AN ABSTRACT OF THE THESIS OF

David Hansen for the Master of Science degree in Fish and Game Management

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Title THE INFLUENCE OF NATURAL MORTALITY AND OTHER LIFE HISTORY FACTORS ON THE YIELD TO THE ANGLER OF PLANTED CUTTHROAT TROUT IN MUNSEL LAKE, OREGON

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(Major professor)

This study was initiated in 1961 to evaluate the contribution of various hatchery plants of cutthroat trout (Salmo clarki clarki Richardson) to the angler in Munsel Lake. Feeding habits, growth rates, migration, natural mortality and yield to the angler were examined.

Analysis of 109 stomachs from the various plants showed changes in percent occurrence and percent by volume of food types consumed during the months studied, as well as differences in food habits of old and new plants. Aquatic insects, plankton and kokanee eggs were the most important foods. Growth rates in the three habitats (lake, outlet and saltwater) were different and seemed to be related to changes in mean volume of stomach contents.

Fish which migrated out of the lake were captured in an upstream-downstream weir where 1,037 cutthroats were tagged subcutaneously. There were ten tag recoveries by anglers in tidewater. About ten percent of the fish in the lake at the start of the downstream migration migrated out of the lake. Migration into the outlet and vertical migrations in the lake also were observed.

Mark-and-recapture methods were used to determine survival of the various plants. Large fish planted late in the season survived better. Natural mortality was the most important factor in determining yield to the angler.

A creel sampling program whereby all holidays and one weekend day and one week day a week were sampled to estimate total catch of the various plants. A total of 1,104 parties (2,260 anglers) fished 4,100 hours in the 1962 season to catch 4,630 hatchery trout. Catch per hour fished, hours fished, number of parties fishing and total catch per day decreased rapidly following each planting. Return to the angler increased with increasing size of fish planted.

THE INFLUENCE OF NATURAL MORTALITY AND OTHER LIFE HISTORY FACTORS ON THE YIELD TO THE ANGLER OF PLANTED CUTTHROAT TROUT IN MUNSEL LAKE, OREGON

by

David Hansen

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Date thesis is presented May 15, 1963

Typed by Anne Bailey

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THE INFLUENCE OF NATURAL MORTALITY AND OTHER LIFE HISTORY FACTORS ON THE YIELD TO THE ANGLER OF PLANTED CUTTHROAT TROUT IN MUNSEL LAKE, OREGON

INTRODUCTION

A study to evaluate the contribution of various hatchery plants of cutthroat trout (*Salmo clarki clarki* Richardson) to the angler in Munsel Lake was initiated by the Division of Wildlife Research of the Oregon State Game Commission in the fall of 1961. Feeding habits, growth rates, yield to the angler, migration and natural mortalities of the various plants were examined.

The total catch of each of the various plants was determined according to a stratified random sampling program utilizing one weekday and one weekend day per week as sampling periods. Fish migrating out of the lake were captured in an upstream-downstream weir. They were tagged subcutaneously. Population estimates to determine survival were made three times in 1962.

Growth rates in the three areas of cutthroat inhabitation in the Munsel Lake drainage were examined. Also changes in food habits during 1962 were determined.

PHYSIOGRAPHY

Munsel Lake is located in Sections 13 and 14, T18S, R12W, Heceta Head Quadrangle, Lane County. Florence, Oregon, lies three miles south of the lake. Munsel Lake is the lowest in a chain of four. Its outlet empties into the Siuslaw River (Figure 1).

It has a surface area of 103 acres and a volume of 3190 acre-feet. The lake's mean depth is 31 feet and the length of the shoreline is 14,720 feet. Thirty-two percent of the lake's area is from zero to 15 feet in depth (8, p. 4). Figure 2 shows the contour map prepared by the Oregon Fish Commission.

On the east shore of the lake is a stand of old timber made up of sitka spruce, Picea sitchensis; Douglas fir, Pseudotsuga menziesii; and hemlock, Tsuga heterophylla. The remainder of the land surrounding Munsel Lake has been recently logged and a dense cover of rhododendrons, Rhododendron sp., huckleberry, Vaccinium spp., salmonberry, Rubus spectabilis, thimbleberry, Rubus parviflorus; salal, Gaultheria shallon, Western red alder, Alnus rubra, and vine maple, Acer circinatum, has formed. Swampy areas are found in the northwest corner and the northern arm of the lake.

Much of the littoral area of Munsel Lake is covered with dense patches of water shield, Brasenia schreberi, and with smaller patches of pond weed, Potamogeton spp., also yellow water lily, Nuphar sp. In the swampy areas sedges, Carex spp., and willows, Salix spp., are predominant.

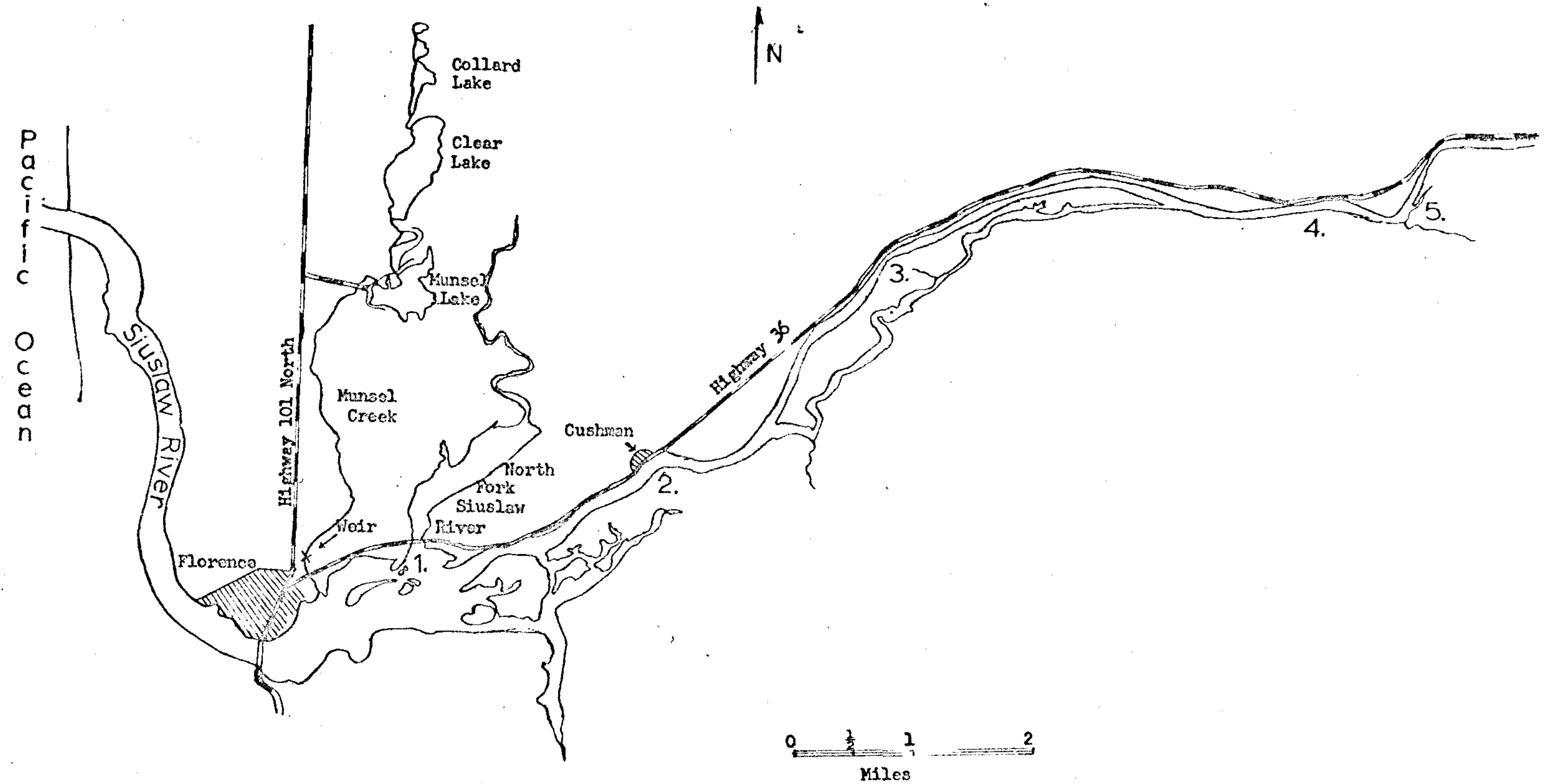
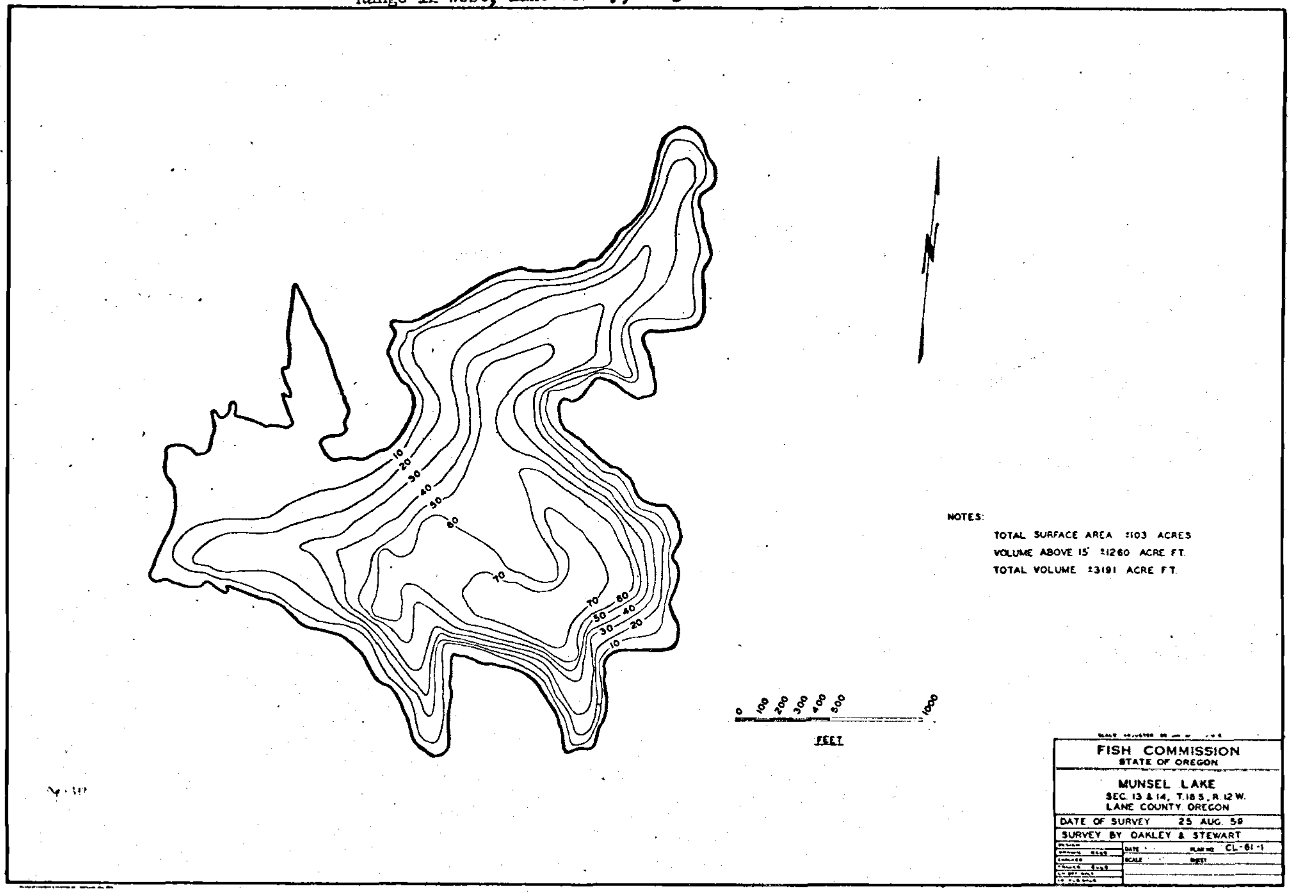


Figure 1. Map of the Munsel Lake Area.

Figure 2. Contour Map of Munsel Lake, Sections 13 and 14, Township 18 South, Range 12 West, Lane County, Oregon.



The following species of fish were found in Munsel Lake during this study: Cutthroat trout, Salmo clarki; rainbow trout, Salmo gairdneri; coho salmon, Oncorhynchus kisutch; kokanee, Oncorhynchus nerka kennerlyi; largemouth bass, Micropterus salmoides; yellow perch, Perca flavescens; bluegill, Lepomis macrochirus; warmouth, Chaenobryttus coronarius; brown bullhead, Ictalurus nebulosus and prickly sculpin, Cottus asper. Three-spined stickleback, Gasterosteus aculeatus and black crappie, Pomoxis nigro-maculatus have been reported in Munsel Lake by Griffiths and Yeoman (4, p. 324). Cutthroats, rainbows, coho and kokanee are common owing to extensive planting of hatchery fish.

Surface temperatures were recorded on a maximum-minimum thermometer located in the southwest corner of the lake at a depth of one foot. Changes in surface temperature are presented in Figure 3. The lowest temperature recorded in 1962 was 37°F and the maximum was 74°F. A rapid increase in surface temperature occurred in March and April while a rapid decrease in lake temperatures occurred in October and December. During the summer months there were only small temperature fluctuations.

Vertical series of temperature readings were made during nine months of 1962 (Figure 4). Munsel Lake "overturned" in the winter but did not freeze. By May, 1962, the lake had developed a thermocline 12 feet in thickness. In August the thermocline reached its maximal thickness of 20 feet with a change in temperature from 71°F at 20 feet to 48°F at 40 feet. By December, 1962, there was only a four degree change in temperature from the surface to the bottom.

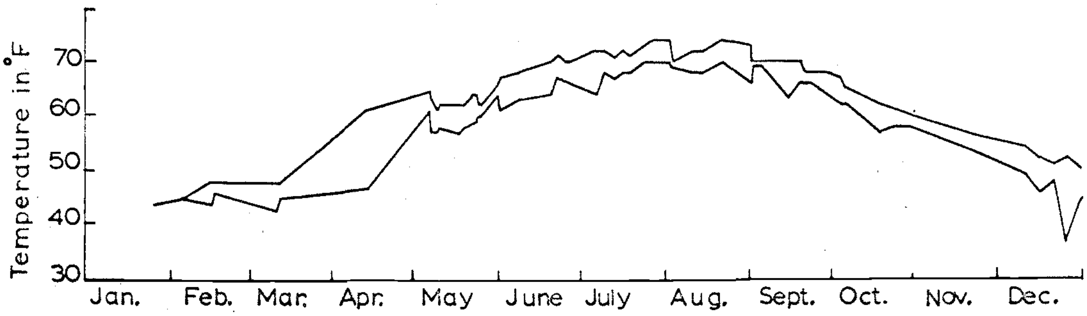


Figure 3. Changes in Maximum-Minimum Surface Temperatures During 1962.

