MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

JOB FINAL REPORT

State Montana

Name Flathead Lake Fisheries Study

Project No. F-33-R-3

Title Flathead Lake, investigation of its fish populations and its chemical and physical characteristics

Job No. I

Period Covered November 1967 through August 1969

ABSTRACT

A sampling program was initiated on Flathead Lake to define the seasonal geographic and depth distribution of fish throughout the year. Sampling was conducted during four seasons; winter transition, spring transition, summer-fall stratification and summer stratification. Major ecological areas and the specialized gear used to sample this large, deep, oligotrophic lake are described.

Distribution data were collected on 3,512 fish, representing 12 of the 19 fish species present in the lake. The average fishing success of the "Flathead Net" (600 feet long) was 41.5 fish per net. Two-thirds of all fish were collected during the two summer seasons with the largest catches taken in areas directly influenced by river currents.

Season variations in species composition are described in detail for the eleven sample areas. Lake whitefish, Dolly Varden, northern squawfish, pygmy whitefish, peamouth and longnose sucker (listed in order of decreasing catch) were collected in all the sample areas.

Three main zones were used by the fish; near the bottom, near the surface, and the open pelagic waters. All species collected, except the cutthroat trout and kokanee, preferred a zone within 8 feet of the bottom. Cutthroat trout showed a distinct preference for the area near the surface while the kokanee selected the open pelagic waters. The depth and spatial distribution of the kokanee were established and periodically checked with the use of a recording sonar. Light penetration and water temperature were the two main factors effecting the kokanee distribution. Variations in these two factors continually altered the kokanee distribution.

Rough fish, such as northern squawfish, peamouth, longnose sucker and large-scale sucker, preferred the shore areas that ranged in depth from the surface to 90 feet with the majority occurring in waters less than 60 feet.

Concurrent to the fish sampling certain chemical, physical and biological characteristics of the lake were measured to assist in defining the aquatic environment and to note changes that might influence fish movements or distribution. Seasonal norms of water chemistry and temperature are presented for each of the eleven lake areas.

CONTENTS

BACKGROUND

Flathead Lake is Montana's most important fishing lake in terms of fishermen days. Due to its size (126,000 surface acres, 400 feet maximum depth) Montana's standard fish population sampling methods have failed to provide the necessary data to accurately interpret fish populations and their yearly fluctuations in Flathead Lake. This lake contains 19 fish species and each occupy slightly different niches in the lake and require special sampling techniques.

Fish distribution in Flathead Lake was first reported by M. J. Elrod when he compiled "The Fishes of Flathead Lake" in 1929 edition of the "Montana Outdoors". Although his work was directed primarily toward the food habits of the fish, he used his collection data as a basis for determining distribution. The majority of the work was conducted during July and August 1916.

He stated the peamouth[1/] was the most abundant fish species in the lake, followed closely by the northern squawfish. Both of these species were taken primarily in shallow areas along the shore. Two suckers, the longnose and the largescale, were present with the latter more common. Redside shiner, then called the Oregon chub, occurred in large schools which were particularly noted in the southern areas of the lake. Elrod experienced the elusiveness of the cutthroat trout to netting when he fished 25,000 feet of net and caught only two fish. He further reported, early in the spring and again in the fall, large numbers of cutthroat trout concentrated along the shorelines and were readily caught by angling. He considered cutthroat to be sparse during the summer.

Dolly Varden showed a wide distribution over the lake with the majority taken between 25 and 150 feet. This char was taken at a maximum depth of 275 feet. The largest specimen caught in 1916 measured 37 inches and weighed 25 pounds and 10 ounces. The small and inconspicuous slimy sculpin, then called the Rocky Mountain bullhead, was occasionally collected along the shore.

The mountain whitefish, considered a desirable food fish, was widely distributed in the lake but was abundant only at times and in certain places. Most whitefish were collected at depths between 25 and 100 feet. During 1915, spawning concentrations of whitefish were trapped at the mouth of the Swan River to secure eggs. In this initial attempt, 30,000 fish were trapped and stripped. Similar efforts were tried during the fall of 1916 and 1917, but numbers were too few and no eggs were taken.

Elrod (1929) also listed several fish species that were introduced into Flathead Lake. His remarks regarding these species were mostly of a descriptive nature, with the exception of the largemouth bass which he found in most shallow waters. He also mentioned their collection efforts failed to show evidence of the previous introductions of lake trout, salmon and lake whitefish.

A listing of fish species and the year of their introduction into Flathead Lake is presented in Table 1.

Other workers who described various aspects of fish life in Flathead Lake include Brunson and Newman (1951) and Bjorklund (1953) who studied the lake whitefish. The general status and size of the kokanee were discussed by Brunson, Castle and Pirate (1952) and Hanzel (1964). A fall collection of cutthroat trout was described by Brunson, Pennington and Bjorklund (1952). Rahrer (1963) determined the age and growth rate of Dolly Varden, peamouth, squawfish and yellow perch from the lake.

OBJECTIVES

The objective of this job is to develop techniques for using specialized equipment in determining the relative abundance of the various species of fish in the lake, their seasonal, geographic and depth distribution and to establish criteria for measuring year-to-year trends in species populations.

1/ Common names of fishes in this report are those given in American Fisheries Society, 1960. A list of common and scientific names of fishes from the United States and Canada. Spec. Pub. No. 2, Second Edition, 102pp.

Table 1. A listing of fish species and year of introduction or plant into Flathead Lake.

Species	Year of Introduction	Reference Source
Largemouth bass	1898	Biennial Report, 1913-14
Lake trout	1905	Biennial Report, 1905-06
Lake whitefish	1909	Biennial Report, 1909-10
Pumpkinseed	1910	Elrod, 1929
White crappie	1910	Elrod, 1929
Smallmouth bass	1910	Elrod, 1929
Black bullhead	1910	Elrod, 1929
Yellow perch	1910[1/]	Fish and Game Records
Brook trout	1912	Biennial Report, 1911-12
Cutthroat trout	1913	Biennial Report, 1913-14
Grayling	1913	Biennial Report, 1913-14
Rainbow trout	1914[2/]	Elrod, 1929
Salmon[3/]	1916	Biennial Report, 1917-18
Kokanee	1935	Fish and Game Hatchery Records (Polson)
Silver (Coho)	1969	Fish and Game Hatchery Records (Anaconda)

1/ Introduction of this species not recorded but it was apparently included in the mass introduction of warm-water fish during 1910.
2/ Year of first recorded plant; possible introduction as early as 1900.
3/ This species purchased as Chinook or Quannat salmon from Oregon; survival reports from this plant indicate it included the Chinook salmon, silver and kokanee. Apparently there was a mixture of eggs or questionable identification.

PROCEDURES

A year around sampling program was initiated to define the seasonal and depth distribution of the fish in Flathead Lake. Twenty-four stations were selected on the basis of ecological characteristics. The sample stations have been grouped into eleven distinct areas and were designated by numbers for discussion in this report.

Fish samples by gill net sets were made during four sampling seasons. Seasons were selected to fit the different conditions of the lake. They were: Season A - winter transition, November, December (1967), January, February, March (1968); Season B - spring transition, May, June, July (1968); Season C - summer-fall stratification, late August, September, October (1968); Season D - summer stratification, June, July, early August (1969).

Sampling was conducted from a 35-foot boat the "Dolly Varden", formerly a commercial fishing boat modified to handle specialized fishing gear (Figure 1). The boat is rigged with gill net reel, boom and a hydraulic powered winch, and

Figure 1. The 35-foot research boat "Dolly Varden" that was used during the sampling program on Flathead Lake, 1967-69.

a recording sonar that is capable of giving precise bottom measurements, locating fish and recording their depth and area distribution.

Gill nets used for this study were specifically designed for Flathead Lake and consisted of three nets joined together, a total of 600 feet of netting: a 100 feet by 8 feet net containing a 50-foot section of 5/8 inch mesh (mesh in stretched measure) and another 50-foot section with a 1-1/4 inch mesh, a 250 feet by 8 feet net and a 250 feet by 24 feet net. The 250 feet long nets have 50-foot sections each of 1-1/2, 2, 2-1/2, 3 and 4-inch mesh. During these series, all stations were sampled with the "Flathead Net" with the exception of Season A when the Flathead Net was used in 6 stations and then had to be discontinued because of icing conditions. Sampling was continued during Season A without the 250 by 24-foot net. The areas sampled by the Flathead Net were in the northern half of the lake and included most of the deep pelagic stations.

A typical set on the bottom was fished overnight for a period of approximately 20 hours. Proper placement and alignment of the net and depths were checked and recorded on sonar tape. The powered gill net reel aided in pulling and storing the netting materials. Two sets were made per day during the sample periods. Sonar was used to record the general fish distribution in the vicinity (20 to 30 acres) of the sample stations.

