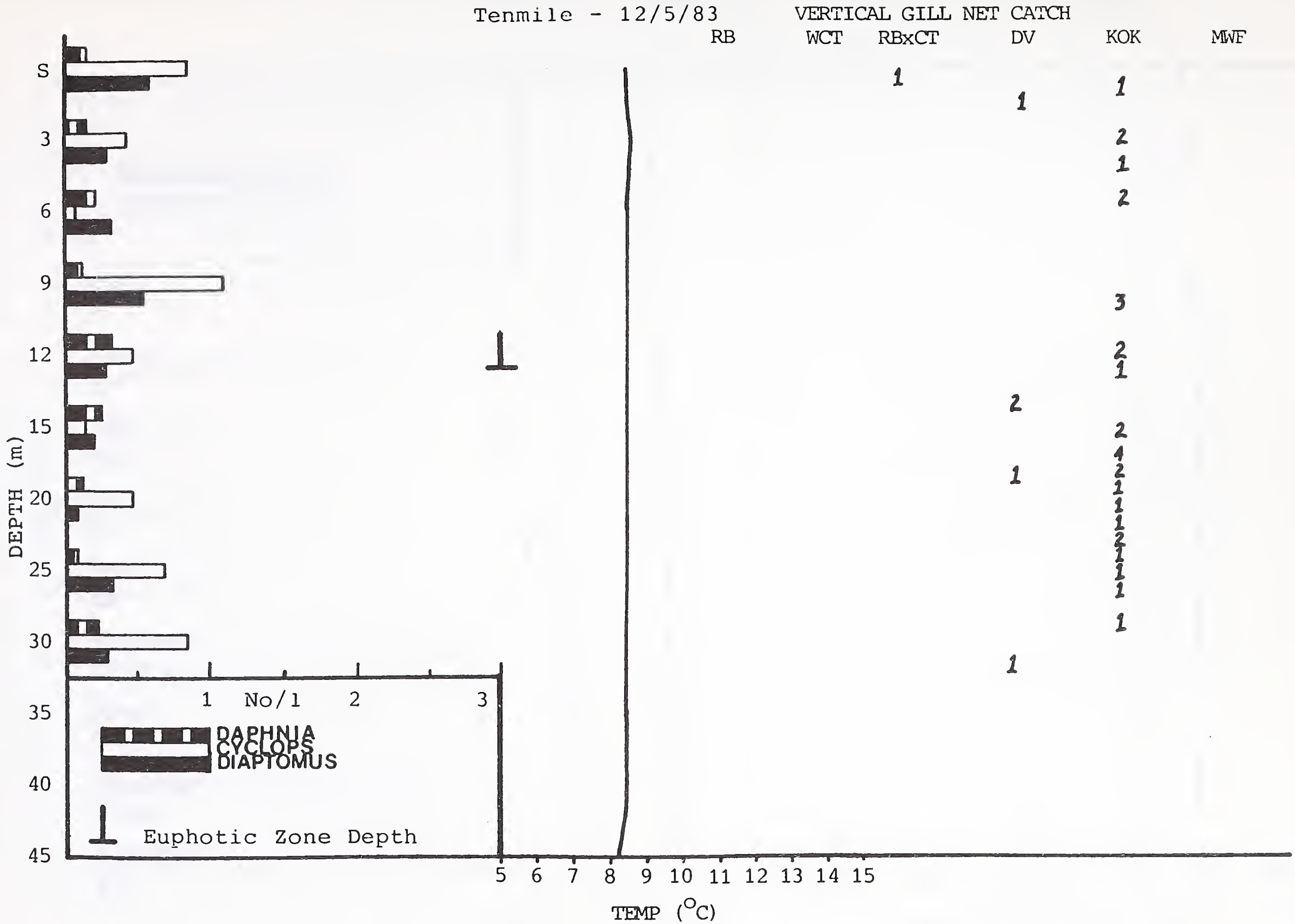
APPENDIX G

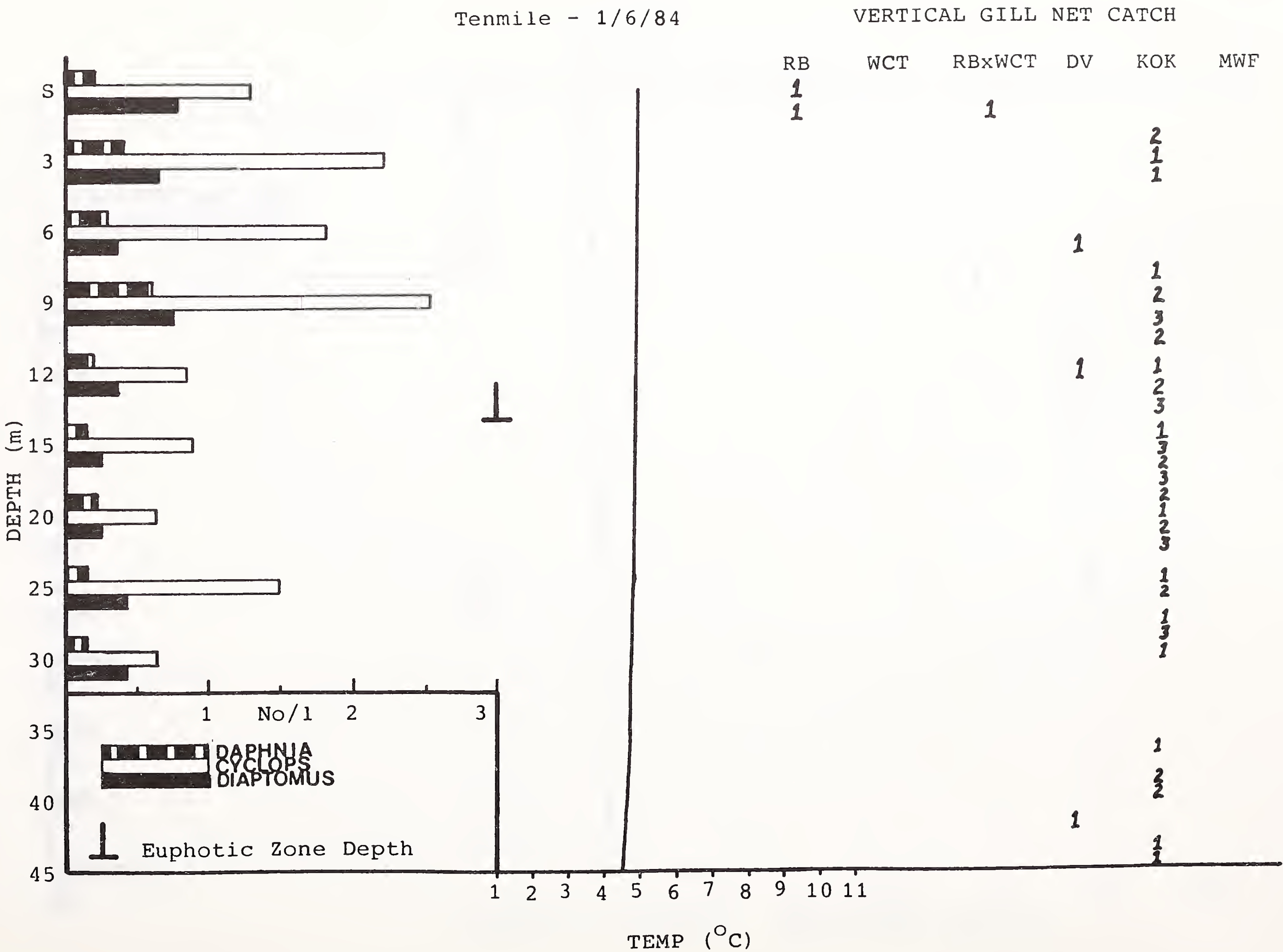
Vertical distributions of fish and zooplankton compared to temperature profiles and euphotic zone depths by date in two areas of Libby Reservoir during 1983 and 1984.

Tenmile - 10/31/83

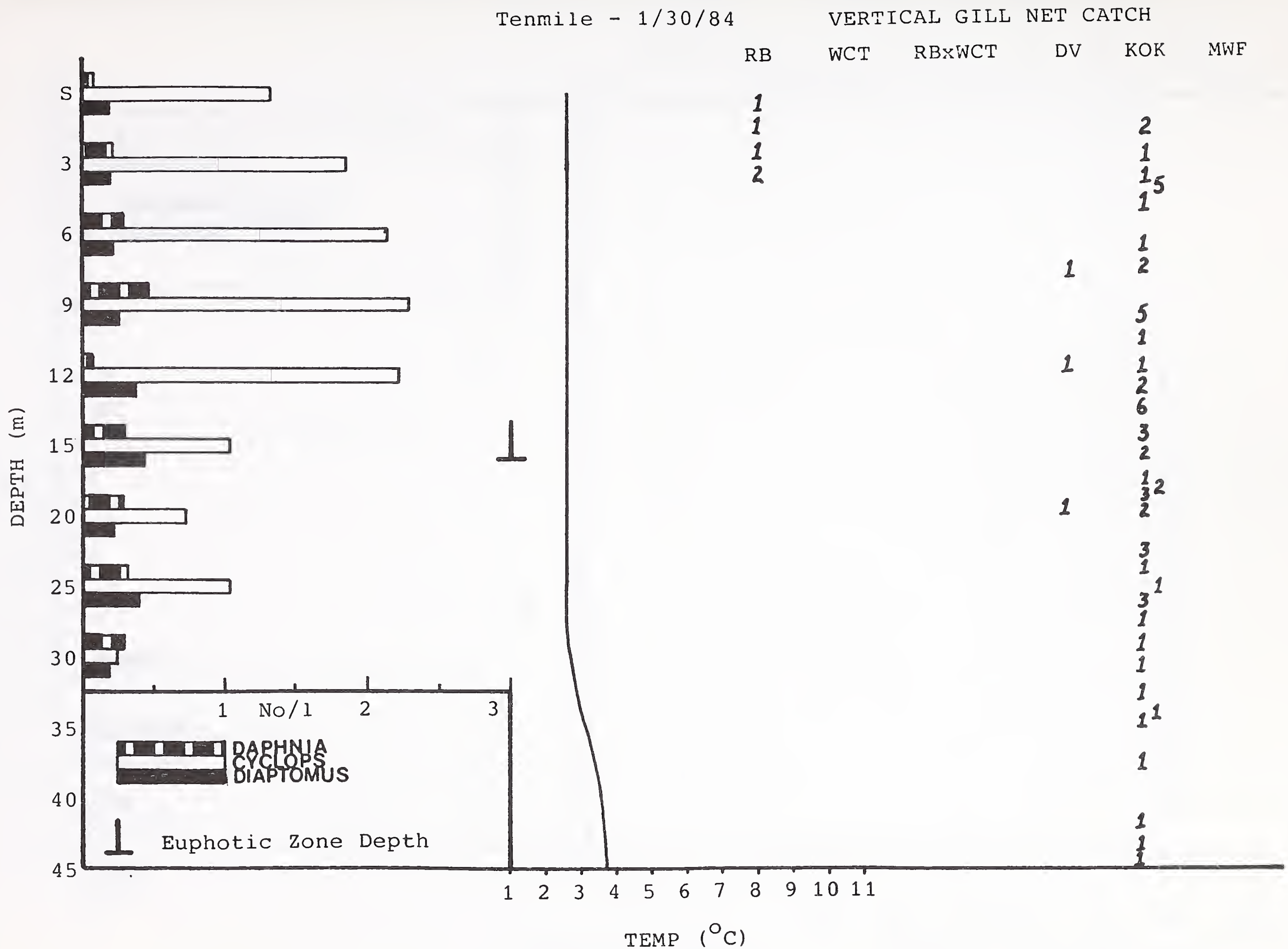


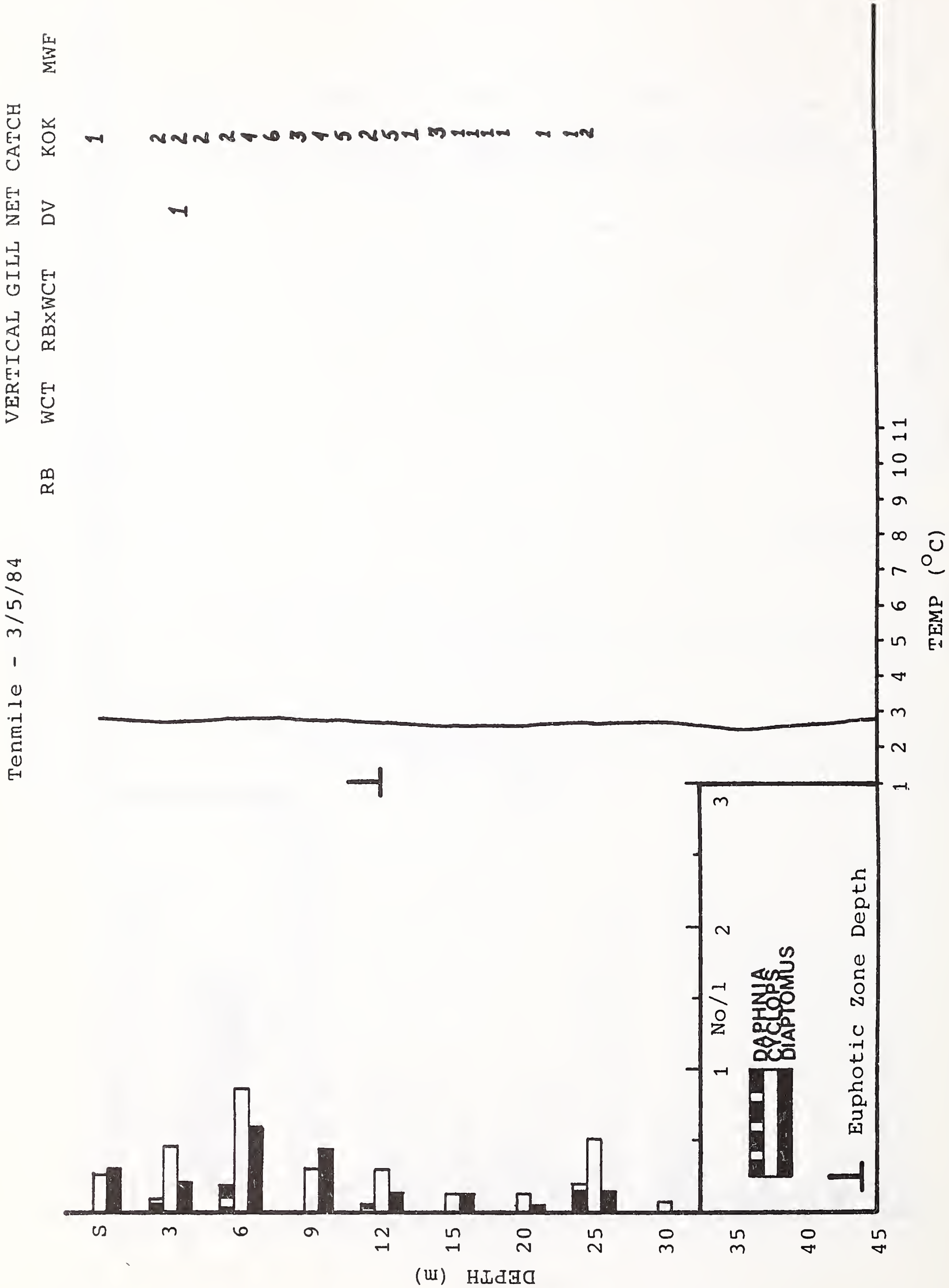
Tenmile - 12/5/83




Tenmile - 1/6/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
1
No/1
2
3
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
TEMP (°C)

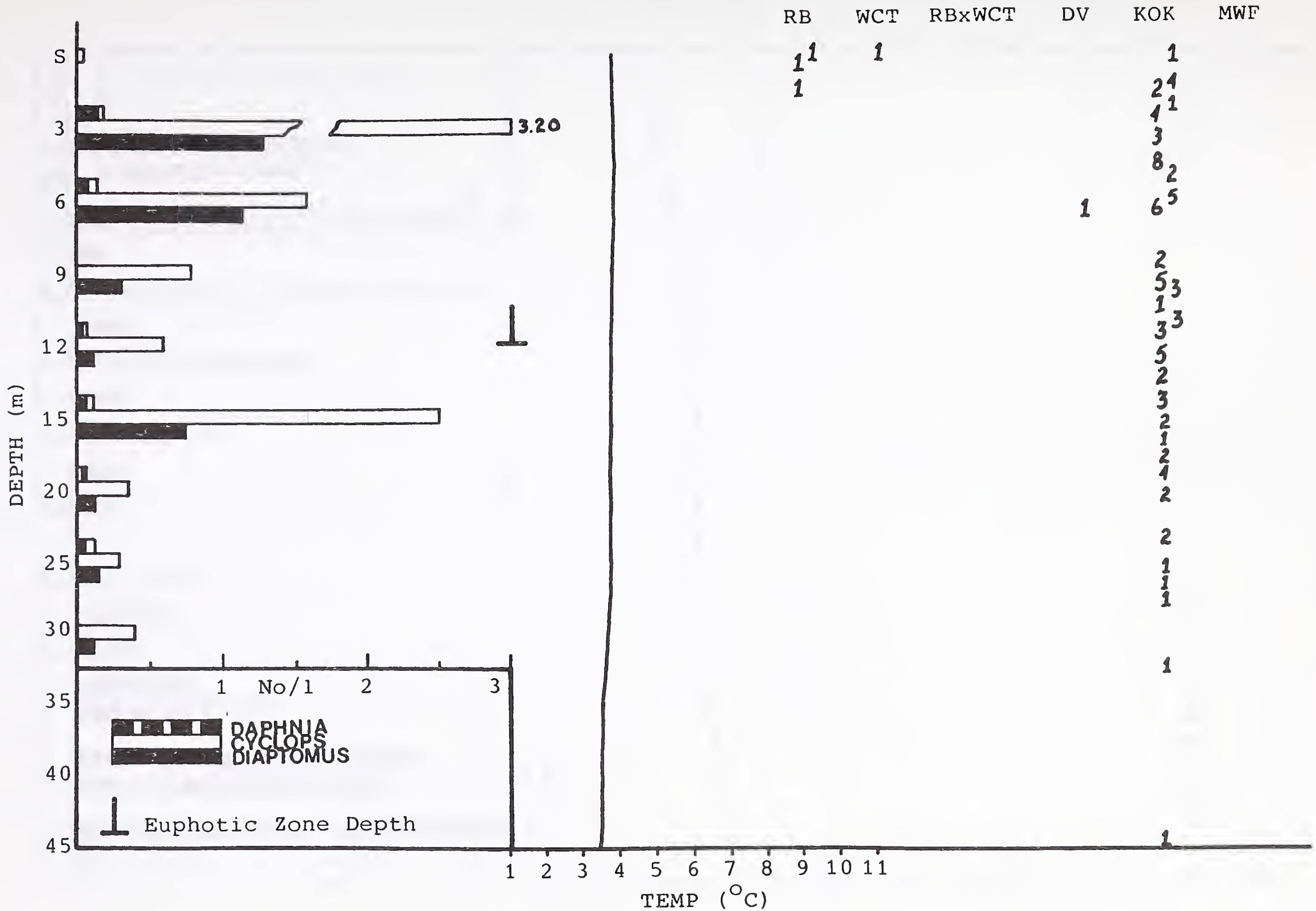
Tenmile - 1/30/84

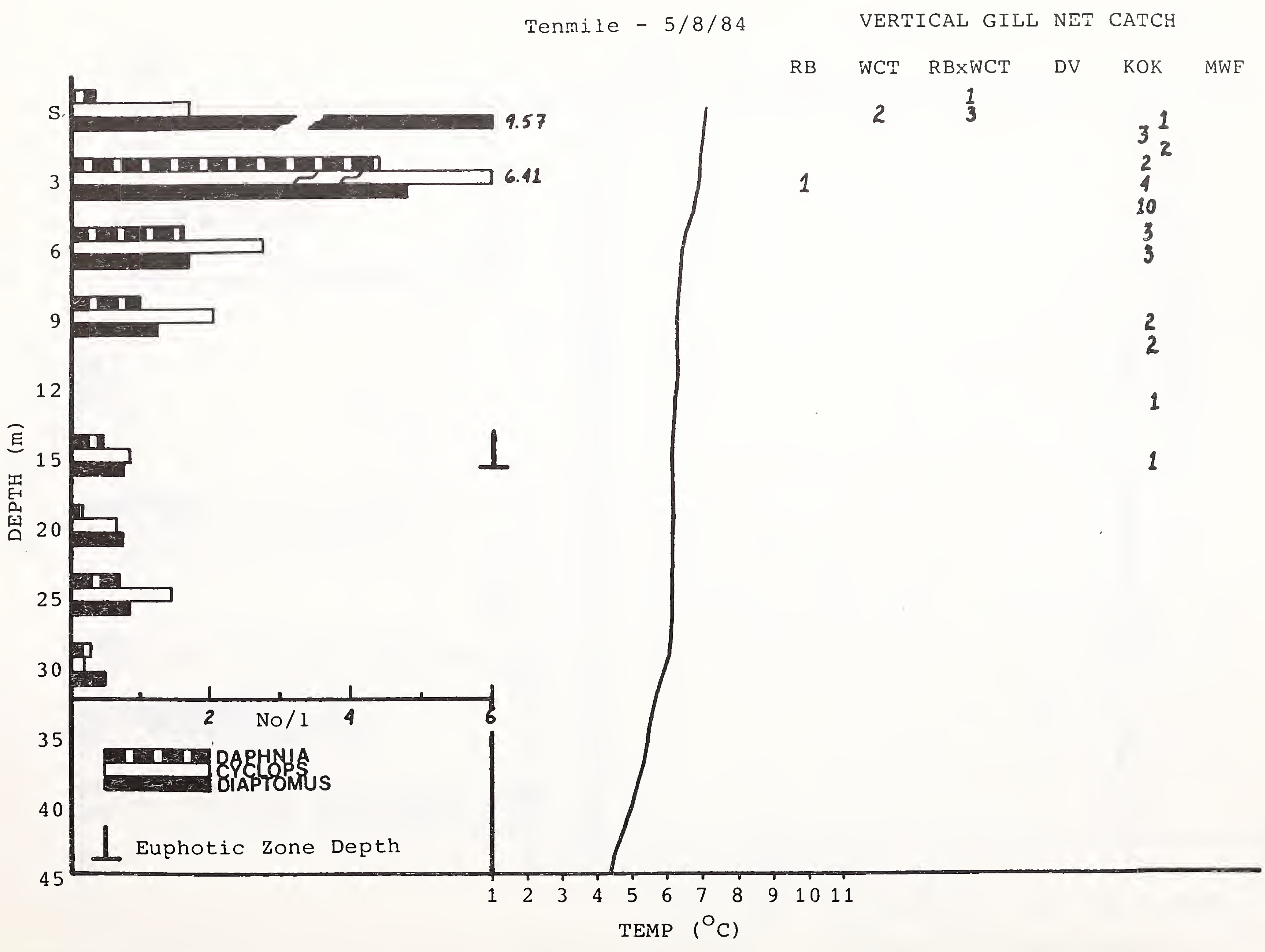




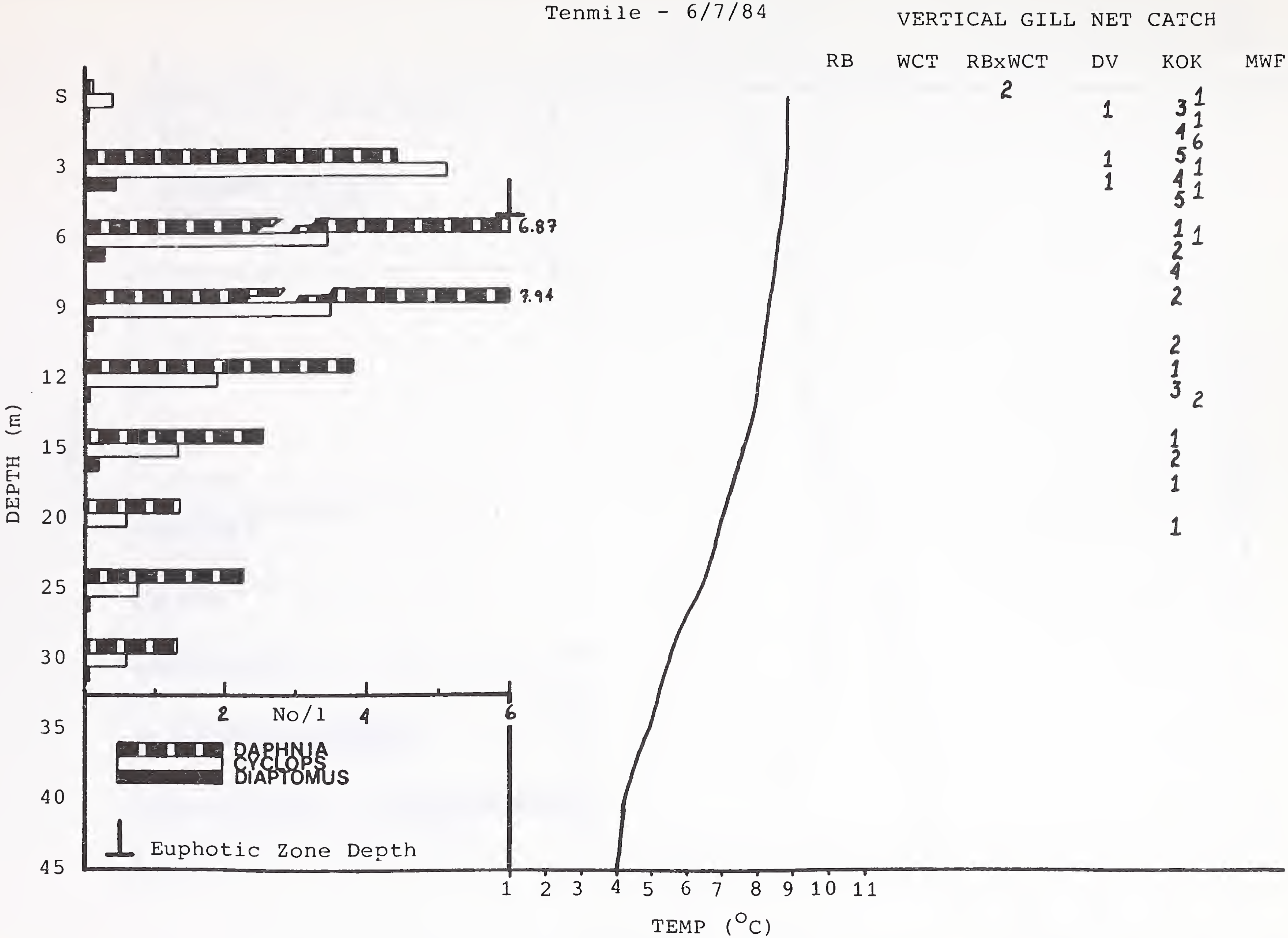
Tenmile - 3/5/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
TEMP (°C)
1 2 3 4 5 6 7 8 9 10 11
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
No/1
1
2
3
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth