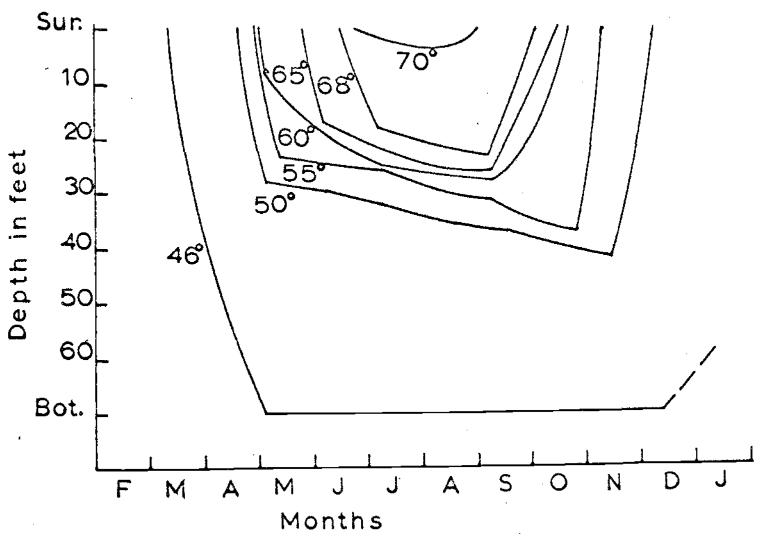


Figure 4. Temperature Change with Depth During the Study.

Chemical properties of Munsel Lake were measured in August, 1960 (8, p. 11-12). A supersaturation of oxygen was found in the thermocline, oxygen in the epilimnion was near saturation, and in the hypolimnion oxygen concentrations ranged down to one part per million. Total dissolved solids ranged from 44 to 50 parts per million; PO_4 was from 0.000 to 0.066 parts per million, and NO_3 ranged from 0.11 to 0.10 parts per million in the two months sampled in 1963 (February and April).

Munsel Lake drainage area is only 3.29 square miles. There are only five tributaries to the lake. The inlet which connects Munsel Lake to Aikerly, Clear and Collard Lakes supplies most of the surface water flowing into the lake. The other four tributaries have a combined drainage of 0.67 square miles (8, p. 9).

Rainfall in the Florence area during a 19-year period has averaged 65.12 inches (5, p. 4). In 1962, there was a total of 65.34 inches. Most rain falls in the months of November through March. The yearly change in lake level has been as much as three feet (8, p. 3), but in 1962 it varied by only two feet.

Munsel Creek flows out of the northwest end of Munsel Lake and then south with a gradient of 30 to 40 feet per mile for three miles until it reaches the estuarine area of the Siuslaw River. The last 300 yards of the creek are subject to tides. Munsel Creek flows through a very dense cover of salal, huckleberry, salmonberry and rhododendrons.

Flows in 1962 ranged from two cubic feet per second in the summer to 21 cubic feet per second in the winter. Lake levels and stream flows are maintained primarily by ground water discharging from sand dunes around Florence (5, p. 13). Flows increase in a downstream direction because of the discharge.

Temperatures in Munsel Creek ranged from 44°F to 63°F. The biggest change in temperature for any one day was 3°F. Night temperatures were usually higher because of the length of time it took water from the lake to reach the weir where temperatures were recorded. Dense stream cover limited the temperature increase during the day.

HATCHERY PLANTS OF TROUT IN MUNSEL LAKE

Planting of trout in Munsel Lake and other coastal lakes of Oregon has been based on the judgement of field biologists as to what species and how many fish of various sizes were best able to supply the angler with legal-sized trout (over eight inches). The season usually opens the third weekend in April and closes the end of October. Since the first introductions of hatchery-raised trout, biologists have switched back and forth between planting of rainbows and cutthroats. Fry, fingerlings and legal fish have been planted in varying numbers (Table 1). Analysis of the yield to the angler of the various plants was usually limited to a few observations of angler success early in the fishing season and total catch of the different plants was not tabulated.

In the fall of 1961 the Research Division of the Oregon State Game Commission began this study. Because there had been only limited work on stocking rates in lakes in this region, planting rates were similar to some of those previously tried. Six plants were made in the year from December 1961 to November 1962 (Table 2).

On November 21, 1961, 7632 both ventral (BV) marked fingerlings were planted by boat. There were 10.6 fish per pound. Length and weight data can be seen in Figures 14 and 15, Section IV. Another plant of 7579 fish was made in Aikerly Creek. The fish were marked with a right ventral-adipose fin clip (RVA). By using two planting procedures which had been used by fishery biologists of the area, differences in yield to the angler were compared. In the following

TABLE 1

Numbers of Trout
Stocked in Years
Prior to Study

Mark	Date of Plant	Number Per Pound	Size in Inches	Species	Number
BV	6/24/61	160	2.5	Cutthroat	35,040
BV	4/10/61	4.1	9	"	1,714
BV	4/14/61	5	8	"	2,300
	1960		2-4	Rainbow	15,052
	1960		8 and over	"	2,998
	1959		6 and over	"	3,000
	1958		" " "	"	5,067
	1957		2-4	"	9,985
	1957		4-6	"	6,650
	1957		6 and over	"	2,574
	1956		2-4	"	6,180
	1956		6 and over	Cutthroats	2,000
	1955		" " "	"	1,500
	1955		2-4	Rainbow	6,400
	1954				
	1953		6 and over	Rainbow	1,550
	1952				

pages the plant will be called the fall plant when reference is made to the total plant, or segments of the plant will be termed the RVA or BV plant (Table 2).

TABLE 2

Cutthroat Plants Made During the Study

Mark	Date Planted	Fish/Pound	Number	Type of Plant
BV	11/21/61	10.6	7,632	Boat
RVA	11/21/61	10.6	7,579	Inlet
LVA	4/2/62	4.5	4,000	Boat
LV	8/2/62	2.7	1,499	Boat
LV-RM	11/1/62	1.4	1,369	Boat
RM	11/29/62	10.9	8,088	Inlet

On April 2, 1962, 4,000 legal cutthroats, marked by an LVA clip, were planted by boat in order to get rapid distribution of the fish. The plant was used to get an estimate of the mortality of the fall fingerling plant. It will be referred to in the following pages as the legal or LVA plant.

On August 2, 1962, 1499 left-ventral-marked cutthroats were planted by boat. The fish were used in a population estimate to determine the number of fish of the three earlier plants that remained after three months of fishing.

On November 1, 1962, 1369 left-ventral-right-maxillary-marked fish (LVRM) at 1.4 fish per pound were planted by boat in

Munsel Lake. They were used to determine the number of fish remaining after the 1962 fishing season.

On November 29, 1962, 8088 right-maxillary-marked fingerlings were planted for study in 1963.

FOOD

Stomach contents from fish collected during eight months (not consecutive) of 1962, were analyzed for volume and percentage of occurrence of food organisms. Food intake and growth rates can be compared. A lack of intake of nutritious foods by hatchery fish gives a possible insight to the cause of mortalities in the various plants.

Fish from which the stomachs were taken were collected by gill netting or were obtained from fishermen's creels. The use of two collecting methods may introduce some bias into the examination of changes in feeding patterns. Fish from creels were utilized in April and May when the lack of apparent evening insect hatches resulted in little change of diet between night and day. Differences in feeding of different sizes of fish was unimportant as the fish collected were of about the same size.

Stomachs were initially fixed in five percent formalin to prevent digestion. Individual stomach contents were later put in vials containing 75 percent ethanol.

Aquatic insect immature stages were identified to family, while all insect adults except mayflies were identified to order. All stomach contents were dried for two minutes on tissue paper before volumes were measured. Stomach contents from the fall of 1961 fingerling plant were used as a base for examining feeding changes. The percentage of occurrence by volume and the total mean volume of all organisms occurring in the LVA stomachs collected in April were about the same as that of the fall plant, indicating a rapid adjustment to feeding on natural foods. When necessary, stomachs from the LVA plant were pooled with fall plant stomachs to give a total of ten stomachs per month sampled. In September, LV plants were pooled with the fall and LVA plants to get a larger sample. Such a procedure tended to reduce the mean volume per stomach because the LV plant had not completely adapted to feeding on natural food but probably increased the reliability of data on the types of food organisms eaten. In December, LV and LVRM plants were used to increase the sample size. The resulting decrease in total mean volumes in December can be seen in Figure 5.

Plankton made up of 99 percent cladocerans and one percent copepods, was the primary food eaten during the late winter and spring of 1962. From February to April and May the volume and percentage of occurrence increased (Figures 6 & 7, Table 3). Plankters were found in much smaller amounts in June. During the remainder of the year they were not found in the stomachs examined. Hildebrand and Towers (6, p. 394) and other authors reported finding plankton in cutthroat stomachs during the summer months.

Aquatic insects consisting primarily of nymphs and subimagos of Ephemeridae constituted the predominant food throughout 1962. Dimick and Mote (3, p. 7) also reported that mayflies were the main food eaten by cutthroat trout in Oregon. Ephemerid nymphs occurred in stomachs in large amounts in February, 1962, and in the sampled summer months of June and August. Subimagos were found in large

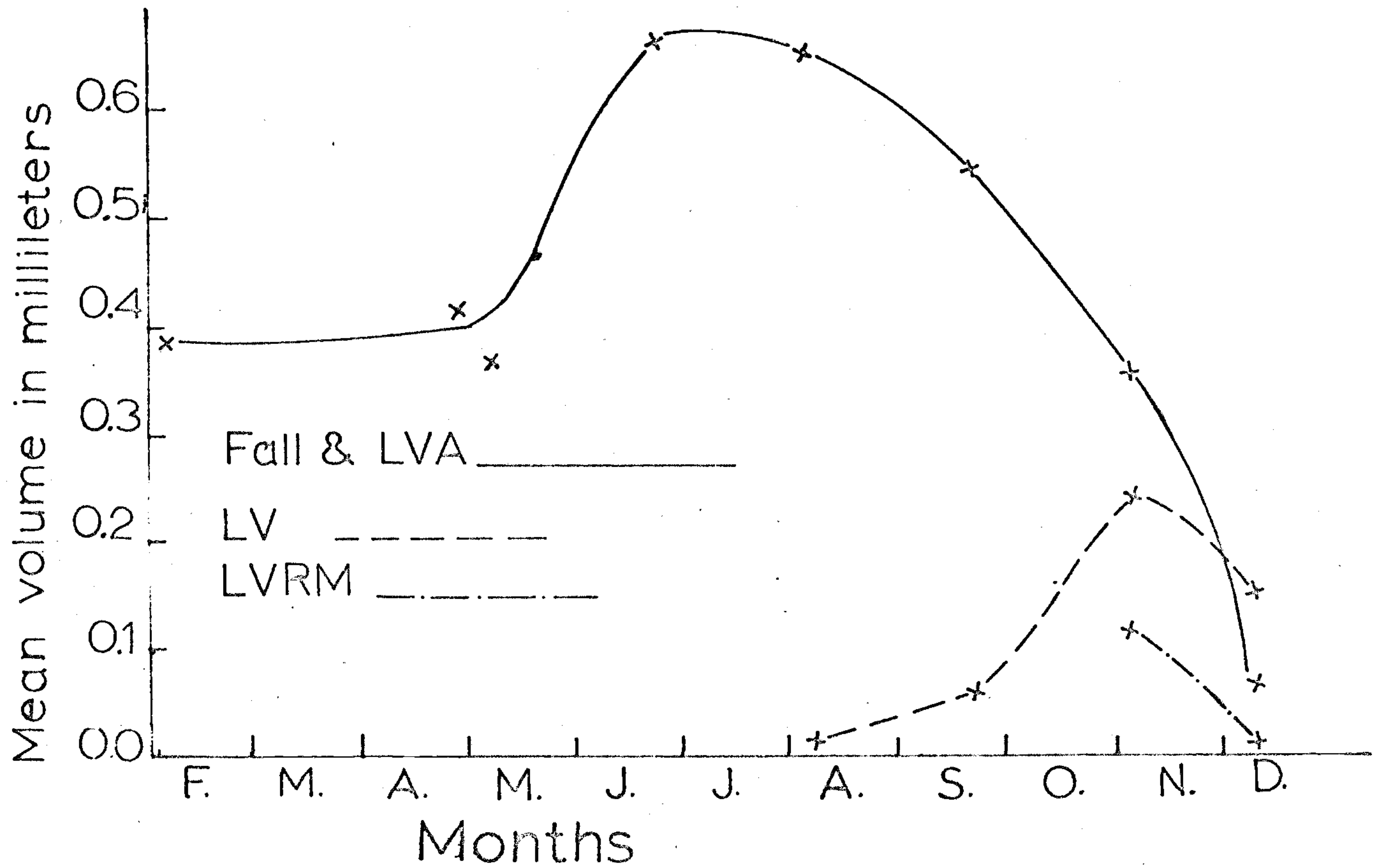


Figure 5. Change in Mean Volume of Stomach Contents of Cutthroat Trout

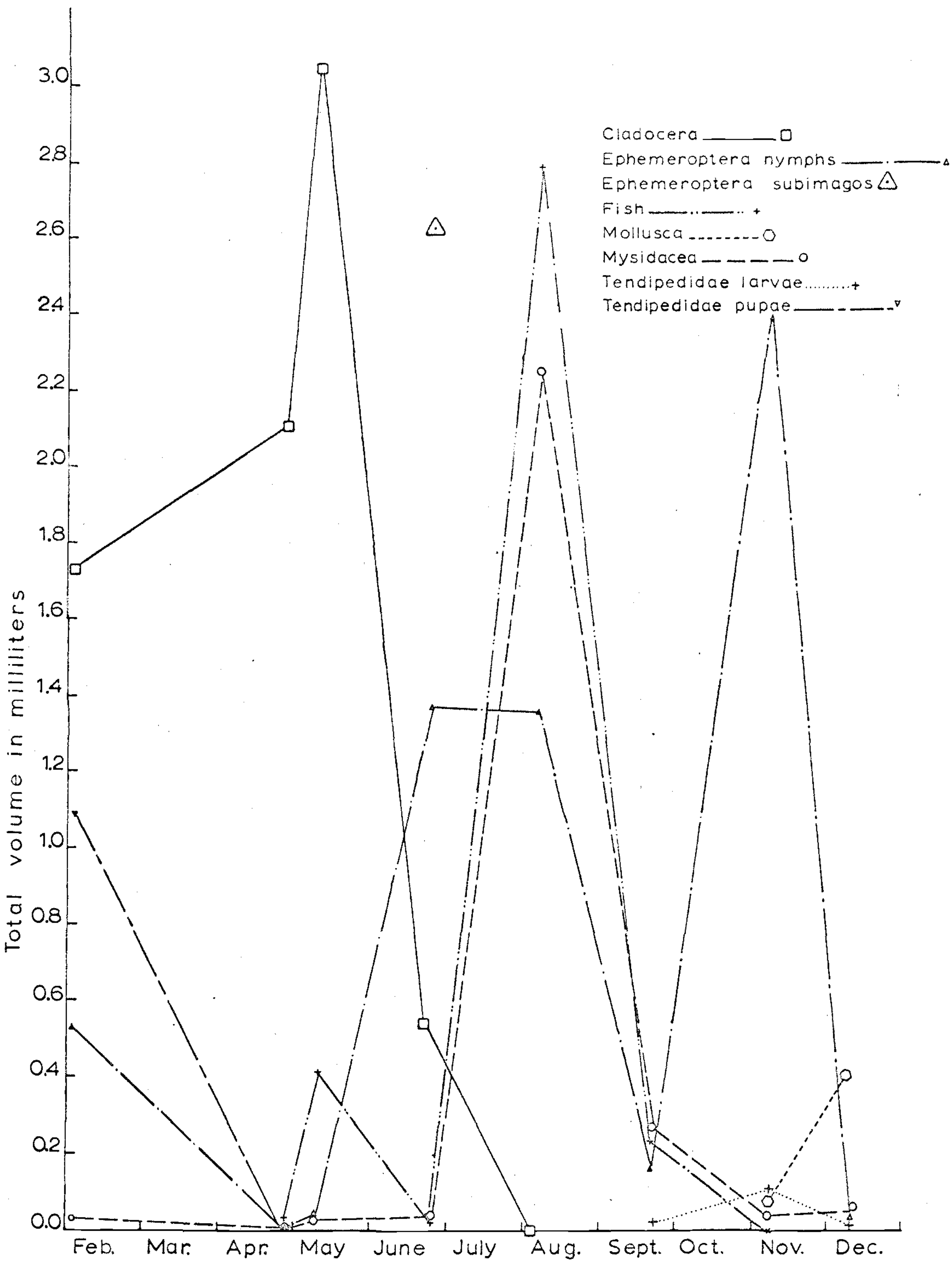


Figure 6. Changes in Total Volume of Aquatic Insects, Cladocera, Fish, Mollusks and Mysids in Stomach Contents of Trout.