Water temperature profiles, basic water chemical analyses, and collections of plankton were conducted concurrently with the fish sampling at all stations. A resistance thermometer coupled to a depth sensor (Bathythermonitor) was used to record water profiles. Water depths were recorded for each 1° F. change in water temperature. A plankton tow net, 45 cm. in diameter, was used to obtain plankton near the surface. A flow meter mounted in the mouth of the net measured the water velocity through the net. Water volume for each two minute tow was calculated.

Water quality measurements, based on "Standard Methods for Examination of Water and Sewage" were made for the following characteristics: total alkalinity, dissolved oxygen, pH and standard conductance. Analyses were made on samples collected from the surface and at levels from 50 to 65 feet below the surface. Secchi disc readings were also made during the water sampling.

The pH readings were made with a line-operated electric pH meter that was calibrated with a standard buffer. Conductance readings were made on a battery operated resistance meter. Uniformity in dissolved oxygen and alkalinity determinations was assured by correcting the normality of the titrants with standard solutions at the time of each measurement.

All fish collected were measured to the nearest one-tenth of an inch in total length, weighed to the nearest one-hundredth of a pound and a scale sample extracted and stored in individual envelopes. A cursory examination was made into the abdominal cavity for sex determination and gonadal development. Notes were made on stomach contents and visible parasites. Numerous specimens were preserved for future reference.

FINDINGS

Description of Areas

Eleven major areas of Flathead Lake were sampled for fish during four different seasons. Efforts were made during the series to maintain consistancy in the sampling techniques. Depth and direction of the net set were two of the main factors that governed the placement of the nets.

The eleven sample areas (Figure 2) were the result of grouping the 24 sampling stations in the lake by their aquatic environment. A brief description of the major areas is as follows:

Area 1 - A shallow, partially isolated area at the northwest end of the lake; shorelines gradually slope to a maximum depth of 120 feet; most of the area is between 10 and 60 feet deep; partially influenced by the inflow of about one-third of the Flathead River; isolated by the extending delta of the Flathead River and the main river current; protected by high terrain on the west from the prevailing southwest wind.

Area 2 - The delta area that is directly influenced by the Flathead River and its main current; heavy silting occurs during the spring; depths vary from 16 feet on the delta to the mid-lake bar of 90 feet; the prevailing wind directly effects the entire area.

Area 3 - Cove areas along the west shore that are influenced directly by the main river current; this shoreline drops off sharply to the 100-foot level, then slowly to the maximum depth of 150 feet; protected from the prevailing wind by the mountainous terrain along this shore area.

Area 4 - North half of Big Arm Bay; partially isolated from the main lake by islands, shallow water and land mass; shoreline drops gently to the maximum depth of 120 feet; no apparent effect from the river current; high ground surrounding the area offers protection from the prevailing wind.

Area 5 - South half of Big Arm Bay; partially isolated from the main lake by islands, shallow water and land mass; no apparent effect of the river current; surrounding terrain offers some protection from the prevailing wind.

Area 6 - Area directly influenced by the outflowing waters; the narrow channel concentrates current effect; steep slopes drop off toward the main lake to a maximum of 240 feet; shallow water extends to the south into a large bay with maximum depth of 30 feet; area is protected by land mass from the prevailing wind.

Area 7 - A deep isolated bay area with steep precipitous slopes on the west and east but only gradual slopes on the south; maximum depth of 270 feet; not directly influenced by river currents or prevailing wind.

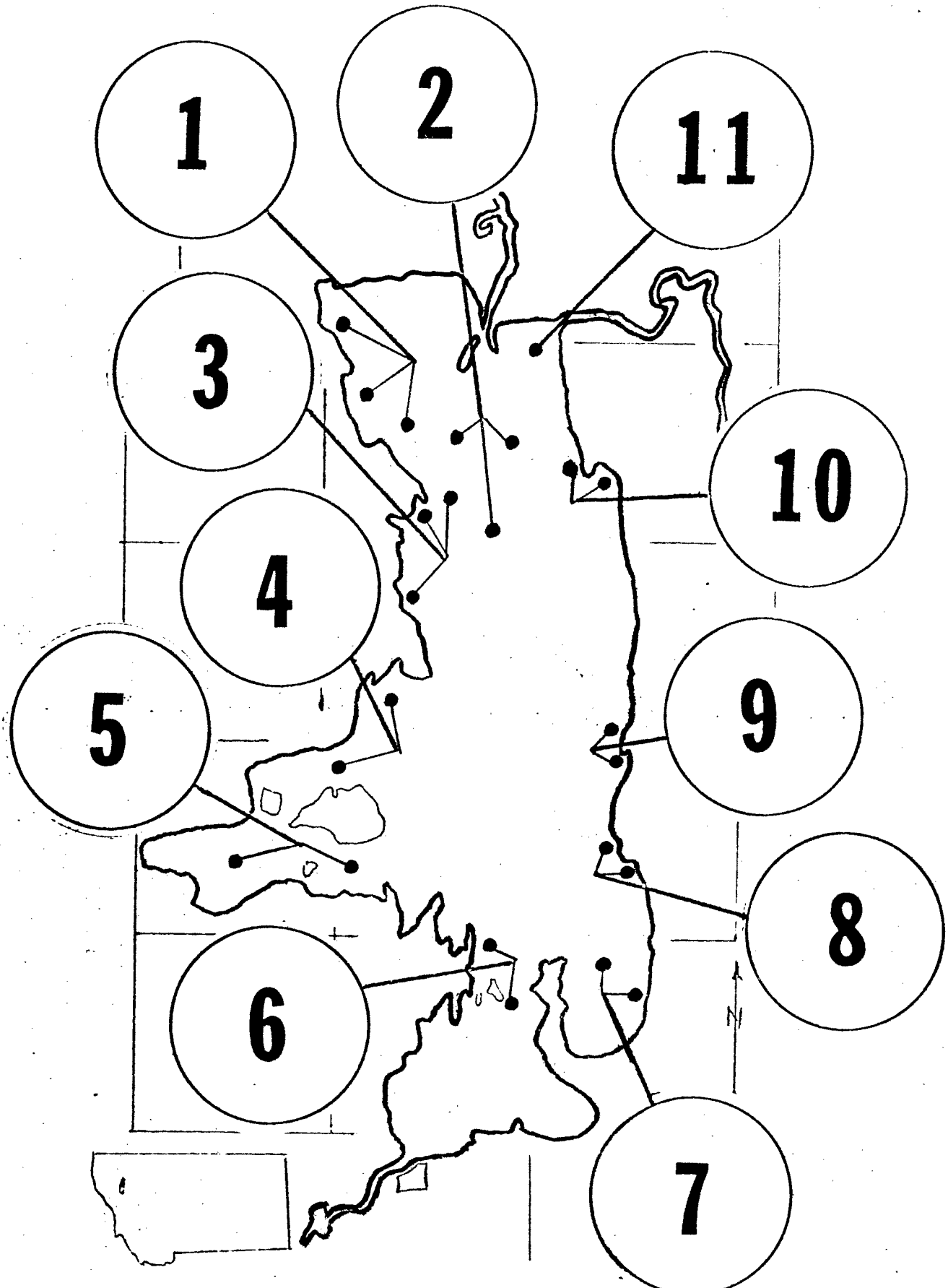

Figure 2. The location of areas and the number of points sampled in Flathead Lake during the 1967-69 season.

Area 8 - A small protected cove area along the east shoreline; the shoreline drops off precipitously to depths over 200 feet; maximum depth occurs in the 300-foot trough that parallels this shore; effects of the prevailing wind is minor.

Area 9 - A small well protected cove area of moderate depth; shoreline drops off gradually to the maximum of 120 feet; no effect of river currents; some protection from the prevailing wind by a spit of land.

Area 10- A large protected bay area with steep precipitous slopes; maximum depth of 230 feet; area may be effected by the inflowing waters of the Swan River; no protection from the prevailing wind; wind has maximum effect.

Area 11- At mouth of Swan River; influenced by the river and possibly by currents from the Flathead River; a small delta gradually drops off to depths of 120 feet; area remains relatively clear of silt, most deposition of this river takes place upstream in Swan Lake; the effect of the prevailing wind is direct in this area.

Catch Data

During the four seasonal series a total of 3,512 fish were collected. The catch figures and the percent of total fish collected for Seasons A, B, C and D for the entire netting program are presented in Table 2.

Table 2. The total number of fish and percent of total collected during the four sample seasons in Flathead Lake.