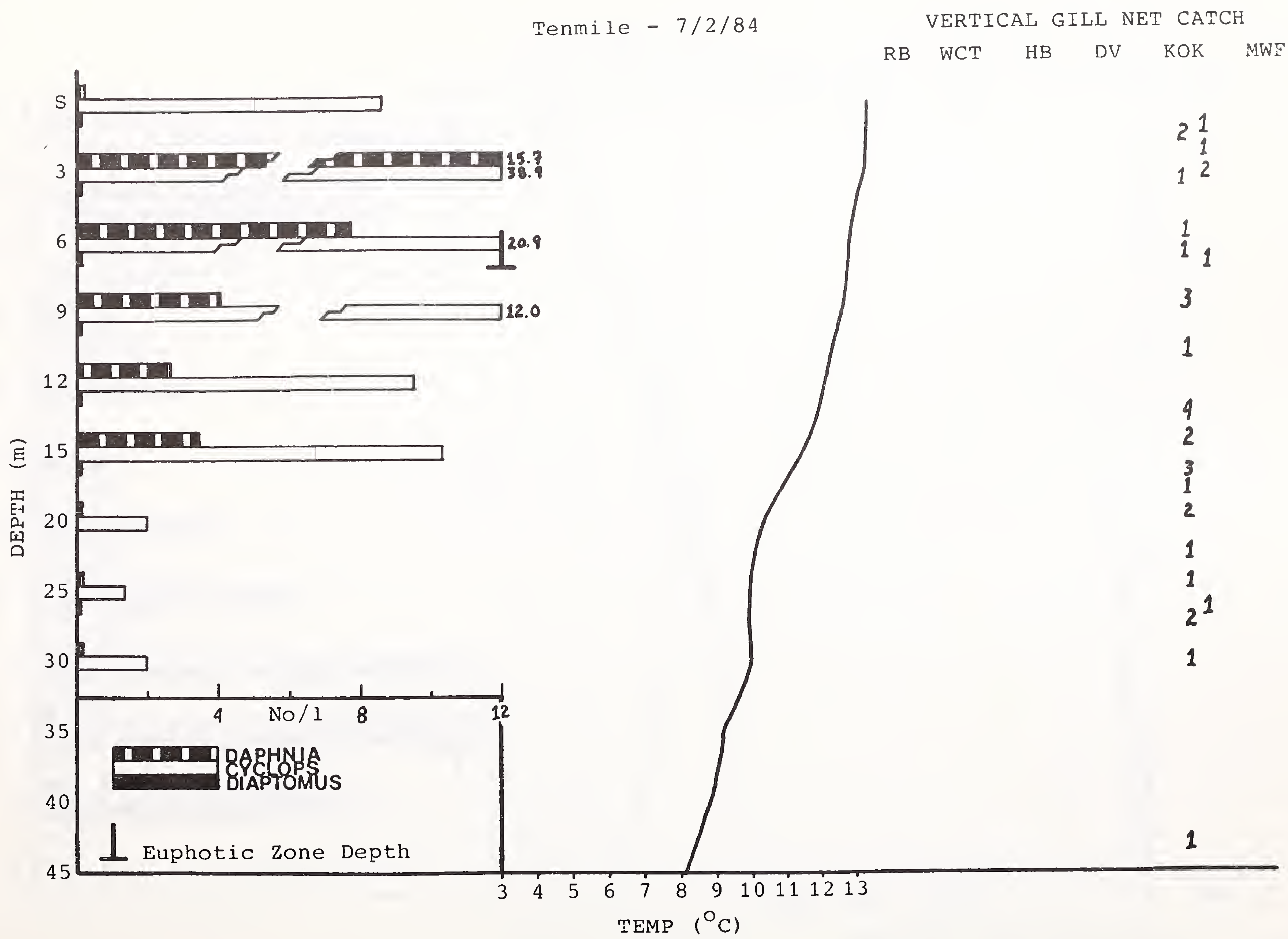
Tenmile - 4/3/84 VERTICAL GILL NET CATCH

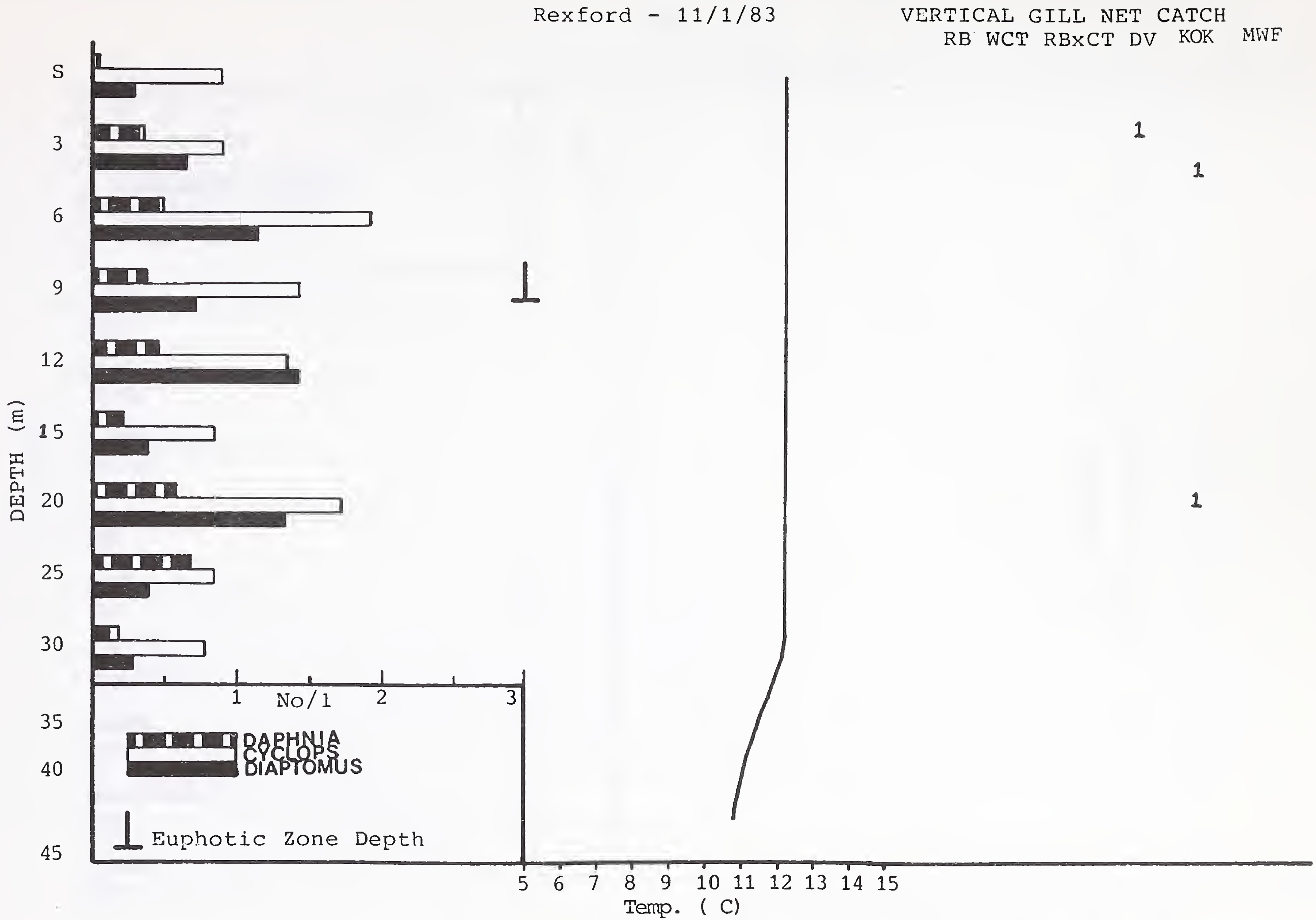


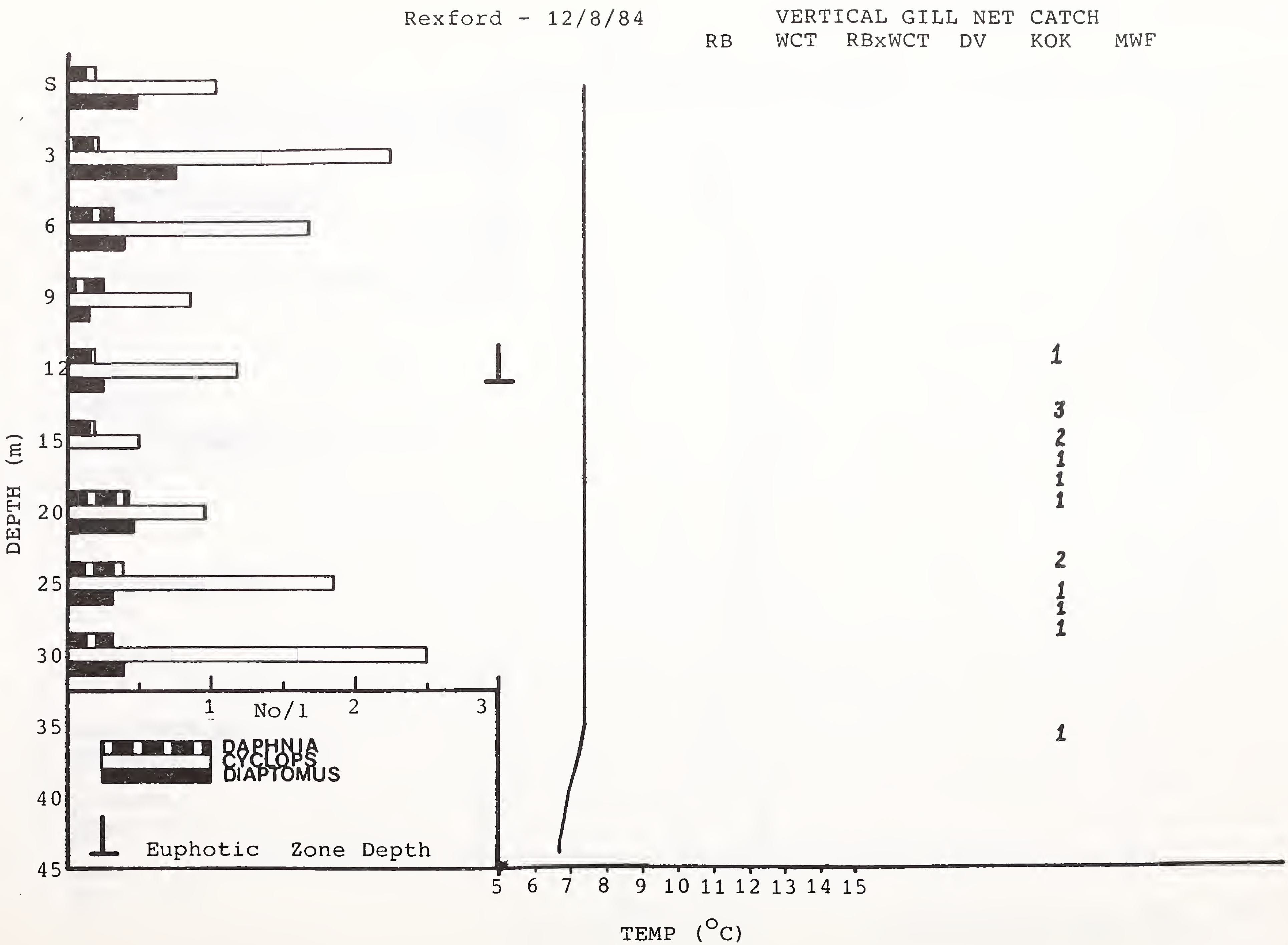

Tenmile - 5/8/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
1
2
3
1
2
3
1
4
10
3
3
2
2
1
1
9.57
6.41
S
3
6
9
12
15
20
25
30
35
40
45
DEPTH (m)
2
No/1
4
6
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
1 2 3 4 5 6 7 8 9 10 11
TEMP (°C)

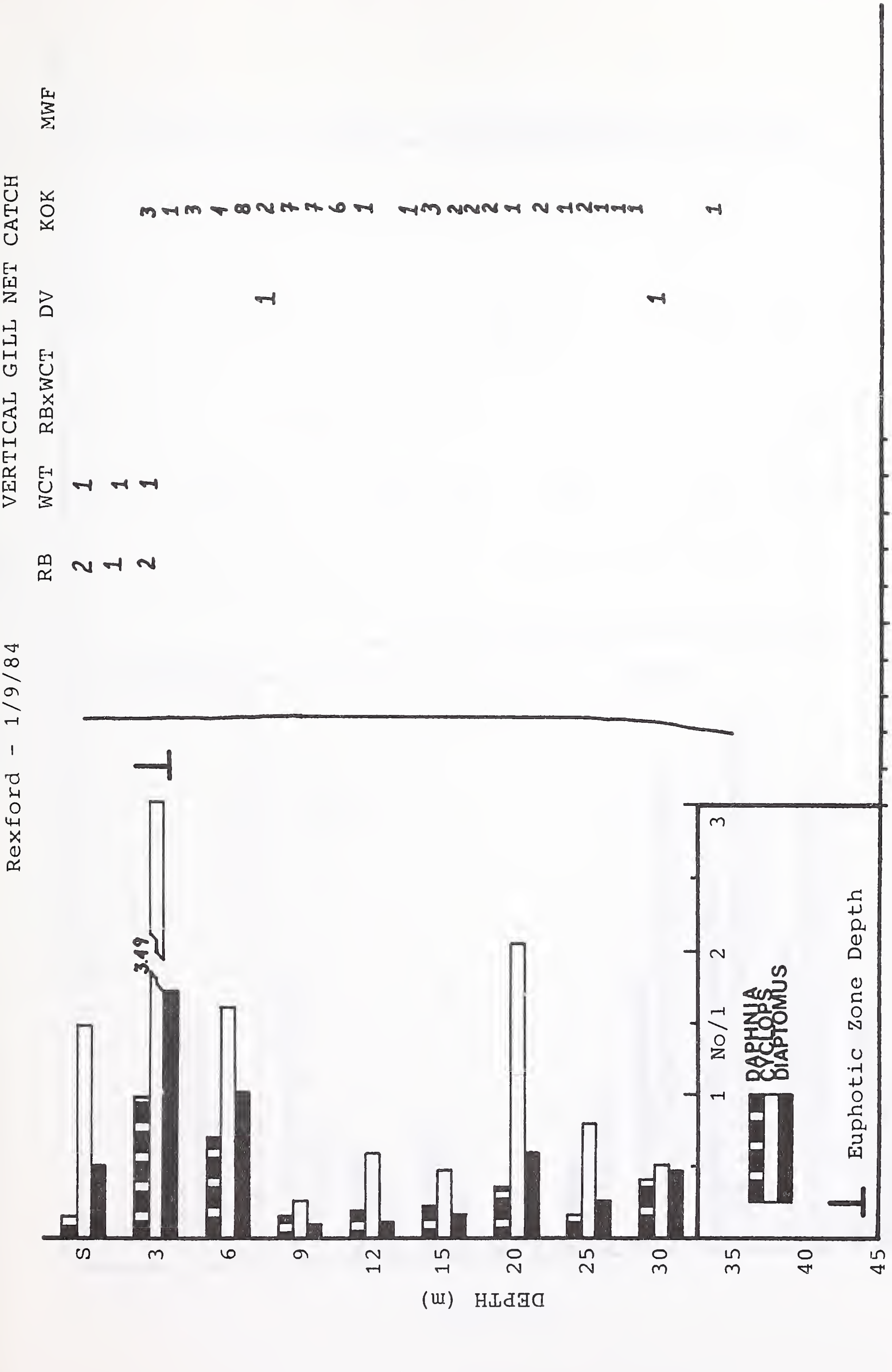
Tenmile - 6/7/84




Tenmile - 7/2/84
VERTICAL GILL NET CATCH
RB
WCT
HB
DV
KOK
MWF
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
15.7
38.9
20.9
12.0
4
No/l
8
12
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
3
4
5
6
7
8
9
10
11
12
13
TEMP (°C)

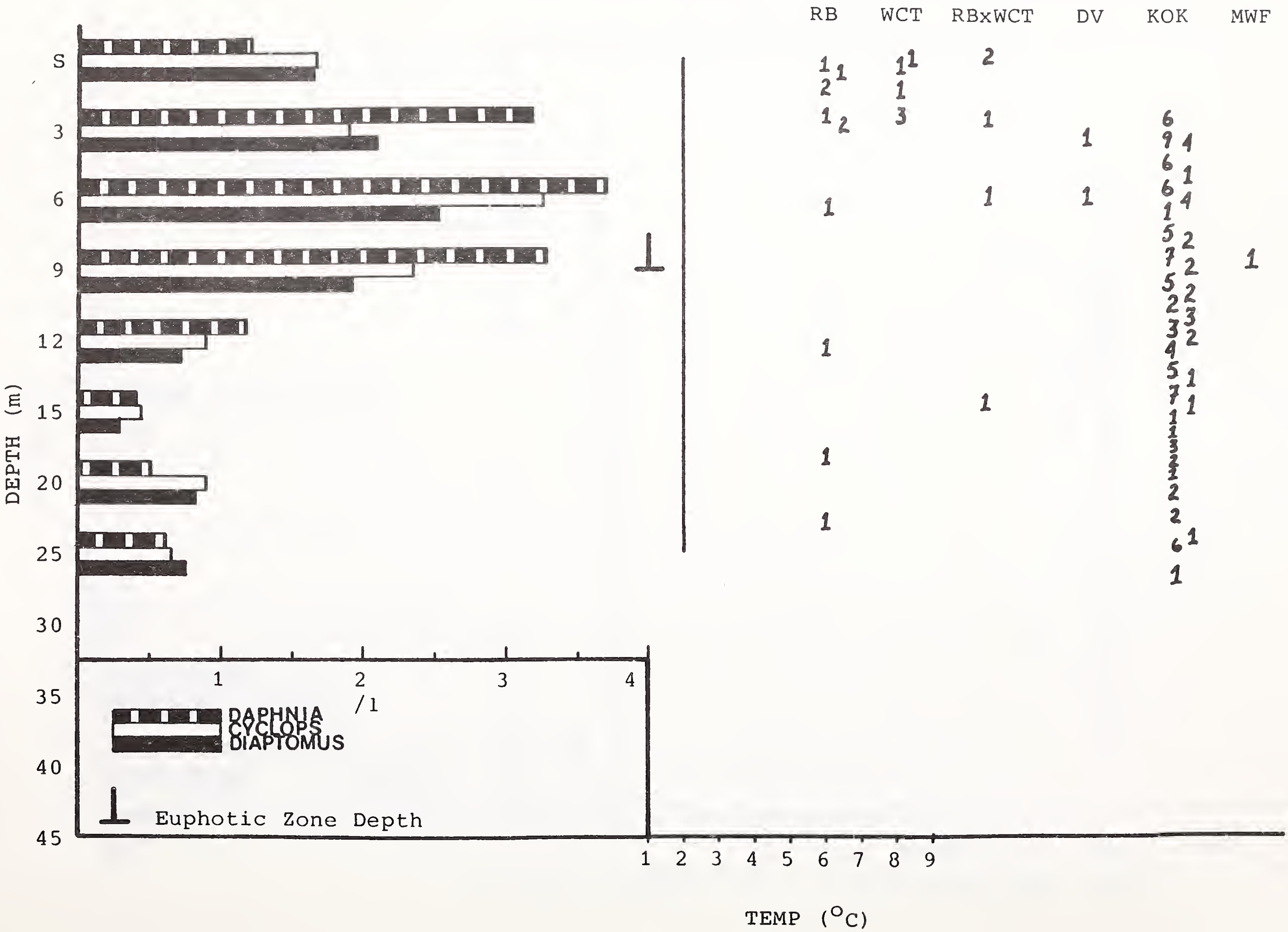

Rexford - 11/1/83
VERTICAL GILL NET CATCH
RB WCT RBxCT DV KOK MWF
1
1
1
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
1
No/l
2
3
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
5 6 7 8 9 10 11 12 13 14 15
Temp. (C)


Rexford - 12/8/84
VERTICAL GILL NET CATCH
RB WCT RBxWCT DV KOK MWF
1
3
2
1
1
1
2
1
1
1
1
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
1
No/1
2
3
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
5 6 7 8 9 10 11 12 13 14 15
TEMP (°C)

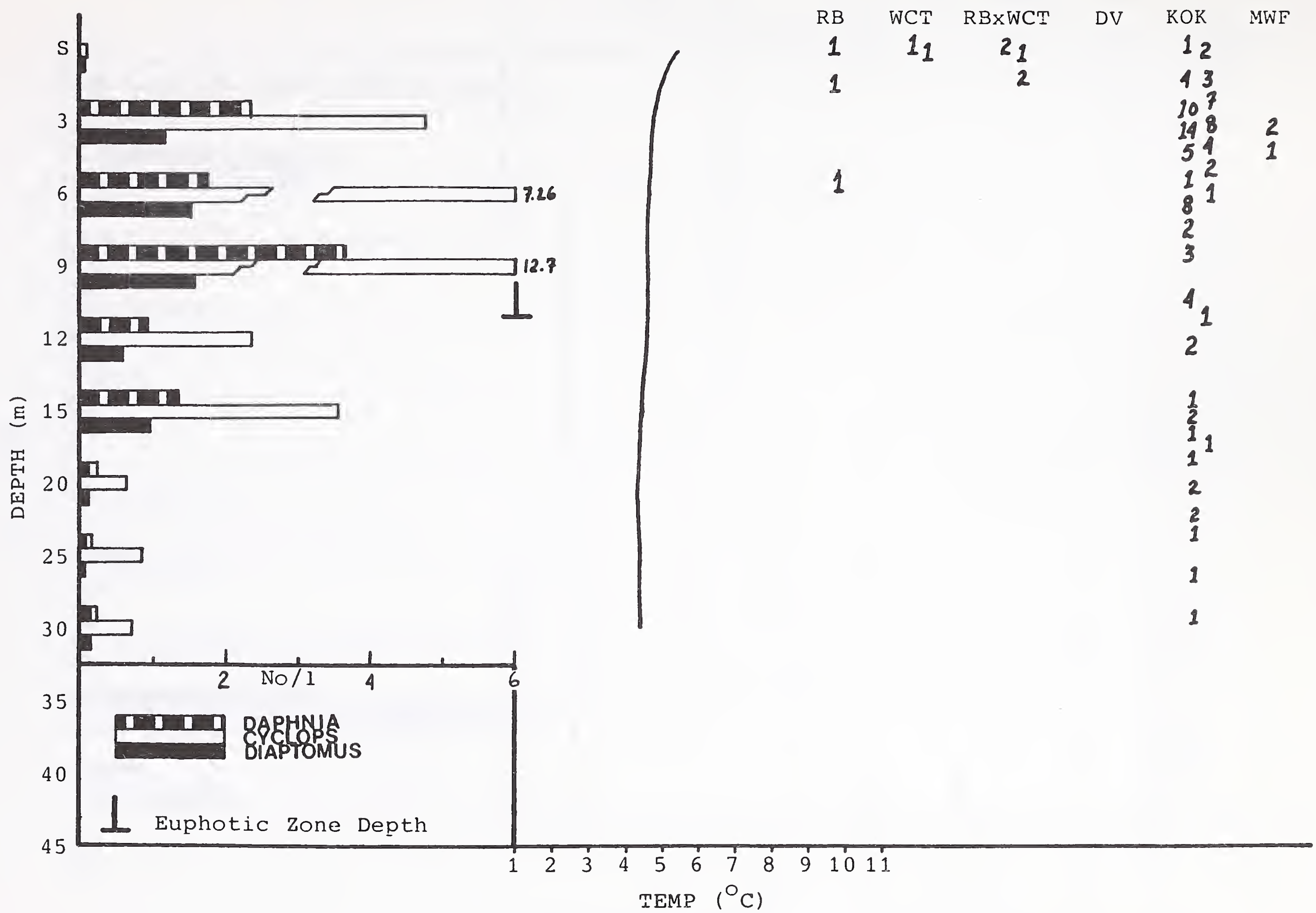

Rexford - 1/9/84
VERTICAL GILL NET CATCH
RB WCT RBxWCT DV KOK MWF
3.49
No/1
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
DEPTH (m)
TEMP (°C)