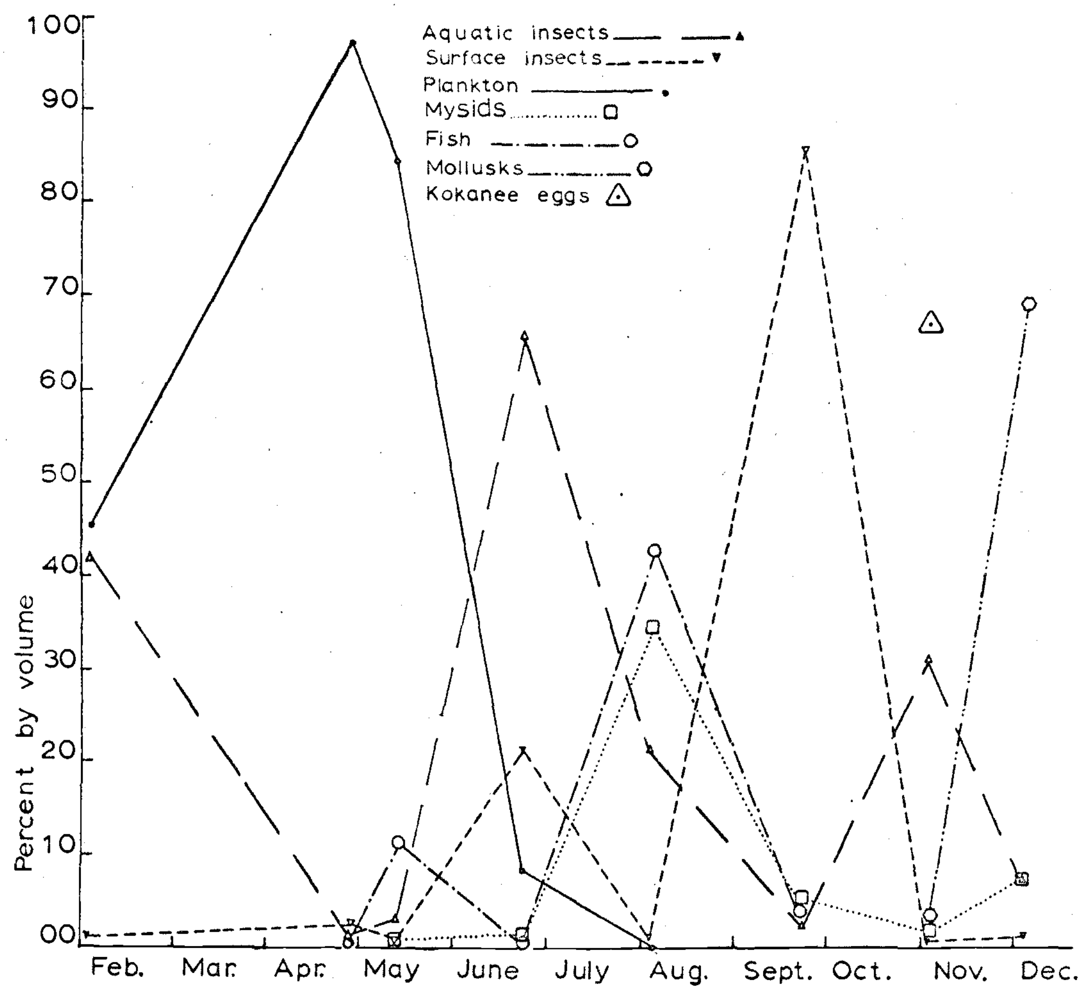


Figure 7. Change in Percent by Volume of Foods Eaten by Cutthroat Trout.

TABLE 3

Percent of Cutthroat Stomachs Containing Various Food Types

Organism	Date of Sample							
	** Feb. 2	* Apr. 28	* May 12	** June 22	** Aug. 3	** Sept. 20	** Nov. 6	** Dec. 12
Cladocera	60	100	70	60				
Copepods	30			30				
Mysids	10		10	10	39	33	20	22
Ephemeridae-Nymphs	40		30	80	23	22	70	11
Ephemeridae-Subimago				30				
Tendipedidae-Larva			20		15	33	10	
Tendipedidae-Pupa	30	30	20	30	8		20	22
Fish-Fry		10	20	30	30	11		
Coleoptera-Adult	10			10	8		10	
Diptera-Adult	10	30	10	10	8			
Hemiptera-Adult	10			20			10	11
Homoptera-Adult	10			10	8		10	
Hymenoptera-Adult				30		11		
Arachnida				20			10	
Eggs-Fish	10						10	
Plant & Dirt Pieces					8	11	20	
Empty					30	44	10	44
Worms (Bait)		30						
Mollusks						11	10	10

**Fish collected in gill nets
*Fish collected by angling

amounts in the June stomach samples. It is probable that during all of June and early July subimagos were present in large amounts. Pupa and larva of Tendipedidae were second in abundance of aquatic insects occurring in stomach contents. In February, tendipedid pupae occurred in large amounts, and in November, larvae made up two percent of the total volume of stomach contents. Chaoborinae, Heleidae and Baetidae were found in cutthroat stomachs also.

Surface food organisms were found in stomachs in every month sampled. In June and September large volumes of flying ants, Hymenoptera, were found in cutthroat stomachs. Coleoptera, Diptera, Hemiptera, Homoptera and Hymenoptera were also present (Figure 8). Arachnida were present in many of the months sampled.

Mysids (Neomysis mercedis Holmes) were fed upon throughout 1962. In August they made up 35 percent of the total volume.

Fish first appeared in stomach contents in late April and were found every month sampled until November. From Figure 7 it is apparent that there were two periods of predatory action on fish. They probably coincide with the times of hatching of cottids, perch, and bass.

Kokanee eggs were eaten in large amounts in November. The extent of feeding was probably increased because of the lack of suitable spawning gravel for kokanee and the resultant exposure of eggs.

Sphaeriidae were found in stomachs in September and November. In December gastropods made up 69 percent of the total stomach volume.

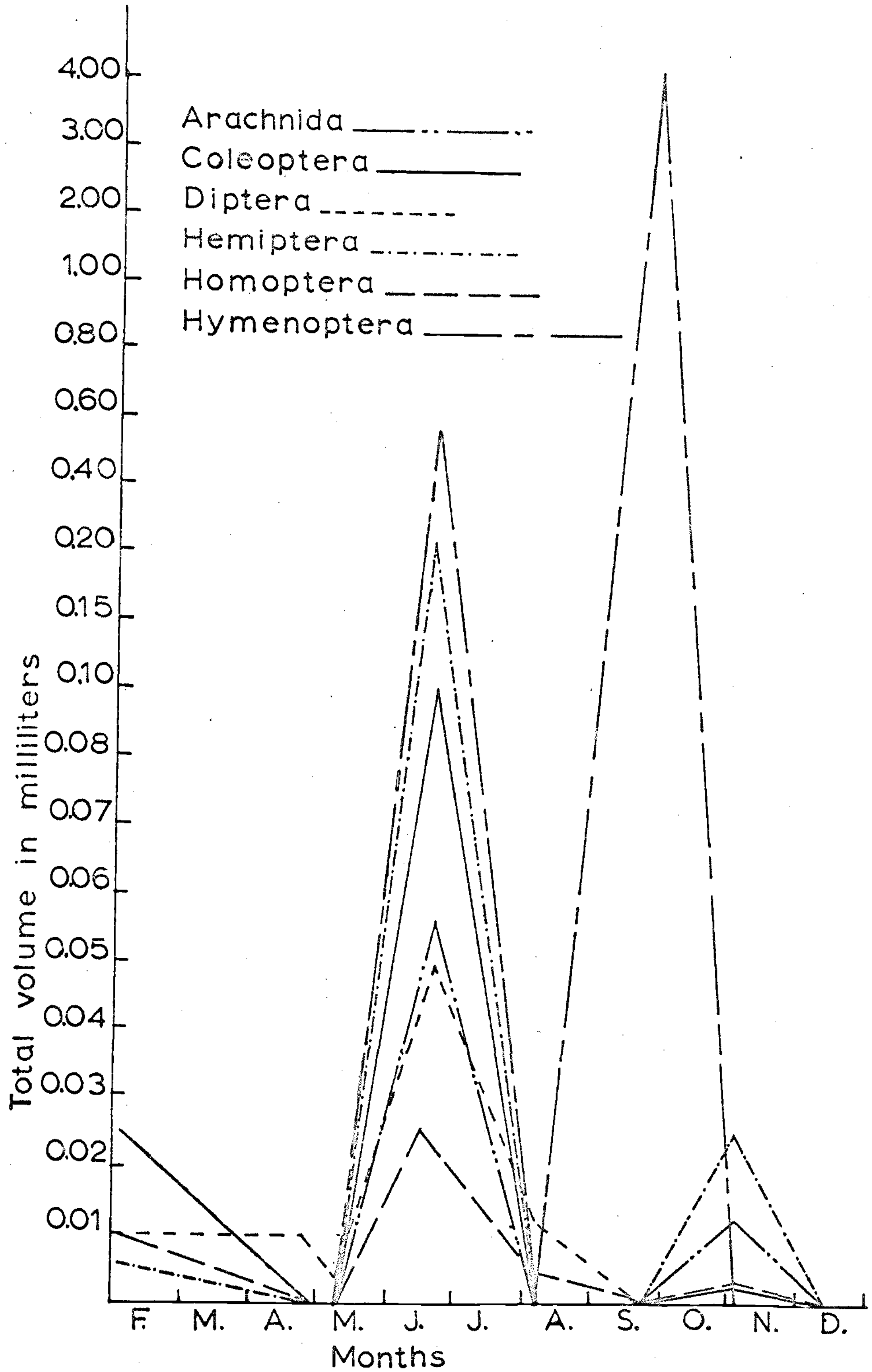


Figure 8. Changes in Total Volume of Surface Foods in Trout Stomachs.

Plants and other detritus, classed as miscellaneous in the graphs, mainly occurred in stomachs of newly planted fish which had not adjusted to feeding on natural foods. Figures 9 and 10 show the differences in feeding patterns of fish that had been in the lake for two months or less to those of older plants during the same period.

Empty stomachs were first found in August. In each of the three months sampled after August empty stomachs also occurred, probably indicating either a lack of food or slow adaptation to winter feeding habits. Fifty-eight percent of the newly planted fish had empty stomachs. Only 18 percent of the stomachs taken from fish of the old plants at the same time were empty. The comparison aids in reaching the conclusion that newly planted fish experienced some difficulty in adapting to a natural environment.

Total food intake throughout 1962 is shown in Figure 11. Aquatic insects were the most prevalent form by volume. Plankton, kokanee eggs and surface insects respectively followed in importance. Fish fry were fifth and mysids sixth. Two percent of the total volume was too well digested to be identified.

Changes in mean volume of stomachs in each sampling period and the change in mean volumes for newly planted fish with respect to the old plants are shown in Figure 5. From these data it can be concluded that the main growing season must have been from early May until about the end of August, coinciding with the growing time as shown in Section IV in the discussion of growth. Fish sampled in February, April and May were maintaining a slight growth rate.

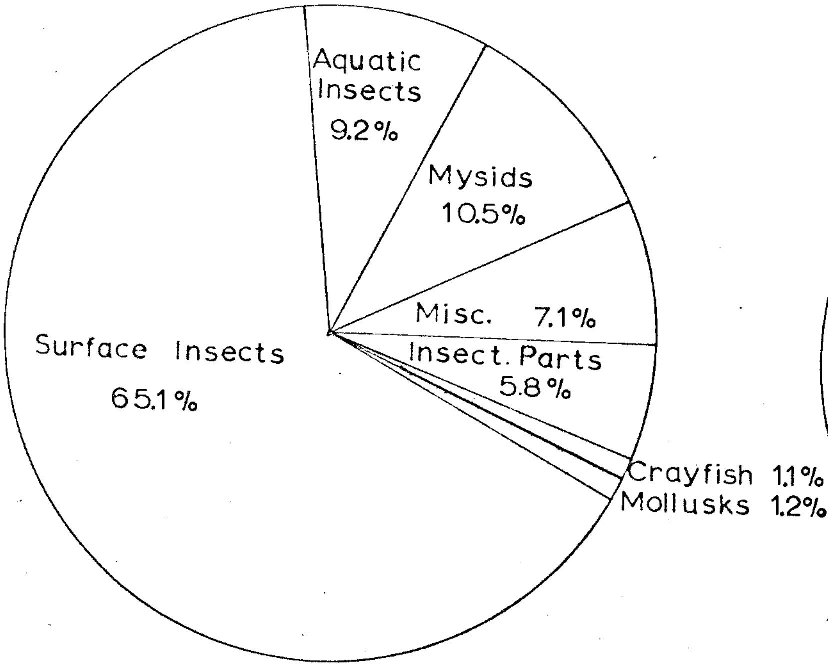


Figure 9. Percent by Volume of Food Types Consumed by New Plants of Cutthroat Trout.

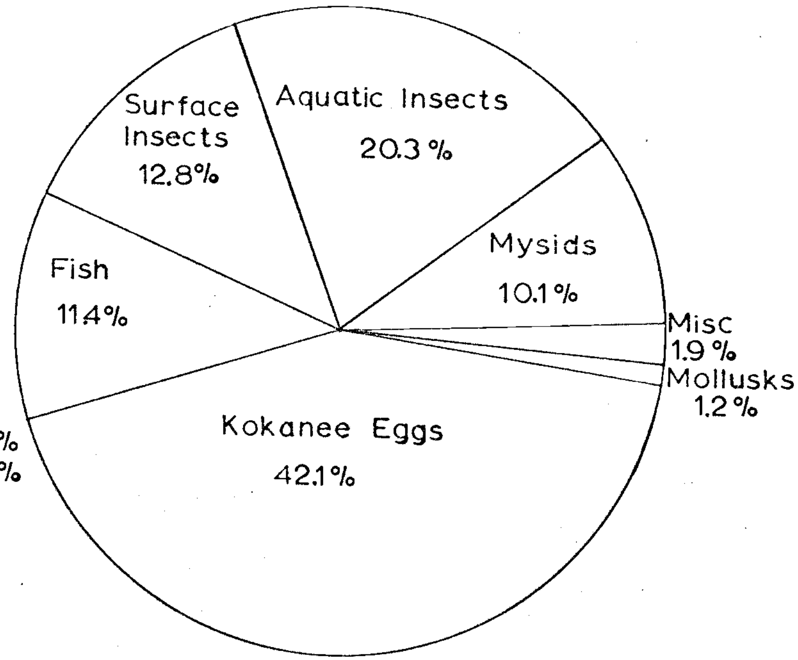


Figure 10. Percent by Volume of Food Types Consumed by Old Plants of Trout During the Same Period as the New Plants.