Season	Total fish	Percent of total
A	702	20.0
B	575	16.4
C	1,088	31.0
D	1,147	32.6

The percent of the total fish collected in each of the sample areas and the proportion of these totals taken during each seasonal series are shown in Figure 3.

The distribution of total catch between areas remained quite constant. Figure 3 shows most fish were collected from Area 1, 17.1 percent, and the least from Area 7, 4.0 percent. Areas 4, 5 and 7 provide the poorest catches; these were characterized as lake areas that are quite isolated and were not effected by direct river currents.

There was considerable variation between seasonal catches and lake areas. A comparison of the seasonal high and low catch ranges is presented in Table 3.

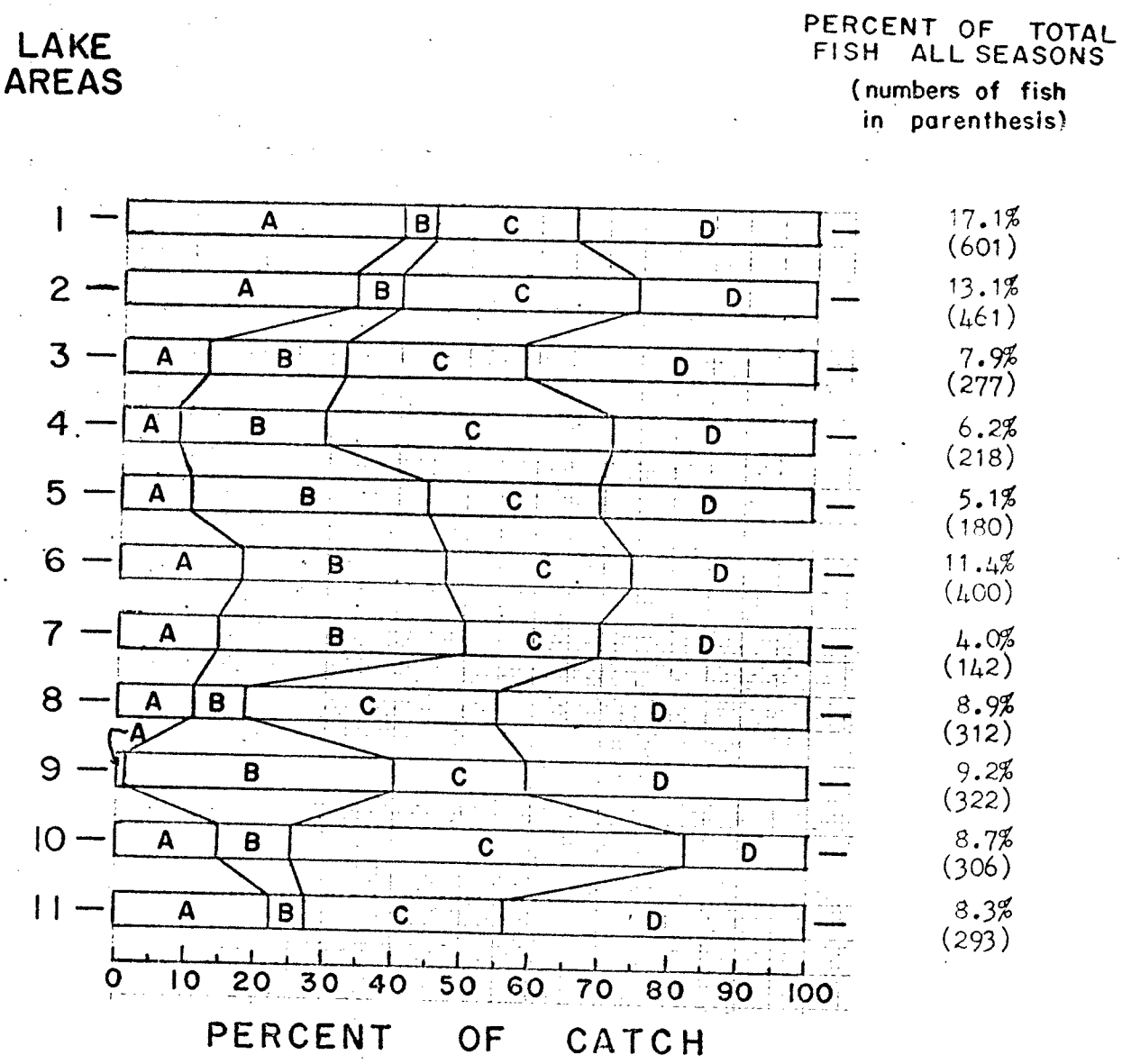

Figure 3. The percent of total fish collected in each sample period for the eleven areas of the lake by sampling Seasons A, B, C and D, in Flathead Lake.

Table 3. The seasonal high and low catch figures (percent of total) during the four sample seasons

Season	Seasonal low catch		Seasonal high catch	
	Percent	Area	Percent	Area
A	1.6	9	40.1	1
B	5.1	11	38.5	9
C	19.7	7	57.5	10
D	17.3	10	44.9	8

It is interesting to note the seasonal change in Areas 9 and 10. Between Seasons A and B, Area 9 percentage figure rose from the lowest to the highest, and Area 10, between Seasons C and D, dropped from the highest to the lowest figure.

Species Composition

The variability of species composition between areas and/or seasons was summarized and is presented in Table 4.

Table 4. Percent of total fish collected in Flathead Lake by species in the netting series during 1967, 1968 and 1969

	Catch percentage for each netting period				
Species	Season A Nov. - Mar. 1967 68	Season B May-June 1968	Season C Aug. - Oct. 1968	Season D June - Aug. 1969	Season A-D Total 1967 - 69
LWf*	53.2%	48.5%	31.3%	50.7%	44.8%
DV	12.0	16.3	14.5	16.0	14.8
Kok	3.0	6.4	19.4	9.9	10.9
SQ	11.0	15.1	12.7	5.5	10.4
PWf	3.0	4.2	8.7	11.3	7.7
PM	11.0	1.9	6.5	1.7	5.0
LNSu	1.3	2.3	2.2	0.8	1.5
Wf	2.0	2.8	0.4	1.2	1.4
YP	0.6	0.2	2.2	0.3	1.0
LT	0.1	2.2	1.5	0.6	1.0
Ct	1.6	-	-	1.5	0.8
CSu	1.2	0.1	0.6	0.4	0.7
Total No. Fish	702	575	1,088	1,145	3,512
Stations Sampled	22	20	19	24	85
Net Length Used (1 set/station)	350'	600'	600'	600'	-
Fish/Net	31.9	28.8	57.3	45.9	41.3

* Species abbreviations on page 12.

Table 4. (Continued)

* Species abbreviations: LWf - lake whitefish; DV - Dolly Varden; Kok - kokanee; SQ - northern squawfish; PWf - pygmy whitefish; PM - peamouth; LNSu - longnose sucker; Wf - mountain whitefish; YP - yellow perch; LT - lake trout; Ct - cutthroat; CSu - largescale sucker.

For comparison, the species composition of all fish collected is represented in a pie diagram, Figure 4. Major fish species listed in order of their relative numbers included lake whitefish, Dolly Varden, kokanee (also referred to as salmon), northern squawfish, pygmy whitefish and peamouth, respectively. The minor species collectively represented 6.4 percent; listed in decreasing numbers, they were longnose sucker, mountain whitefish, yellow perch, lake trout, cutthroat trout and largescale sucker. Several fish species previously recorded for Flathead Lake were not taken during the netting. They were rainbow trout, brook trout, largemouth bass, pumpkinseed, redside shiner, slimy sculpin and black bullhead. These species either occur in such small numbers or occupy such small and specific areas that they were not available to the conventional gear used during the series.

The distribution for each of the twelve species by lake area is summarized in Table 5. The detailed species catch data by area and by season for the sample program is presented in Appendix I. Seven species were taken in all of the eleven lake areas, but not necessarily during all the sample seasons. Area 10 was the only area where all twelve species were represented during the entire program. There were four species that were not collected in certain areas of the lake; these species and the areas are presented in Table 6.

Changes in species composition in any one area can occur rapidly and the possibility of missing a particular change or movement is assumed in the present study. The results of the netting series does provide the basic pattern of fish distribution within this large and complex lake system.

The predominant species over the entire lake was the lake whitefish (Table 4). It was only during Season C, (August through October 1969), that this species dropped below 50 percent of the total seasonal catch. Dolly Varden showed the most stable numbers during the series with an average catch of 14.8 percent.

Due to the numerous seasonal and area changes that occurred in the species composition, pie diagrams were used to represent and illustrate the changes in percent species composition by area and by season (Figures 5, 6, 7 and 8).

This method enables rapid comparisons for the entire lake, between areas and seasons. The sequence in presenting species within the pie diagram is consistant; species not listed were not taken. The percentage data used in the pie diagrams are presented in tabular form in Appendix II.