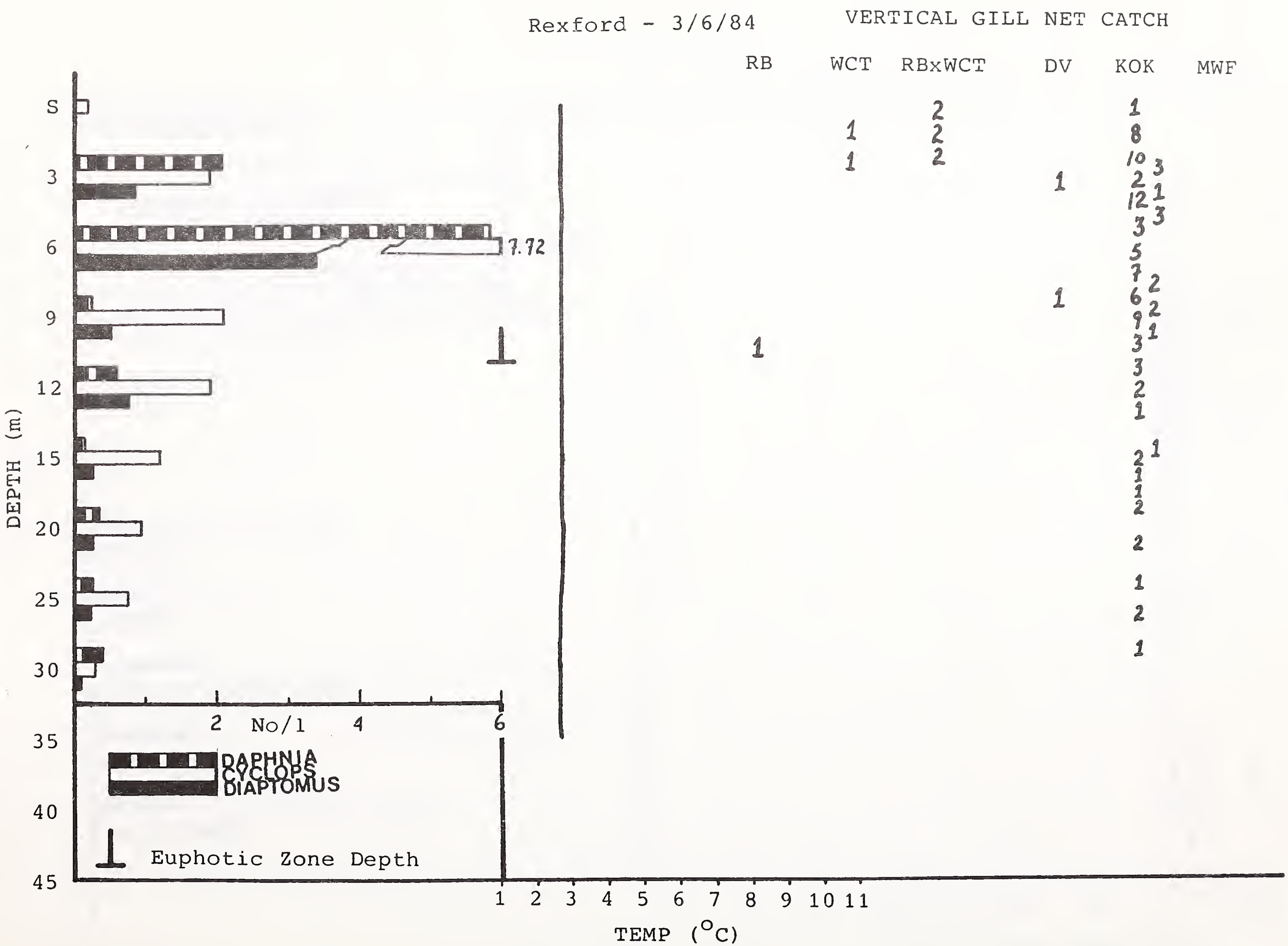
Rexford - 2/2/84

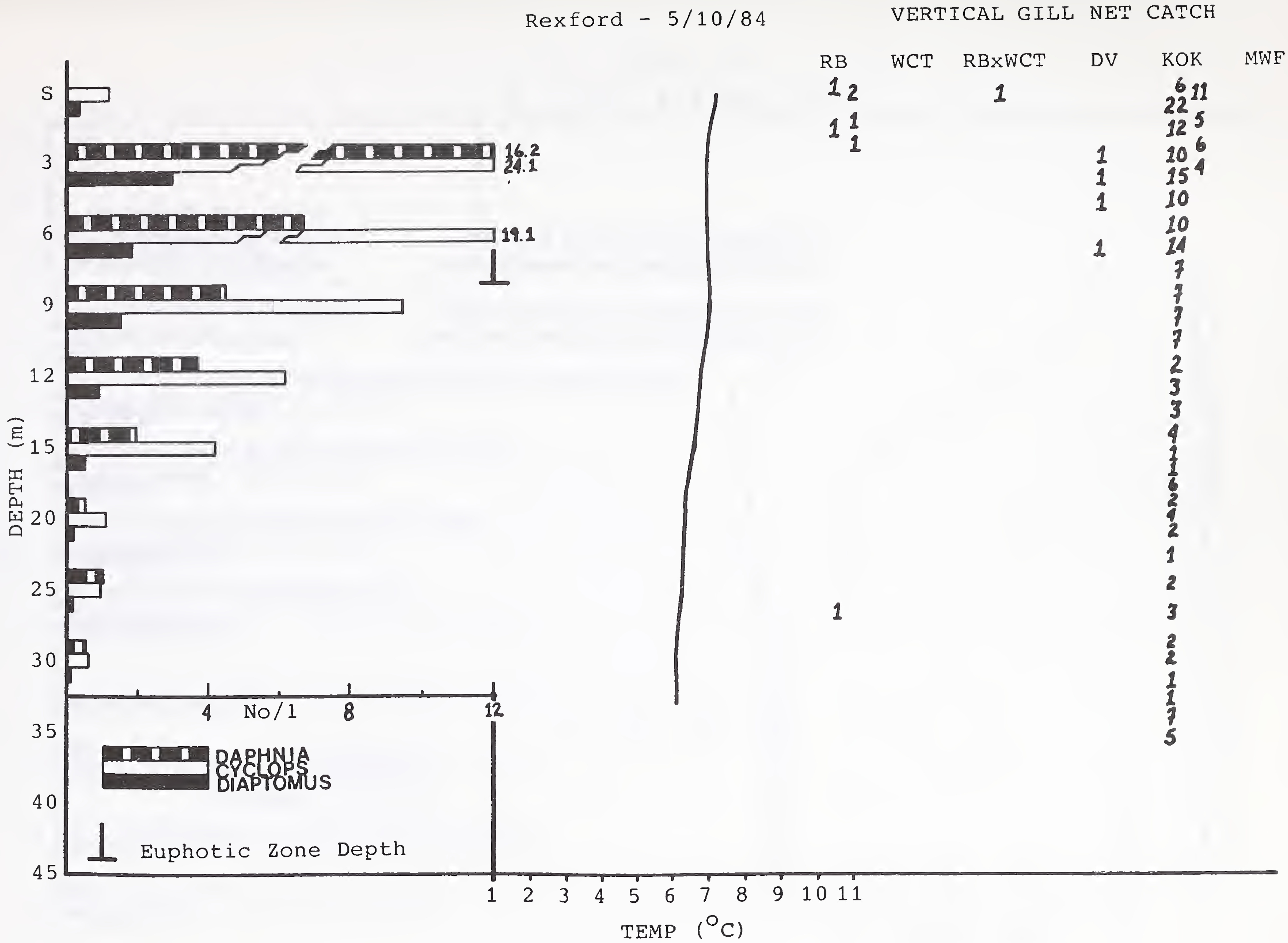
VERTICAL GILL NET CATCH

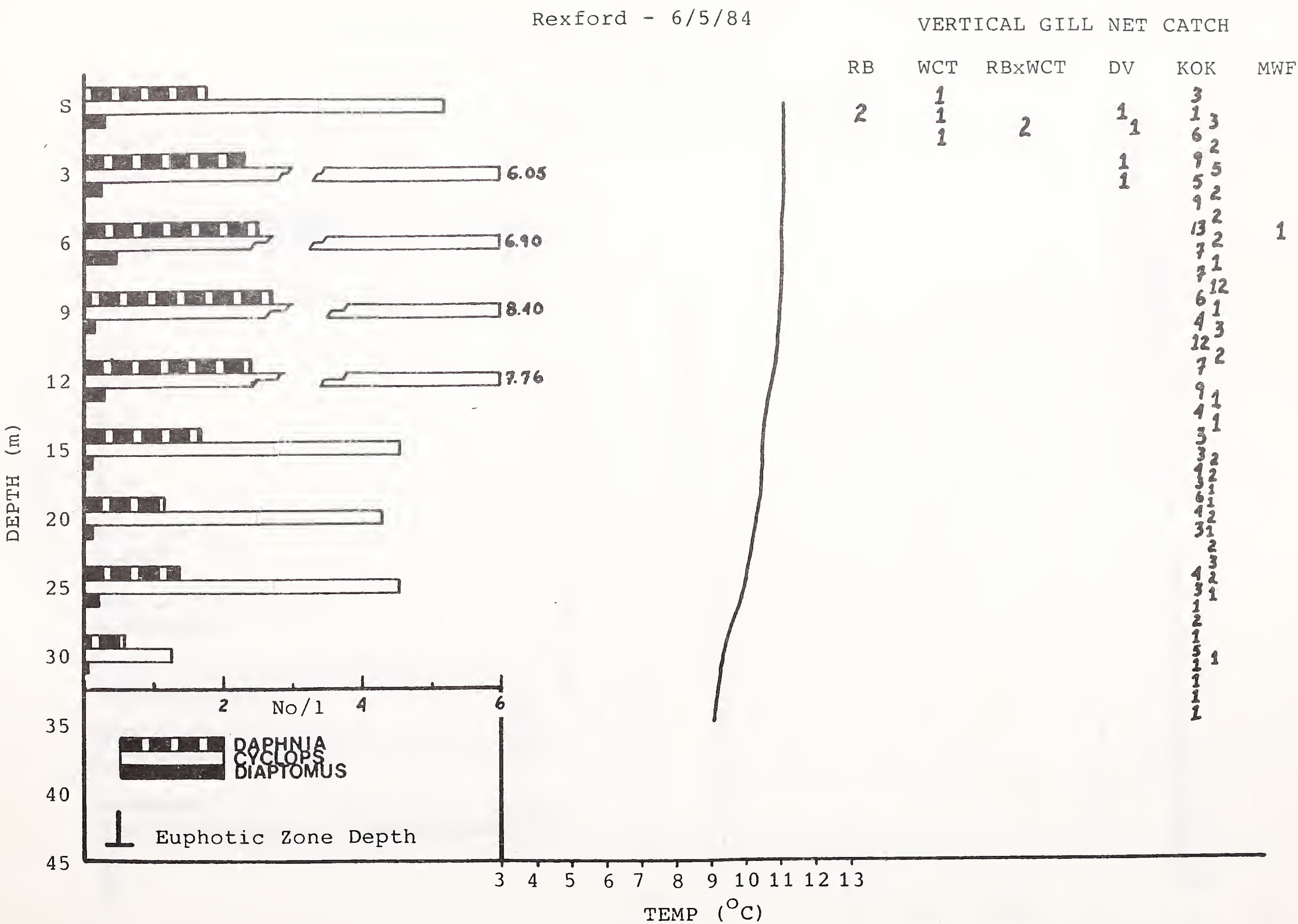


Rexford - 4/4/84 VERTICAL GILL NET CATCH

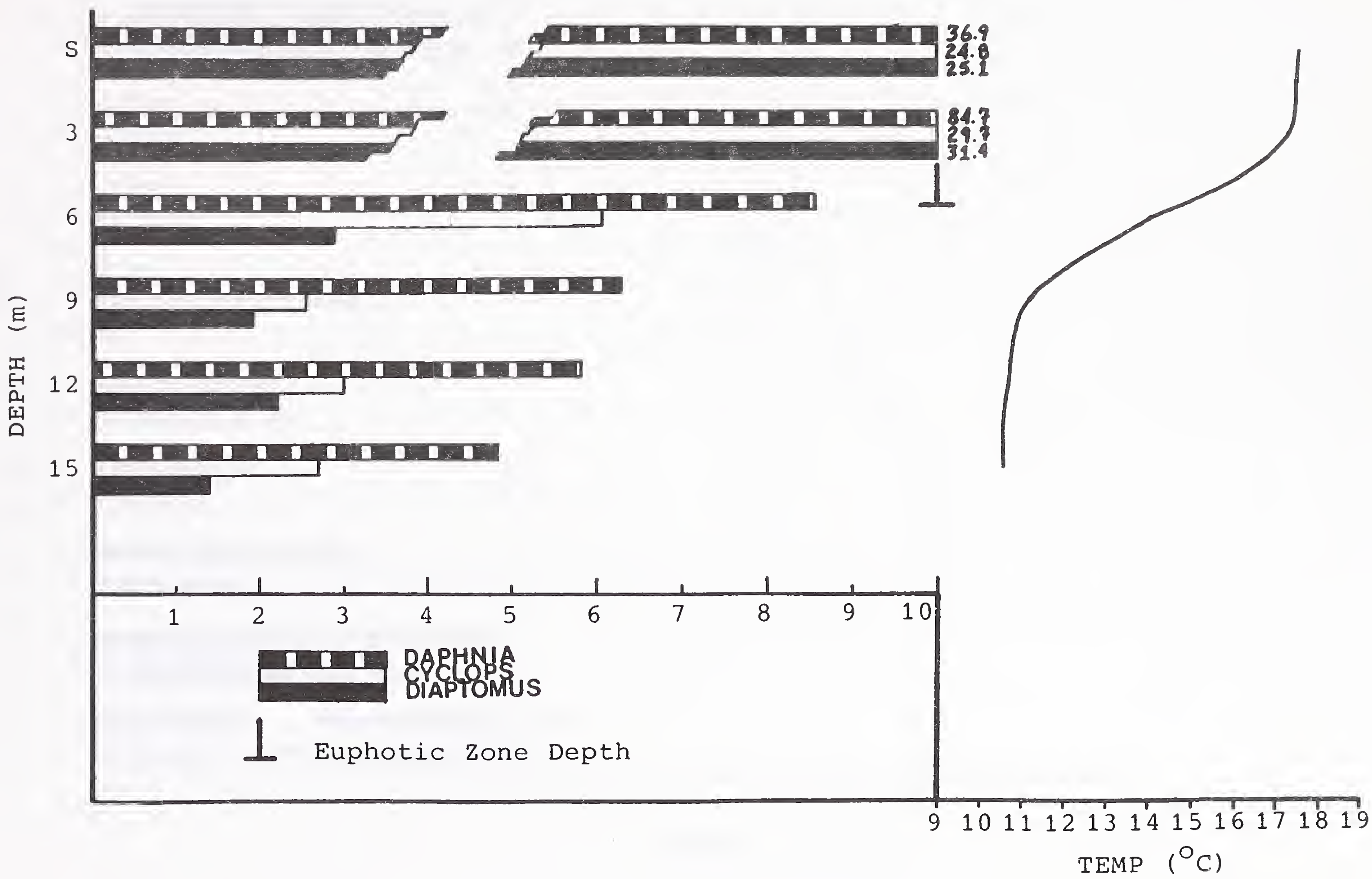



Rexford - 3/6/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
7.72
2
No/1
4
6
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
1 2 3 4 5 6 7 8 9 10 11
TEMP (°C)


Rexford - 5/10/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
16.2
24.1
19.1
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
4
No/1
8
12
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
1 2 3 4 5 6 7 8 9 10 11
TEMP (°C)

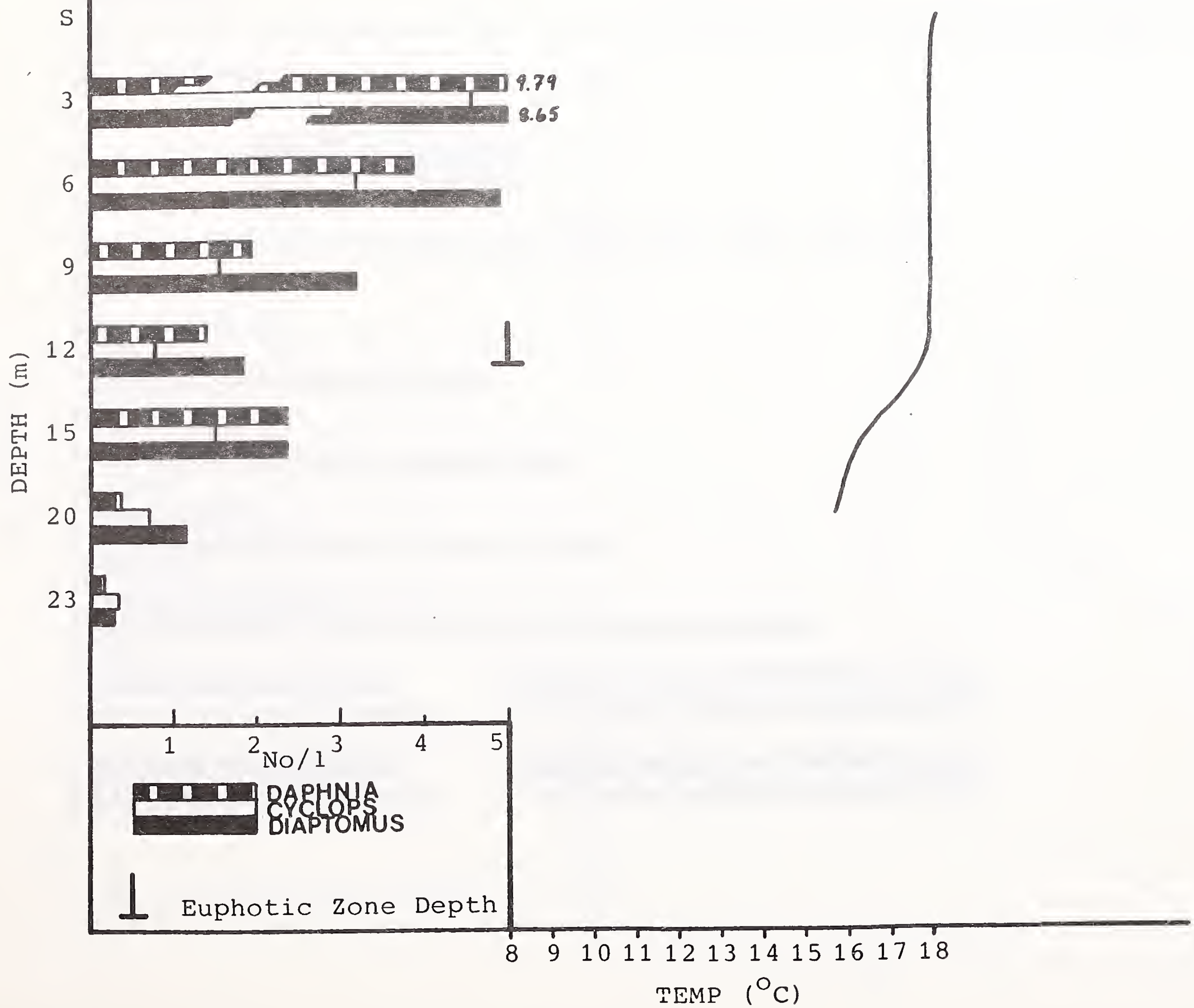

Rexford - 6/5/84
VERTICAL GILL NET CATCH
RB
WCT
RBxWCT
DV
KOK
MWF
DEPTH (m)
S
3
6
9
12
15
20
25
30
35
40
45
6.05
6.90
8.40
7.76
2
No/l
4
6
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
3 4 5 6 7 8 9 10 11 12 13
TEMP (°C)

Canada - 7/5/84



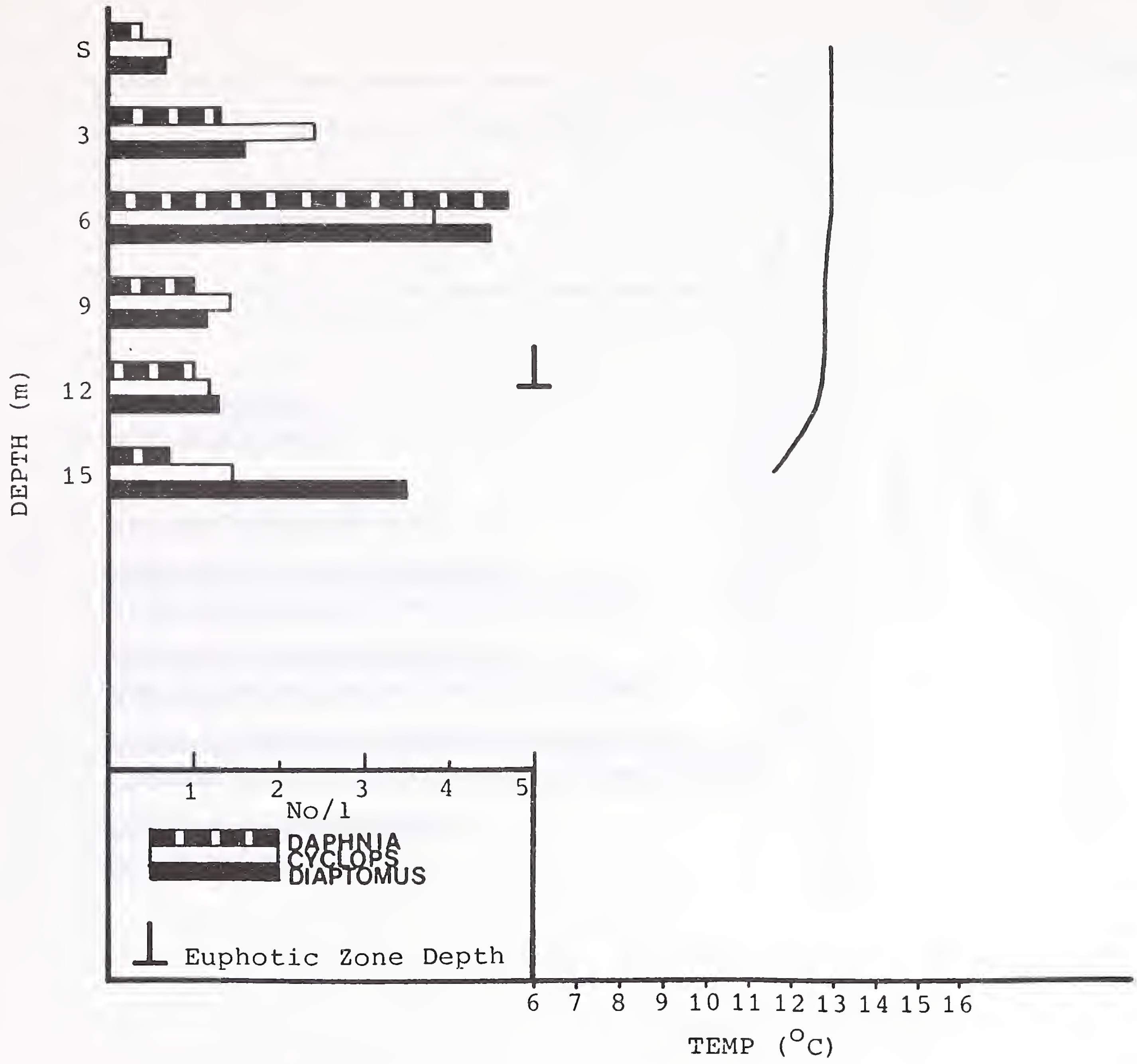
36.9
24.8
25.1
84.7
29.7
31.4
S
3
6
9
12
15
DEPTH (m)
1 2 3 4 5 6 7 8 9 10
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
9 10 11 12 13 14 15 16 17 18 19
TEMP (°C)

Canada - 9/8/83

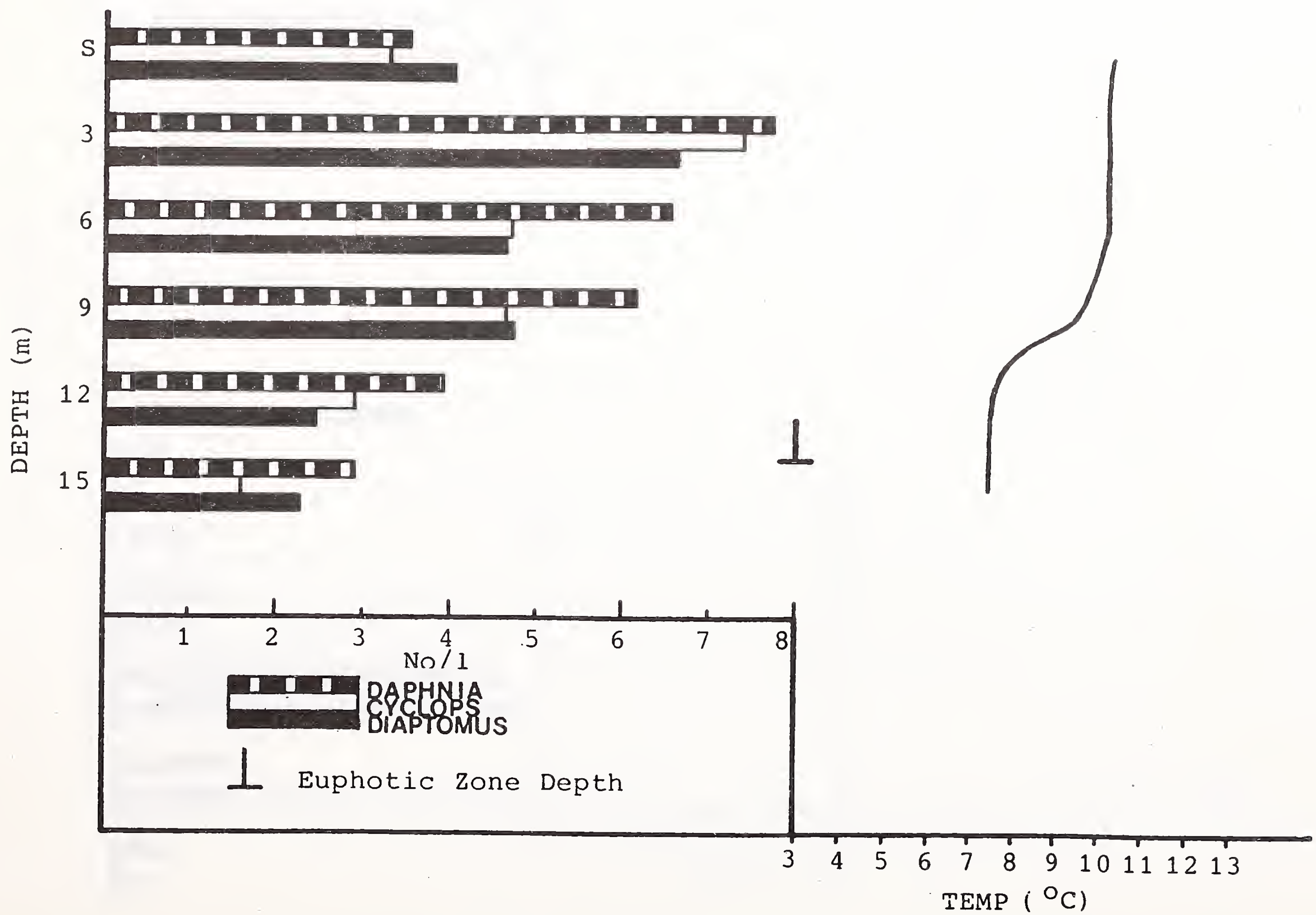


S
3
6
9
12
15
20
23
DEPTH (m)
9.79
8.65
1 2 3 4 5
No/1
DAPHNIA
CYCLOPS
DIAPTOMUS
Euphotic Zone Depth
8 9 10 11 12 13 14 15 16 17 18
TEMP (°C)

Canada - 10/7/83



Canada - 11/3/83



APPENDIX H

Timing of juvenile and adult movement through traps
located in Bristow, Big, Young, Fivemile,
and Fortine creeks during 1984
and tag return information for
1983 and 1984.