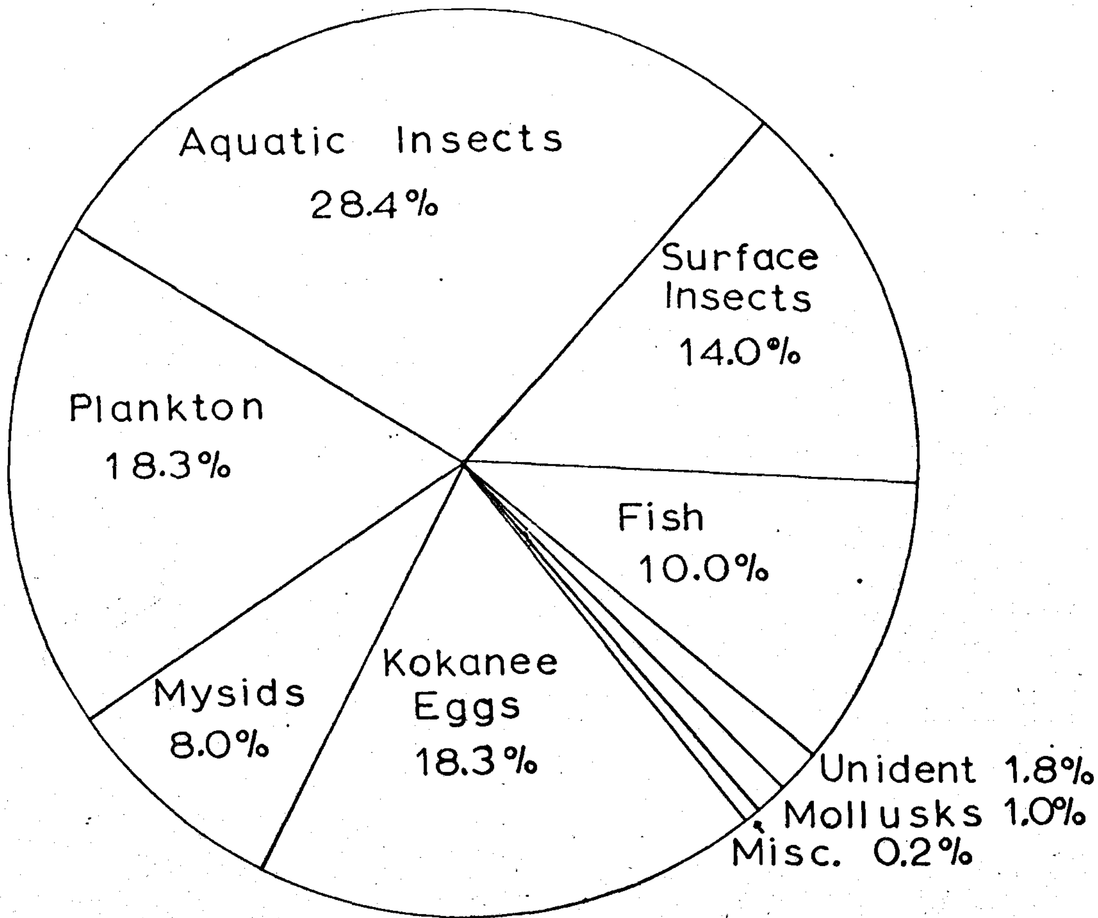


Figure 11. Percent Occurrence of Food Types in All Trout Stomachs Analyzed.

In each of the times sampled the mean volume of stomach contents was just over 0.38 milliliters. Thus it appears that the mean volume is enough to maintain condition in fish feeding mainly on plankton and small aquatic insects. In the period from February to May the average maximal temperature was 55°F with means of 48, 48, 57 and 59 degrees in the four months of the period.

In the sample of fish collected in September, November and December there was a drop in weight and condition. The mean volume of stomach contents of fish collected in November and December (not including volume made up of eggs) was under 0.15 milliliters. In September one of the nine fish sampled had 85 percent of the total volume. The mean volume of the other eight fish was 0.09 milliliters. From the fish examined in the three months it appears that with a mean volume of 0.15 milliliters or less of a particular food, there is a loss of condition in these months. The mean maximal temperature for the four-month period, from September to December, was 60°F. Means of 70, 63, 56 and 52 degrees respectively occurred in the four months.

GROWTH

In an evaluation of hatchery plants it is necessary to know growth rates and condition factors of the planted fish. Such values are an indication of the success of the fish in meeting natural conditions. Fingerling plants should grow enough to reach the legal size by the opening of the season.

Before a plant was made, lengths and weights were obtained at the Alsea Hatchery from a sample of fish, thus fixing the first point on the growth curve. This point usually cannot be compared with those that are obtained later since the collection methods in the hatchery and those in the lake are probably different in selectivity. Periodically throughout the year fish were collected by gill nets and from fishermen. Lengths were measured to the nearest millimeter. Fork lengths were used because modification of the caudal fin in hatcheries made the use of total lengths impractical. Weights were measured to the nearest gram. Condition factors were computed using fork lengths, K_{FL} (7, p. 160-162).

Because the fall, 1961, fingerling plant migrated through or inhabited three areas in the Munsel Lake drainage the increase in length in each area was studied (Figure 12). The main period of growth in Munsel Lake was from April to the end of August. The apparent increase in length from November, 1961, to March, 1962, may have resulted from gill net selectivity for the larger fish in February and March. Data from individuals of the plant indicated that less than five percent of the fingerlings were under eight inches

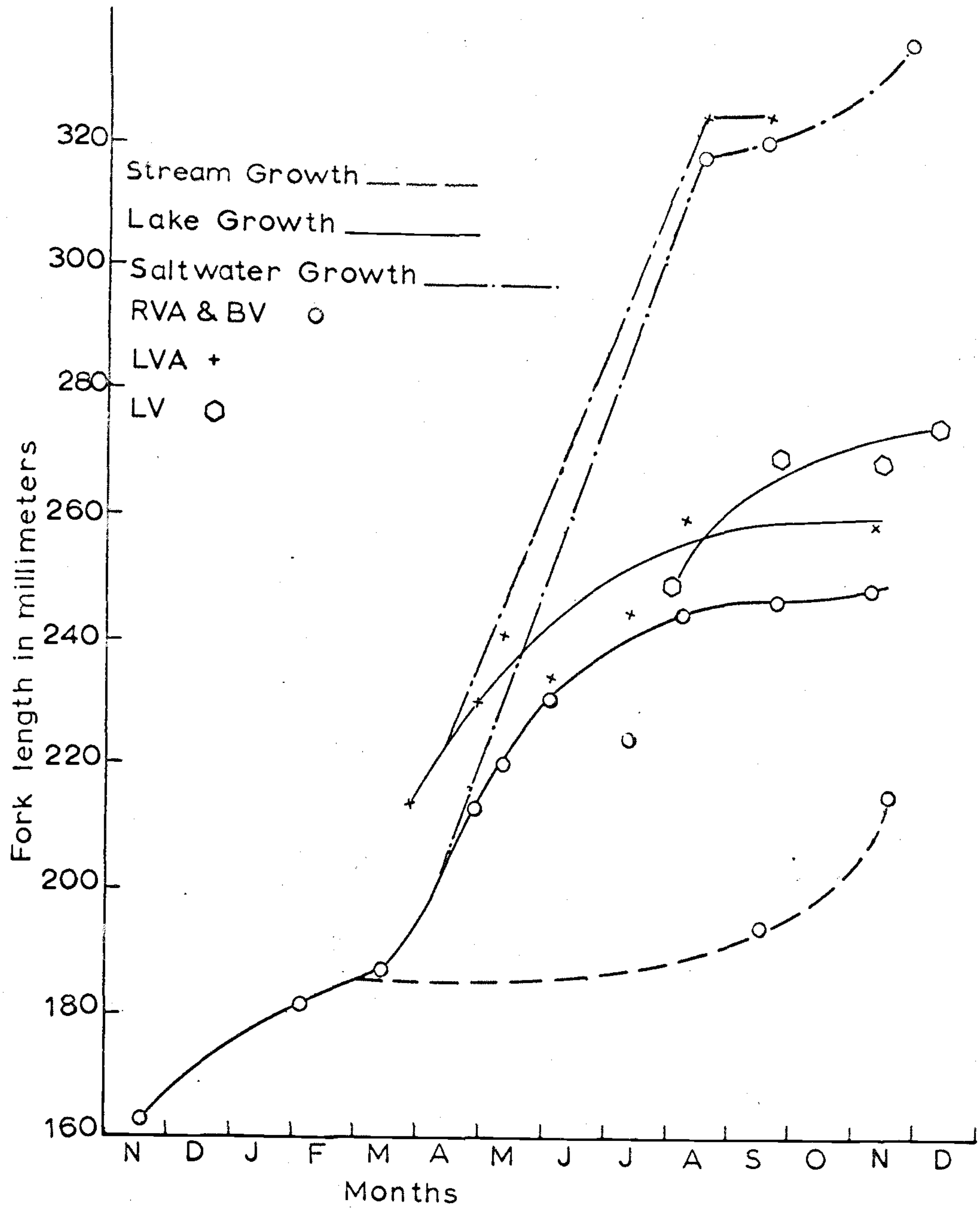


Figure 12. Gain in Length of the Various Trout Plants During the Study.

in total length, the legal length in Oregon coastal streams, by the opening of the season on April 21, 1962. The average gain in length per month was seven millimeters. Fish from the plant which migrated out of the lake and took up residence in Munsel Creek had a much slower growth rate, four millimeter per month. Because the estimate was computed from the size when planted, it is probably high. It is probable that the fish entered the outlet in late February or early March when they had a mean length of about 185 millimeters, giving a growth rate of about 1.7 millimeters per month. In streams in Western Oregon the spring months are the period when growth rates are highest.[1] Saltwater growth rates were considerably higher than in either of the other habitats; 21 millimeters per month. A slight decline of growth rate appears to start in August possibly coinciding with the time of movement of searun fish from the ocean to tidewater.

Weights were taken only from lake-dwelling fish (Figure 13). From the initial planting date until the end of August data from samples of the fingerling plant showed that they had a steady gain in weight. The largest rate of gain was from late March to late August. For the remainder of the year the fish appeared to have a slight loss of weight possibly because of the apparent lack of sufficient food or because of the competition for food after the August plant.

Condition factors were periodically calculated for all plants but because of the large confidence limits the value of the estimates was minimal. There seemed to be a decrease in condition soon after planting and an increase during the summer months.

[1] Personal communication with Joseph H. Wales, Oregon State University

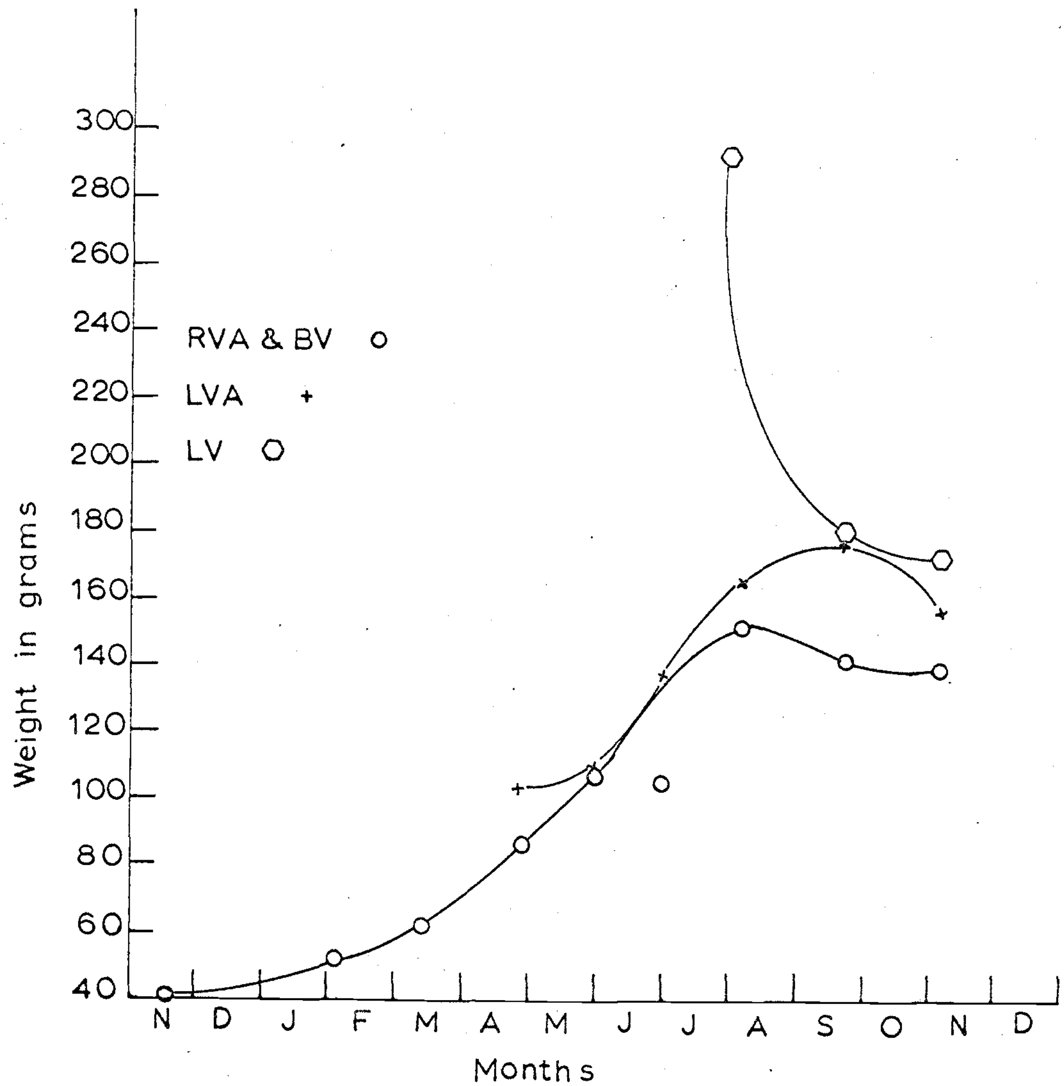


Figure 13. Changes in Weight of the Various Trout Plants.

The data taken from a sample of the LVA plant showed that they had an increase in length of six millimeters a month in the lake. In saltwater they had the same growth rate as the fall plant; 21 millimeters per month. The plant, therefore, had the relatively same pattern of growth during the year as the fall plant.

The LV plant in August had an extremely high condition factor before planting. After the plant it had an apparently normal gain in length but lost over 40 percent of its weight. In the hatchery these fish were feeding under almost optimum conditions and when planted the lake environment could not duplicate these conditions. Slow acclimatization to feeding under wild conditions probably contributed to the loss of weight.

MIGRATION

When coastal cutthroat trout are planted in streams during the spring months, usually most of them migrate downstream to the ocean.[2] This limits the number of newly planted fish which can be caught by anglers. When fish are planted in a lake with an outlet, migration out of the lake has been known to occur. The number of fish making up this migration has not been determined.

To measure the extent of the migration from Munsel Lake, an upstream-downstream weir was constructed about 100 yards upstream from highway 36 (Figure 1and 14). It has two electrically driven screen drums, four feet in diameter and ten feet long, which pass debris over the weir, thus minimizing clogging of the traps.

There are two downstream traps. One is an inclined plane trap where water flows over a flat screen, tilted downward in the direction of the flow. Fish swimming down this screen are collected in a screened box connected to the lower end of the inclined screen. This box is divided into two sections. The forward section has a series of bars which allow small fish to fall through, while fish eight inches or over pass on to the second section. The other downstream trap catches fish which pass through a pipe two inches in diameter. Water flows through the pipe due to a head difference between the backed up water upstream from the weir and the water in the trap. A screen prevents fish from escaping from this trap.