Depth Preference

Fish collected during the series exhibited some preferred depth zones. These zones were: 1) near the bottom; 2) near the surface; 3) the pelagic, or

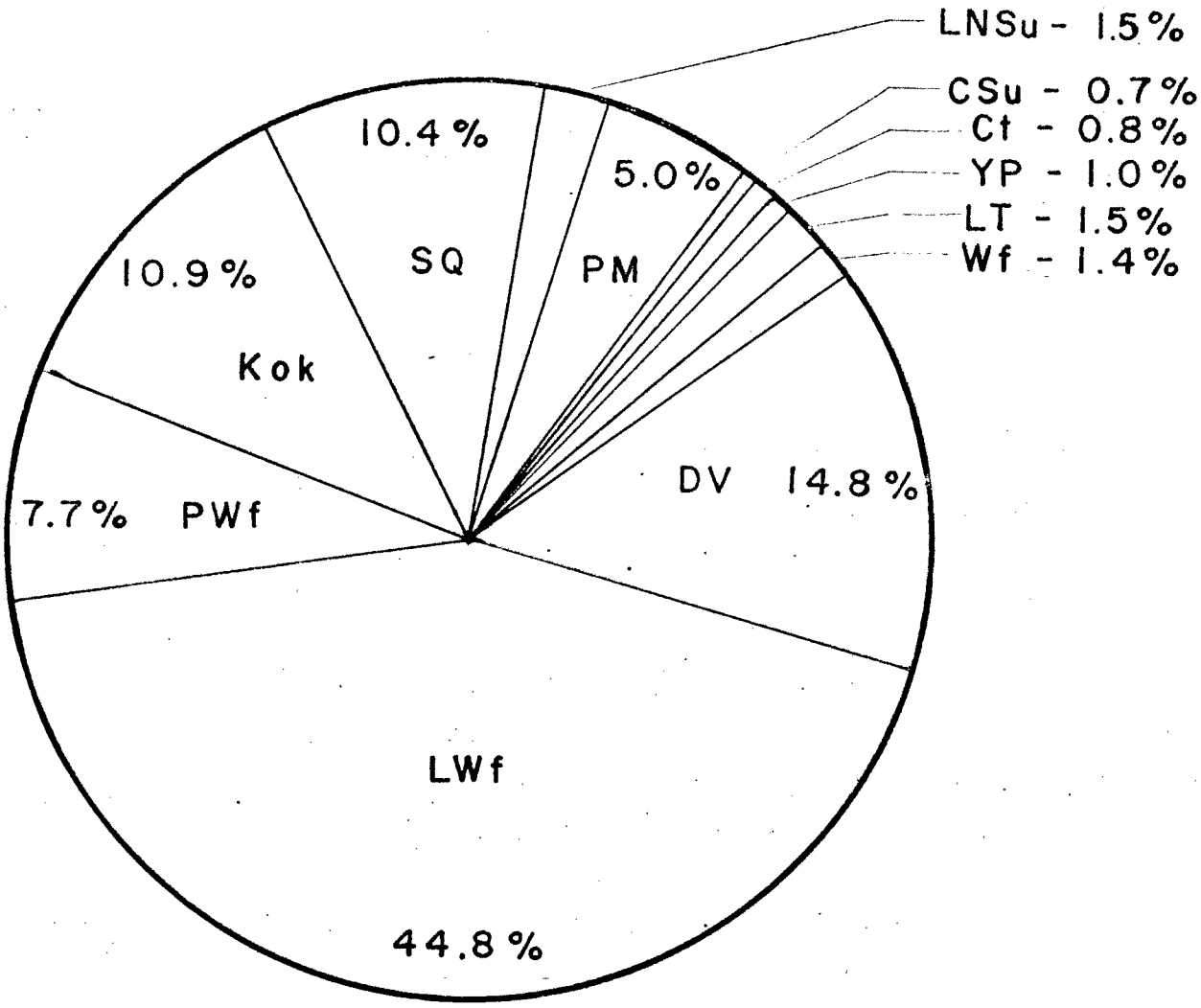

Figure 4. Percent composition by species of total fish netted in Flathead Lake, November 1967 through August 1969.

Table 5. Percent of the total fish for each species caught in the eleven (11) sample areas during the netting in Flathead Lake, 1967-69

Lake Areas	Percent by species											
Areas	DV	LWf	PWf	Kok	SQ	LNSu	PM	CSu	Ct	YP	LT	Wf
1	21.3%	19.3%	20.4%	3.3%	9.6%	20.4%	20.9%	9.1%	65.5%	14.7%	- %	18.0%
2	12.5	16.9	17.0	7.4	8.2	9.3	9.0	9.1	-	-	5.6	-
3	6.7	10.5	9.3	8.4	3.6	13.0	2.3	-	-	-	13.8	-
4	10.0	3.8	24.1	3.8	3.0	1.8	1.7	13.6	13.8	-	8.3	2.0
5	8.5	4.8	3.7	2.8	5.2	7.4	1.7	-	-	-	30.6	4.0
6	6.0	9.8	1.5	3.1	23.6	1.8	41.2	18.2	6.9	64.7	-	22.0
7	5.4	3.6	1.9	3.1	7.1	1.8	0.6	18.2	-	2.9	5.6	10.0
8	7.3	8.3	14.1	3.8	10.9	13.0	13.0	18.2	-	5.9	13.8	20.0
9	9.0	10.5	3.3	5.6	15.3	11.1	2.8	-	-	2.9	16.7	10.0
10	7.7	3.7	0.3	36.3	9.3	11.1	5.6	9.1	3.4	5.9	5.6	14.0
11	5.6	8.8	4.4	22.3	4.1	9.3	1.1	4.5	10.3	2.9	-	-
Total Numbers	520	1,574	270	390	365	54	177	22	29	34	36	50

Table 6. Areas of the lake where some species failed to be collected during the current sampling

Species	Areas not collected
Largescaled sucker	3 - 5 - 9
Lake trout	1 - 6 - 11
Cutthroat trout	2* - 3* - 5 - 7* - 8* - 9*
Mountain whitefish	2* - 3* - 11*

* Other collections have been made in these areas with these species being represented.