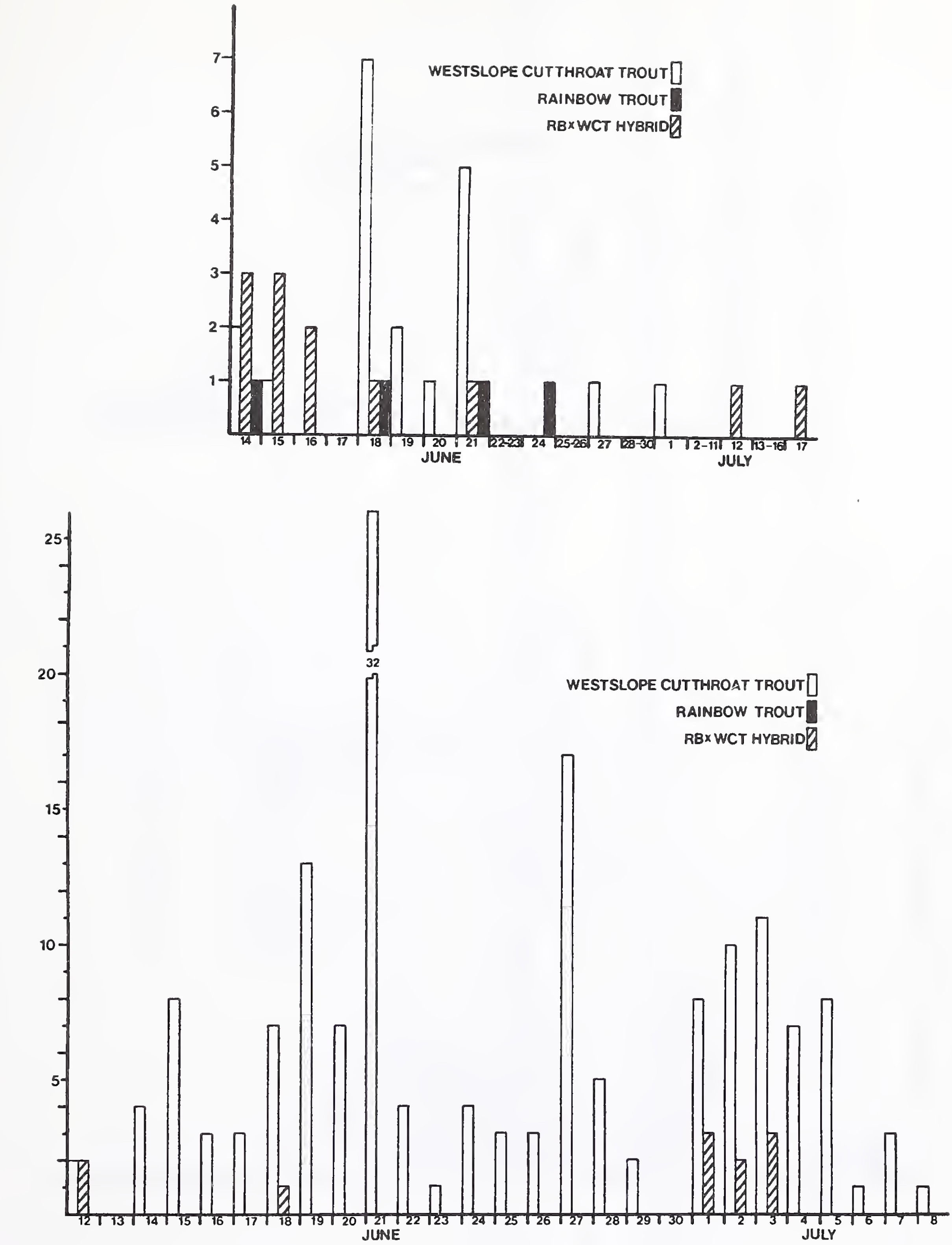


Figure H1. Timing of adult (top) and juvenile (bottom) trout movement downstream through a trap located in Bristow Creek during 1984.

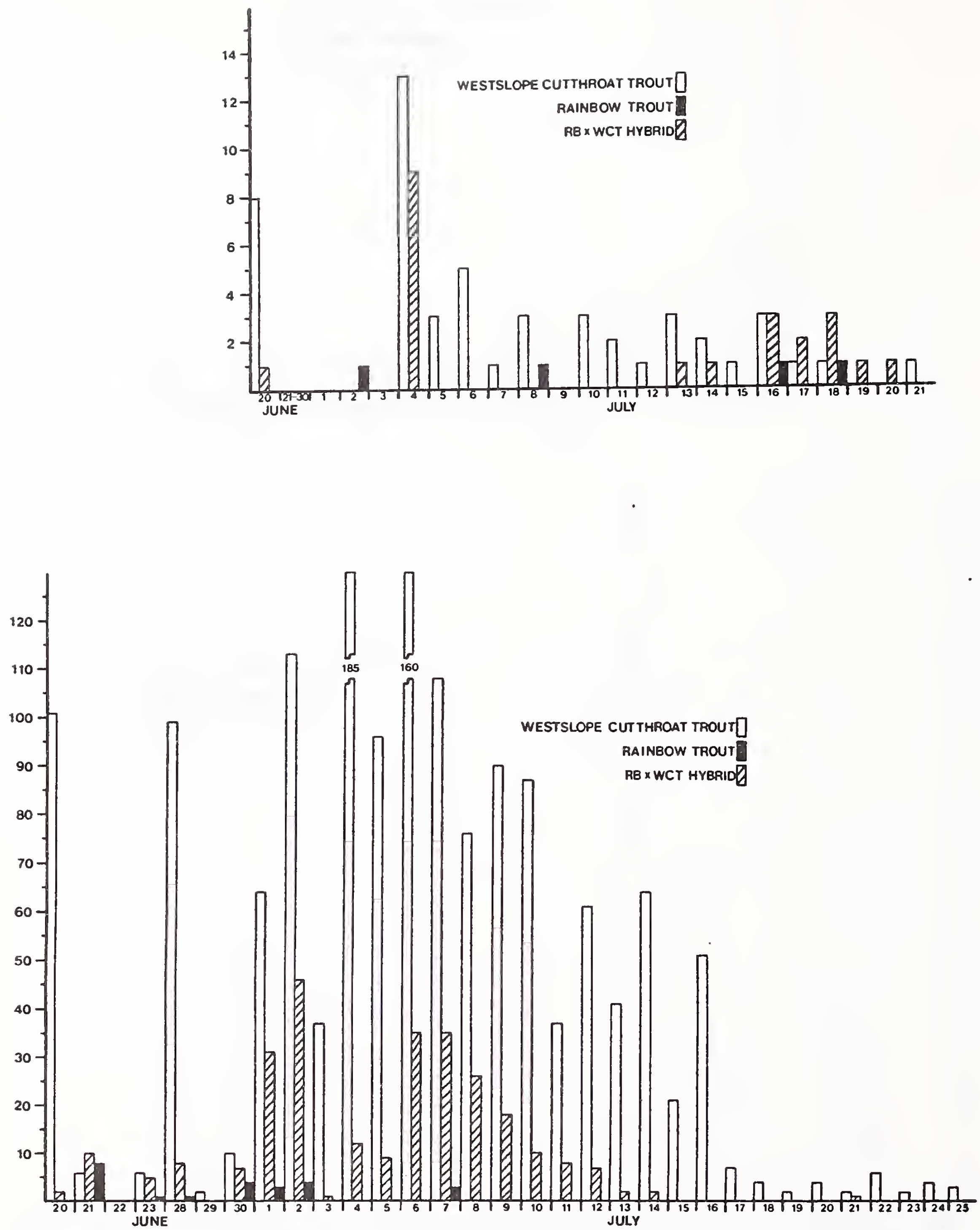


Figure H2. Timing of adult (top) and juvenile (bottom) trout movement downstream through a trap located in Big Creek during 1984.

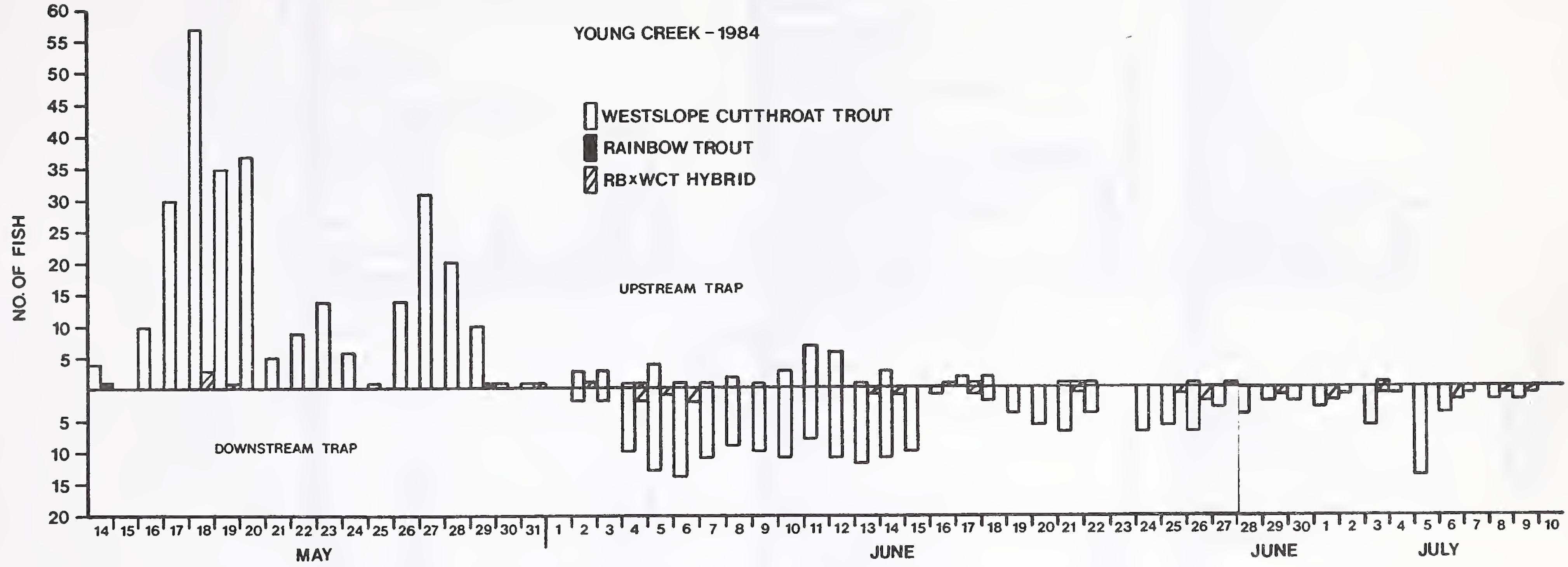


Figure H3. Timing of adult trout movement upstream and downstream through a permanent trap located in Young Creek during 1984.

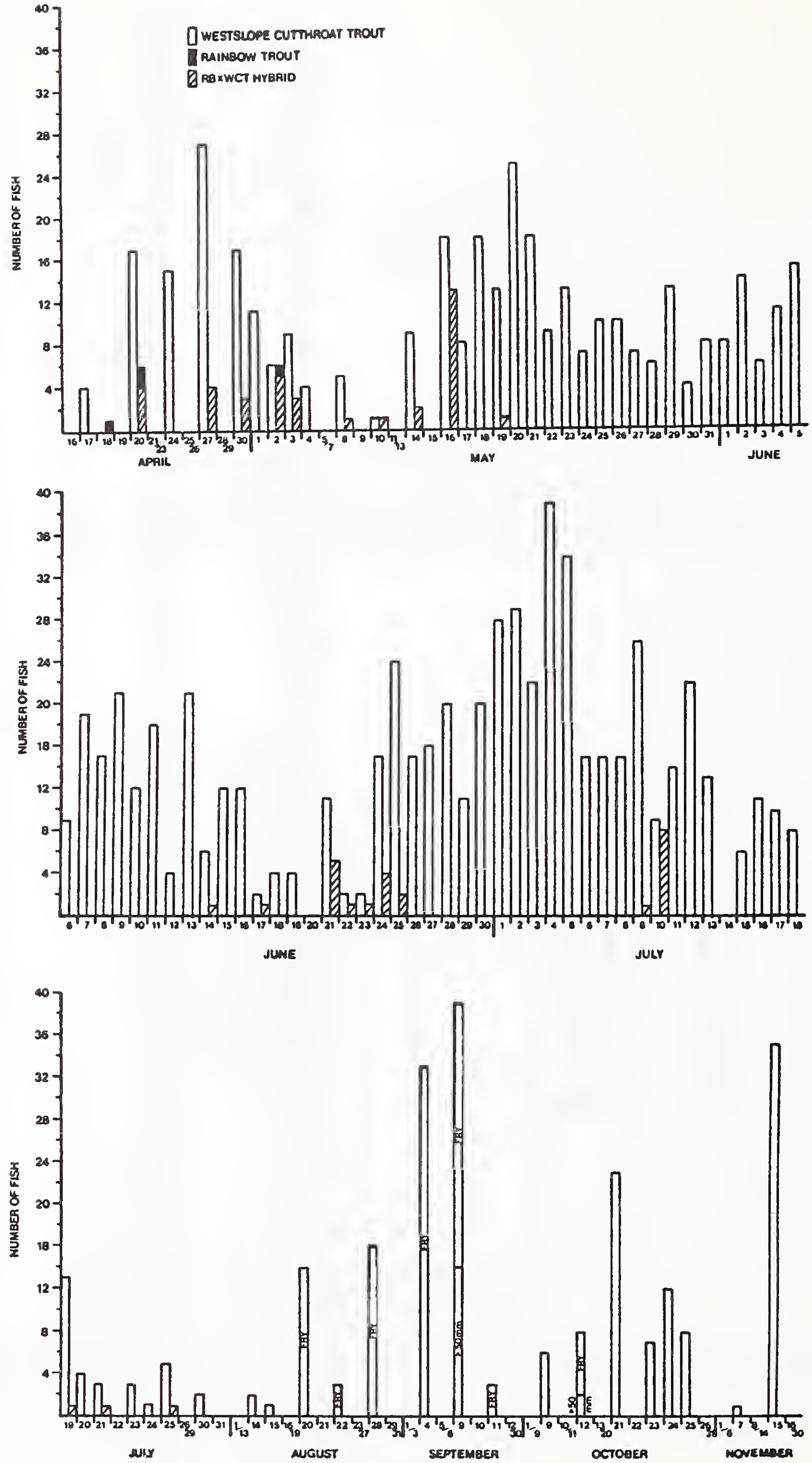


Figure H4. Timing of juvenile trout movement downstream through a trap located in Young Creek during 1984.

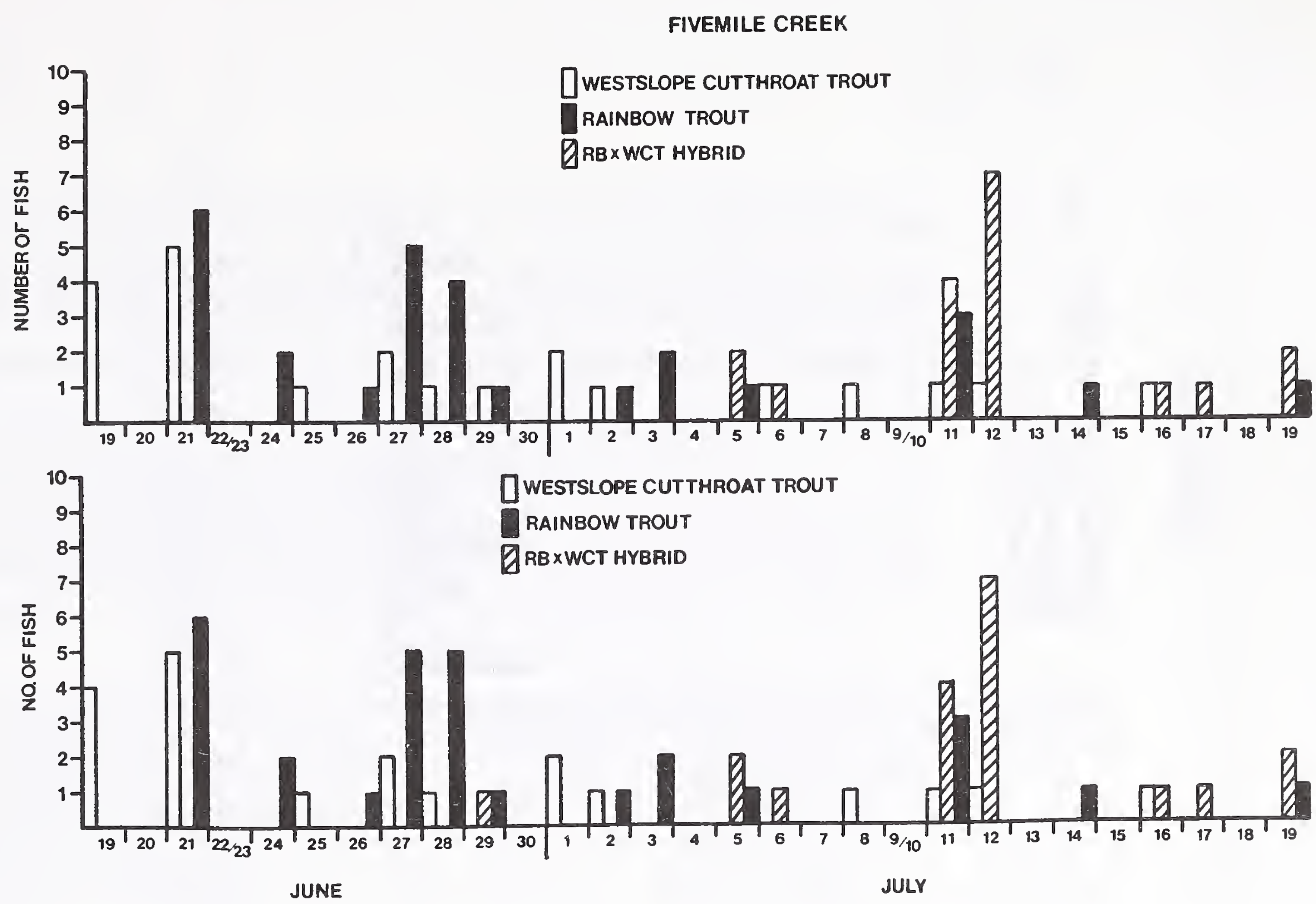


Figure H5. Timing of adult (top) and juvenile (bottom) trout movement downstream through a trap located in Fivemile Creek during 1984.

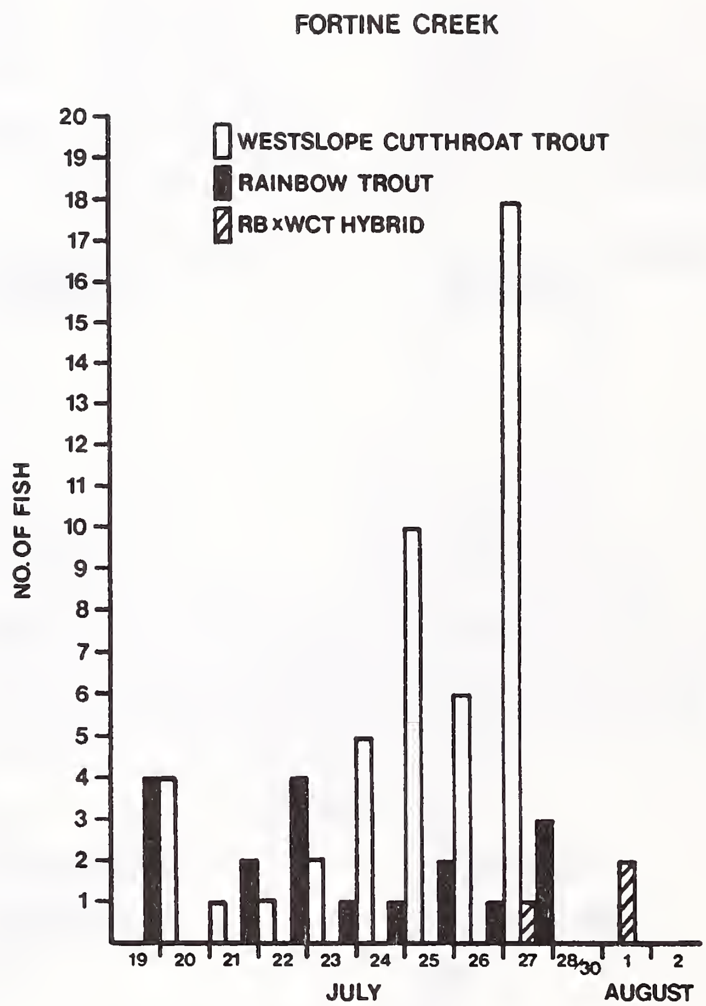


Figure H6. Timing of juvenile trout movement downstream through a trap located in Fortine Creek during 1984.

Table H1. Tag return information for adult trout tagged in Libby Reservoir and its tributaries during 1983 and 1984.

Location Tagged	Tagging Information Tag#	Date	Sp[a]	L	Wt	Return Information Date	L[b]	Wt[b]	Location[c]
Fish Trap									
Young Creek:	2494	06/15/83	WCT	407	544	11/05/83	381	680	Black Lake Bay (LK)
	2493	06/15/83	WCT	398	526	07/04/83			Big Creek
	2499	06/15/83	WCT	401	526	10/—/83			No location
	2554	06/06/83	WCT	372	456	08/26/83	330	526	Mouth of Tobacco R. (LK)
	2569	06/07/83	WCT	425	—	09/24/83	406	454	Mouth of Barren Ck. (LK)
	2598	06/10/83	WCT	397	544	07/03/83	356		Mouth of Elk R. (LK)
	2780	06/17/83	WCT	370	816	09/23/83	394	567	Westbank Tenmile (LK)
	2790	06/18/83	WCT	375	517	08/11/83			Lower Elk River, B.C.
	2795	06/19/83	WCT	395	535	09/—/83	406	317	Peck Gulch (LK)
	3438	06/25/83	WCT	380	536	08/10/83	440	963	S.P. Tobacco Bay (LK)
	3448	06/28/83	WCT	305	249	11/16/83			Warland area (LK)
	3460	06/29/83	WCT	395	526	09/30/83	395	680	Koocanusa Bridge (LK)
	3807	07/02/83	WCT	380	425	10/22/83	381	680	Sutton Creek Bay (LK)
	3439	06/23/83	WCT	391	580	05/22/84	391	473	So. Pt. Bristow (LK)[d]
	4094	06/14/84	WCT	392	530	06/18/84	381		No Location
	4068	06/16/84	WCT	402	621	06/16/84	393	567	Peck Gulch (LK)
	2584	06/08/83	HB	417	448	04/29/84	445	907	Mouth of Young Ck. (LK)
	2593	06/09/83	WCT	380	47	04/29/84	356		No location
	3450	06/29/83	WCT	405	522	04/29/84	356		No location
	4058	06/08/84	WCT	381	544	06/16/84	406		Above Sutton Ck. (LK)
	4185	07/02/84	HB	382	517	07/06/84			Mouth Young Ck. (LK)
	4127	06/15/84	WCT	396	635	06/20/84	406		Murray Bay (LK)
	3815	07/14/83	WCT	365	403	05/01/84	355		Tobacco Bay (LK)
	4043	06/07/84	WCT	410	581	06/07/84	406	907	No location
	5867	07/16/84	WCT	359	366	07/22/84	356		Mouth Young Ck. (LK)
	2575	06/07/83	WCT	395	550+	07/11/84	381		Fivemile Ck. (LK)
	4021	06/05/84	WCT	407	713	06/17/84	406		East side of Dam (LK)
	4066	06/09/84	WCT	407	576	06/13/84	356	454	Rexford area (LK)
	2783	06/16/83	WCT	406	521	06/22/84	406	793	Fivemile Creek
	3426	06/21/83	WCT	376	481	08/09/84	431		By Libby Dam (LK)
	3398	06/16/84	WCT	410	598	08/13/84	406		In front of Dam (LK)
	2594	06/09/83	WCT	387	512	09/—/84			No location
	4012	06/04/84	WCT	371	571	09/—/84			No location
	4182	07/18/84	WCT	382	544	09/08/84	356		Above dam east (LK)
	5856	07/05/84	WCT	380	490	09/07/84	406	907	10 miles below Rex (LK)
Big Creek:	4310	07/06/84	WCT	406	520	07/07/84	416	793	Peck Gulch (LK)
	4299	07/21/84	HB	450	550	07/22/84	431		Left side by dam (LK)
	5527	06/28/84	WCT	390	586	09/09/84	381	454	2 Mi. S. Peck Gulch (LK)
	4342	07/19/84	WCT	362	444	09/08/84	356		East above dam (LK)
	4346	07/19/84	HB	352	550	09/23/84			Mouth Barren (LK)
Five Mile:	5489	06/19/84	WCT	377	455	07/13/84			1/2 mi. No. Dam (LK)
	5544	07/05/84	RB	404	488	07/12/84			Westshore Dam (LK)
	3488	06/19/84	WCT	395	424	07/26/84			No location
	5524	06/27/84	RB	405	430	07/19/84	381		Peck campground (LK)
	5539	07/02/84	RB	359	339	07/19/84	317		Kootenai River
	5560	07/11/84	HB	401	415	07/11/84	406		West shore above Dam (LK)
	5546	07/06/84	WCT	357	351	11/16/84	304		2 mi. So. Bridge (LK)
Pinkham:	4224	07/18/84	RB	365	410	08/04/84	279		Mouth of Pinkham Ck. (LK)
	4226	07/18/84	WCT	378	402	08/04/84	279		Mouth of Pinkham Ck. (LK)
	4216	07/02/84	WCT	352	412	11/30/84	406		Kootenai River below dam