[2]Personal communication with Paul Vroman, Game Commission Hatchery, Alsea, Oregon

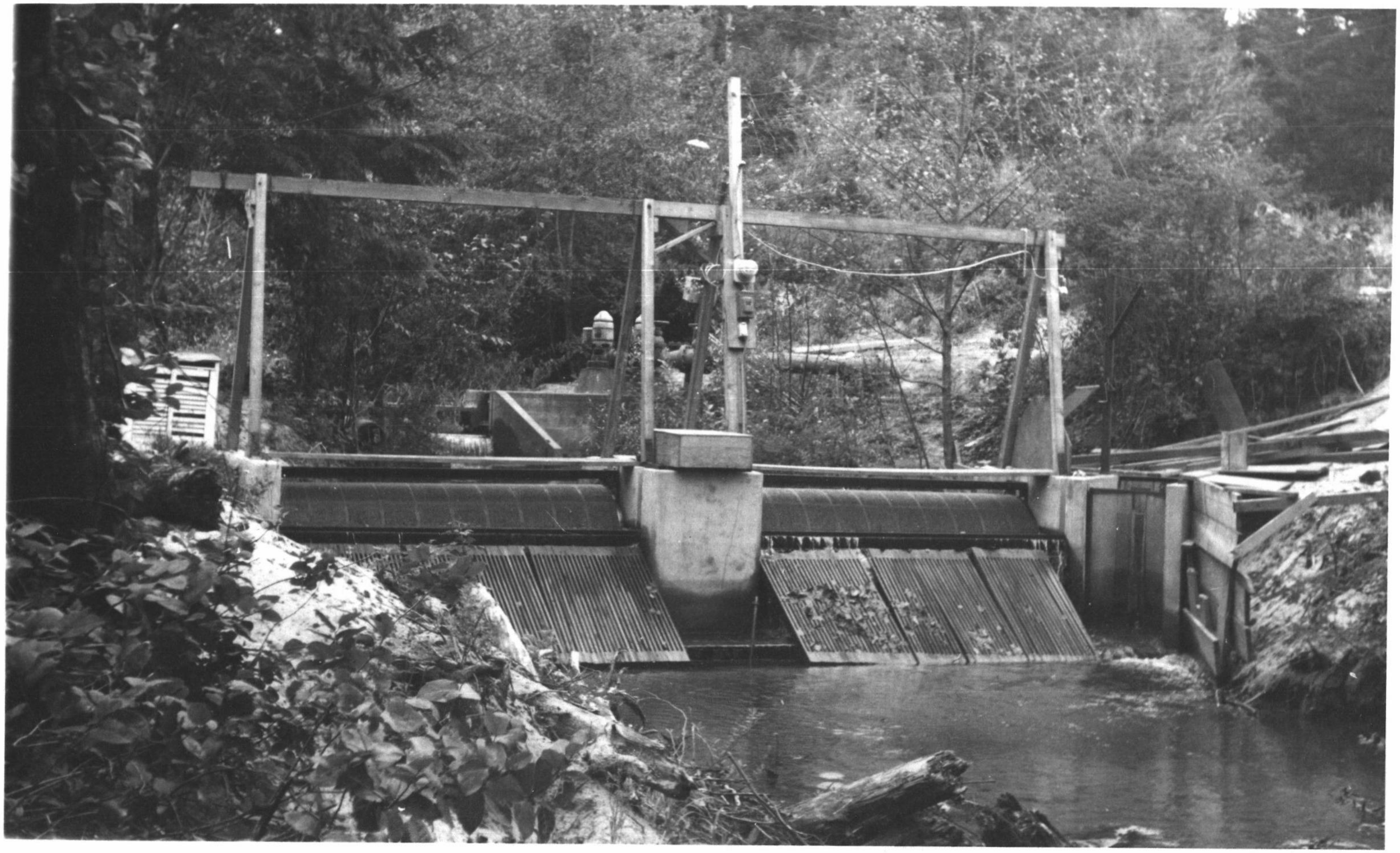


Figure 14. Upstream View of the Munsel Creek Weir.

Water flowing into these traps flows under stoplogs separating the downstream traps from the upstream trap and up through a screen grating in the floor of the upstream trap. This water forms an attraction for upstream migrating fish by passing through a "V"-shaped lead constructed of screen. Downstream trapping began on March 30, but the upstream trap did not begin operating until April 27.

All fish passing through the weir were measured to the nearest millimeter, fork length. Twelve species of fish were caught in the weir during the 1962 trapping season: Cutthroat trout, rainbow trout, kokanee, coho, largemouth bass, bluegill sunfish, perch, brown bullhead, three-spined stickleback, prickly sculpin, brook lamprey (Lampetra planeri) and Pacific lamprey (Lampetra tridentata). A large number of crayfish were captured also.

All cutthroats which were caught in the weir were tagged with a yellow subcutaneous tag. The fish were anesthetized with M.S.222. The tagging procedure was the same as explained by Butler (1, p. 203-206). The tags were numbered consecutively to facilitate identification of individual fish. The numbered side was inserted so it could be read through the skin (Figure 15). The underside of the tag had "Return to OSGC" written on it. A total of 1,037 cutthroat trout and 58 rainbow trout were tagged at the weir from April to December, 1962.

Because construction work on the weir was not completed until the end of March, a total count of fish migrating out of the lake was not obtained. Sumner (10, p. 78) found that during a period of three years of study on Sand Creek only ten percent of the downstream

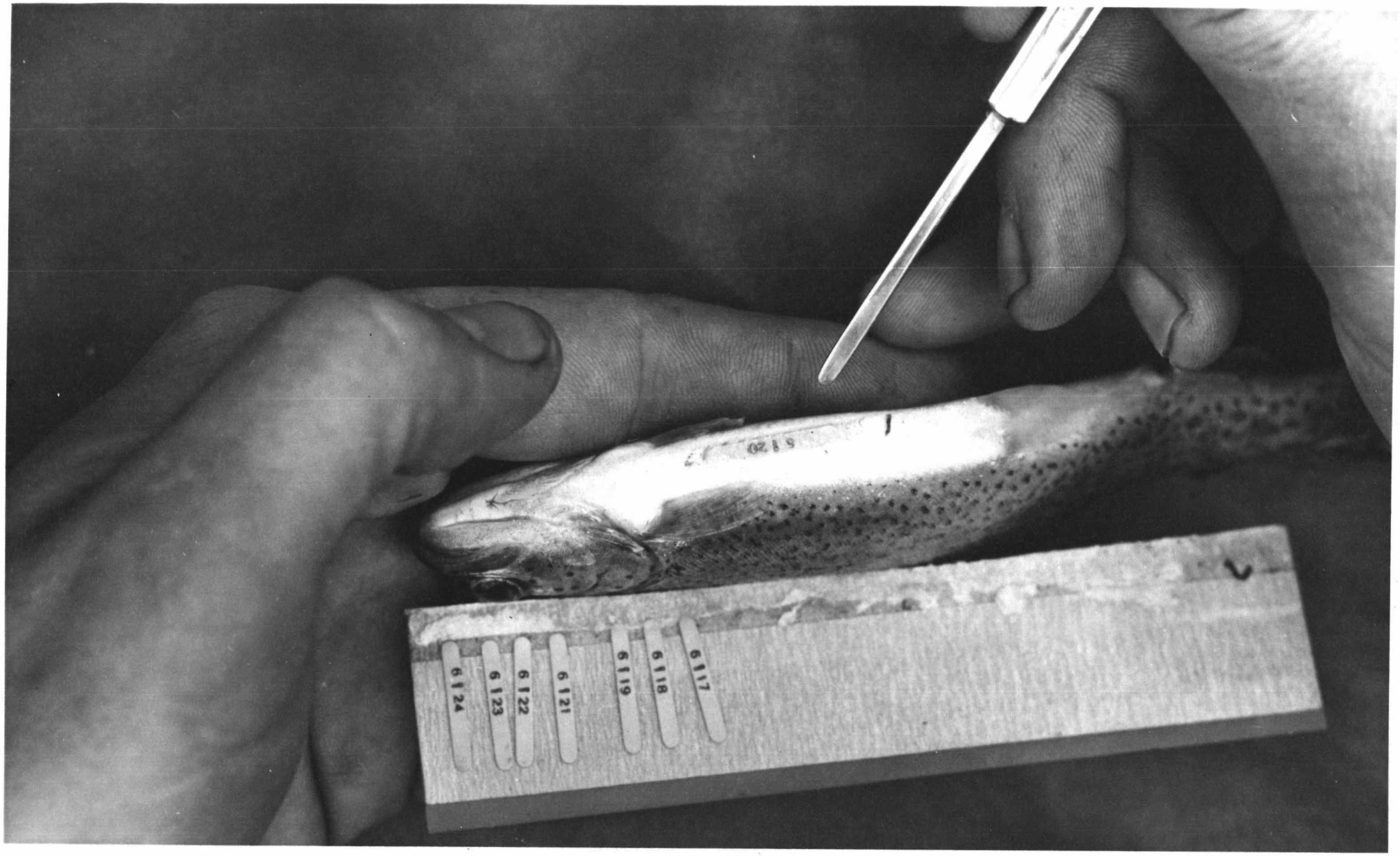


Figure 15. Tagging Tool and Subcutaneous Tag in a Cutthroat Trout.

migration occurred before April. The total number of migrants of the fall plants in Munsel Creek, as shown in Table 4, is therefore probably ten percent too low. An estimate of the total number of migrants computed by multiplying the total known migration by 1.10 is shown in Table 4. Fish may have escaped capture during periods when debris clogged the traps. No estimate can be made of the number escaping but it is probably quite low.

TABLE 4

Number of Downstream Migrant Cutthroat Tagged at the Weir

Mark	Total Number of Downstream Migrants	Percent of Total Plant	Estimate of Total Migrants	Estimated Percent of Total Plant
BV	309	4.05	340	4.45
RVA	286	3.77	313	4.12
LVA	422	10.55	422	10.55

The migrational pattern in weekly intervals of the BV, RVA and LVA plants can be seen in Figure 16. Most of the downstream migration occurred during April and May. By the end of June downstream migration was complete. On July 3, the last cutthroat was captured in the downstream trap. A total of eight fish of the 1961 legal plant were captured during the downstream migration. Fourteen wild cutthroats were captured in the downstream traps.

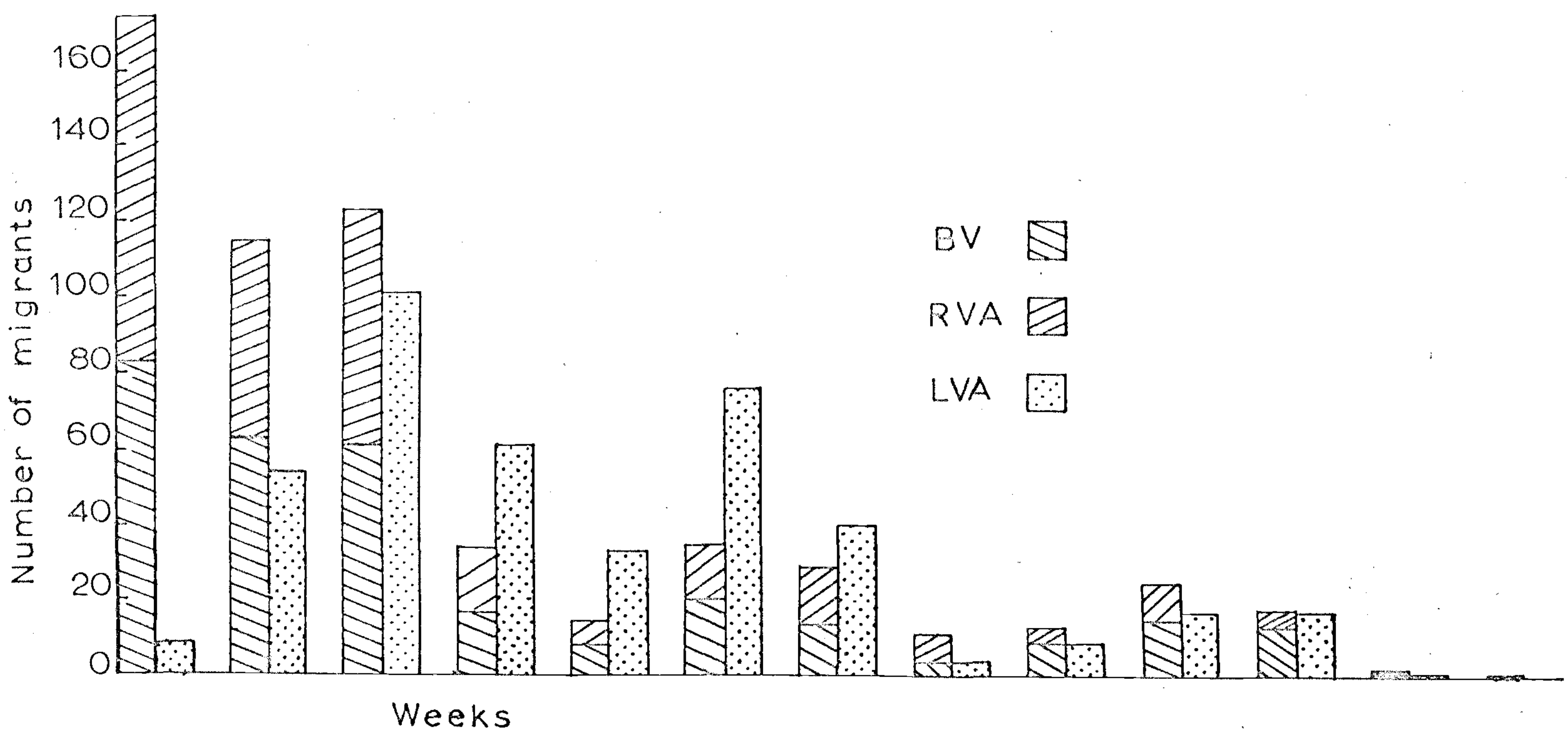


Figure 16. Number of Downstream Migrants from the Various Cutthroat Trout Plants Each Week, Starting March 30th and Ending July 6th.

Upstream migration until November was made up primarily of small wild cutthroats probably migrating into Munsel Creek from the upper tributaries of the Siuslaw River. Only ten of these fish were caught.

In November two searun cutthroats were captured in the upstream trap. These were the only searun trout captured in the weir. Three other searuns were captured below the weir, two in November and one in February. Other trout were seen below the weir but were not recovered. Throughout the year there was poor trapping efficiency resulting from a lack of attraction water. High tides which occurred in the winter months caused flooding of the upstream trap. High water behind the weir during high tides allowed fish to jump over the revolving drums.

Ten tagged cutthroats were reported by anglers fishing in tidewater in the Siuslaw River. Figure 1 shows the five locations where these fish were caught: 1. Mouth of North Fork of Siuslaw River, one fish; 2. Cushman, two fish; 3. between Cushman and C & D Dock, one fish; 4. in front of C & D Docks, three fish, and 5. by Davidsons Mill, two fish. All reported tag recoveries were from fish taken above the mouth of Munsel Creek. Five of them were over eight miles upstream from Munsel Creek. It is therefore probable that searun cutthroat trout wander throughout most of the tidewater area before homing to their spawning stream.