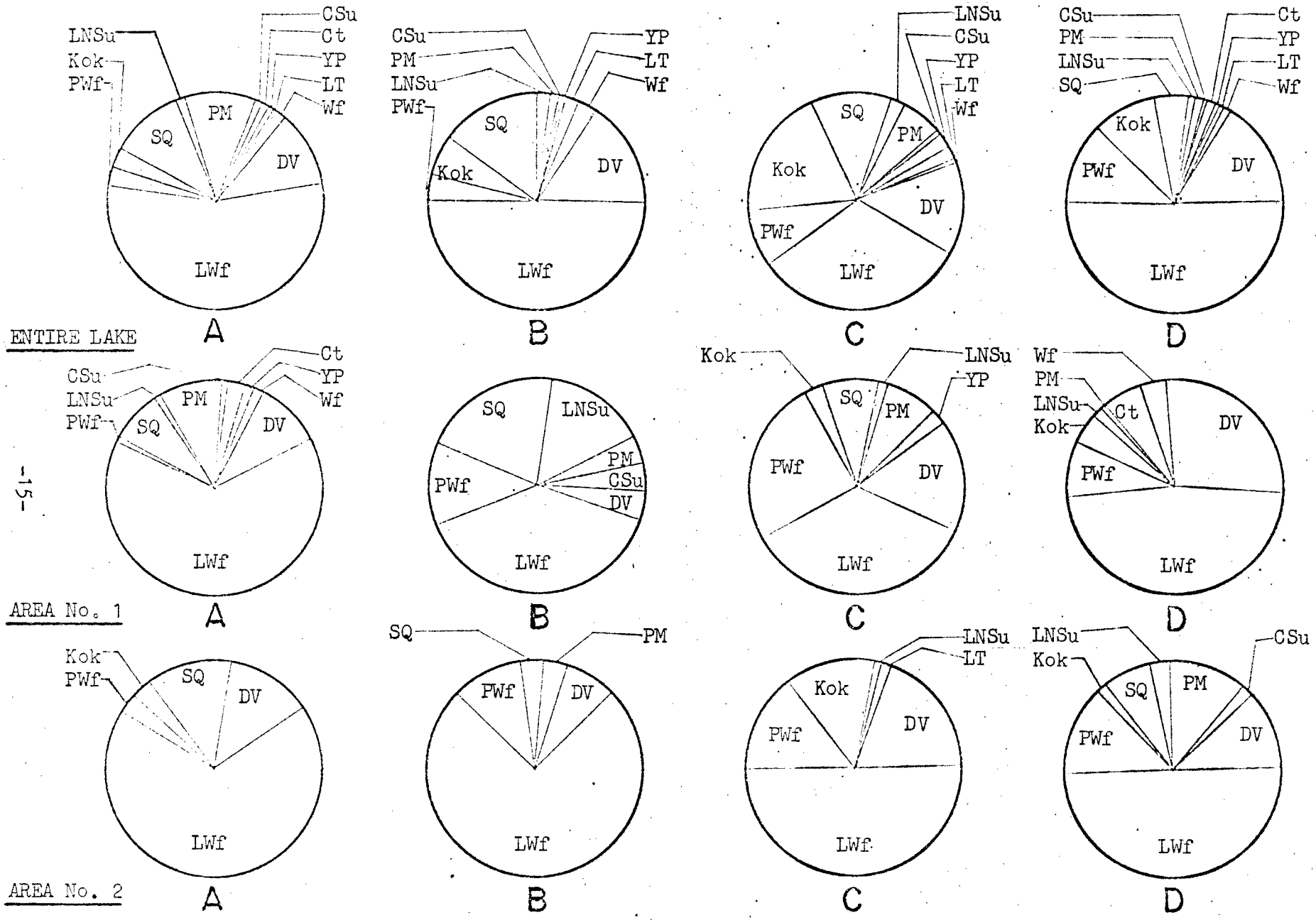

Figure 5. Pie diagrams expressing percent species composition of total fish collected from the entire lake and Areas 1 and 2, during sample Seasons A, B, C and D.

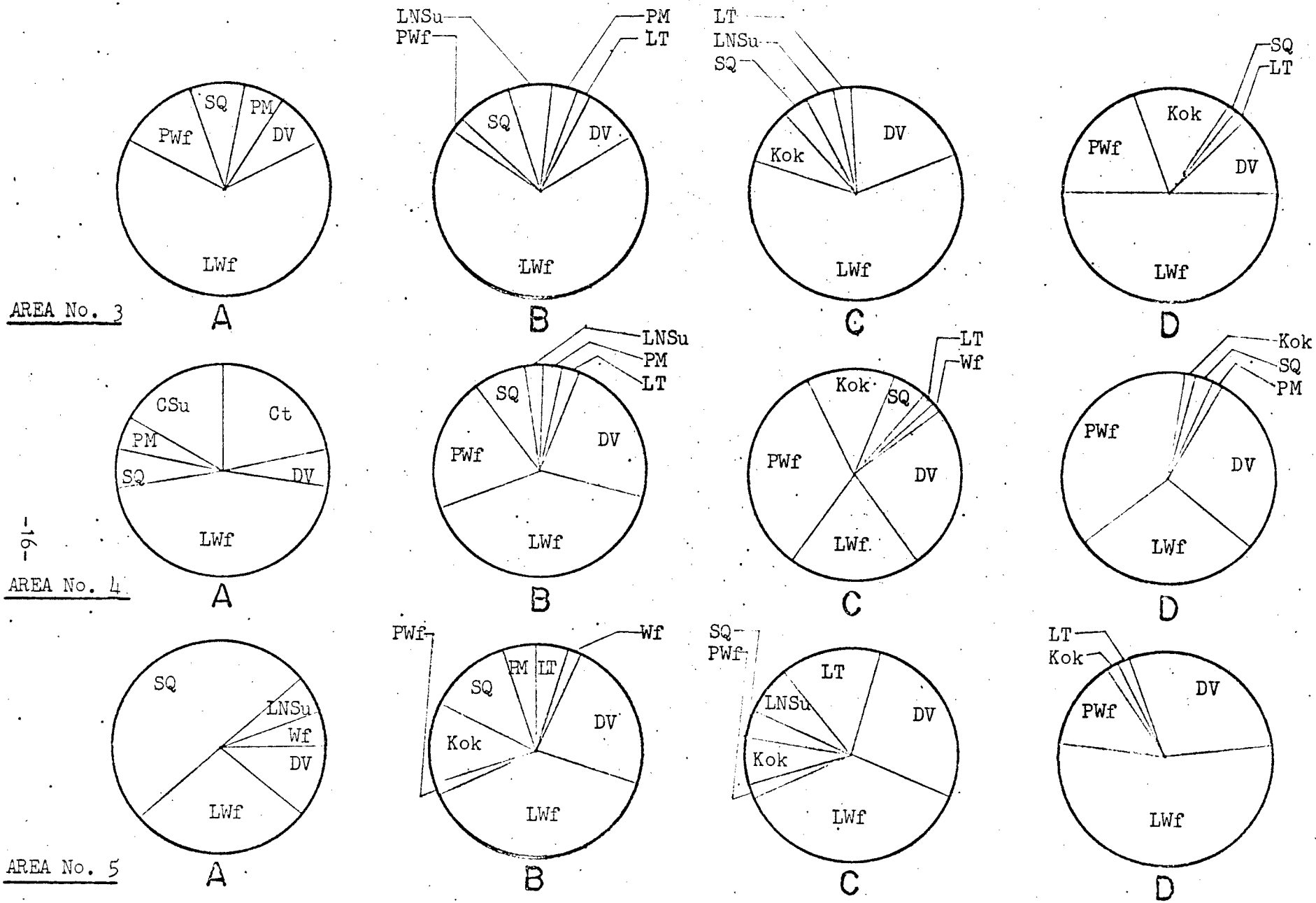

Figure 6. Pie diagrams expressing percent species composition of total fish collected from Areas 3, 4 and 5, during sample Seasons A, B, C and D.

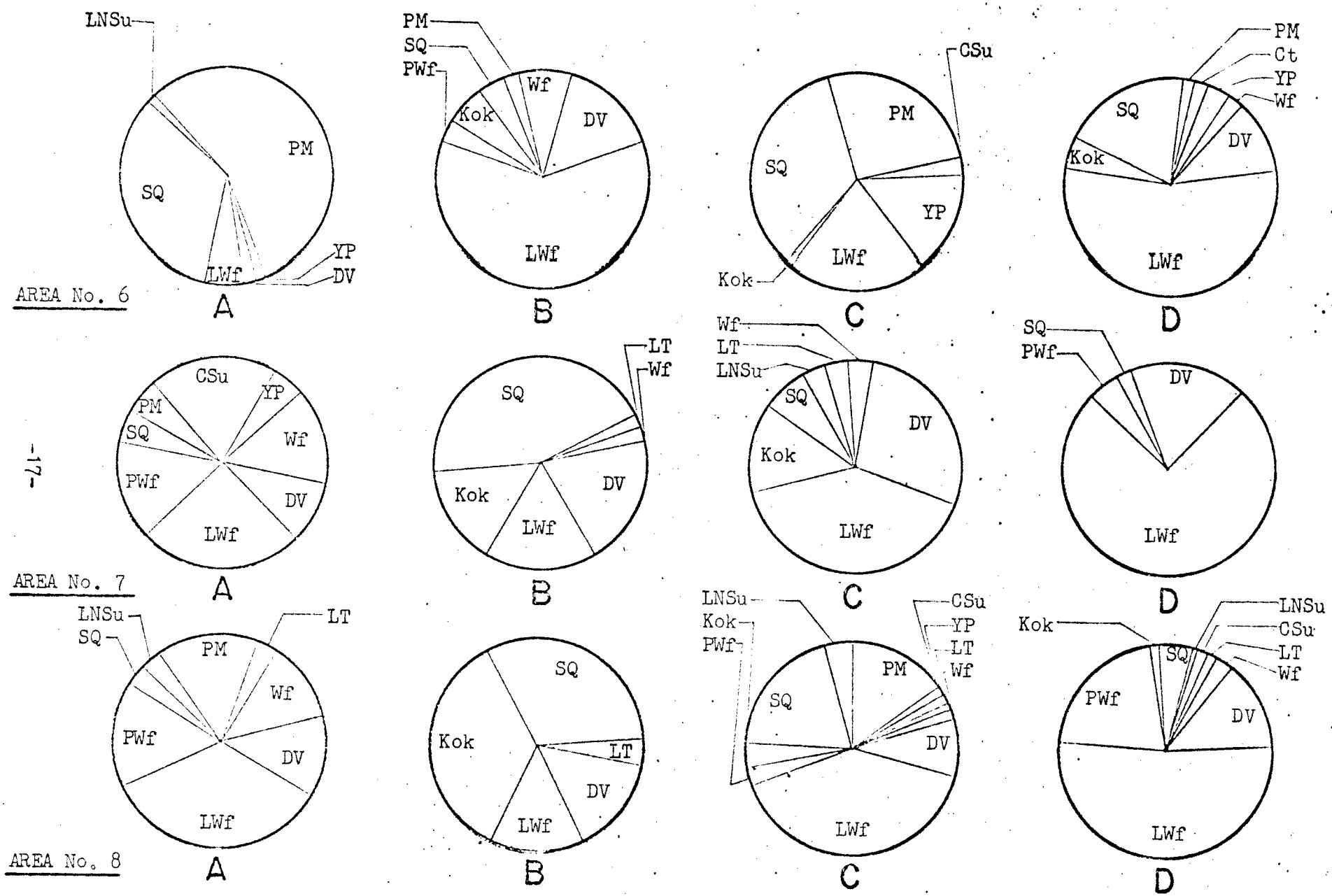

Figure 7. Pie diagrams expressing percent species composition of total fish collected from Areas 6, 7 and 8, during sample Seasons A, B, C and D.