Table . Continued

Tagging Information						Return Information			
Location Tagged	Tag#	Date	Sp	L	Wt	Date	L	Wt	Location
Bristow:	5500	06/19/84	WCT	380	500	07/03/84	368		Mouth of Canyon Ck. (LK)
Purse Seine									
Tenmile Area									
Sutton Creek	5461	05/04/84	RB	302	315	08/—/84	425		Canada area (LK)
2E	2601	11/28/83	WCT	308	278	12/01/83			Mouth of Warland Ck. (LK)
Rexford Area									
S. Border Buoy	5197	04/10/84	RB	340	417	04/28/84	343	227	Koocanusa Bridge (LK)
Young Cr. Bay:	5159	03/29/84	WCT	405	743	06/03/84	406		Above bridge (LK)
	5161	03/29/84	HB	313	349	06/11/84	406		Rexford boat ramp (LK)
	5155	03/29/84	RB	308	313	06/05/84	311	340	Koocanusa
	5132	03/29/84	RB	432	694	07/04/84			Gold Creek
	5163	03/29/84	HB	357	481	08/13/84	406	793	Near Dam (LK)
	5160	03/29/84	WCT	358	481	06/10/84	330	340	Canyon Creek
So. Pt. Young:	5112	03/29/84	WCT	310	331	06/16/84	330		Above Souse Gulch (LK)
	5120	03/29/84	RB	348	440	09/—/84			No location
	5116	03/29/84	WCT	382	626	07/12/84			No location
Far So. Tobacco:	5177	03/30/84	WCT	304	290	05/27/84	304		Rexford Point (LK)
	5174	03/30/84	WCT	387	608	08/11/84	393	1134	5 mi. N. Elk River (LK)
So. Murray Spg.	5071	03/28/84	RB	399	653	04/24/84	397	653	N. pt. Fivemile (LK)[d/]
N.N.Pt. Tobacco:	5045	03/28/84	RB	417	712	08/09/84	432		West shore above dam (LK)
	5188	04/09/84	HB	337	432	04/03/84	468		North of Bridge (LK)
	5065	03/28/84	WCT	316	362	08/27/84	432	680	L. Koocanusa
	5061	03/28/84	WCT	296	249	10/01/84			Mouth of Wigwam, B.C.
	5055	03/28/84	WCT	403	667	05/15/84	432		Behind Dam (LK)
	5051	03/28/84	WCT	387	607	04/15/84	406		Near Bridge (LK)
	5186	04/09/84	WCT	338	431	05/02/84	330	680	Tenmile area (LK)
	5411	05/01/84	RB	332	386	06/14/84	330	340	Btwn Marina & Warland (LK)
	5262	04/13/84	WCT	334	335	06/11/84	330	453	Behind dam (LK)
Tobacco Bay:	5001	03/26/84	RB	353	544	06/20/84	330		Mouth of Boulder Ck. (LK)
	5254	04/12/84	RB	325	367	06/—/84	330		Mouth of Pinkham Ck. (LK)
	5003	03/26/84	WCT	398	689	05/27/84	386		Tobacco River
	5440	05/02/84	HB	352	490	06/14/84			No location
	5078	03/28/84	RB	420	816	06/23/84	1355	793	Mouth of Pinkham Ck. (LK)
	5438	05/02/84	WCT	319	353	05/27/84		680	No location
	5089	03/28/84	RB	386	608	04/20/84	368	567	Rexford area (LK)
	5004	03/26/84	HB	401	734	07/01/84	406	793	Mouth of Parsnip Ck. (LK)
Far So. Tobacco	5180	03/30/84	WCT	418	721	05/25/84	470		Bristow Ck.
Sullivan Creek:	5228	04/14/84	WCT	398	671	05/22/84	409	648	S. pt. Tenmile Ck. (LK)[d/]
	5232	04/12/84	RB	416	762	06/15/84	413	716	N. pt. Fivemile Ck. (LK)[d/]
	5227	04/12/84	WCT	280	245	09/13/84	330	453	2 mi. S. Peck Gulch (LK)
	5021	03/27/84	RB	430	703	08/—/84	425		Canada area (LK)
	5022	03/27/84	RB	335	403	11/07/84	330		Koocanusa
Poverty Creek:	5210	04/12/84	WCT	302	317	06/22/84	318		West above dam (LK)
	5218	04/12/84	HB	447	839	05/08/84	431		Koocanusa East (LK)

Table . Continued

Location Tagged	Tagging Information: Tag#	Date	Sp	L	Wt	Return Information: Date	L	Wt	Location
Electrofish									
Mouth Elk:	5365	04/19/84	DV	541	1415	08/30/84	558	1588	Wigwam River
	5363	04/19/84	WCT	310	312	08/31/84	374	680	Wigwam River
	5368	04/19/84	WCT	338	367	08/10/84	304		Elk Dam, Elk River
Kikomun:	5332	04/17/84	RB	376	562	07/24/84	368	340	Peck Gulch (LK)
	5327	04/17/84	RB	443	816	06/04/84	355		Just above bridge (LK)
N. Kikomun:	5351	04/18/84	RB	250	190	04/—/84			Mouth Kikomun (LK)
	5338	04/18/84	WCT	326	371	06/03/84			Mouth Kikomun (LK)
Bristow Creek:	511	07/14/83	RB	445	585	06/14/84	435	626	Big Bend (LK)[d]
	779	06/20/83	WCT	410	550+	10/12/83	381		Canada (LK)
	773	06/20/83	WCT	390	484	09/20/83	386	571	S. pt. Tenmile Ck. (LK)[d]
Big Creek:	742	06/28/83	WCT	384	412				Big Creek
	218	07/14/83	HB	416	534	12/—/83			No location
Bristow Creek	443	06/27/83	HB	372	412	05/18/84	406		Parsnip Mouth (LK)

a/ Species abbreviations explained in the "Methods" section.
b/ Lengths and weights for returns were often estimates from anglers.
c/ (LK) designates Libby Reservoir.
d/ These returns were captured in our sampling gear.

Table H2. Tag return information for juvenile trout tagged with dangler tags in Libby Reservoir tributaries during 1983 and 1984. Species abbreviations were explained in the "Methods" section. Lengths and weights of returned fish were estimated by anglers.

Location Tagged	Tagging Information					Return Information			
	Tag#	Date	Sp	L	Wt	Date	L	Wt	Location
Fish Trap									
Young Creek:	5455	06/08/83	HB	168	47	10/09/83	304		Below Elk River (LK)
	356	06/21/83	WCT	195	70	10/—/83	228		Warland area (LK)
	2082	06/30/84	WCT	213	109	09/08/84	241		Souse Gulch (LK)
	3553	07/19/84	WCT	192	76	09/27/84	254	150	Kokomun Creek, B.C.
	561	06/21/84	WCT	142	29	08/—/84			B.C., Canada
	2532	07/11/84	WCT	156	40	08/07/84	177		Rexford Campground (LK)
Big Creek:	890	06/18/83	WCT	160	38	08/14/83	203		Kootenai River below dam
	971	06/19/83	HB	180	54	08/21/83	265		Peck Gulch (LK)
	480	06/27/83	HB	150	32	08/02/83	177		Big Creek
	852	06/30/83	HB	184	54	07/30/83			Big Creek
	880	07/01/83	WCT	156	33	12/—/83			No location
	889	06/18/83	HB	169	39	05/—/84	279		Mouth Young Creek (LK)
	960	07/09/84	WCT	151	30	07/—/84			Big Creek
	2602	07/06/84	WCT	141	22	08/21/84	189	54	Tenmile area (LK)[a/]
	3199	07/09/84	WCT	164	37	09/—/84			No location
	2912	07/04/84	HB	136	17		152		Big Creek
	482	06/21/83	WCT	204	74	07/22/83			Big Creek

[a/] Captured in our sampling gear.

APPENDIX I

Food habits information for fish collected during August 1983 from Libby Reservoir

Table I1. Index of relative abundance for gamefish collected in Libby Reservoir during the summer of 1983.

Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Diptera Larvae	Diptera Pupae	Diptera Adult	Arachnids	Misc. Other	Fish KOK	Fish Trout	Fish Other	Insect parts	Debris	Algae
	Rb	≤330	5	68.3	—	38.8	—	25.3	—	—	13.6	6.9	6.7	—	—	—	30.4	10.1	—
	Rb	>330	30	51.5	3.4	15.6	—	51.3	2.3	—	5.7	2.6	1.1	1.3	—	4.6	14.1	5.3	3.5
	Wct	≤330	10	77.6	3.4	12.0	3.4	31.4	—	6.8	10.1	7.2	—	—	—	—	32.1	—	—
	Wct	>330	12	44.6	2.7	16.4	—	59.5	2.7	—	5.7	2.9	—	—	—	—	47.7	—	—
	Hb	≤330	5	76.6	—	14.5	—	24.6	6.7	—	13.5	20.8	—	—	—	—	34.9	—	—
	Hb	>330	4	79.4	—	27.8	—	17.8	—	—	—	—	—	—	—	8.3	12.5	—	12.5
	MWF		6	89.3	4.4	35.1	12.7	8.4	12.4	4.3	4.3	—	—	—	—	—	—	—	—
	KOK		5	99.8	13.5	13.3	13.3	—	—	6.7	—	—	—	—	—	—	10.0	—	—
	CSU		13																
	FSU		3																
	NSQ		8																
	CRC		13																
	RSS		12																

Table I2. Percentage of the number of each type of food ingested by fish collected in Libby Reservoir during the summer of 1983.

Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Diptera			Arachnids	Misc. Other	Fish			Insect parts	Debris	Algae
									Larvae	Pupae	Adult			KOK	Trout	Other			
	Rb	≤330	5	79.2	—	19.9	—	0.8	—	—	0.1	<0.1	—	—	—	—	n/a	n/a	n/a
	Rb	>330	30	77.7	0.3	11.4	—	10.4	<0.1	—	0.1	<0.1	—	<0.1	—	<0.1			
	Wct	≤330	10	95.8	0.1	1.2	0.2	2.0	—	0.4	0.2	0.1	—	—	—	—			
	Wct	>330	12	55.5	0.2	10.6	—	33.3	0.1	—	0.2	0.1	—	—	—	—			
	Hb	≤330	5	98.3	—	0.4	—	1.0	0.1	—	0.1	0.1	—	—	—	—			
	Hb	≥330	4	89.8	—	9.7	—	0.5	—	—	—	—	—	—	—	<0.1			
	MWF		8	95.4	0.2	3.3	1.0	0.1	0.1	<0.1	<0.1	—	—	—	—	—			
	KOK		5	99.7	0.2	<0.1	<0.1	—	—	<0.1	—	—	—	—	—	—			
	CSU		13	86.0	0.3	1.6	0.5	—	6.6	1.1	1.3	—	2.6	—	—	—			
	FSU		3	58.5	0.3	—	0.8	—	23.4	—	17.0	—	—	—	—	—			
	NSQ		8	73.3	—	6.7	—	—	—	—	—	—	—	—	—	20.0			
	CRC		13	96.5	—	—	—	0.2	0.5	—	—	—	2.9	—	—	—			
	RSS		12	82.0	—	3.4	11.4	—	—	—	0.9	—	2.6	—	—	—			

Table I3. Percent of the weight of each type of food ingested by gamefish collected in Libby Reservoir during the summer of 1983.

Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Diptera Larvae	Diptera Pupae	Diptera Adult	Arachnids	Misc. Other	Fish KOK	Fish Trout	Fish Other	Insect parts	Debris	Algae
8/16-8/19	Rb	≤330	5	25.8	—	56.5	—	15.2	—	-	0.8	0.6	—	—	—	—	0.8	0.3	-
	Rb	>330	30	3.8	T	5.4	—	86.4	T	-	0.1	0.7	0.2	0.8	—	0.7	1.2	0.7	T
	Wct	≤330	10	47.0	T	4.8	T	32.3	—	T	0.1	1.5	—	—	—	—	14.1	—	-
	Wct	>330	12	3.4	T	5.5	—	70.3	—	-	T	0.4	—	—	—	—	20.4	—	-
	Hb	≤330	5	71.5	—	3.0	—	12.9	0.1	-	0.5	2.2	—	—	—	—	9.8		
	Hb	>330	4	48.4	—	48.8	—	2.8	—	-	—	—	—	—	—	T	T	—	T
	MWF		8	72.4	0.1	27.1	0.1	0.2	0.1	T	T	—	—	—	—	—	—	—	-
	KOK		5	99.6	0.4	T	T	—	—	T	—	—	—	—	—	—	T	—	-
	CSU		13																
	FSU		3																
	NSQ		8																
	CRC		13																
	RSS		12																

Table I4. Frequency of occurance of each type of food ingested by gamefish collected in Libby Reservoir during the summer of 1983.

Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Diptera Larvae	Diptera Pupae	Diptera Adult	Arachnids	Misc. Other	Fish KOK	Fish Trout	Fish Other	Insect parts	Debris	Algae
8/16-8/19	Rb	≤330	5	100	—	40	—	60	—	—	40	20	20	3	—	—	60	20	—
	Rb	>330	30	73	10	30	—	57	7	—	17	7	3	3	—	13	27	10	7
	Wct	≤330	10	90	10	30	10	60	—	20	30	20	—	-	—	—	50	—	—
	Wct	>330	12	75	8	33	—	75	8	—	17	8	—	-	—	—	75	—	—
	Hb	<330	5	60	—	40	—	60	20	—	40	60	—	-	—	—	60	—	—
	Hb	>330	4	100	—	25	—	50	—	—	—	—	—	-	—	25	25	—	25
	MWF		8	100	13	75	37	25	37	13	13	—	—	-	—	—	—	—	—
	KOK		5	100	40	40	40	—	—	20	—	—	—	-	—	—	20	—	—
	CSU		13	85	8	31	8	—	23	8	23	—	8	-	—	—	23	92	—
	FSU		3	67	33	—	33	—	67	—	33	—	—	-	—	—	33	33	—
	NSQ		8	37	—	13	—	—	—	—	—	—	—	-	—	25	50	37	25
	CRC		13	85	—	—	—	8	15	—	—	—	8	-	—	—	23	23	—
	RSS		12	67	—	17	8	—	—	—	8	—	8	-	—	—	8	17	—

Table I5. Average number of each type of food ingested by fish collected in Libby Reservoir during the summer of 1983.

Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Diptera Larvae	Diptera Pupae	Diptera Adult	Arachnids	Misc. Other	Fish KOK	Fish Trout	Fish Other	Insect parts	Debris	Algae
08/16/83	Rb	≤330	5	786.2	—	197.2	—	7.8	—	—	1.4	0.2	—	—	—	—	n/a	n/a	n/a
08/19/83	Rb	>330	30	157.3	0.6	23.0	—	21.0	0.1	—	0.2	0.1	—	—	—	0.1			
	Wct	≤330	10	151.5	0.1	1.9	0.3	3.2	—	0.6	0.3	0.2	—	—	—	—			
	Wct	>330	12	64.8	0.2	12.4	—	38.9	0.1	—	0.3	0.1	—	—	—	—			
	Hb	≤330	5	750.8	—	3.4	—	8.0	0.4	—	—	—	0.6	—	—	—			
	Hb	>330	4	89.3	—	9.7	—	0.5	—	—	—	—	—	—	—	—			
	MWF		8	477.1	0.9	16.3	4.9	0.3	0.5	0.1	0.1	—	—	—	—	—			
	KOK		5	1149.4	2.8	—	—	—	—	0.4	—	—	—	—	—	—			
	CSU		13	32.5	0.1	0.6	0.2	—	2.5	0.4	0.5	—	1.0	—	—	—			
	FSU		3	126.7	0.7	—	1.7	—	50.7	—	36.7	—	—	—	—	—			
	NSQ		8	1.1	—	0.1	—	—	—	—	—	—	—	—	—	0.3			
	CRC		13	40.5	—	—	—	0.1	0.2	—	—	—	1.2	—	—	—			
	RSS		12	9.6	—	0.4	1.3	—	—	—	0.1	—	0.3	—	—	—			

Table I6. Average weights of each type of food ingested by fish collected in Libby Reservoir during the summer of 1983.

									Diptera				Misc.	Fish			Insect		
Date	Species	Length Class	n	Daphnia	Epischara	Leptodora	Other	Terrestrial insects	Larvae	Pupae	Adult	Arachnids	Other	KOK	Trout	Other	parts	Debris	Algae
8/16-8/19	Rb	≤330	5	0.2066	T	0.4516	——	0.1211	——	——	.0066	.0048	——	——	——	——	0.0062	.0024	-
	Rb	>330	30	0.0377	T	0.0527	——	0.8445	T	——	.0008	.0067	.0018	.0081	——	.0070	0.0114	.0065	T
	Wct	≤330	10	0.0429	T	0.0044	T	0.0295	——	T	.0001	.0014	——	——	——	——	0.0129	——	-
	Wct	>330	12	0.0175	0.0002	0.0284	——	0.3653	——	——	T	.0023	——	——	——	——	0.1059	——	-
	Hb	<330	5	0.1857	——	0.0078	——	0.0334	.0004	——	.0012	.0058	——	——	——	——	0.0254	——	-
	Hb	>330	4	0.0221	——	0.0223	——	0.0013	——	——	——	——	——	——	——	T	T	——	T
	MWF		8	0.0994	0.0001	0.0372	0.0001	0.0003	.0001	——	T	——	——	——	——	——	——	——	-
	KOK		5	0.3020	0.0012	T	T	——	——	T	——	——	——	——	——	——	.0001	——	-
	CSU		13					——	.0046	.0005	.0008	——	.0008	——	——	——	.0005	T	-
	FSU		3					——	.0213	——	.0996	——	——	——	——	——	T	T	-
	NSQ		8					——	——	——	——	——	——	——	——	.0031	.0012	T	T
	CRC		13					.0001	.0004	——	——	——	.0009	——	——	——	.0013	.0030	-
	RSS		12					——	——	——	T	——	T	——	——	——	.0069	.0009	-

APPENDIX J

Average estimated densities and composition (%) of zooplankton by genera in three areas of Libby Reservoir, 1983-84

Table J1. Mean zooplankton densities (#/l)and percents (in parentheses) estimated from 0-30 m vertical tows during 1983 in the Tenmile area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
08/16/83	1.20 (30)	0.35 (9)	1.72 (42)	0.74 (18)	0.04 (1)	4.05
08/29/83	0.80 (15)	0.16 (3)	2.76 (54)	1.40 (27)	0.01 (1)	5.13
09/06/83	1.44 (21)	0.34 (4)	3.25 (47)	1.94 (28)	----	6.97
09/21/83	1.81 (14)	0.06 (1)	5.86 (44)	5.45 (41)	----	13.18
10/05/83	1.85 (31)	T (T)	2.54 (42)	1.66 (27)	---- (—)	
10/17/83	1.80 (35)	0.01 (T)	1.98 (38)	1.37 (27)	---- (—)	5.16
11/01/83	0.78 (23)	T (T)	1.40 (40)	1.26 (36)	0.01 (1)	3.45
12/06/83	0.43 (15)	---- (—)	1.35 (47)	1.07 (38)	---- (—)	2.85

Table J2. Mean zooplankton densities (#/l)and percents (in parentheses) estimated from 0-30 m vertical tows during 1984 in the Tenmile area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
01/06/84	0.55 (15)	---- (—)	2.29 (62)	0.84 (22)	0.04 (1)	3.72
01/16/84	0.53 (9)	---- (—)	3.79 (66)	1.44 (25)	0.01 (T)	5.77
02/02/84	2.56 (27)	0.05 (1)	4.81 (50)	2.11 (22)	---- (—)	9.53
03/05/84	0.28 (10)	0.02 (1)	1.47 (54)	0.97 (35)	---- (—)	2.74
04/03/84	0.28 (12)	0.02 (1)	1.20 (50)	0.87 (37)	---- (—)	2.37
04/23/84	0.59 (28)	0.03 (1)	0.88 (42)	0.62 (29)	---- (—)	2.12
05/08/84	0.60 (28)	0.04 (2)	0.79 (36)	0.73 (34)	---- (—)	2.16
05/21/84	1.55 (47)	0.07 (2)	1.09 (33)	0.58 (18)	---- (—)	3.29
06/08/84	1.99 (33)	0.33 (5)	3.53 (58)	0.19 (3)	---- (—)	6.04
06/22/84	1.91 (16)	0.72 (6)	8.09 (68)	1.14 (10)	0.01 (T)	11.87
07/03/84	3.22 (23)	1.22 (9)	9.35 (66)	0.31 (2)	0.07 (T)	14.17
07/19/84	1.12 (20)	0.74 (13)	3.34 (60)	0.37 (7)	0.01 (T)	5.58
07/31/84	1.93 (18)	1.78 (16)	5.78 (53)	1.42 (13)	0.05 (T)	10.96

Table J3. Mean zooplankton densities (#/l)and percents (in parentheses) estimated from 0-30 m vertical tows during 1983 in the Rexford area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
08/17/83	0.48 (18)	0.11 (4)	1.24 (46)	0.81 (30)	0.03 (1)	2.67
09/07/83	0.75 (16)	0.07 (2)	1.90 (41)	1.91 (41)	T (T)	4.63
09/21/83	1.31 (10)	0.03	5.34 (42)	5.90 (47)	0.01 (T)	12.58
10/06/83	0.70 (14)	0.03 (1)	2.01 (40)	2.26 (45)	---- (—)	5.0
10/19/83	1.02 (16)	0.01 (T)	2.39 (38)	2.86 (46)	---- (—)	6.28
11/02/83	0.58 (12)	0.01 (T)	2.13 (46)	1.95 (42)	0.01 (T)	4.68
12/08/83	0.55 (14)	0.01	2.56 (65)	0.80 (20)	0.04 (1)	3.96

Table J4. Mean zooplankton densities (#/l)and percents (in parentheses) estimated from 0-30 m vertical tows during 1984 in the Rexford area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
01/09/84	2.13 (24)	0.09 (1)	4.11 (47)	2.49 (28)	0.01 (T)	8.82
02/02/84	2.50 (31)	0.06 (1)	3.36 (42)	2.09 (26)		8.01
03/07/84	0.98 (16)	0.04 (1)	4.00 (64)	1.19 (19)	--- (—)	6.21
04/05/84	1.82 (18)	0.01 (T)	6.62 (66)	1.64 (16)	--- (—)	10.09
04/27/84	2.07 (24)	0.07 (1)	5.58 (66)	0.74 (9)	--- (—)	8.46
05/10/84	3.50 (18)	0.32 (2)	12.15 (67)	2.09 (12)	--- (—)	18.06
05/23/84	3.92 (26)	0.12 (1)	9.51 (64)	1.31 (9)	--- (—)	14.80
06/06/84	2.80 (21)	1.49 (11)	8.74 (65)	0.35 (3)	--- (—)	13.35
06/22/84	2.09 (19)	0.80 (7)	7.01 (62)	1.35 (12)	--- (—)	11.25
07/03/84	2.04 (19)	0.94 (9)	7.38 (68)	0.51 (5)	0.01 (T)	10.88
07/19/84	2.34 (22)	0.94 (9)	6.12 (58)	1.16 (11)	0.01 (T)	10.56
08/01/84	1.93 (17)	1.08 (9)	6.97 (61)	1.35 (12)	0.06 (1)	11.39

Table J5. Mean zooplankton densities (#/l) and percents (in parentheses) estimated from 0-30 m vertical tows during 1983 in the Canada area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
08/18/83	5.40 (32)	--- (—)	7.23 (43)	4.33 (25)	---- (—)	11.96
09/08/83	2.64 (24)	0.08 (1)	3.23 (30)	4.92 (45)	T (—)	10.87
09/22/83	2.97 (28)	0.09 (1)	3.28 (31)	4.09 (39)	0.04 (T)	10.47
10/07/83	4.64 (29)	0.16 (1)	4.85 (31)	6.13 (39)	0.01 (T)	15.78
10/20/83	2.52 (25)	0.03 (T)	3.64 (36)	4.03 (39)	---- (—)	10.22
11/03/83	11.17 (41)	0.25 (1)	7.89 (29)	8.03 (29)	---- (—)	27.34

Table J6. Mean zooplankton densities (#/l)and percents (in parentheses) estimated from 0-30 m vertical tows during 1984 in the Canada area of Libby Reservoir.