Migration of fish out of the lake to Munsel Creek where the fish took up residence was found to occur. Trout in Munsel Creek were collected with a pulsating direct current backpack shocker, developed by Oceanic Instrument Company of Seattle, Washington. In September and November about one-fifth of the outlet was covered by this method. In September, 13 marked and four wild cutthroats were captured. All were tagged with the subcutaneous tag. In November when shocking in the same areas of the outlet, eight marked and three wild cutthroats were captured. Two of the marked fish that were tagged in September were recaptured. All of the marked fish were of the two fall fingerling plants. Chapman (2, p. 100-101) found that in coho salmon the fish which had established a territory usually were able to keep that territory when other coho tried to obtain it. This type of behavior in cutthroats would explain why no LVA fish were caught since they began their downstream migration at least a month later than the fingerling plant.

In June, cutthroats in Munsel Lake undergo a vertical migration from the surface to the cooler water in the thermocline. This occurred when the surface temperature was above about 65°F. This was substantiated by a rapid drop in bank angler success because they were not able to fish in water as deep as boat anglers. In September, these fish returned to the surface where they became easier to catch. This resulted in an increased catch per angler hour.

In the evenings during June and July, fish came to the shallow areas of the lake to feed during abundant May fly hatches and could be caught at the surface. In the daytime they were rarely caught at or near the surface.

These three types of migration serve to reduce yield to the angler. Migration out of the lake to the ocean causes a loss to the angler of up to 11 percent of the total plant (Figures 17, 18, 19 and 20). These fish have a two-to-five-month period of ocean residence when they are not subject to angling pressure. During this period natural mortality can reduce the number of fish before they return to tidewater where they enter the fishery. Fish that migrate into Munsel Creek and remain there are for the most part safe from the angler due to the heavy undergrowth along the stream and inaccessibility of the stream throughout much of its length. Vertical migrations of fish into the thermocline makes them less available to the angler who fishes the lake's surface. During this period the thermocline mortality reduces the number of fish that may be caught in the fall.

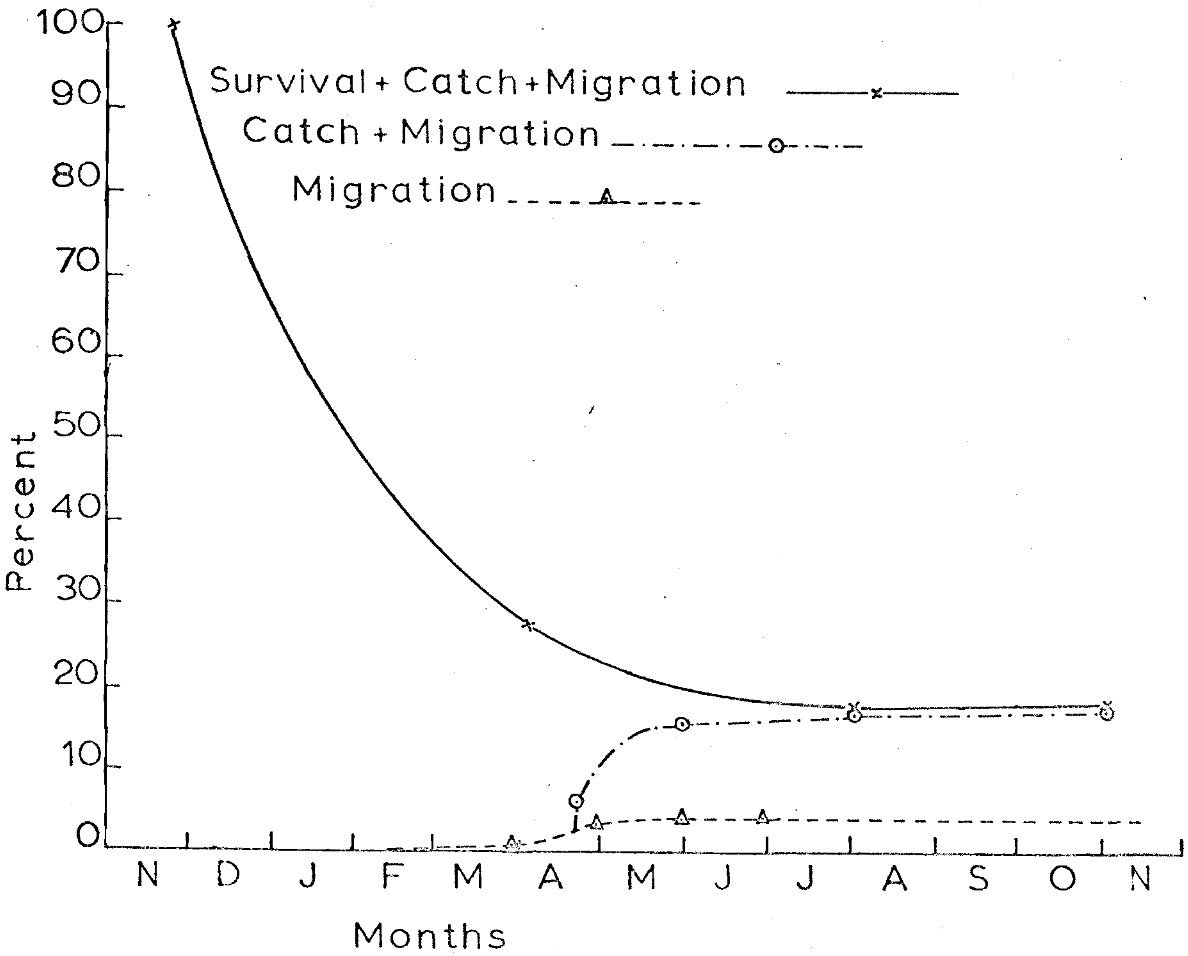


Figure 17. Catch, Migration and Survival of the BV Plant, November, 1961, to November, 1962.

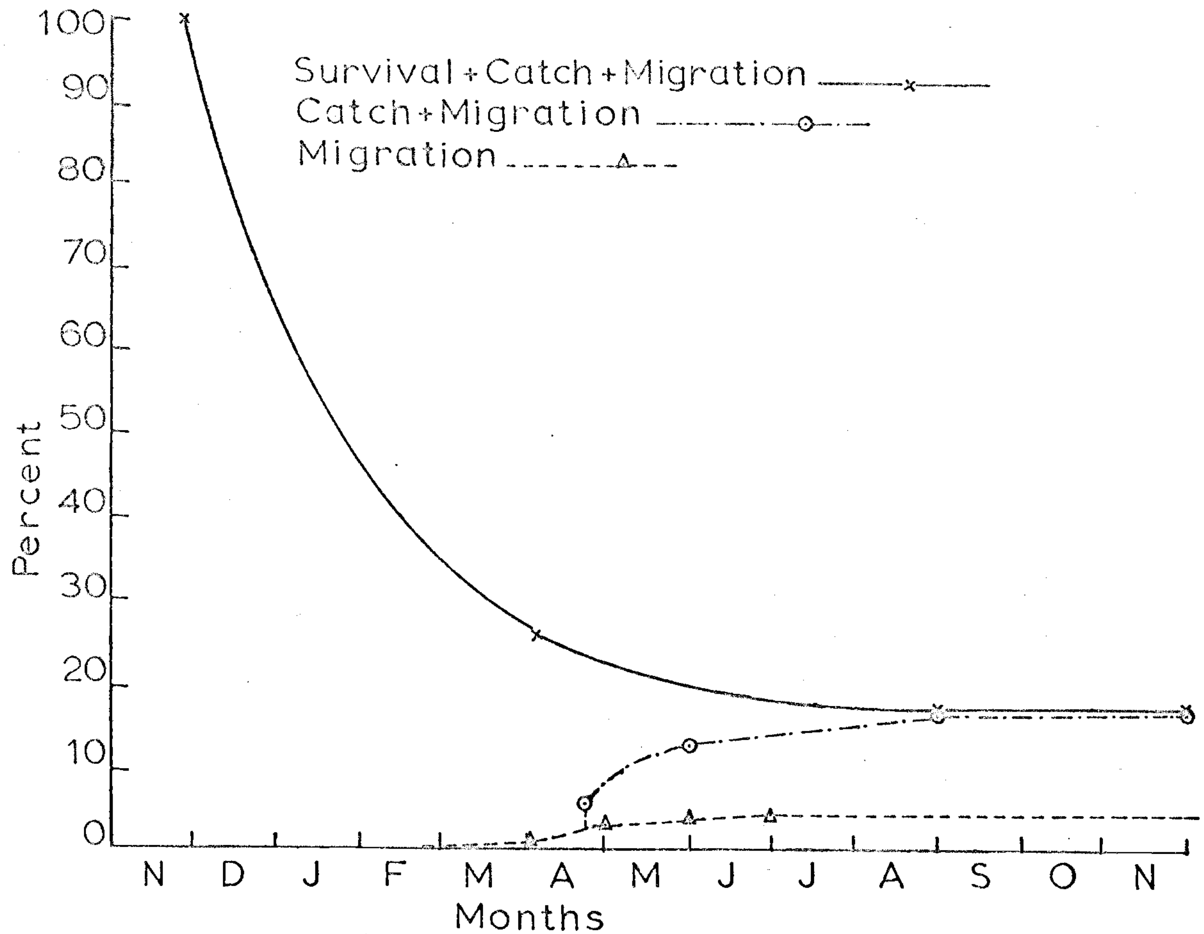


Figure 18. Catch, Migration and Survival of the RVA Plant, November, 1961, to November, 1962.

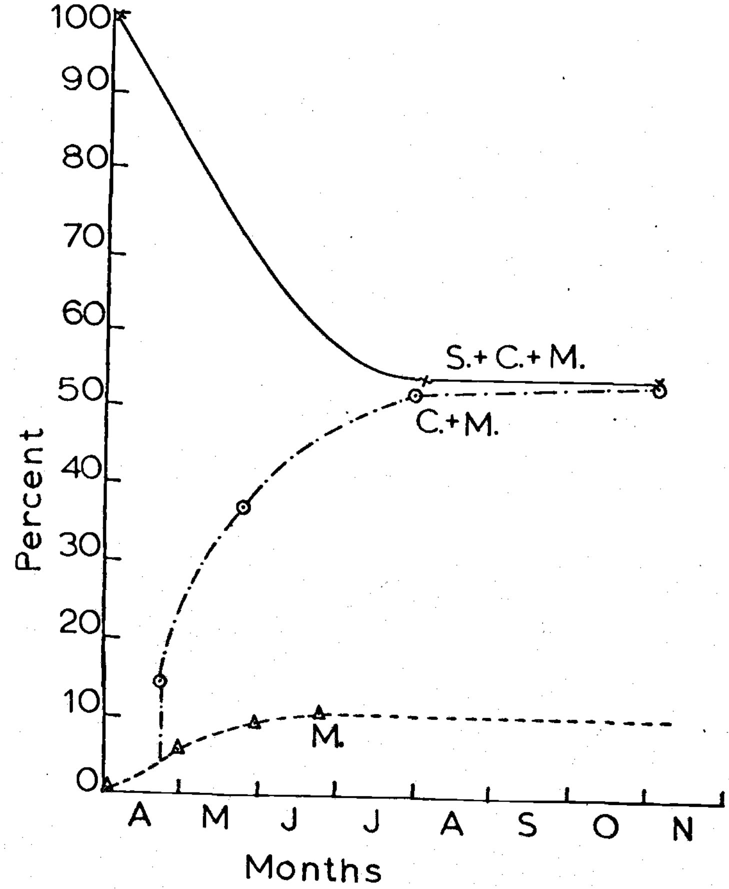


Figure 19. Catch, Migration and Survival of the LVA Plant, April, 1962, to November, 1961

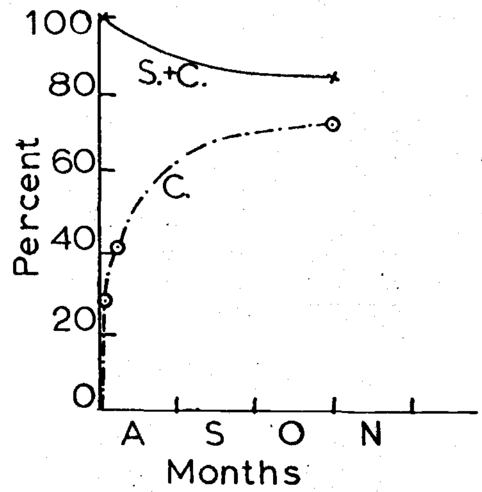


Figure 20. Catch and Survival of the LV Plant, August, 1962, to November, 1962.

NATURAL MORTALITY

Estimates of survival of the different plants were made three times in 1963. Natural mortality and migration out of the lake determine the number of fish available to the angler.

Marked cutthroats were boat-planted in the lake to obtain a marked-unmarked ratio upon recapture. Trap nets, high-speed trawls, gill nets, the weir and creel census were all used in an attempt to recapture fish, thereby determining the ratio.

Experimental sinking gill nets with one, one and one-half, two and three inch stretch mesh, 100 feet long were used. Netting sites were chosen randomly. No nets were set completely in water over 40 feet in depth (in the hypolimnion) as I felt that they would not catch fish. Because all fish caught would be of the same year class and the nets used had a variety of mesh sizes, it was felt that there would be very little selectivity for fish of any one plant. It was found that this assumption was not correct at least during the first estimate. It was necessary to use gill nets in later estimates because they were found to be the only way fish could be caught after they had moved into the thermocline.

If the fish were allowed to remain in the lake for about a month before fishing on them, marked-unmarked ratios of fish taken by anglers proved to be a reasonably unbiased estimate of the actual ratio. This occurred only during the first estimate and could therefore not be used in the two later estimates.

Migration out of the lake of the different plants proved to be a reliable way of getting an estimate since the number of migrants of each mark is a good indication of their abundance in the lake. This method can only be used in the spring when there is downstream movement out of the lake.

Trap nets and a high-speed trawl were each used for two days to try to capture fish during the summer months. No fish were captured by these methods. I felt that the trout were swimming over the leads on the trap net rather than entering the trap and the swimming speed of trout over eight inches long allowed them to evade the trawl.

In April the LVA plant was used as marked fish to determine the survival of the fingerling plant. Fish were recaptured using gill nets, the weir and by angling. The total population and the variance of the population were computed using a Peterson estimate (9, p. 83-84). The number of survivors from the BV and RVA plants was determined by subtracting the known number of marked fish from the estimated total population and multiplying by the number of fish with a specific mark which were captured and dividing by the number of fish caught, not including those of the LVA plant. Confidence limits (95 percent) for the other two methods of recapture were determined by calculating the variance and using a normal distribution (Table 5).

The gill net estimate showed a survival rate of eight to 11 percent for the two fingerling plants. There was no significant difference in survival estimates as shown by the migration and

TABLE 5

Results of the Estimates of Population Survival of the Various Cutthroat Plants

Mark	Month of Estimate	Mean Number of Survivors	95% C.L.	Percent Remaining From Plant	Percent Total Mortality	Sampling Procedure
BV	April	762	405- 939	5.3-12.3	91.2	Gill net
RVA	April	706	428- 984	5.6-13.0	90.7	Gill net
BV	April	2,189	2,048-2,330	26.8-30.5	71.3	Migration
RVA	April	1,888	1,761-2,015	23.2-26.6	75.0	Migration
BV	April	2,085	2,020-2,150	26.5-28.2	73.2	Creel Census
RVA	April	1,939	1,876-2,002	24.8-26.4	73.8	Creel Census
BV	August	40	2- 274	0- 3.6	82.3	Gill net
RVA	August	97	5- 525	0- 6.9	83.8	Gill net
LVA	August	74	4- 629	0-15.7	46.2	Gill net
BV	November	18	14- 22	0.1- 0.3	82.0	Gill net
RVA	November	46	25- 67	0.3- 0.9	83.8	Gill net
LVA	November	65	37- 93	0.9- 2.3	45.6	Gill net
LV	November	176	81- 271	5.4-18.1	14.9	Gill net

creel census data, 20 to 33 percent. In both estimates the calculated number of survivors from the BV plant was greater than the RVA plant, however the difference was not significant. The conclusion was made from these data that a fingerling plant made in November must be four times as large as a legal plant made near the season opening to provide the same number of fish to the angler.