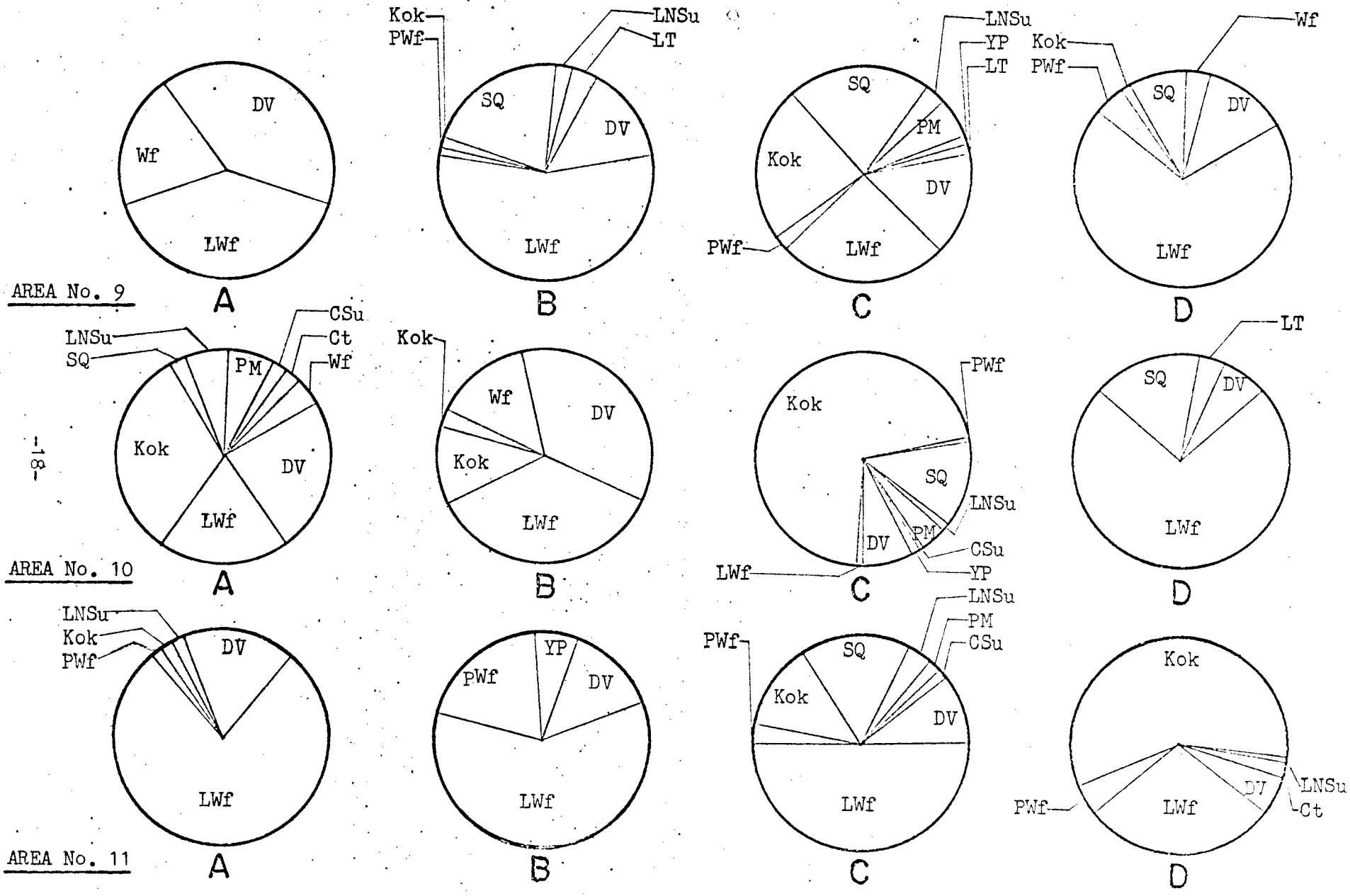

Figure 8. Pie diagrams expressing percent species composition of total fish collected from Areas 9, 10 and 11, during sample Seasons A, B, C and D.

area of deep open water. Depth preference was determined by the location of fish caught in the nets, by sonar records and by direct observation from the flying bridge of the "Dolly Varden".

Most species in Flathead Lake preferred an area within 24 feet of the bottom. The majority of bottom fish preferred a zone 8 feet above the bottom as illustrated by observing three-fourths of all lake whitefish being taken in this zone. The vertical distribution of the remaining lake whitefish was quite uniform in the 16-foot layer above the 8-foot bottom zone. Four-fifths of the Dolly Varden and three-fifths of the lake trout showed a similar preference for the lower 8-foot zone. The maximum depths from which any fish were recorded or collected was 180 feet.

Rough fish, including the northern squawfish, peamouth and the two species of suckers were also associated with the bottom zone, but were never taken at depths greater than 90 feet. Most concentrations of rough fish were near shore, in the shallow waters less than 60 feet.

The redside shiner was generally a shoreline fish found within the 20-foot contour. They were found in the dense vegetation and other cover types. During the summer of 1968, a school of shiners, estimated to be 200 to 300 individuals, were sighted on the surface more than a mile from shore moving toward the open area of the lake.

Small numbers of spiny-ray fish, yellow perch, largemouth bass and pumpkinseed were seen over most of the lake, but were rarely collected in waters deeper than 30 feet.

The cutthroat trout was directly associated with the surface zone. All cutthroat were collected either in surface floating nets or in areas where bottom depths were less than 30 feet. During the summer months, cutthroat were sighted in the open areas of the lake as individuals or groups of ten or more. These fish were cruising within 2-3 feet of the surface, often more than five miles from the shore, and were apparently feeding on insects.

The kokanee showed the widest range of depth preference of all fish in the lake. Generally their preferred zone was defined by either temperature or light penetration. This depth zone never remained static but was continually disturbed by wind and weather. Some diurnal preferences were indicated on sonar records made before and after sunset. The diurnal patterns generally found the summer kokanee schools at their greatest depth after sunset; then during the evening hours they gradually rose to either the surface or to the 60° F. level (the upper limit of their preferred temperature range). As summer progressed and the fish approached their spawning season the effect of temperature on the school depth lessened with the depth of light penetration, apparently becoming the controlling factor. Although light penetration depths measured with a secchi disc are crude, predictions of school depths based on secchi disc readings were the same depths as determined from sonar records. During the winter period when waters are isothermic, salmon depths were associated with the depth of light penetration. The maximum depth at which the schooling kokanee were found, by sonar, was 90 feet.

Other seasonal and depth information will be discussed in more detail in the section "General Fish Distribution".

General Fish Distribution

Season A (November 1967 through March 1968) During the winter sampling period the heaviest concentrations of fish netted or recorded by sonar were found in the shallow waters along the entire shoreline of the lake. Spawning lake whitefish were found off the gravel beach areas in waters less than 15 feet, while juveniles of this species remained off shore in waters deeper than 40 feet. As the lake level continued to drop during this period, kokanee eggs were washed out of the gravel. This created food for fish and in turn concentration areas for lake whitefish and cutthroat trout. Examination of stomachs from these species disclosed they were filled with kokanee eggs. The peak of the lake whitefish spawning occurred during the last week of January; the last ripe female was taken late in February.

All sizes of Dolly Varden were found at nearly all sample depths, from the surface to 100 feet; however, during the period when salmon were dying, Dolly Varden showed some movement from the shallow shoreline areas to the deeper (40 to 90 feet) areas of the bays and into the main parts of the lake.

Lake trout were predominately found in Area 7 at depths from 90 to 120 feet. Two concentrations (extending for one-half mile) of large fish, probably lake trout, were recorded by sonar at 112 and 180 feet. The fish at 180 feet is the deepest record we have found. Bottom depths in this area were 310 feet.

Kokanee populations were recorded in most of the southern bays (Areas 8 and 9) at depths between 18 and 90 feet. During calm, evening hours, large numbers of salmon were seen surfacing. Spin casting during these hours was quite successful.