Date	Daphnia	Bosmina	Cyclops	Diaptomus	Epischura	Total
07/05/84	4.94 (37)	0.64 (5)	5.00 (38)	2.67 (20)	--- (—)	13.24
07/20/84	4.76 (25)	0.02	11.34 (62)	2.59 (14)	0.03 (T)	18.42
08/02/84	5.00 (56)	0.40 (4)	2.83 (32)	0.67 (8)	0.01 (T)	8.9

APPENDIX K

Average seasonal catch of macroinvertebrates by order in near-shore and limnetic tows on the surface of Libby Reservoir during 1983 and 1984

Table K1. Surface macroinvertebrate densities and biomass by Order during the summer 1983.

n	TENMILE N.S.	TENMILE L	TENMILE Combined	REXFORD N.S.	REXFORD L	REXFORD Combined	CANADA N.S.	CANADA L	CANADA Combined
	(# tows = 14)			(# tows = 10)			(# tows = 8)		
Number/ha									
Terrestrial:									
Hymenoptera	43	428	235	3	24	14	4	4	4
Pscoptera	5	17	11	3	20	12	-	8	4
Orthoptera	2	—	1	-	3	2			
Hemiptera									
Homoptera	17	12	15	7	-	3	4	13	8
Coleoptera	12	--	6	3	-	2	21	13	17
Lepidoptera									
Neuroptera									
Other	17	6	11	7	11	9			
TOTAL TERRESTRIAL	43	463	278	23	58	41	29	38	34
Aquatic:									
Diptera	17	21	19	7	10	9	17	42	30
Tricoptera							-	4	2
Ephemeroptera									
Other									
TOTAL AQUATIC	17	21	19	7	10	9	17	46	32
GRAND TOTAL	110	484	297	30	68	49	46	84	65
Grams/ha									
Terrestrial:									
Hymenoptera	.238	1.712	.975	.018	.081	.049	.002	.008	.005
Pscoptera	0.008	0.019	.013	.003	.035	.019	---	.016	.008
Orthoptera	3.301	---	1.650	---	2.811	1.405			
Hemiptera									
Homoptera	0.076	0.146	.111	.226	---	.113	.004	1.088	.546
Coleoptera	0.176	---	.09	.215	---	.108	.718	.297	.507
Lepidoptera									
Neuroptera									
Other	0.640	0.042	.341	.023	.005	.014			
TOTAL TERRESTRIAL	4.373	1.91	3.141	.485	2.932	1.708	.724	1.409	1.066
Aquatic:									
Diptera	0.053	0.125	.089	.003	.007	.005	1.018	1.012	
Tricoptera							---	.026	.013
Ephemeroptera									
Other									
TOTAL AQUATIC Parts	0.053	0.125	.089	.003	.007	.005	1.018	1.038	1.028
GRAND TOTAL	4.426	2.035	3.231	.488	2.939	1.714	1.742	1.447	2.109

Table K2. Surface macroinvertebrate densities and biomass by Order during the fall 1983.

n	TENMILE N.S.	TENMILE L	TENMILE Combined	REXFORD N.S.	REXFORD L	REXFORD Combined	CANADA N.S.	CANADA L	CANADA Combined
	(# tows = 16)			(# tows = 14)			(# tows = 10)		
Number/ha									
Terrestrial:									
Hymenoptera	4	2	3	-	5	2	20	10	15
Pscoptera	2	2	2	-	2	1			
Orthoptera									
Hemiptera	2	8	5		2	1	17	17	17
Homoptera	4	2	3	2	26	14	420	6	213
Coleoptera	2	4	3	10	12	11	20	10	15
Lepidoptera							3		2
Neuroptera				9	17	13			
Other	4	4	4	7	17	12	3		2
TOTAL TERRESTRIAL	18	22	20	19	64	42	483	43	263
Aquatic:									
Diptera	10	10	10	9	17	13	97	10	54
Tricoptera					2	1			
Ephemeroptera									
Other (Plecoptera)							3		2
TOTAL AQUATIC	10	10	10	9	19	14	100	10	55
GRAND TOTAL	28	32	30	28	83	56	583	53	318
Grams/ha									
Terrestrial:									
Hymenoptera	.013	.013	.013		.001	.0005	.026	1.374	.700
Pscoptera	.002	.005	.004		.003	.002			
Orthoptera									
Hemiptera	.009	.048	.028		.338	.169	.205	.935	.570
Homoptera	.0003	.006	.003	.002	.160	.080	.451	.035	.243
Coleoptera	.002	.012	.007	.124	.257	.190	.556	.162	.359
Lepidoptera							.019		.009
Neuroptera									
Other	.034	.112	.073	.027	.137	.082	.004		.002
TOTAL TERRESTRIAL	.060	.196	.128	.153	.896	.53	1.261	2.506	1.883
Aquatic:									
Diptera	.054	.004	.029	.027	.052	.040	.309	.047	.178
Tricoptera				---	.017	.009			
Ephemeroptera									
Other							.003		.001
TOTAL AQUATIC	.054	.004	.029				.312		
Parts									
GRAND TOTAL	.114	.200	.157				1.573	2.553	2.062

Table K3. Surface macroinvertebrate densities and biomass by Order during the winter 1983 and 1984.

n	TENMILE			REXFORD			CANADA		
	N.S.	L	Combined	N.S.	L	Combined	N.S.	L	Combined
<u>Number/ha</u>	(# tows = 8) all empty			(# tows = 12)			(no tows frozen)		
Terrestrial:									
Hymenoptera				22	19	20			
Pscoptera									
Orthoptera									
Hemiptera					3	1			
Homoptera				14	8	11			
Coleoptera					8	4			
Lepidoptera									
Neuroptera									
Other				11	11	11			
TOTAL TERRESTRIAL				47	49	48			
Aquatic:									
Diptera				3	22	13			
Tricoptera									
Ephemeroptera									
Other									
TOTAL AQUATIC				3	22	13			
GRAND TOTAL				50	71	61			
<u>Grams/ha</u>									
Terrestrial:									
Hymenoptera				.056	.050	.053			
Pscoptera									
Orthoptera									
Hemiptera					.002	.001			
Homoptera				.008	.004	.006			
Coleoptera					.060	.030			
Lepidoptera									
Neuroptera									
Other				.057	.028	.043			
TOTAL TERRESTRIAL				.121	.144	.133			
				.005	.032	.019			
Aquatic:									
Diptera									
Tricoptera									
Ephemeroptera									
Other									
TOTAL AQUATIC Parts				.005	.032	.019			
GRAND TOTAL				.126	.176	.151			

Table K4. Surface macroinvertebrate densities and biomass by Order during the spring 1984.

n	TENMILE N.S.	TENMILE L	TENMILE Combined	REXFORD N.S.	REXFORD L	REXFORD Combined	CANADA N.S.	CANADA L	CANADA Combined
Number/ha	(# tows = 28)			(# tows = 26)					
Terrestrial:									
Hymenoptera	31	31	31	8	3	5			
Pscoptera									
Orthoptera									
Hemiptera	1	1	1						
Homoptera	6	2	4						
Coleoptera	14	11	12	4	1	3			
Lepidoptera	1		.5						
Neuroptera									
Other	5	4	4	4	7	6			
TOTAL TERRESTRIAL	58	49	53	16	11	14			
Aquatic:									
Diptera	108	158	133	254	433	344			
Tricoptera									
Ephemeroptera	5		2						
Other				4	3	3			
TOTAL AQUATIC	113	158	135	258	436	347			
GRAND TOTAL	171	207		274	447	361			
Grams/ha									
Terrestrial:									
Hymenoptera	.199	.140	.169	.169	.003	.086			
Pscoptera									
Orthoptera									
Hemiptera	.001	.007	.004						
Homoptera	.011	.004	.007						
Coleoptera	.238	.046	.142	.199	.017	.108			
Lepidoptera	.842		.421						
Neuroptera									
Other	.041	.036	.039	.033	.060	.046			
TOTAL TERRESTRIAL	1.332	.233	.783	.401	.080	.240			
Aquatic:									
Diptera	.468	.602	.535	.698	1.457	1.067			
Tricoptera									
Ephemeroptera	.006		.003						
Other				.012	.025	.019			
TOTAL AQUATIC Parts	.474	.602	.538	.710	1.482	1.096			
GRAND TOTAL	1.806	.835	1.301	1.111	1.562	1.336			

Table K5. Surface macroinvertebrate densities and biomass by Order during the summer 1984.

n	TENMILE N.S.	TENMILE L	TENMILE Combined	REXFORD N.S.	REXFORD L	REXFORD Combined	CANADA N.S.	CANADA L	CANADA Combined
	(# tows = 18)			(# tows = 12)			(# tows = 12)		
Number/ha									
Terrestrial:									
Hymenoptera	22	15	19	25	9	17			
Pscoptera				22	6	14	6	6	6
Orthoptera									
Hemiptera	2	6	4	6	8	7	6	6	6
Homoptera	20	19	19	28	8	18	20	14	17
Coleoptera	24	4	14	47	14	30	9	11	10
Lepidoptera		2	1	6	3	4		6	3
Neuroptera									
Other	15	6	10	9	3	6	9		4
TOTAL TERRESTRIAL	83	52	67	143	51	97	50	43	46
Aquatic:									
Diptera	21	26	24	25	17	21	11	11	11
Tricoptera								3	1.5
Ephemeroptera	2		1				6	3	4
Other							8		4
TOTAL AQUATIC	23	26	25	25	17	21	25	17	21
GRAND TOTAL	106	78	92	168	68	118	75	60	67
Grams/ha									
Terrestrial:									
Hymenoptera	.5	.269	.385	.213	.078	.146	.057	.073	.065
Pscoptera				.007	.001	.004			
Orthoptera									
Hemiptera	.01	.009	.01	.011	.104	.058	.046	.015	.031
Homoptera	.034	.030	.032	.122	.051	.086	.015	.006	.011
Coleoptera	.879	.093	.485	1.506	.440	.973	.514	.234	.374
Lepidoptera		.010	.005	.008	.009	.008		.022	.011
Neuroptera									
Other	.135	.027	.081	.090	.017	.054	.060		.030
TOTAL TERRESTRIAL	1.558	.438	.998	1.957	.7	1.329	.692	.350	.522
Aquatic:									
Diptera	.171	.105	.138	.258	.051	.155	.586	.065	.325
Tricoptera							.017	.004	.01
Ephemeroptera	.010		.005						
Other									
TOTAL AQUATIC Parts	.181	.105	.143	.258	.051	.155	1.023	.069	.546
GRAND TOTAL	1.739	.543	1.141	2.215	.751	1.484	1.715	.419	1.068

APPENDIX L

Initial modeling effort on the Libby Reservoir fishery by the United States Geological Survey

United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
301 South Park Avenue, Room 428
Federal Building, Drawer 10076
Helena, Montana 59626-0076

October 24, 1984

Bradley B. Shepard
Montana Department of Fish, Wildlife
and Parks
Route 1, Box 1270
Libby, Montana 59923

Dear Brad:

Our proposal with your agency was to construct and test a computer model that describes the effect of reservoir drawdown on the trophic dynamics of Lake Koocanusa. During the first year (FY 84) of the modeling effort, our plan was to develop a preliminary model for Lake Koocanusa. This preliminary model was to be a coarse model by which the feasibility of continuing model development would be evaluated.

After review of literature that addresses ecological structure and function of reservoir ecosystems, Rodger Ferreira's original approach was to adapt either the CLEANER series of aquatic ecosystem models developed for the U.S. Environmental Protection Agency or the CE-QUAL water quality models developed at the U.S. Army Engineers Waterways Experiment Station. However, because of the numerous literature-derived variable coefficients and large amounts of data required for these and similar models, Rodger was advised against their use. Determining cause and effect relationships would be difficult because of the large number of coefficients; the coefficients might not even be applicable to Lake Koocanusa. At a meeting, March 6, 1984, at which you, Steve McMullen, Rodger Ferreira, and Jim LaBaugh of the U.S. Geological Survey were present, development of a simplified model of reservoir drawdown and carrying capacity of fish was decided as the best approach. If this effort indicated a relationship between reservoir drawdown and fish biomass, the U.S. Geological Survey was to continue model development of the trophic dynamics of Lake Koocanusa.

Analysis of fisheries data from Lake Koocanusa showed no strong correlation between annual reservoir drawdown and catch as an estimate of fish carrying capacity. A regression of reservoir drawdown with catch of rainbow trout per net-night during autumn at the Rexford site (fig. 1) had a coefficient of determination (r^2) equal to .087 and was not significant ($p>F$ = .477) (table 1). At the Cripple Horse site a regression of the same variables (fig. 2) also showed a poor correlation (r^2 = .013; $p>F$ = .791) (table 2).

The first year of reservoir growth of rainbow trout by migration class was also regressed against annual reservoir drawdown (figs. 3, 4, and 5). These regressions were not significant, p>.05, and explained little variation in the amount of first year reservoir growth (tables 3, 4, and 5). However, there is "hint" of an inverse relationship (fig. 4) which describes an increase in the first-year reservoir-growth of migration class 1 with decreasing reservoir drawdown (r^2 = .335; p>.05 = .080). Perhaps additional data would better define this relationship. Log transformations of the fish growth data and the catch data did not improve any of the regressions.

Regression analysis indicated a relatively strong relationship (fig. 6, table 6) between increasing condition factor of rainbow trout and increasing reservoir drawdown. This relationship is significant (p<.05) with 82 percent of the variation in fish condition described; however, this trend was not expected based on our theoretical understanding of the effects of reservoir drawdown. The increase in "robustness" of fish netted during the fall could be the result of greater reservoir surface-elevation recovery in the summer and fall following a relatively deep reservoir-drawdown. Or it could be the result of relatively few fish, compared to the amount of food available, being able to take advantage of the increased density of food organisms concentrated by deeper reservoir drawdown.

The basic logistic equation of population growth on a yearly time step was used to "model" changes in population growth, as represented by the catch data in response to carrying capacity as represented by reservoir drawdown. However, the regression relationship between fish catch at Rexford and reservoir drawdown with an r^2 equal to .087 was used to force the "model" to match the observed data. Consequently, the "model" had no meaning with respect to understanding how reservoir drawdown was related to changes in fish population or could be used to predict these changes.

Based on fisheries data that we have at the present time, it appears unlikely that a model could be developed to simulate the effect of reservoir drawdown on fish production of the reservoir. Lack of a strong correlation could result from several reasons: 1) The fish data represent fish populations that exist soon after reservoir impoundment. Fish populations have been observed in other reservoirs to fluctuate sharply during the first five to ten years of impoundment until trophic equilibrium is reached. 2) Reservoir drawdown might not have varied enough to show a change in the size of the fish populations. Reservoir drawdown from one year to the next varied by no more than 20 feet during the first five years of impoundment. These years were most likely during a time of trophic instability. During the last four years of data, 1979 to 1982, reservoir drawdown from one year to the next varied from 12 feet to only 4 feet. These years most likely are a time of trophic equilibrium. 3) If major controlling factors on fish production occurs by changes in the food web, there may be a lag time before reservoir drawdown would show effects on fisheries production. It may be that the only ways to distinguish the effects of reservoir drawdown might be to draw the reservoir down to the same elevation for several years in a row to allow a new trophic equilibrium to be reached. 4) Other factors affecting observed fish production in the reservoir could result from changes that occur in tributary streams. A change in water quality or quantity of the streams could affect fish spawning or juvenile growth and therefore recruitment to the lake.

Because many other factors could be complicating a direct effect of reservoir drawdown on fish production, a model that incorporates several input factors might be used to indicate various channels of indirect effects. Attached is a flow chart for a proposed model that incorporates changes in the food organisms of fish. Major changes include the availability of benthic invertebrates, terrestrial insects, and zooplankton. Each of these food organisms are theoretically affected by reservoir drawdown in the model (fig. 7). The changes in zooplankton are controlled through changes in primary production as estimated through regression models proposed by Woods and Falter (1982). Changes in the thermal structure and mixing stability, which are factors affecting primary productivity in Lake Koocanusa, will be driven in the lake model by use of a thermal model developed by Adams (1974). Change in the number of fish with time is controlled by a self-regenerating fish stock routine that, by default, will use historical rates of fish growth and mortality. The rates of growth and mortality are adjusted by specified amounts depending on how the biomass of fish predicted by available food energy compares to the biomass of fish predicted by the self-regenerating fish stock model. Determining by what amount growth rates and mortality rates will be adjusted will be determined as part of the calibration process of the model.

Model output will be on an annual basis, however, changes in the fish population will be calculated on a seasonal basis, starting with spring. Using seasons will allow simulation of changes in food organisms as affected by reservoir drawdown.

Input driving variables for the model would include:

1) Reservoir elevation change per season (ft)
2) Mean solar radiation per season (cal/cm^2/min)
3) Water temperature of inflow and outflow (°C)
4) Volume of inflow and outflow (Ac.ft)

Input state variables for the model include:

1) Initial number of juvenile fish in tributaries
2) Historic growth rates of fish in tributaries and Lake Koocanusa
3) Historic mortality rates of fish in tributaries and Lake Koocanusa
4) Fishing rate in Lake Koocanusa
5) Recruitment coefficients, $\underline{a}$ and $\underline{b}$, of spawning fish
6) Initial temperature profile of Lake Koocanusa (°C)
7) Initial surface water elevation of Lake Koocanusa (ft)
8) Season of spawning and emigration
9) Number of migration classes of fish
10) Percentage distribution of fish among migration classes
11) Age of migration for each migration class
12) Total number of fish in reservoir during intitial year
13) Light restrictions and water density controls for zooplankton
14) Water temperature controls for fish

Driving variables incorporated as block data in the model:

1) Mean quarterly number of terrestrial insects per m^2
2) Mean quarterly number of benthic invertebrates per m^2 at each of three sampling areas
3) Mean quarterly euphotic zone depth (ft)
4) Mean quarterly euphotic zone dissolved solids concentrations (mg/L)
5) Mean quarterly surface illumination (foot candles)
6) Mean quarterly percent growth of fish resulting from zooplankton, phytoplankton, and terrestrial insects

All organism counts or biomass values will be converted to units of energy (kilocalories) for internal calculations of energy flow in the model. Details will need to be worked out for reservoir elevation changes as related to inflow and outflow volumes. Either inflow and outflow volumes will be specified by the user and a resultant reservoir elevation change calculated or the reservoir elevation change can be specified and outflow volume adjusted to correspond with inflow volumes.

Model output variables will include:

1) Cohort population size for each cohort by year
2) Length of individuals in each fish cohort by migration class and year (mm)
3) Weight of individuals in each fish cohort by migration class and year (gm)
4) Total spawning biomass per year (gm)
5) Recruitment number of fish to the reservoir each year
6) Total catch of fish each year (gm)

Development of the model will continue through FY 1985 and 1986. Output from the model during development will be analyzed to determine the most important factors that affect the production of fish. This analysis will be accomplished through calibration checks with actual data and sensitivity tests. If output from the model is determined not to represent changes resulting from actual occurrences of important factors in the system, new directions in modeling or sampling will be considered. If new directions in modeling or sampling are not feasible, the model will not be developed any further. If new directions in sampling are feasible, or if output from the model is determined to represent changes resulting from actual occurrences of important factors in the system, the model will be developed further and refined with each successive year of sampling.

The feasiblity of adapting the model to Hungry Horse Reservoir will be determined in early 1986. If the model is appropriate, it will be applied to Hungry Horse Reservoir and further refined during 1986.

During model development, the Montana District will receive assistance from James LaBaugh (GS-13 Hydrologist-Limonology), who will act as advisor to the project. Jim is familiar with lake and ecosystem modeling as part of his work in the Lake Hydrology Group of the Office of the Regional Research Hydrologist, Central Region.

Project Products and Reports:

Model output will be in the form of a computer printout. A progress report describing model development will be published as a U.S. Geological Survey Water-Resources Investigations Report at the end of FY 1985. At the end of FY 1986, a final report describing the model and the trophic dynamics of each reservoir will be published in a referred scientific journal.

Funding:

The total cost of the project in FY 85 which includes programming the proposed flow chart, running calibration checks, and conducting sensitivity analysis, is $56,200. Funding can be adjusted to comply with the dates of your operating fiscal year. The project will be funded as a cooperative program with the Montana Department of Fish, Wildlife and Parks. Because data collected by your agency from Lake Koocanusa and Hungry Horse Reservoir is used for the modeling project, a portion of the the cost is included as direct services. Therefore cost to the Montana Department of Fish, Wildlife and Parks is $22,500. Funding for the federal side of the costs are provided through the Merit Fund program of the U.S. Geological Survey.

Proposed Funding Arrangements for FY 85:

U.S. Geological Survey	Montana Dept. of Fish, Wildlife and Parks		TOTAL
Matching Funds	Matching Funds	Direct Services	
$28,100	$22,500	$5,600	$56,200

A breakdown of the total costs for model development of Lake Koocanusa during FY 85 is as follows:

Employee Cost (Salary and Benefits):	
Rodger F. Ferreira, GS-12, Hydrologist (Biology)	$37,390
James W. LaBaugh, GS-13, Hydrologist (Limnologist)	--
Gary W. Rogers, GS-12, Computer Specialist	7,170
	$44,560
Travel Expenses:	
Transportation:	
Kalispell (2 trips)	
GSA Vehicle: 1 month @ $131/month	$ 130
800 miles @ $0.17/mile	140
Denver (3 trips)	
Airfare: 3 trips @ $440 trip	1,320
Per Diem: Rodger F. Ferreira, 21 days @ $75/day	1,580
	$3,170
Computer Operation and Maintenance:	
Prime System Operation costs: 6 months @ $300/month	$1,800
Maintenance: 6 months @ $100/month	600
Model and Data Storage, Tape backup: 10 months @ $15/month	150
Computer operator costs: 10 months @ $15/month	150
Computer Supplies	170
	$2,870
Direct Services	$5,600
TOTAL	$56,200

Sincerely,

George M. Pike
District Chief

Enclosures

CITED REFERENCES

Adams, D. B., 1974, A predictive mathematical model for the behavior of thermal stratification and water quality of Flaming Gorge Reservoir, Utah-Wyoming: Cambridge, Mass., Massachusetts Institute of Technology, unpublished Masters Thesis, 213 p.

Woods, P. F., and Falter, C. M., 1982, Limnological investigations: Lake Koocanusa, Montana, Part 4: Factors controlling primary productivity: Hanover, New Hampshire, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 82-15, 106 p.

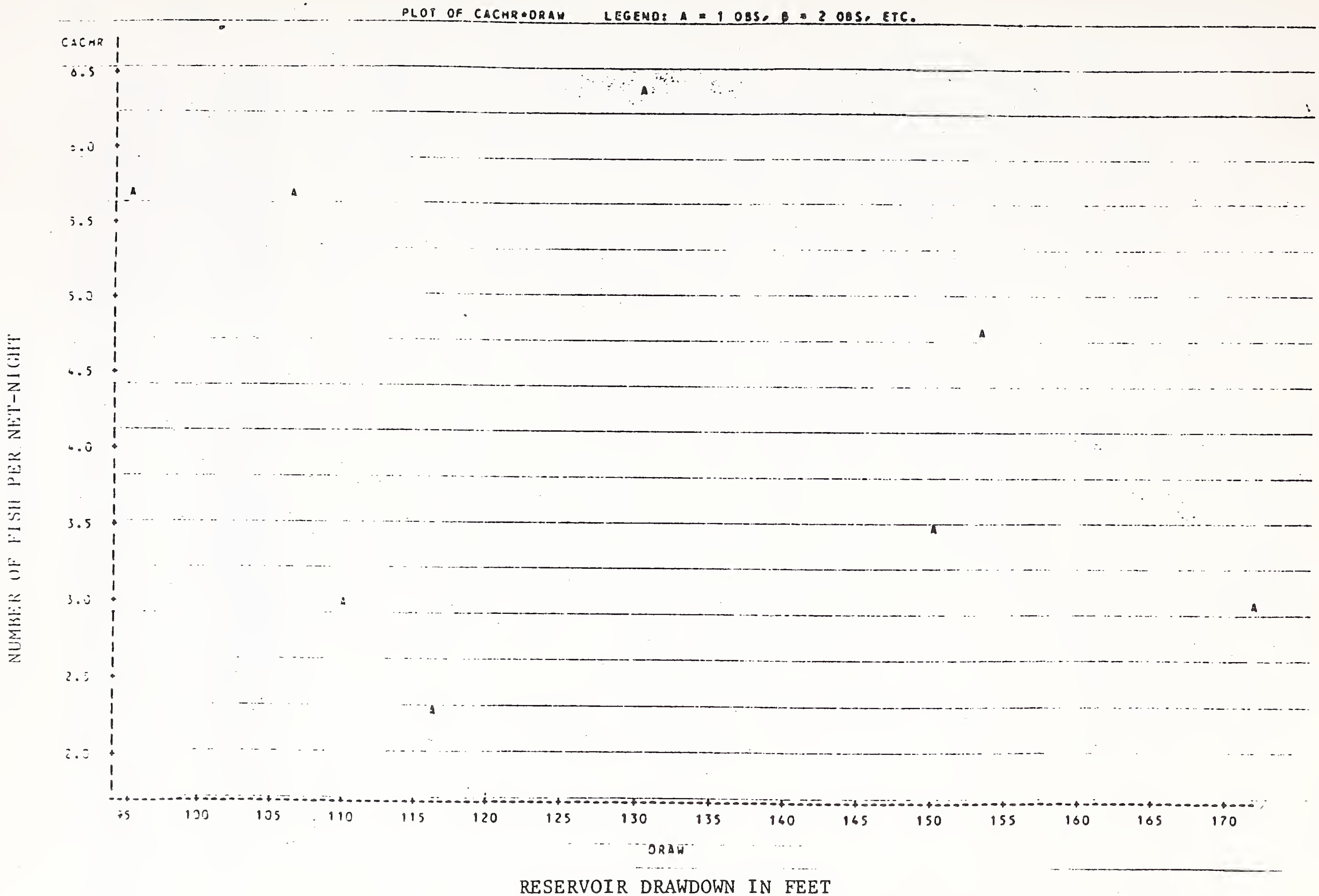


Figure 1.--Catch of rainbow trout at the Rexford sampling area in Lake Koocanusa during the Autumn from 1974 to 1982 plotted against annual reservoir drawdown.

Table 1.--Regression statistics for catch of rainbow trout at the Rexford sampling area in Lake Koocanusa during the Autumn from 1974 to 1982 as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: CACHR

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	1.43946889	1.43946889	0.57	0.4772	0.087358	36.9249
ERROR	6	15.03828111	2.50638018		ROOT MSE		CACHR MEAN
CORRECTED TOTAL	7	16.47775000			1.58315514		4.28750000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	1.43946889	0.57	0.4772	1	1.43946889	0.57	0.4772

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	6.45356848	2.21	0.0689	2.91897842
DRAW	-0.01682999	-0.76	0.4772	0.02220783

OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1 *	.	3.88358028	.	1.99236275	5.77479781
2 *	.	3.56381051	.	0.85535168	6.27226934
3	4.80000000	3.88358028	0.91641972	1.99236275	5.77479781
4	3.03000000	3.56381051	-0.53381051	0.85535168	6.27226934
5	3.45000000	3.93407025	-0.48407025	2.15135831	5.71673218
6 *	.	4.77556966	.	2.68769441	6.86344490
7	6.40000000	4.27067001	2.12932999	2.89998240	5.64135762
8	5.69000000	4.85971960	0.83028040	2.55985276	7.15958644
9	5.65000000	4.67458973	0.97541027	2.82042757	6.52875188
10	2.97000000	4.60726978	-1.63726978	2.89209352	6.32244603
11	2.31000000	4.50628985	-2.19628985	2.96522780	6.04735189

* OBSERVATION WAS NOT USED IN THIS ANALYSIS

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	15.03828111
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
PRESS STATISTIC	23.04036760
FIRST ORDER AUTOCORRELATION	0.22044915
DURBIN-WATSON D	1.18249522

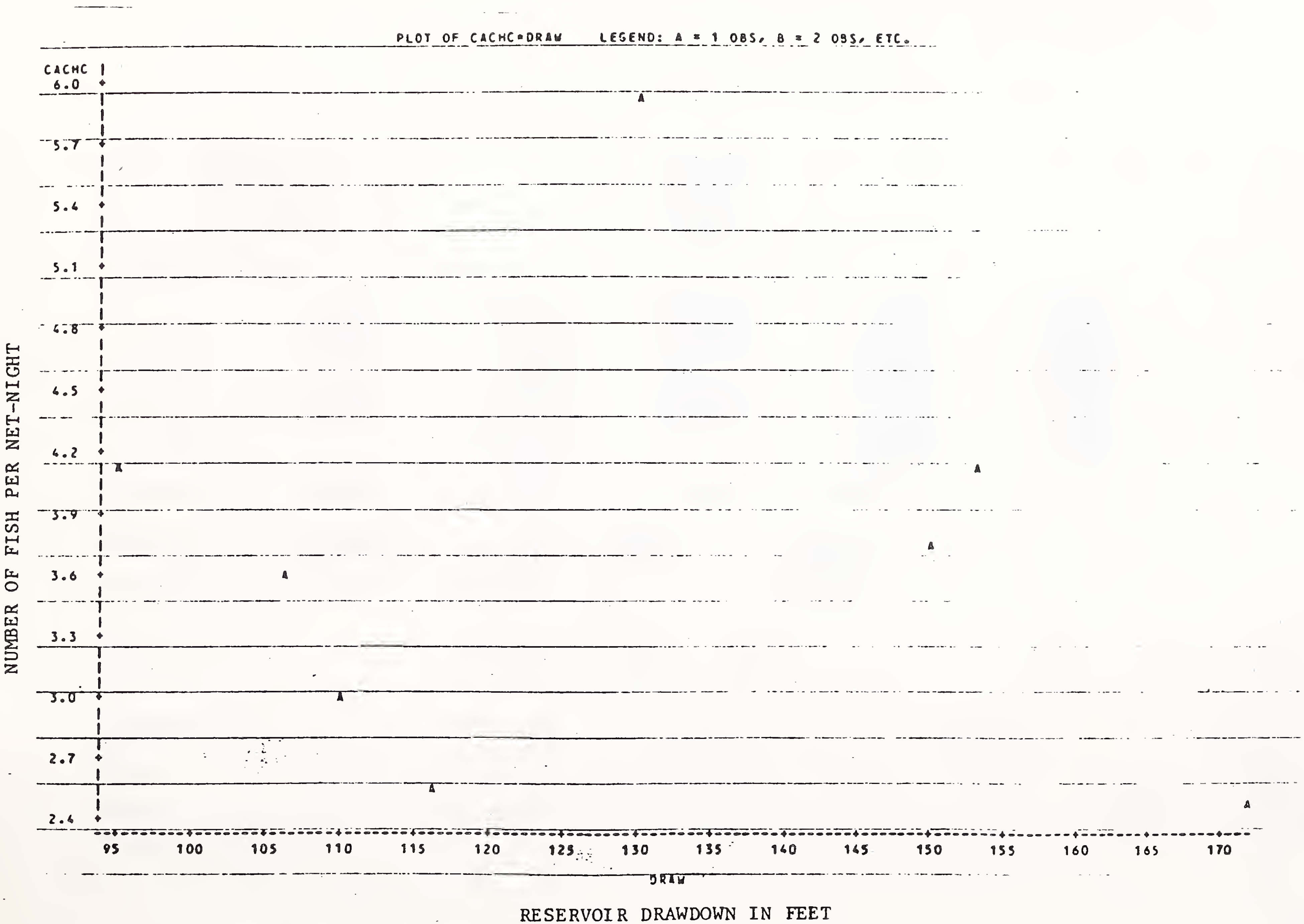


Figure 2.--Catch of rainbow trout at the Cripple Horse sampling area in Lake Koocanusa during the Autumn from 1974 to 1982 plotted against annual reservoir drawdown.