In August the LV plant was used as marked fish to determine the survival of the fingerling and legal plants after three months of fishing. Fishermen were removing the newly planted fish during this estimate thus survival was estimated using the Schnabel method. A complete creel census was therefore conducted during the five days used to determine the dilution of marked fish. Gill nets were used to capture the fish.

The survival was determined using the formula:

$$\hat{N}_x = \frac{\Sigma(C_t M_t)}{R}$$

Where:

$\hat{N}_x$ = Total population in the lake.

C_t = Total sample taken on day t.

M_t = Total number of marked fish at start of day t.

R = Total number of recaptures during the census.

Survival of each plant was obtained by subtracting the total number of planted fish from the N_x estimate.

Ninety-five percent confidence limits were set using the normal distribution and computing the variance by using the following formula:

$$V(\hat{N}) = \frac{\Sigma (M-K)^2 \ SS(C-R)}{n \ SSR}$$

Where:

$$(M-K)^2 = \Sigma M_t^{\ 2}$$

$$SS(C-R) = SSC_t$$

$$n = \text{Number of days sampled}$$

The results of this estimate is shown in Table 5. The large confidence limits are a result of the small number of fish captured, 51 recaptures. The actual number of survivors from each plant undoubtedly falls within the large confidence limits. Selectivity of gill netting may have caused some bias in the estimate. However, I feel that this estimate is correct. Results of creel census data also indicates that the plants have been greatly reduced in number.

After the close of the fishing season the number of remaining fish was determined using the LVRM plant as marked fish in a gill net census. The total number of fish in the lake was computed using a Petersen estimate and confidence limits were set using a binomial distribution. Because of gill net selectivity the actual results may be somewhat biased. They do indicate that at the close of the fishing season fishermen had eliminated almost all of the fish available to them.

The results of the three population estimates showed that natural mortality is the major factor in determining yield to the angler of any plant and that natural mortality is probably related to time of plant and size of fish (Figures 17, 18, 19 and 20). The determination of when to plant fish is therefore necessarily dependent on the natural mortality expected from the plant.

CREEL CENSUS

The most important aspect in determining the value of any plant of fish is the yield to the angler. Changes in catch per unit of effort, numbers of fish caught and number of hours fished in relation to the various plants were examined.

The fishing in Munsel Lake is typical of almost all coastal lakes in that the heaviest fishing pressure occurs during the first few weeks after the start of the fishing season. During this period few of the weekend anglers are from the Florence area, and in the summer months vacationing anglers fish almost as many hours as resident anglers. Except for a few weekends following the opening of the season, resident fishermen out-number anglers from other than the Florence area.

Boats may be rented at the Munsel Lake Resort on the west shore of the lake or may be launched at a public boat ramp at the south-west corner. Bank anglers fish in an area 300 yards on each side of the launching site. Many home owners in the area keep boats at the lake.

With the cooperation of the Department of Statistics at Oregon State University, a creel sampling program was devised to estimate the total catch of the various hatchery plants. A stratified random sampling scheme whereby weekends, weekdays and holidays were treated separately was used. Because of the size of Munsel Lake and the presence of only two access points it was possible to interview almost all of the parties that had completed fishing on the days sampled. One weekday and one weekend day a week was sampled. It was necessary to make the assumption that all weekdays were alike, and that all weekend days were alike. The day sampled was chosen randomly, and was not sampled again until all days of the stratum were sampled. All holidays were sampled. Saturday and Sunday of the opening weekend was sampled because of the large angling pressure on these days. The first five days after planting 1500 cutthroats in August were censused because of the increased angling pressure.

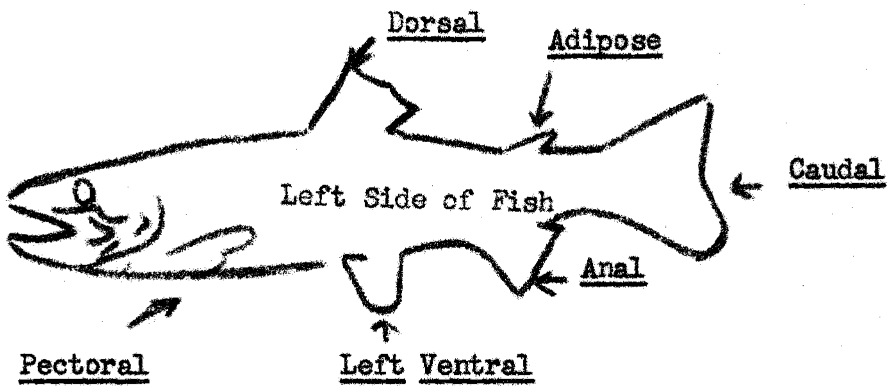
All parties leaving at either of the two access points were checked for total number of fish caught of each mark, number of fishermen in the party and total hours fished. Residents of the lake who did not use the two access points were asked to keep their own records of each fishing trip. A creel census form and a key to identification of marked fish was given to all of these residents (Figure 21 and 22). Because each resident was interviewed every month, there was an excellent return of the forms.

The total catch estimate was determined by dividing consecutive weekend or weekdays sampled into groups which were strata, with similar numbers of total fish caught. On some of the days sampled, a complete check of all anglers fishing the lake could not be made. Of a total of 409 boat or bank fishing parties fishing Munsel Lake on the days censused, 385 or 94.1 percent, were checked as they left the lake. The assumption that the missed parties caught the same number of fish on the average had to be made. Total catch

Figure 21. Key Used by Resident Anglers for Identification of Marks on Cutthroat Trout

RECORDING MARKS

CUTTHROAT TROUT



Steps

1. Check adipose: a. If present mark is a both ventral "BV" If fish is over 11" recorded "BV 1961"

   b. If absent see step 2

2. Check ventral fins:
   a. If right ventral is shorter than the left the mark is RVA
   b. If left ventral is shorter than the right the mark is LVA

The BV marked fish over 11 inches long were planted in the spring of 1961.

The RVA and BV marked fish were planted in November 1961.

The LVA marked fish were planted in April 1962.

Fish with no mark are probably wild fish.

Figure 22. Resident Angler Creel Census Form

Lake Resident Creel Census

April

Date and day	Number of fishermen	Total hours fished	Number of fish of each species caught				Species fished for
			Bass	Perch	Rainbows	Cutthroat	
21 Sat							
22 Sun							
23 Mon							
24 Tues							
25 Wed							
26 Thurs							
27 Fri							
28 Sat							
29 Sun							
30 Mon							

estimates were made by using the formula:

$$TC = \left(\sum_{i,y} \frac{M_{iy} F_{ix}}{m_{iy}} \right) \frac{N}{n} = (\Sigma F'_{ix}) \frac{N}{n}$$

Where: TC_x = Total catch of fish with the mark x.

M_{iy} = Total number of parties of a known type y, boat or bank, on the sampled $i^{\underline{th}}$ day.

m_{iy} = Total number of parties sampled, of a known type y, boat or bank, on the sampled $i^{\underline{th}}$ day.

F_{ix} = Number of fish caught and recorded of the mark x on the $i^{\underline{th}}$ day.

N = Total number of days in the stratum.

n = Number of days sampled in the stratum.

F'_{ix} = Estimate of the number of fish caught of the mark x on the $i^{\underline{th}}$ day.

The total catch of any plant, mark, can be determined by summing the total catch estimates of all strata.

The variance of the total catch of the individual strata can be determined by using the formula:

$$V(TC) = \Sigma \frac{N^2}{n} s^2 \; F'_{ix}$$

Where: $$s^2 F_{ix} = \frac{\Sigma F_{ix}^2 - \frac{(\Sigma F'_{ix})^2}{n}}{n-1} \times \frac{N-n}{N}$$

By pooling (adding) the variances of the total catch of all the strata, the total variance of all the strata can be determined.

The decline in total catch of each plant on the weekends and holidays censused is presented in Figure 23. Figure 24 shows the decline in total fish caught of each plant on the weekdays censused. The rapid decline in numbers of fish as the season progressed is quite apparent. In the first six weeks of the fishing season, anglers had taken about 90 percent of the estimated total catch of the BV, RVA and LVA plants for the entire season. The LV plant made in August followed the same rapid decline as that of the LVA, BV and RVA plants. Five days after making the LV plant, 50 percent of the total 1962 catch of these fish had been made.

The calculated total catch of each plant is shown in Table 6. The LV plant made in August was the most successful with 68 to 89 percent of them getting into the fisherman's creel. The legal plant was the next most successful with 34 to 47 percent taken. The fingerling plants were the poorest in percentage of return to the angler, with nine to 15 percent for the BV plant and nine to 12 percent for the RVA plant. It can therefore be concluded that the larger the fish at planting time, the greater the yield to the angler; or that the later the plant is made the more fish of that plant will be taken. Wales and Borgeson (12, p. 405) also found that the percentage of return to the angler is greater with rainbows of larger size. These statements are true even if migration is added. The biggest factor determining the yield of a plant to the angler is the natural mortality of the plant.

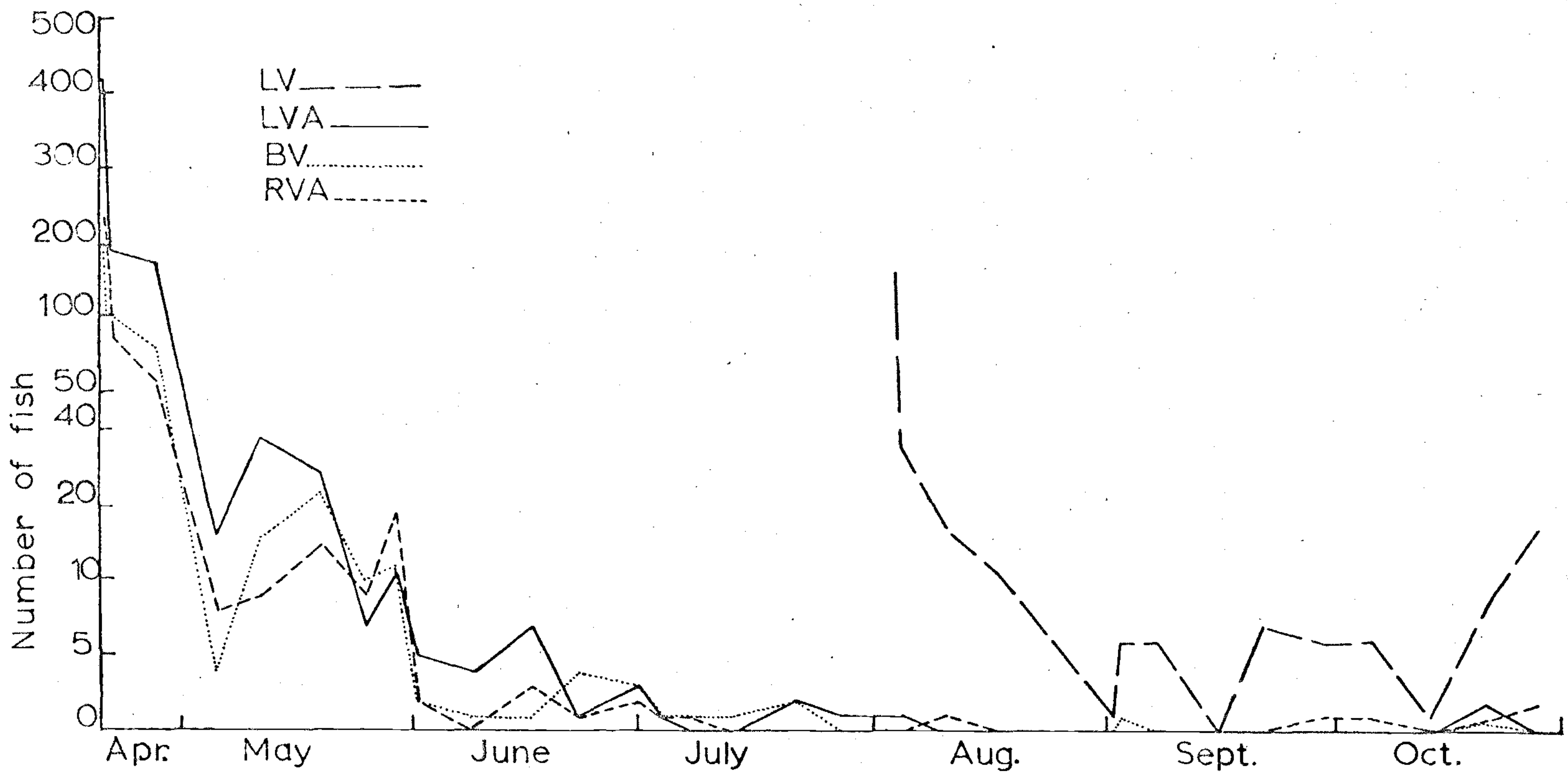


Figure 23. Total Catch of the Various Plants in the Holidays and Weekend Days Sampled.

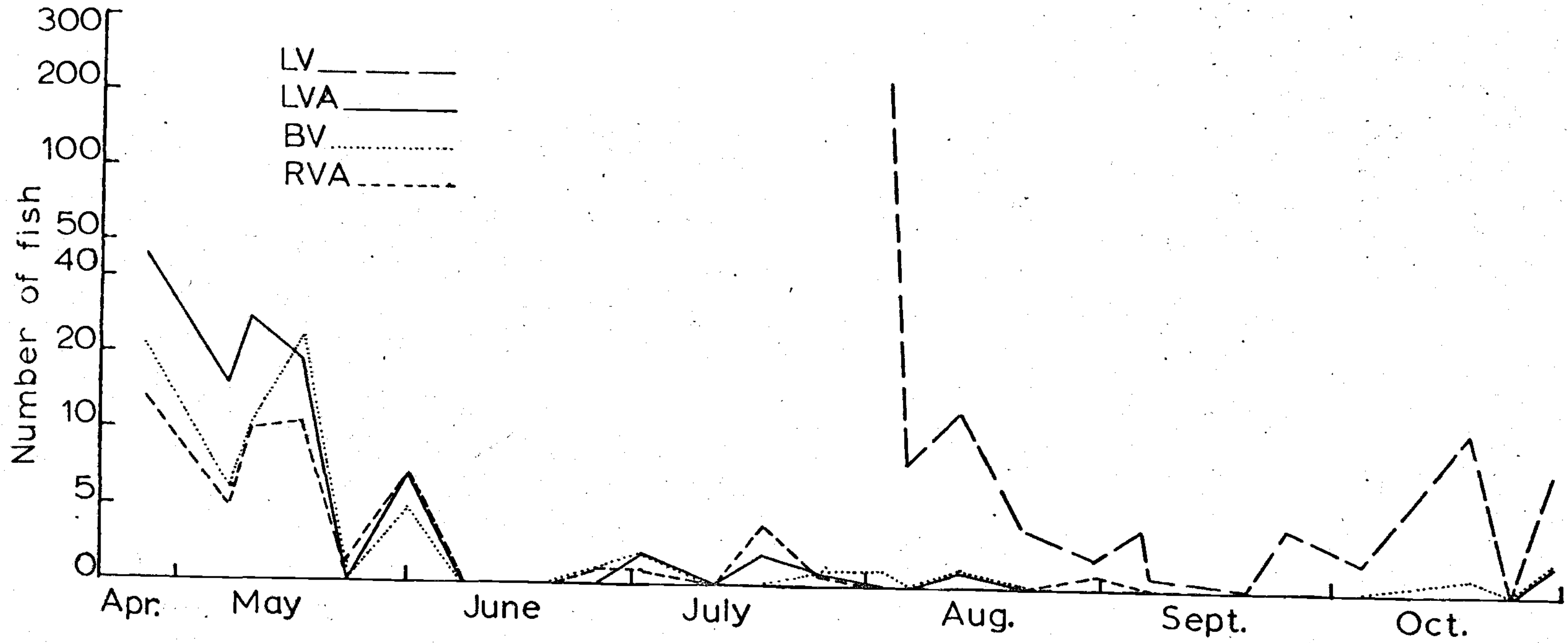


Figure 24. Total Catch of the Various Plants in the Weekdays Sampled.