Rough fish, primarily peamouth and northern squawfish, were taken in the shallow net sets in less than 40 feet of water. The largest numbers of these species were taken in Area 6.

Yellow perch, mountain whitefish, pygmy whitefish, largescale suckers and longnose suckers were collected in too few numbers to indicate distribution.

Water temperatures remained generally isothermic during this season with only 1° F. change from the surface to 285 feet. The temperature ranged from 43° F. in November to 36° F. by January, and finally reaching a low of 34° F. in February. Late March water temperatures were starting to warm and reached 36° F. Inlet waters at this time were 43° F.

Season B (May through July 1968) Sampling in the early spring season was to obtain information from the spring turnover to the period of thermal stratification. Surface temperatures ranged from 47° to 73° F. By the end of this sampling period thermoclines were forming, with the upper limits remaining between 10 to 20 feet. Surface waters along the east shore and bay areas were generally 5° to 6° F. warmer than the surface waters in the main portion of the

lake. Water profiles varied widely over the sample period. Waters below 100 feet were 40° F. to depths of 380 feet.

The most significant change in the fish distribution was the complete absence of kokanee in the northern areas of the lake. Several schools of salmon moved in along the east shore by mid-June, and remained in these schools during the month. The first movement of kokanee schools along the west shore was noted in late June when a school of salmon was recorded on sonar at 18 feet and moving in a westernly direction from Areas 8 and 9 toward Area 4, north of Wildhorse Island. The research boat, the "Dolly Varden", had been in the area for two days and had not previously recorded any salmon. Fishermen in Area 5, approximately two miles south of Area 4, reported catching salmon two weeks earlier; these salmon were also located at 18 feet below the surface. Kokanee reached Areas 1, 2 and 11 near the north end of the lake by early July. As the water warmed, the salmon schools dropped to depths around 40 feet. No large concentrations were found in the open water areas of the lake.

All other species of fish collected were taken within 18 feet of the bottom. These fish included Dolly Varden, lake whitefish, mountain whitefish, pygmy whitefish, lake trout, northern squawfish, peamouth, longnose sucker, largescaled sucker and yellow perch.

Season C (August through October 1968) The August to October sampling period was completed as the lake thermocline began to disappear. During this period surface temperatures ranged between 52° F. (October 17) and 67° F. (September 11). The upper limit of the thermocline dropped progressively during the season from 45 to 74 feet; the lower limit dropped from 70 to 109 feet and in turn the thermocline stratum or area of rapid temperature change widened from 25 feet to 35 feet by late August. The stratum then narrowed down to 20 feet as lake temperatures cooled. Early in October, temperature profiles found the thermocline sinking with isothermic conditions existing down to 120 feet. Wind action resulted in an earlier than usual breakdown of the thermocline in the open water and northern areas.

The major areas of kokanee distribution during this period were in Areas 1, 4, 5, 7, 10 and 11. The salmon remained in large, tight schools in these areas and were found to be utilizing waters deeper than recorded the previous summer.

During August, the salmon preferred depths from 24 to 54 feet. It has been recognized that the kokanee have the most specific temperature preferences of all the Pacific salmon. Brett (1952), described this range as being between 53.7° and 57.6° F. The salmon in Flathead Lake did demonstrate this temperature tolerance which seem to govern their summer depth distribution. The temperature patterns were constantly changing causing the salmon to react and change their depth distribution. The schools, by early October, were found between 25 and 94 feet. This is the deepest record of salmon in Flathead Lake. The transparency of water (Secchi disc readings) and concentration of plankton, apparently determines the upper limits of the salmon during the seasons when the surface temperature and waters to depths beyond 100 feet are within the preferred zone. Variations that occurred in the depth distribution of salmon as recorded by sonar, were defined in Table 7.

Table 7. The depth distribution of salmon schools, as indicated by sonar, in selected areas during the fall of 1968

Date	Area	Range in depth of salmon schools (feet)	Majority of fish found (depth in feet)
7/15	9	24 - 54	24 - 42
8/06	4	18 - 54	Scattered within range
10/01	7	18 - 78	48 - 72
10/01	9	30 - 84	42 - 54
10/01	8	18 - 78	48 - 72
10/02	9	30 - 60	Scattered within range
10/02	7	24 - 78	24 - 54; 48 - 78
10/03	6	15 - 96	30 - 48; 78 - 96

The early run of kokanee entered and progressed up the Flathead River to the upper river spawning areas between September 15 and October 15.

The Dolly Varden were randomly distributed over the entire lake, with more being taken in the areas of the salmon concentrations.

Stomach examinations showed the kokanee to be a preferred food of the Dolly Varden during this season. The Dolly Varden collected ranged in size from 6.5 to 30.0 inches with the largest weighing 9 pounds. Over half, or 53 percent, were less than 15-inches and all of these were found to be immature. These smaller fish were primarily taken off the mouth of the Flathead River, in Areas 1, 2, 4 and 5. Most of the Dolly Varden (90 percent) were taken within 8 feet of the bottom.

The lake trout distribution was the same as found during the previous sample periods, primarily on the delta bar in Area 2 and in Areas 5 and 7. All were taken on the bottom. Their size ranged between 20.5 and 35.5 inches with the largest weighing 21 pounds.

Lake whitefish, the most numerous species, were taken in every net set. The size ranged from 5.5 to 19.8 inches and 45 percent were 14-inches or larger with the largest weight of 2.56 pounds. The majority of the lake whitefish were also taken within 8 feet of the bottom. Some adult whitefish were taken by salmon snaggers in the Flathead River near Kalispell.

The largest collection of pygmy whitefish was taken during this late summer season. Major concentrations were in Area 2 and 4 with more than 20 fish taken per net in these areas. The size ranged between 3.6 and 6.9 inches. Observation of gonads of the mature individuals indicated they were not ripe by the first of October.

Peamouth, northern squawfish and suckers ranged in distribution over the entire littoral area of the lake, but rarely were any taken in waters deeper than

60 feet. An occasional mountain whitefish was taken in the nets in Area 5 and 7. Although fishermen caught cutthroat trout along the shoreline during the period, none were taken in the nets.

The first yearling kokanee (1.5-inches total length) collected were found in the stomach of a 6-pound Dolly Varden taken in the nets in Area 7. Another 14-inch Dolly Varden stomach contained a 7-inch Dolly Varden which, in turn, had eaten a 3.6-inch pygmy whitefish. Data were obtained from all three fish.

Season D (June through August 1969) The movement of kokanee schools into the northern areas of the lake during July was the most dramatic change in the fish distribution during this season. There were at least three well-defined schools (20-30 acres) that were found moving around in Areas 1, 10 and 11. The school in Area 1 dispersed twice during July. During these dispersals, concentrations of salmon were located at the mouth of the Flathead River (Area 2) and were believed to be the fish from Area 1.

Salmon concentrations (75-100 acres estimated by sonar) in the southern half of the lake were more evenly distributed than the northern areas. At this time approximately two-thirds of the lake had some salmon. During July, kokanee were checked in the creels of fishermen south of Area 6. Prior to this record, very few specimens have been taken in this area.

Depths utilized by the kokanee were quite varied over the entire lake. Schools of salmon on the east side of the lake were generally found between 18 and 42 feet below the surface; whereas the western schools were found at depths from 32 to 60 feet. This is apparently associated with the temperature patterns.

The kokanee were well distributed over the lake in late August, but seemed to maintain tight schools of approximately 10 acres in size. The depth distribution was primarily at two levels; between 15 and 25 feet and 40 and 50 feet below the surface. This concentration was similar to the depth distribution the previous August. The fish at both levels seem to be constantly on the move. These movements were generally oriented toward the north end of the lake.

Three-hundred-thirty kokanee measured during the last week of August had an average length of 11.0 inches. This is 0.7 inches larger than the average of those taken in 1968. Average lengths taken during the last week in August in previous years were: 1962 - 11.2 inches, 1963 - 12.1 inches, 1967 - 9.6 inches, 1968 - 10.3 inches. The 1969 average lengths and size ranges of 330 salmon, by areas, are presented in Table 8.

The other species of fish showed little change in the seasonal movement. Lake whitefish, Dolly Varden and pygmy whitefish made up 75 percent of all fish collected during this sample period. By mid-July concentrations of these species moved to the delta bar located off the mouth of the Flathead River (Area 2). Large lake trout and Dolly Varden were found on the bar area again and provided excellent sport fishing. Lake whitefish and some kokanee were also found on this bar area. The first small lake trout, less than 20-inches total length, were collected during the period in Areas 3, 5, 8 and 10.