Table 2.--Regression statistics for catch of rainbow trout at the Cripple Horse sampling area in Lake Koocanusa during the Autumn from 1974 to 1982 as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: CACHC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	0.10848296	0.10848296	0.08	0.7906	0.012683	32.2500
ERROR	6	8.44520454	1.40753409		ROOT MSE		CACHC MEAN
CORRECTED TOTAL	7	8.55368750			1.18639542		3.67875000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	0.10848296	0.08	0.7906	1	0.10848296	0.08	0.7906

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	4.27475945	1.95	0.0985	2.18744363
DRAW	-0.00462023	-0.28	0.7906	0.01664225

OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1 *	.	3.56786452	.	2.15061124	4.98511780
2 *	.	3.48008018	.	1.45039713	5.50976324
3	4.10000000	3.56786452	0.53213548	2.15061124	4.98511780
4	2.46000000	3.48008018	-1.02008018	1.45039713	5.50976324
5	3.74000000	3.58172521	0.15827479	2.24578458	4.91766584
6 *	.	3.81273662	.	2.24811066	5.37736258
7	5.90000000	3.67412977	2.22587023	2.64695469	4.70130485
8	4.11000000	3.83583776	0.27416224	2.11234812	5.55932740
9	3.58000000	3.78501525	-0.20501525	2.39553077	5.17449973
10	3.00000000	3.76653434	-0.76653434	2.48120404	5.05186463
11	2.54000000	3.73881297	-1.19881297	2.58396155	4.89366438

* OBSERVATION WAS NOT USED IN THIS ANALYSIS

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	8.44520454
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
PRESS STATISTIC	14.17229921
FIRST ORDER AUTOCORRELATION	0.15134624
DURBIN-WATSON D	1.49360366

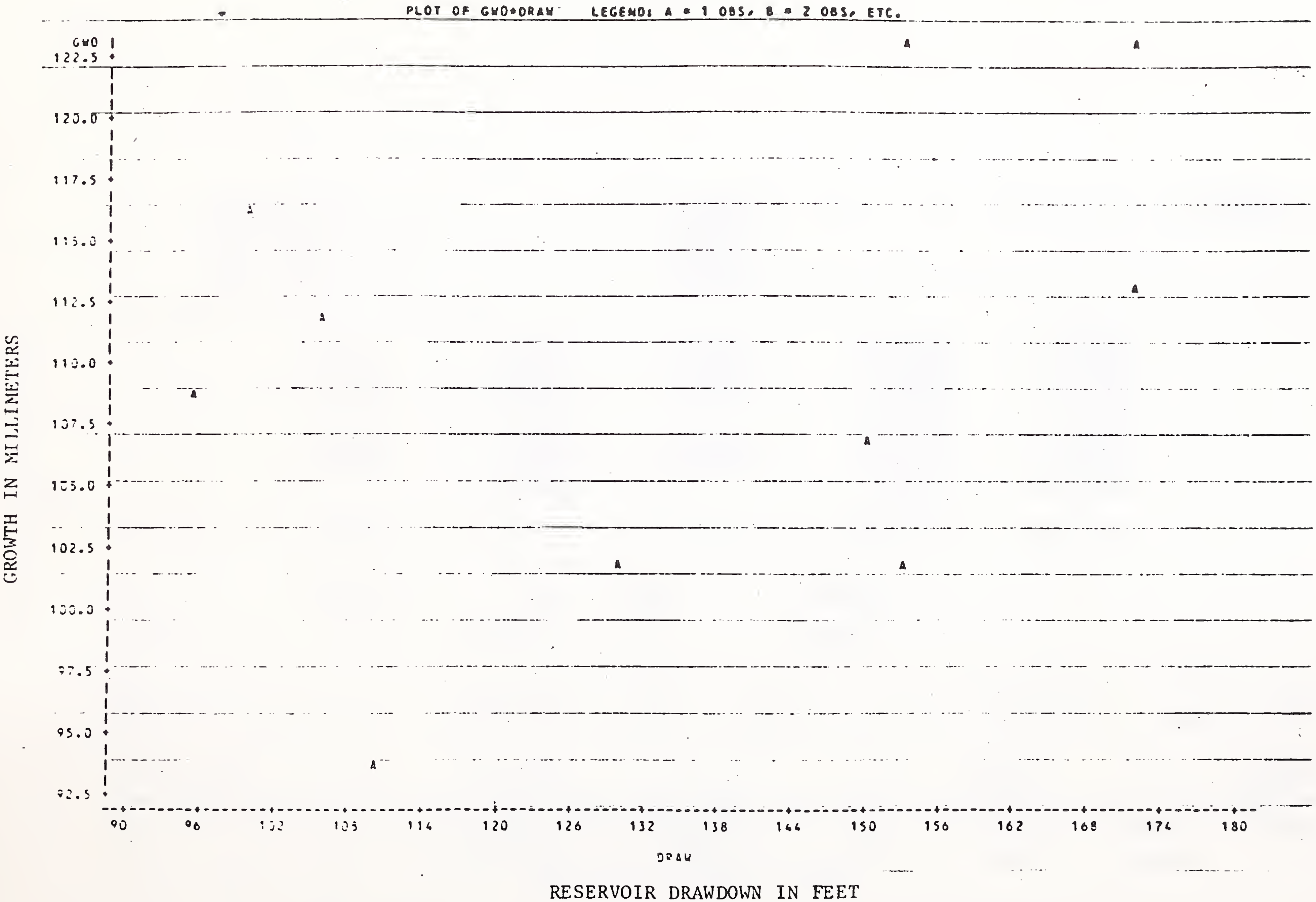


Figure 3.--First year of reservoir growth of rainbow trout from migration class 0 in Lake Koocanusa plotted against annual reservoir drawdown.

Table 3.--Regression statistics for first-year reservoir-growth of rainbow trout from migration class 0 in Lake Koocanusa as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: GWO

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	91.21595297	91.21595297	1.06	0.3338	0.116809	8.4332
ERROR	8	689.68404703	86.21050588		ROOT MSE		GWO MEAN
CORRECTED TOTAL	9	780.90000000			9.28496128		110.10000000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	91.21595297	1.06	0.3338	1	91.21595297	1.06	0.3338

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	95.70764879	6.69	0.0002	14.29664622
DRAW	0.10732551	1.03	0.3338	0.10433924

OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1	123.00000000	112.12845218	10.87154782	103.97219980	120.28470457
2	123.00000000	114.16763692	8.83236308	102.80972297	125.52555086
3	102.00000000	112.12845218	-10.12845218	103.97219980	120.28470457
4	113.00000000	114.16763692	-1.16763692	102.80972297	125.52555086
5	107.00000000	111.80647565	-4.80647565	104.02955727	119.58339403
6	116.00000000	106.44020003	9.55979997	95.80240054	117.07799952
7	102.00000000	109.65996540	-7.65996540	102.81761257	116.50231823
8	109.00000000	105.90357247	3.09642753	94.31256342	117.49453151
9	112.00000000	107.08415310	4.91584690	97.51559845	116.65270776
10	94.00000000	107.51345515	-13.51345515	98.59890237	116.42800793
11 *	.	108.15740923	.	100.10689083	116.20792562

* OBSERVATION WAS NOT USED IN THIS ANALYSIS

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	689.68404703
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
PRESS STATISTIC	1044.48657895
FIRST ORDER AUTOCORRELATION	-0.24663737
DURBIN-WATSON D	2.05712717

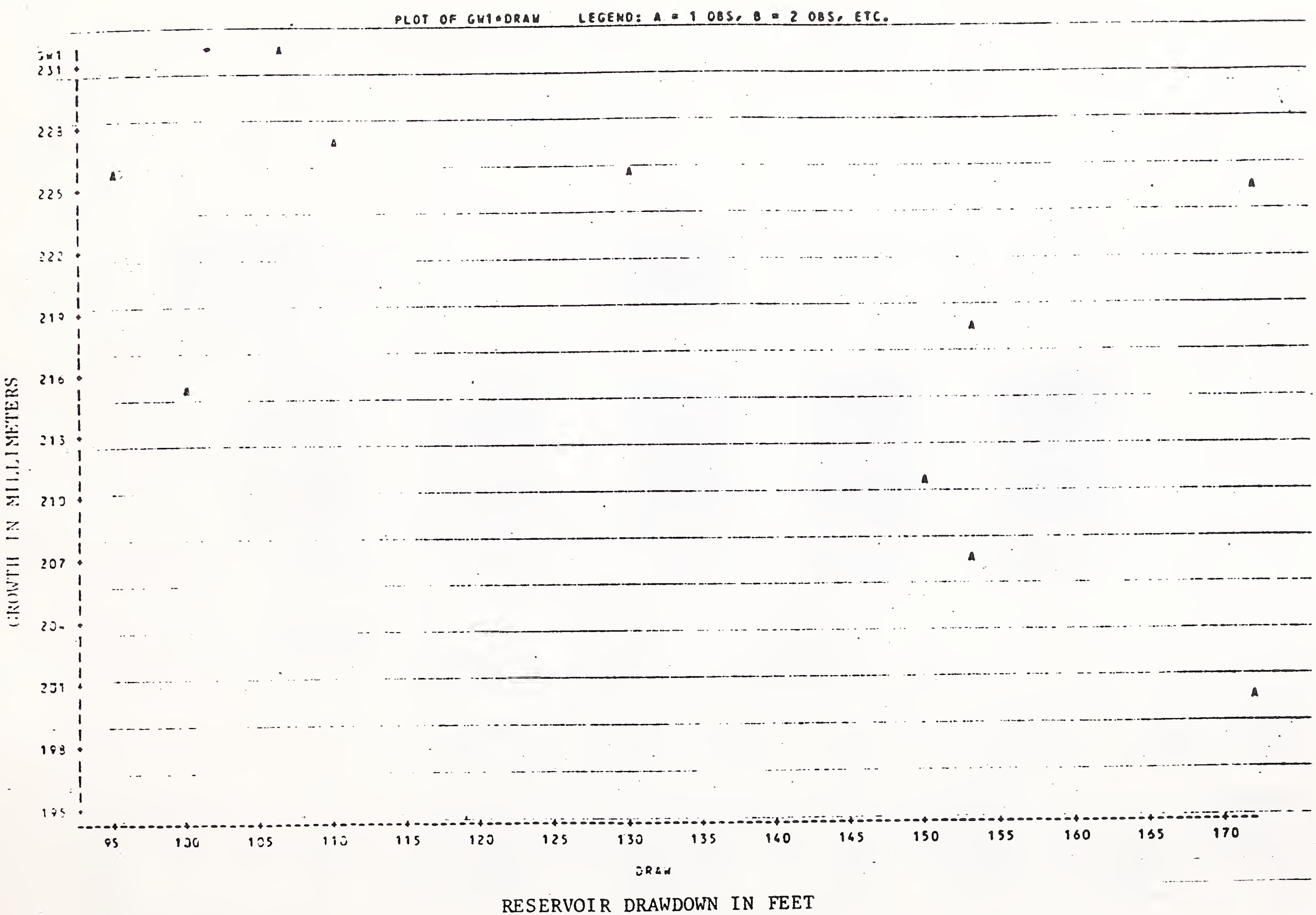


Figure 4.--First year of reservoir growth of rainbow trout from migration class 1 in Lake Koocanusa plotted against annual reservoir drawdown.

Table 4.--Regression statistics for first-year reservoir-growth of rainbow trout from migration class 1 in Lake Koocanusa as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: GW1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	319.12842567	319.12842567	4.03	0.0795	0.335184	4.0672
ERROR	8	632.97157433	79.12144679		ROOT MSE		GW1 MEAN
CORRECTED TOTAL	9	952.10000000			8.89502371		218.70000000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	319.12842567	4.03	0.0795	1	319.12842567	4.03	0.0795

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	245.62025029	17.93	0.0001	13.69623452
DRAW	-0.20074758	-2.01	0.0795	0.09995734

OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1	207.00000000	214.90587076	-7.90587076	207.09215392	222.71958761
2	225.00000000	211.09166677	13.90833323	200.21074753	221.97258602
3	218.00000000	214.90587076	3.09412924	207.09215392	222.71958761
4	200.00000000	211.09166677	-11.09166677	200.21074753	221.97258602
5	211.00000000	215.50811350	-4.50811350	208.05779989	222.95842711
6	215.00000000	225.54549243	-10.54549243	215.35444522	235.73653964
7	226.00000000	219.52306507	6.47693493	212.96806835	226.07806179
8	226.00000000	226.54923032	-0.54923032	215.44500519	237.65345545
9	232.00000000	224.34100696	7.65899304	215.17429985	233.50771407
10	227.00000000	223.53801664	3.46198336	214.99784550	232.07818778
11 *	.	222.33353117	.	214.62110880	230.04595355

* OBSERVATION WAS NOT USED IN THIS ANALYSIS

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	632.97157433
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
PRESS STATISTIC	1096.23918000
FIRST ORDER AUTOCORRELATION	-0.08412799
DURBIN-WATSON D	2.05057594

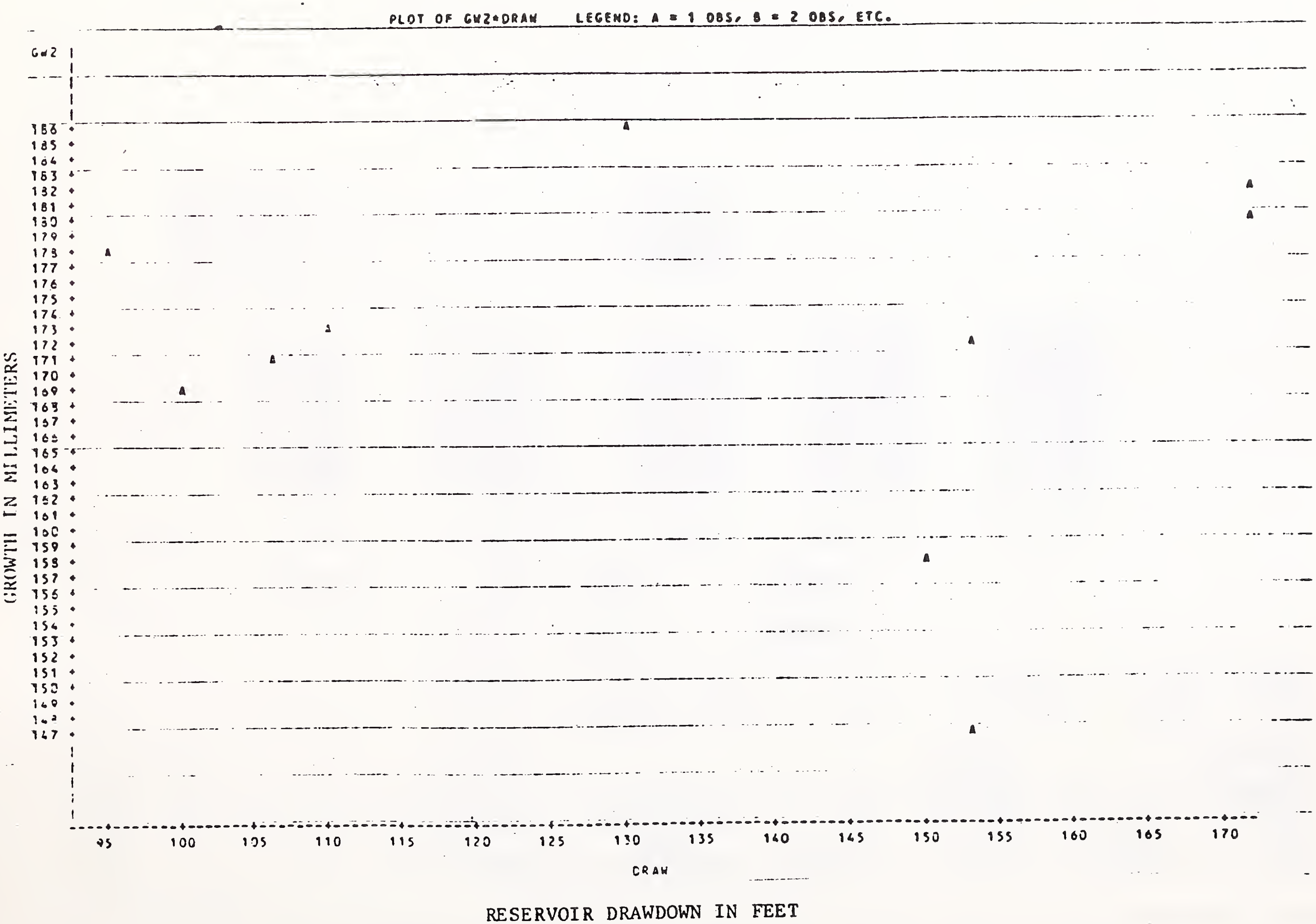


Figure 5.--First year of reservoir growth of rainbow trout from migration class 2 in Lake Koocanusa plotted against annual reservoir drawdown.

Table 5.--Regression statistics for first-year reservoir-growth of rainbow trout from migration class 2 in Lake Koocanusa as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: GW2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	4.98073722	4.98073722	0.03	0.8612	0.004061	7.2006
ERROR	8	1221.41926278	152.67740785		ROOT MSE		GW2 MEAN
CORRECTED TOTAL	9	1226.40000000			12.35626998		171.60000000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	4.98073722	0.03	0.8612	1	4.98073722	0.03	0.8612

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	174.96312619	9.20	0.0001	19.02573584
DRAW	-0.02507924	-0.18	0.8612	0.13885290

OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1	172.00000000	171.12600235	0.87399765	160.27179914	181.98020556
2	132.00000000	170.64949677	11.35050323	155.53457632	185.76441723
3	147.00000000	171.12600235	-24.12600235	160.27179914	181.98020556
4	180.00000000	170.64949677	9.35050323	155.53457632	185.76441723
5	158.00000000	171.20124007	-13.20124007	160.85184816	181.55063199
6	169.00000000	172.45520211	-3.45520211	158.29859783	186.61180639
7	186.00000000	171.70282489	14.29717511	162.59713705	180.80851272
8	178.00000000	172.58059832	5.41940168	157.15547882	188.00571781
9	171.00000000	172.30472667	-1.30472667	159.57105540	185.03839794
10	173.00000000	172.20440970	0.79559030	160.34107311	184.06774630
11 *	.	172.05393426	.	161.34044139	182.76742713

* OBSERVATION WAS NOT USED IN THIS ANALYSIS

SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	1221.41926278
SUM OF SQUARED RESIDUALS - ERROR SS	-0.00000000
PRESS STATISTIC	1784.48930879
FIRST ORDER AUTOCORRELATION	-0.44813757
DURBIN-WATSON D	2.89513153

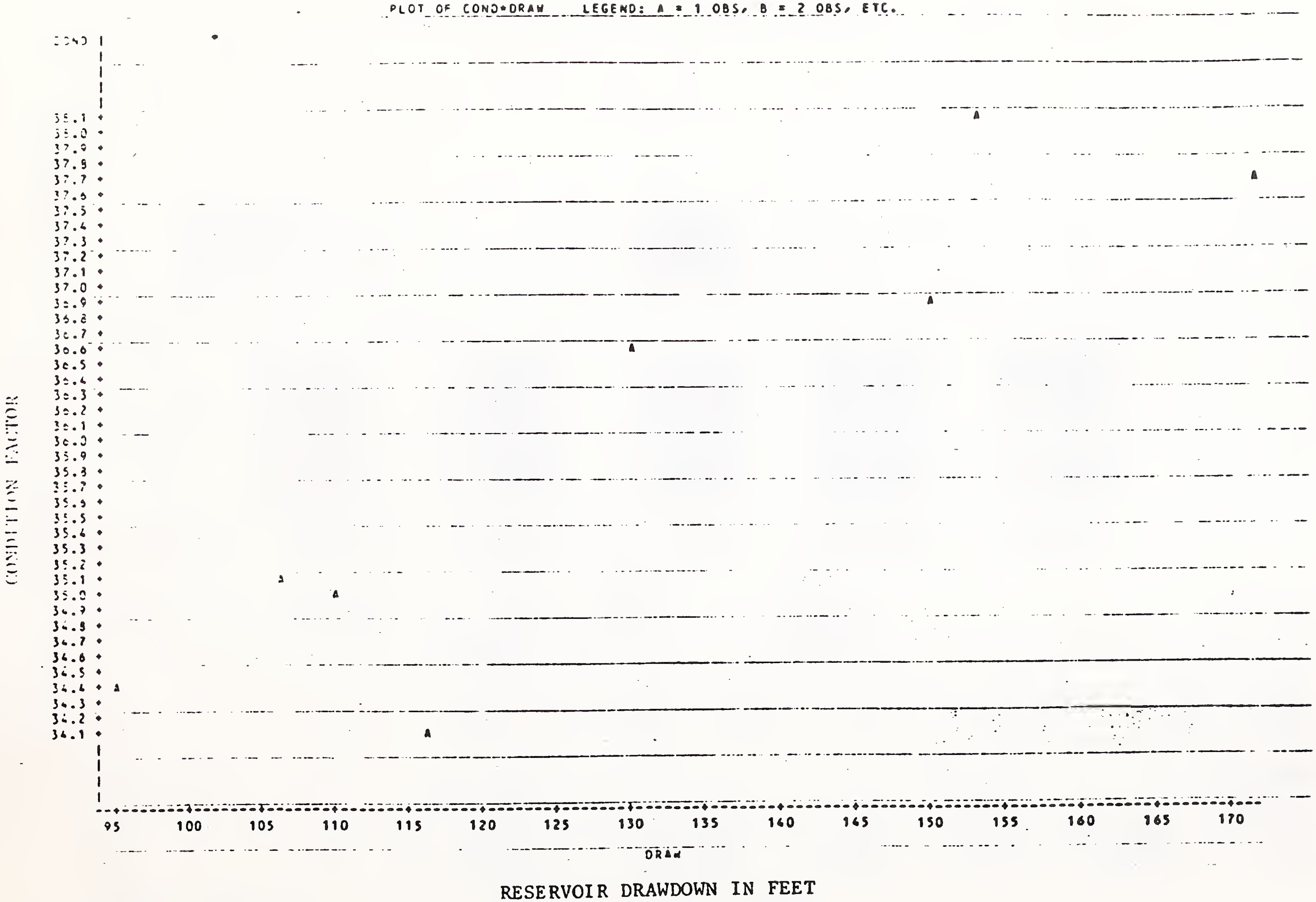


Figure 6.--Condition factor of rainbow trout in Lake Koocanusa during the Autumn of 1974 to 1982 plotted against annual reservoir drawdown.

Table 6.--Regression statistics for condition factor of rainbow trout in Lake Koocanusa during the Autumn of 1974 to 1982 as predicted by annual reservoir drawdown.