TABLE 6

Estimates of the Total Catch
of the Various Plants of Cutthroats

Mark	Total Catch	95% CL	95% CL of Percent of Plant Caught
BV	1,002	785 to 1,219	10.28 - 15.97
RVA	847	732 to 963	9.66 - 12.71
LVA	1,686	1,483 to 1,889	37.08 - 47.22
LV	1,100	948 to 1,252	63.24 - 83.52

The total number of parties was calculated by using the same method as in determing the total catch. By using the total number of parties fishing on the sampled day instead of F'_{ix} the total number of parties and their variance can be calculated. Table 7 shows the results of the calculations. A total of 1104 parties ($\pm$ 84 at 95 percent C.L.) of all types (resident, boat and bank) fished in Munsel Lake during the 1962 fishing season. By multiplying the mean number of parties of each type by the average number of anglers per party of that type and adding the products, an estimate of the total number of anglers was determined to be 2262.

Changes in the number of boat parties fishing each month can be seen in Table 8. The decline in number of boat parties per day is less rapid than the decline in number of fish caught per day. After the middle of May to the LV plant in August, the number of parties fishing is nearly constant. The highest peak during the period occurred on Memorial Day. The LV plant in August caused an increase in number of parties fishing until September. From then on there was very little fishing.

Changes in the number of bank parties fishing each month are shown in Table 8. Until June the number of parties fishing each day was nearly constant. After June the fish evidently moved to the thermocline and became hard to catch so that the number of bank parties fishing declined to almost zero. When the LV plant was made the fish could be caught from the bank and the number of bank parties increased.

TABLE 7

Number of Parties of Each Type
Fishing in Munsel Lake During the 1962 Fishing Season

Day	Type of Party	Number of Parties	Anglers Per Party	Total Number of Anglers	95% CL Parties
All	Resident	83	2.41	200	0
WE & H	Boat	337	2.13	718	307- 367
WD	Boat	451	2.14	965	289- 613
All	Boat	788			624- 952
WE & H	Bank	78	1.65	129	28- 128
WD	Bank	155	1.61	250	87- 223
All	Bank	233			149- 317
Total	All	1,104		2,262	919-1,289

TABLE 8

Change by month in the Average Number of Hours Fished and Parties Fishing on the Days Censused

	Weekends and Holidays					Weekdays				
		Boat and Resident Anglers		Bank Anglers			Boat and Resident Anglers		Bank Anglers	
Month	Number of Days Sampled	Ave. Number of Hrs. Fished	Ave. Number of Parties Per Day	Ave. Number of Hrs. Fished	Ave. Number of Parties Per Day	Number of Days Sampled	Ave. Number of Hrs. Fished	Ave. Number Parties Per Day	Ave. Number Hrs. Fished	Ave. Number Parties Per Day
April	3	242.3	30.0	18.3	3.7	1	50.0	6.0	7.0	2.0
May	5	49.6	9.2	16.4	5.0	4	22.8	4.0	6.8	3.0
June	4	23.8	5.0	4.2	1.3	5	8.6	2.6	1.8	1.0
July	5	20.2	2.7	0.0	0.0	4	8.0	2.7	0.2	0.2
August	4	39.5	8.2	7.0	3.0	5	15.8	4.8	1.8	1.4
September	6	7.3	1.3	0.2	0.2	4	2.5	1.0	0.2	0.2
October	4	6.2	1.0	0.0	0.0	4	5.0	0.8	0.2	0.2

Total hours fished by each type of angler was computed in the same way as the total number of parties was calculated (Table 9). Boat and resident anglers fished a total of 3531 hours (± 470 hours 95% CL). Bank anglers fished a total of 543 hours (± 142 hours 95% CL).

TABLE 9

Number of Hours Fished by the Angler Types

Day	Fisherman Type	Total Hours Fished	95% CL
WE & H	Boat & Res.	2,078	1,978 - 2,178
WD	Boat & Res.	1,453	993 - 1,913
All	Boat & Res.	3,531	3,061 - 4,001
WE & H	Bank	279	231 - 327
WD	Bank	264	130 - 398
All	Bank	543	401 - 685
Total	All	4,074	3,583 - 4,565

The changes in number of hours fished each month can be seen in Table 8. These changes reflect the same pattern as was found in fish caught and number of parties fishing.

In evaluating the success of any plant of fish, catch per unit effort as well as total catch is important. Opinion on what is a good catch per unit effort varies with the species, habitat, and the biologist. Usually for a trout fishery a fish per angler hour is considered good. Wales and Borgeson (12, p. 402) state that one rainbow trout per hour is a good yield.

A fishery with a sustained catch per angler hour of about one fish per hour seems more desirable than one in which a high catch per unit effort at the start of the fishing season quickly is reduced to under a half a fish per hour. Such a drop usually occurs following the planting of hatchery trout. The declines in catch per unit of effort for all of the plants made before the start of the fishing season (LVA, BV and RVA) are shown in Figure25. The drop in catch per unit of effort is rapid, almost logarithmic. Almost all points on the curves are based on a total of 50 hours of fishing. In September and October the total effort each month was slightly under 50 hours so that the catch per hour was based on one month of fishing. The curve is based on boat angler catch per hour. Because of the small number of bank anglers a catch per hour curve was not drawn.

The mean catch per hour of all plants for boat, bank and resident anglers is shown in Table 10. There was a substantial reduction in catch per hour of the BV, RVA and LVA plants during August. This may be explained by the fact that prior to August, fishermen had been trolling deep where the fish were but after the LV plant was made they fished near the surface for the more catchable trout thus reducing the frequency of catch of the older plants. During the last two months of the 1962 fishing season there was a slight increase in catch per angler hour. Decreasing surface temperatures may have

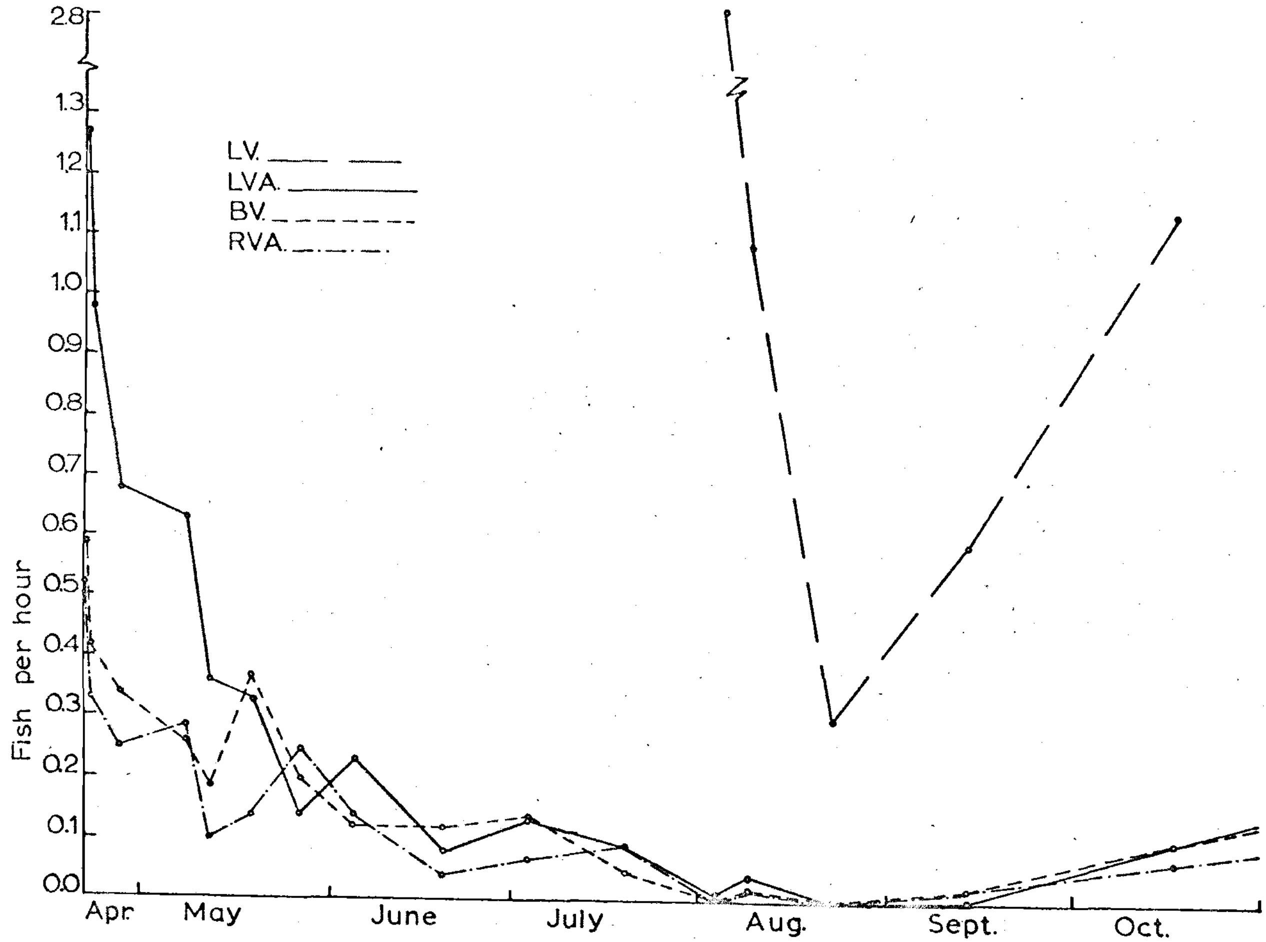


Figure 25. Change in Number of Fish Caught Per Hour with Time.

allowed fish to move to surface waters and to become more available to the angler. The increase could have been caused by a reduced food supply which promoted more active food seeking.

TABLE 10

Catch per Angler Hour
of Each Plant of Cutthroats
for the 1962 Fishing Season

Type of Angler	All Plants	All But LV Plant	Fall Plants	BV	RVA	LVA	LV
Resident	2.02	1.79	1.04	0.54	0.50	0.64	1.61
Boat	1.35	1.04	0.50	0.28	0.22	0.54	1.54
Bank	0.52	0.30	0.13	0.04	0.09	0.17	1.37

The effect of making a plant during the season can be seen in the large catch per hour of the LV plant. The rapid reduction in catch per hour of this plant is similar to that which occurred with other plants. The reduction did not continue but in September and October rose again to over a fish per hour. The fish apparently did not eat readily during their first month in Munsel Lake. It is therefore feasible that with increasing appetites they became easier to catch in spite of their reduced numbers. Von Geldern (11, p. 260) made a similar observation and said that it may be related to habit adjustment, increased hunger, distribution, or other unknown factors.

The achievement of a stable catch per hour is impractical but may be reached by increasing the number of plants without increasing the number of fish planted. By reducing the number of fish planted before the season opening (late April) and planting them later, after June 15, the natural mortality and migration out of the lake may be reduced thus increasing the percentage of return to the angler (Figures 17, 18, 19 and 20). Hatchery mortality in fish of legal size is less than one percent during these two months.[3] Feeding costs for a two month period for fish of this size is about ten cents per fish. Migration and natural mortality amounts to about a 40 to 50 percent loss. Therefore a plant in June of 1000 fish would return about 400 more than a similar April plant at a net cost of 40 cents per extra fish. A plant in August would undoubtedly be necessary again to increase the catch per angler hour. The determination of how many fish are needed for each plant cannot be adequately deduced at this time. The study will be continued for at least four more years in an attempt to determine the required numbers.

[3]Personal communication with Paul Vroman, Game Commission Hatchery, Alsea, Oregon

SUMMARY AND CONCLUSION

1. This investigation was initiated in 1961 by the Division of Wildlife Research of the Oregon State Game Commission to determine factors which may affect the yield to the angler of various plants of cutthroat trout in a coastal lake with an outlet to the ocean. The major objectives of the study were: (a) to determine feeding patterns of recent versus old plants; (b) to study growth rates in the lake and other habitat used by these fish; (c) to determine the affect of migration on the yield to the angler; (d) to estimate natural mortality for the different plants; and (e) to analyze catch information in relation to the previous objectives. Four plants were intensively studied.

2. Fish from which stomachs were obtained were collected primarily by gill netting. Stomach contents were identified to family for aquatic insects and to order for surface foods. During the winter and spring months, plankton was the most important food. Aquatic insects were second in occurrence during this period and in the summer were the primary food organism found in the stomachs examined. In the fall, kokanee eggs and surface insects were the most abundant. Feeding habits and volume of contents for plants which had been in the lake for less than two months were unlike that found in older plants.

3. Growth rates were examined utilizing lengths and weights obtained from fish in the three habitats: (a) lake, (b) outlet, and (c) salt water. Growth rates in these areas were found to be different. In the lake growth averaged between six and seven millimeters a month.

In the outlet stream it was under two millimeters a month. Salt water growth was about 21 millimeters a month and seemed to be divided into two periods which probably indicate a fast growth while in the ocean and a slower growth in the estuary. Growth rates were related to changes in mean volumes of stomach contents.

4. Fish migrating out of the lake were captured by means of a weir. They were then tagged subcutaneously for future identification. A total of 1017 downstream migrating cutthroats of the plants made during this study were tagged. Approximately ten percent of the trout in the lake at the start of the downstream migration were captured at the weir. Downstream migrants were captured in the weir from April to July; the bulk of the migration was in April and May. Only 15 tags were recovered. Fishermen reported catching ten tagged fish. All angler recoveries were upstream from the mouth of the outlet of the lake which empties into the estuary. This indicated that there was movement of searun fish throughout tidewater before homing to their spawning stream. Migration in the lake and outlet was also studied.

5. Survival estimates were determined three times during this study. Marked fish were boat-planted in the lake and recapture was conducted using gill nets, angling and the weir to determine the marked-unmarked ratios. Mortality was the most important factor in determining yield to the angler. The amount of mortality was determined in relation to the time of planting and the size of the fish planted. Mortality in two November fingerling plants was between

78 and 82 percent, for an April plant 46 percent and for an August plant 15 percent.

6. A stratified random sampling scheme whereby weekdays, weekends and holidays were treated separately was used to determine the total catch of the various plants. Angling pressure was heaviest during the first two weeks after the season opened. A total of about 110 parties (2260 anglers) fished 4100 hours in the 1962 season to catch 4630 hatchery trout. Catch per angler hour averaged 1.35 for the 1962 fishing season. A month or less after planting, the catch per hour was reduced to less than a half fish per hour. The August plant showed the largest return to the angler (74 percent), the April plant second largest (42 percent) and the fingerling plants the lowest (11 to 13 percent).

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