DEPENDENT VARIABLE: COND

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	13.48666667	13.48666667	27.32	0.0020	0.819920	1.9524
ERROR	6	2.96208333	0.49368056		ROOT MSE		COND MEAN
CORRECTED TOTAL	7	16.44875000			0.70262405		35.98750000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DRAW	1	13.48666667	27.32	0.0020	1	13.48666667	27.32	0.0020

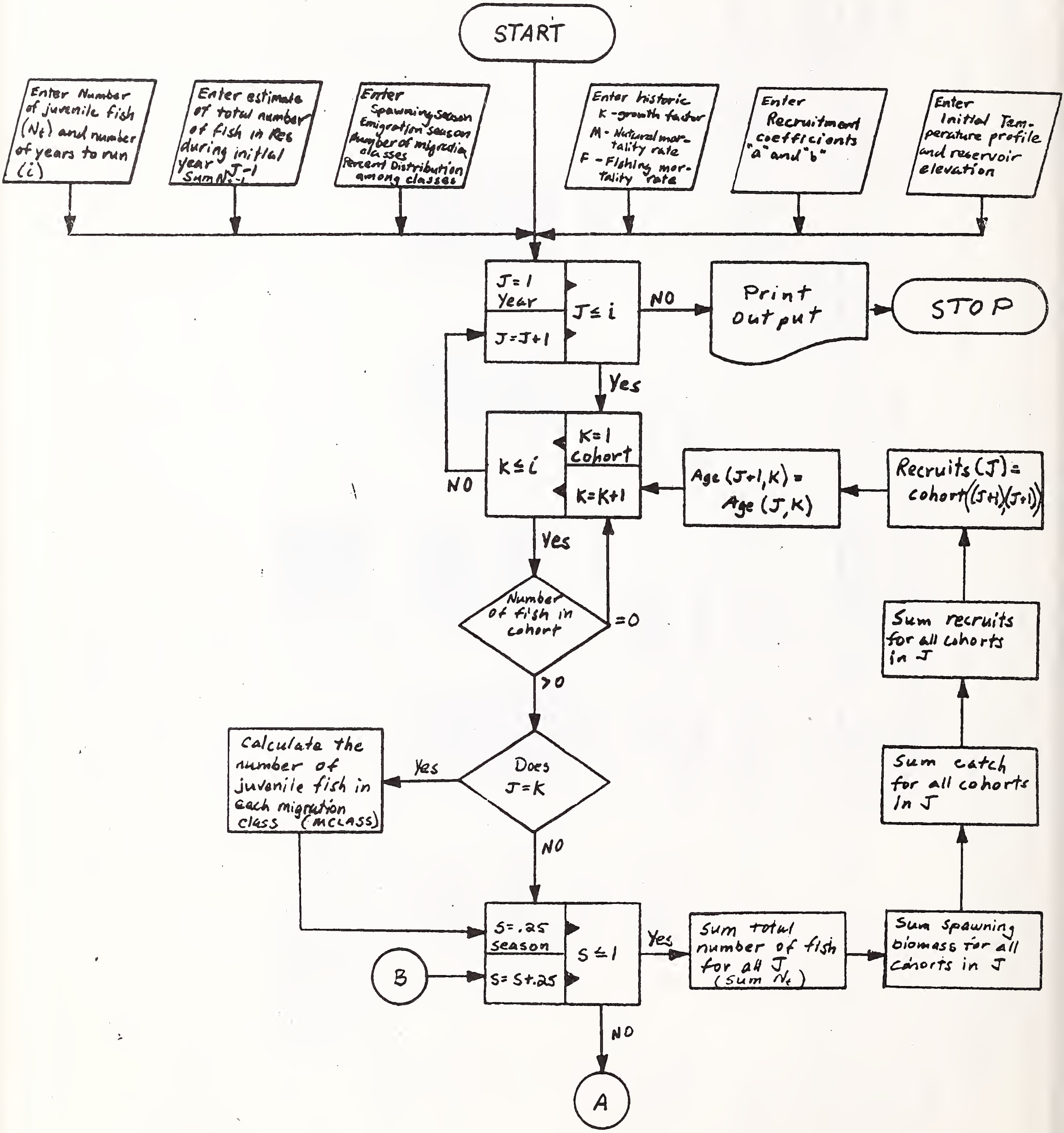
PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	29.34204545	22.65	0.0001	1.29547913
DRAW	0.05151515	5.23	0.0020	0.00985611

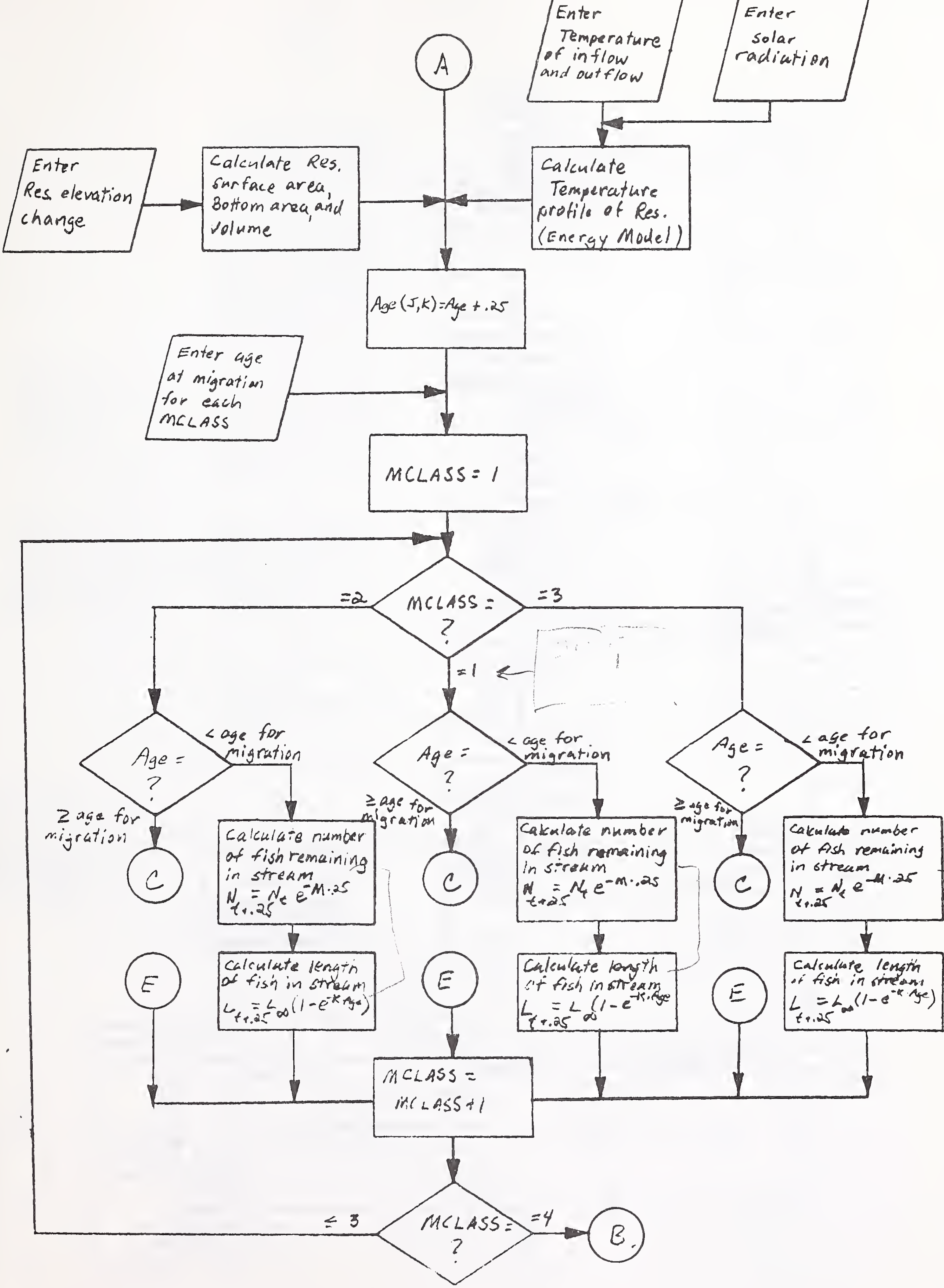
OBSERVATION	OBSERVED VALUE	PREDICTED VALUE	RESIDUAL	LOWER 95% CL FOR MEAN	UPPER 95% CL FOR MEAN
1 *	.	37.22386364	.	36.38451764	38.06320963
2 *	.	38.20265152	.	37.00060361	39.40469942
3	38.10000000	37.22386364	0.87613636	36.38451764	38.06320963
4	37.70000000	38.20265152	-0.50265152	37.00060361	39.40469942
5	36.90000000	37.06931818	-0.16931818	36.27812833	37.86050803
6 *	.	34.49356061	.	33.56693546	35.42018575
7	36.60000000	36.03901515	0.56098485	35.43068685	36.64734346
8	34.40000000	34.23598485	0.16401515	33.21527518	35.25669452
9	35.10000000	34.80265152	0.29734848	33.97975116	35.62555187
10	35.00000000	35.00871212	-0.00871212	34.24749545	35.76992880
11	34.10000000	35.31780303	-1.21780303	34.63386042	36.00174564

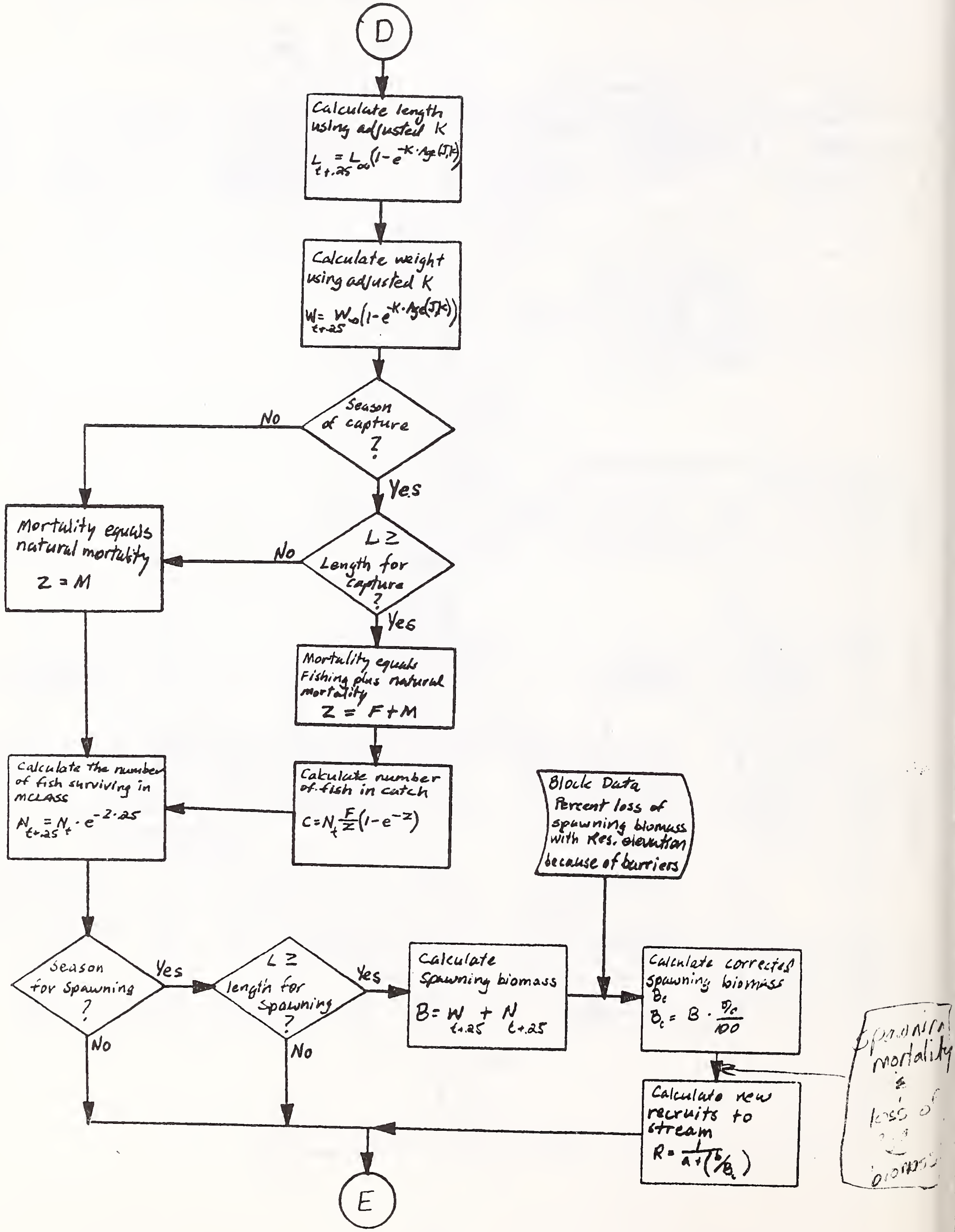
* OBSERVATION WAS NOT USED IN THIS ANALYSIS

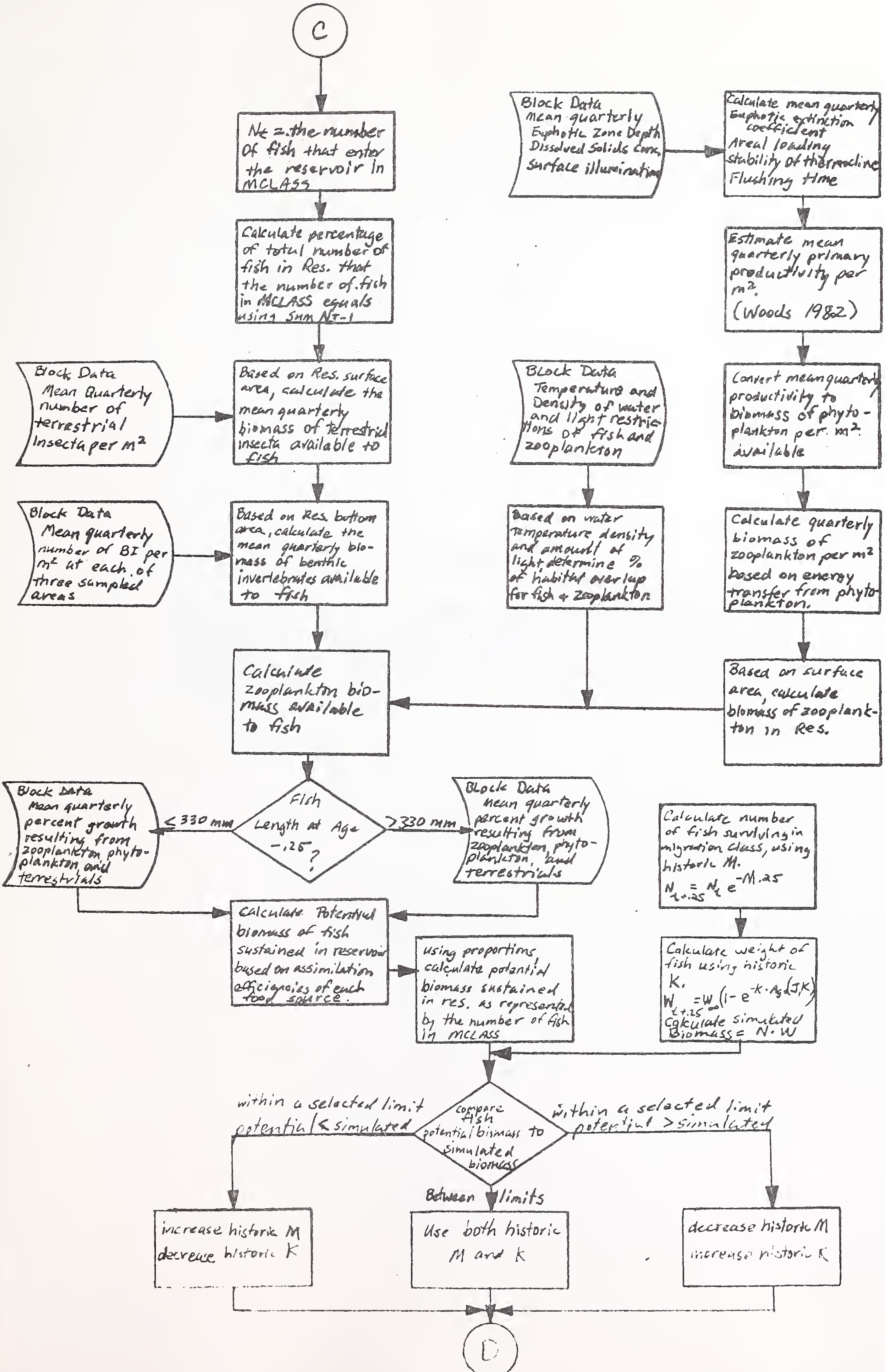
SUM OF RESIDUALS	0.00000000
SUM OF SQUARED RESIDUALS	2.96208333
SUM OF SQUARED RESIDUALS - ERROR SS	0.00000000
PRESS STATISTIC	5.05368306
FIRST ORDER AUTOCORRELATION	-0.10177613
DURBIN-WATSON D	1.44372923

Figure 7.--Proposed flow chart for ecosystem model of Lake Koocanusa




A
Enter Temperature of inflow and outflow
Enter solar radiation
Enter Res. elevation change
Calculate Res. surface area, Bottom area, and volume
Calculate Temperature profile of Res. (Energy Model)
Age (J,K) = Age + .25
Enter age at migration for each MCLASS
MCLASS = 1
MCLASS = ?
=2
=3
=1
Age = ?
< age for migration
≥ age for migration
C
E
Calculate number of fish remaining in stream
$N_{t+.25} = N_t e^{-M \cdot .25}$
Calculate length of fish in stream
$L_{t+.25} = L_\infty(1-e^{-K \cdot Age})$
MCLASS = MCLASS+1
MCLASS = ?
≤ 3
=4
B.


D
Calculate length using adjusted K
$L_{t+.25} = L_\infty(1-e^{-K \cdot Age(J,K)})$
Calculate weight using adjusted K
$W_{t+.25} = W_\infty(1-e^{-K \cdot Age(J,K)})$
Season of capture ?
No
Yes
L ≥ Length for capture ?
No
Yes
Mortality equals natural mortality
Z = M
Mortality equals Fishing plus natural mortality
Z = F+M
Calculate the number of fish surviving in MCLASS
$N_{t+.25} = N_t \cdot e^{-Z \cdot .25}$
Calculate number of fish in catch
$C = N_t \frac{F}{Z}(1-e^{-Z})$
Block Data
Percent loss of spawning biomass with Res. elevation because of barriers
Season for Spawning ?
Yes
No
L ≥ length for Spawning ?
Yes
No
Calculate Spawning biomass
$B = W_{t+.25} + N_{t+.25}$
Calculate corrected spawning biomass B_c
$B_c = B \cdot \frac{\%c}{100}$
Calculate new recruits to stream
$R = \frac{1}{a+(b/B_c)}$
Spawning mortality
loss of
biomass
E


C
Nt = the number of fish that enter the reservoir in MCLASS
Calculate percentage of total number of fish in Res. that the number of fish in MCLASS equals using Sum NT-1
Block Data Mean Quarterly number of terrestrial Insecta per m²
Based on Res. surface area, calculate the mean quarterly biomass of terrestrial insecta available to fish
Block Data Mean quarterly number of BI per m² at each of three sampled areas
Based on Res. bottom area, calculate the mean quarterly biomass of benthic invertebrates available to fish
Calculate zooplankton biomass available to fish
Block Data mean quarterly Euphotic Zone Depth Dissolved Solids Conc. Surface illumination
Calculate mean quarterly Euphotic extinction coefficient Areal loading stability of thermocline Flushing time
Estimate mean quarterly primary productivity per m². (Woods 1982)
Block Data Temperature and Density of water and light restrictions of fish and zooplankton
Convert mean quarterly productivity to biomass of phytoplankton per m² available
Based on water temperature density and amount of light determine % of habitat overlap for fish & zooplankton
Calculate quarterly biomass of zooplankton per m² based on energy transfer from phytoplankton.
Based on surface area, calculate biomass of zooplankton in Res.
Block Data Mean quarterly percent growth resulting from zooplankton phytoplankton and terrestrials
≤ 330 mm
Fish Length at Age -.25 ?
> 330 mm
Block Data mean quarterly percent growth resulting from zooplankton, phytoplankton, and terrestrials
Calculate number of fish surviving in migration class, using historic M.
N t+.25 = Nt e^-M.25
Calculate Potential biomass of fish sustained in reservoir based on assimilation efficiencies of each food source.
using proportions calculate potential biomass sustained in res. as represented by the number of fish in MCLASS
Calculate weight of fish using historic K.
W t+.25 = W∞ (1 - e^-K·Ag(J,K))
Calculate simulated Biomass = N·W
within a selected limit potential < simulated
compare fish potential biomass to simulated biomass
within a selected limit potential > simulated
Between limits
increase historic M decrease historic K
Use both historic M and K
decrease historic M increase historic K
D

APPENDIX M

Comments by Gene R. Ploskey, Aquatic Ecosystems Analysts, on the First Annual Report (1984) and proposed Work Plan (in prep.) for the study "Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries"

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PHONE 501/442-3744

December 20, 1984

Brad Shepard
Montana Dept. Fish, Wildl., and Parks
P. O. Box 67
Kalispell, Montana 59903

Dear Brad,

On attached sheets you will find my comments concerning your work plan and first annual report on the Libby Reservoir project. You obviously have put a lot of thought and effort into the project, which is one of the more comprehensive sampling efforts I have seen in recent years. The results should contribute significantly to our understanding of the ecology of cold-water reservoirs in the U.S. Time constraints forced me to restrict comment to perceived problem areas. I hope my thoughts are of some use to you.

Merry Christmas,

Gene R. Ploskey

Gene R. Ploskey

Page 4 (top) -- I agree that changes in living space associated with water-level fluctuations may limit fish-food resources and production, but negative impacts are most pronounced when drawdown occurs during the growing season. Impacts in winter are usually moderated by low water temperatures that reduce primary production, food requirements, growth, and predation. Primary and secondary productivity would be low regardless of water levels. I can visualize protracted negative impacts of winter drawdown on benthos production because overwintering populations in the fluctuation zone are decimated annually and reproduction and recolonization would require several months during the following spring and summer. Algae and zooplankton production typically is minimal in winter, and therefore unlikely to be limited by drawdown, unless the drawdown occurs during spring, summer, or fall. The highly seasonal nature of zooplankton and phytoplankton production, and dessication resistant overwintering mechanisms in the former group (e.g., ephipial eggs) make protracted damage unlikely.

Pages 5-21 -- I have no problem with your sampling efforts as you seem to have adequately covered all important variables. Your efforts on food habits, zooplankton, and benthos are good and will be indispensible for defining trophic relations.

Page 21 (Objective 5) -- I have serious reservations about using habitat suitability models to assess impacts of water-level fluctuations. A loss of habitat to drawdown (especially in winter) rarely causes a proportional reduction in fish abundance. Habitat suitability models have been most criticized because habitat units rarely can be correlated with density or standing crop. A better approach to assessing impact of winter drawdown might be to compare size-specific mortality of fish or abundance among seasons. If mortality is substantially higher during winter drawdown than in summer, some basis exists for implicating drawdown as a detrimental agent. Most literature indicates that fish metabolism, consumption, and growth drops substantially in winter, although stomach contents may not decrease due to reduced food processing rates, i.e., a food item may require days to digest. Due to reduced food needs, winter losses of invertebrate food resources and predation on young fishes should be less significant in winter. I have often found positive correlations between fish abundance and annual water-level fluctuation whereas habitat losses due to fluctuation might suggest that the effect would be distinctly negative. Until the mechanisms and effects are understood, relying on habitat changes to project population impacts could be misleading.

Page 24 (Revegetation) -- Vegetation in the upper fluctuation zone is very important for spawning and nursery habitat for certain species, especially in warm-water impoundments. California Biologists have had some successes along these lines--see McCammon and von Geldern (1979) in Predator-prey Systems In Fisheries Mgmt. (SFA Publ., Page 431), NAJFM 2(4): 307-315, and an excellent review by Whitlow and Harris (1979). A copy of the review by Whitlow and Harris is enclosed.

Page 27 (Factorial Analysis of Variance) -- Statistically, a weak part of the study is that 3-4 years of replication probably will be inadequate to statistically quantify relations between reservoir operations and changes in populations of fish or fish-food biota. Seasonal and areal variations in most variables usually exceed annual variations, especially when annual fluctuation regimes do not differ significantly from year to year. Consequently, you may not be able to demonstrate significant differences among years unless you standardize the data by area and season and use these standardized deviates as replicates. I prefer to use one-way analysis of variance to look for differences among years, seasons, or areas because 3-way ANOVA's always yield many interactions that cannot be explained. If adequate replication is a problem because samples from different areas are highly variable or have different variances, try standardizing all dimensions (years, seasons, or areas) except the one you want to test. You will want to use a nonparametric test such as the Kruskal-Wallis test if sample variances are not homogeneous.

In my experience, the ability to predict reservoir-wide operational effects on fish requires at least 8-10 years of data unless you are lucky enough to sample fewer years under highly variable flow conditions.

The limited replication of hydrological cycles (4 years; 4 springs; 4 summers, etc.) should not prevent the study from meeting its stated objectives or your group from formulating valuable recommendations to maintain or enhance the reservoir fishery. It probably will force the development of a more conceptual than mathematical model for predicting effects, and one with more assumptions. For example, documented differences in summer benthos populations in areas that were dewatered one winter and not another can be used to project effects on fish that feed on benthos by using trophic transfer coefficients and many assumptions.

Your sampling seems more than adequate to describe the reservoir trophic system and to suggest the important interactions between target fishes and their habitat and food resources. Therefore it should be adequate to conceptualize a trophic model. However, the 3-4 years of data probably will be insufficient to derive relations between reservoir operations and biotic variables, relations that are needed to drive a trophic model. Unless operational trends differ significantly among years and seasons and affect different areas, it will be impossible to attribute a change in fish-food biota or fish to operations.

As you indicated, the best chance for success lies with obtaining significant modification of the water-level regimes in one or two of the years, which would at least permit paired comparisons of means of biotic variables.

Page 28 -- If you pursue a trophic model, you may have difficulty modeling fish species for whom only catch per unit effort data were recorded. Salmo and kokanee should be less of a problem.

Final Annual Report (May-Oct., 1983)

Page 27 (last sentence; 1st full paragraph) -- Zooplankton production may also be limited by high rates of water exchange (> than once in 30 days). However, production already limited by temperature (in winter) will not be impaired significantly by high rates of water exchange.

(2nd full paragraph) -- I can think of no better justification for your efforts than the fact that we know virtually nothing about the biology of cold-water fishes in reservoirs. What you find should be valuable to conservation and regulatory agencies who will run into similar problems in the future.

Page 44 (Predicting benefits) -- I believe the development of a trophic model for fish is premature because it cannot predict effects of operations on fish unless driving variables are identified and related to reservoir operations. Food types consumed by fish are primary driving variables of a trophic model. If you have a species of fish that consumes 3 food types (benthos, zooplankton, prey fishes) and plan to use a trophic model to project effects of water levels on this species, you must guess or project the effects of water levels on the three food types in order to drive the model. You may find you can project effects of some operations (such as drawdown) on fish recruitment, growth, or mortality without having to first project effects on fish foods (among other things). Trophic models also tend to have large errors (± 150 percent of actual values) associated with predictions. A well thought-out conceptual model can be as useful as a mathematical model, less expensive to develop, and readily changed as new information becomes available. I recommend a thorough analysis of all data to fill in or correct your existing conceptual model (alluded to in Pages 38 and 43 of the Annual Report and Page 4 of the Work Plan) before considering a complex trophic model. I would guess that other operational constraints will severely limit the amount of operational modification possible.

It would be difficult to justify an elaborate model to predict effects of operations on fish if operations are too inflexible to be altered significantly. From your extensive data collections you should acquire a workable understanding of essential water-level requirements from which you probably could develop a suitable rule curve.

Page 45 (last paragraph) -- Unless analysis of your data yields relationships that provide other driving variables, your proposed trophic model will be weak.

DOE/BP-12660-2
June 1985