Table 8. Average total length (inches) and length range of kokanee by area taken during the last week in August 1969

Areas	Average total length (inches) sexes combined	Size range (inches)
1	10.7	7.5 - 12.4
2	11.2	8.6 - 12.5
4-5	10.8	7.8 - 11.9
11	10.7	8.6 - 12.1

Surface temperatures warmed from 51° to 73° F. during June and July. The east shore waters were again found to be about 5° to 7° F. warmer than the west shore waters.

Thermoclines were evident during the period, with the stratum and depth of the thermocline widening and dropping progressively during the season. Upper limits first stratified at approximately 20 feet and dropped to nearly 60 feet by the end of July. The width of the thermocline stratum ranged from 3 feet to 25 feet. The narrow thermocline stratum with widths of 3 feet, was the sharpest temperature change recorded for Flathead Lake. This was recorded in 172 feet of water in Area 9 on July 14, 1969. The upper limits of the thermocline occurred at 28 feet and the lower margin at 31 feet below the surface. A 9° F. drop (from 62° to 53° F.) was noted within the first foot and a 5° F. change followed in the next 2 feet of water (52° to 47° F.). A 6° F. drop was recorded from there to the bottom in 172 feet (41° F.). The area of rapid change was initially detected on sonar. This was probably due to the change in water density.

Surface water temperatures reached a maximum of 73° F. in early August but generally cooled to 66° F. over the entire lake during the rest of the month. Although the thermocline remained well established over the lake, the upper limits of the stratum dropped from 25 to 40 feet below the surface.

Other Limnological Measurements

Concurrent to the fish sampling, certain limnological characteristics such as surface plankton, water chemistry, light penetration and water temperatures were measured to assist in defining the aquatic environment and to note changes that might influence fish movement distribution.

Surface Plankton A gravimetric measurement was made of the total surface plankton collected from two-minute hauls made parallel to the net sets. The data were expanded and expressed in volume of plankton per acre foot (ml/AF). The plankton collections were made to assess the conditions as they occurred during the fish collections, and to assist with other plankton studies being conducted by graduate students working at the Yellow Bay Biological Station, University of Montana. Two theses describing aspects of plankton production in Flathead were completed during the period; Morgan (1968) and Moghadam (1969).

The plankton collections taken during the netting series did indicate low surface populations during the fall and winter months, September through December (Figure 9, Appendix III). Maximum production apparently occurred during the early summer, May through July, with a smaller peak occurring during the ice-free spring period, February through March 1968. Variation in total surface plankton was evident between areas during the sample seasons and is presented in Figure 10. Volumes and dates of these collections are presented in Appendix IV. The average volume (ml/AF) of plankton based on two-minute hauls, by the sample periods were: Season A - 1,362, Season B - 8,445, Season C - 895, Season D - 8,068.

Water Chemistry Water chemistry data for Flathead Lake have been given by Howard (1928), Young (1935), Potter and Baker (1961), Morgan (1968) and Moghadam (1969). All these workers concluded that Flathead Lake waters varied only slightly during the year and that the analyses in more recent studies show no major changes from the data reported by Howard (1928). Since most of these studies were undertaken during the summer months, little information was available on water chemistry during the spring and winter periods.

During the present study water chemical analyses were made during all the major seasons, including an ice-cover period, and are presented by seasons in Figures 11, 12, 13, 14 and 15.

The ice-cover period occurred during February 1968 when most of the lake was frozen with ice depths ranging from 8 to 16 inches. Wind and the river current kept a small area open during a period when the air temperatures varied from -20° to -40° F. Two calm days during this cold allowed the ice to completely form across the lake. The lake remained in this state for seven days (February 3 - 10, 1969). The last record of the lake being completely frozen was in February 1962.

pH The range of pH over the entire lake during the sampling followed the same general pattern described by Hanzel (1969). That being, "The pH values will range, at the surface, between 7.25 and 7.90 during November through May; then rise and maintain a level between 7.90 and 8.30 from June through October".

Exceptional high seasonal readings, i.e. more alkaline, were recorded in Areas 4, 5 and 6 during Season A. The seasonal high and low pH during Season B occurred in the outlet and inlet areas, respectively. In other words, during the early spring runoff 1968, incoming water was more acidic than the water flowing from the lake (pH 7.55 and 8.25 respectively). During both summer periods (Season C and D) little variation occurred over the lake but the sub-surface waters were generally more acidic than corresponding surface waters. Reading during the ice-cover period ranged from 7.25 to 8.00 and were recorded in Areas 5 and 1 respectively.

Total Alkalinity Seasonal averages for total alkalinity (methyl-orange) varied between 82 and 89 ppm. A slight increase of 10 ppm over the seasonal average during the ice-cover period was found in the inlet areas (Areas 2 and 11). The highest of these readings was 103 ppm which was the maximum concentration found during this study.

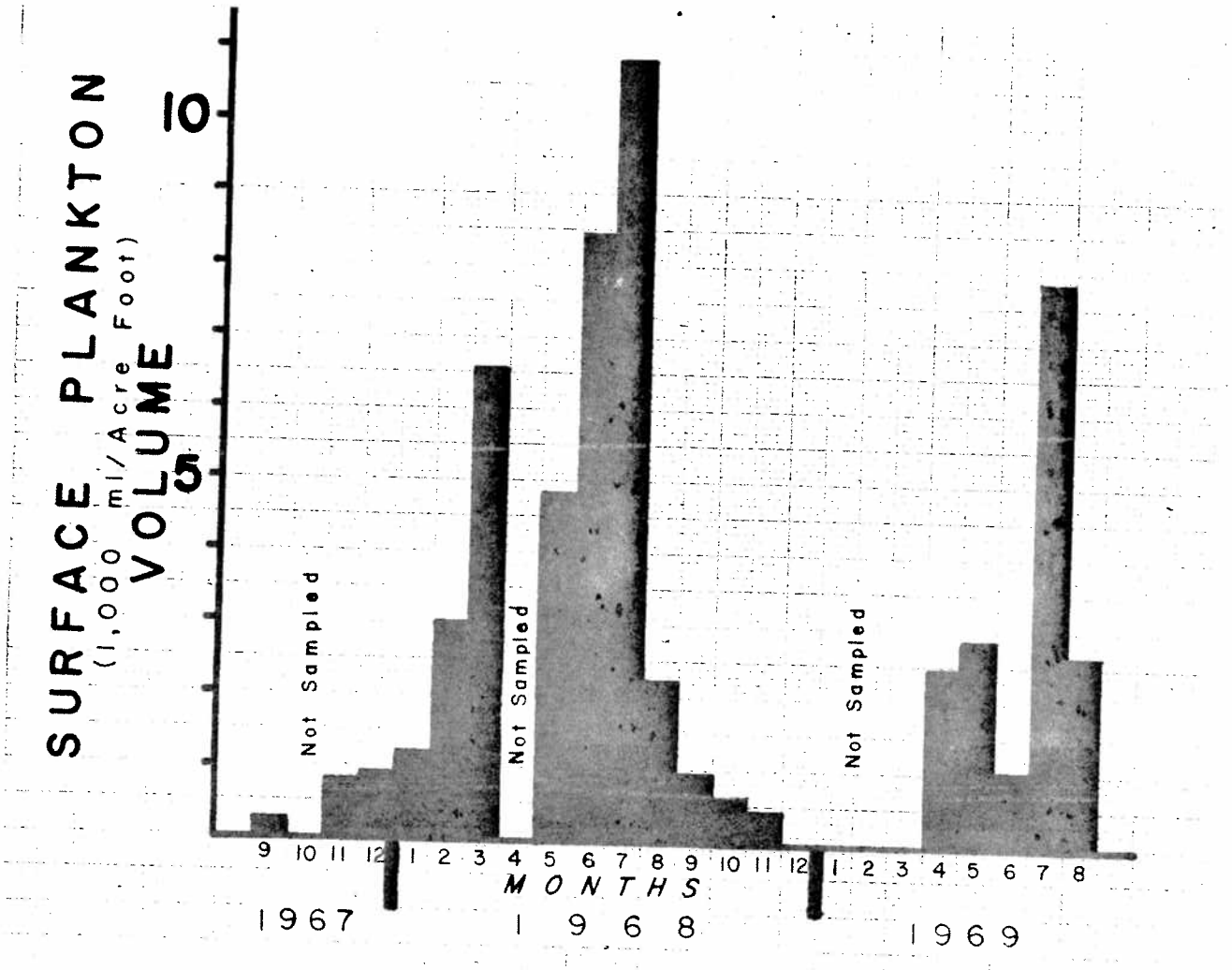

Figure 9. The monthly mean of total surface plankton, expressed in 1,000 ml/acre foot, collected in Flathead Lake, 1967-69.

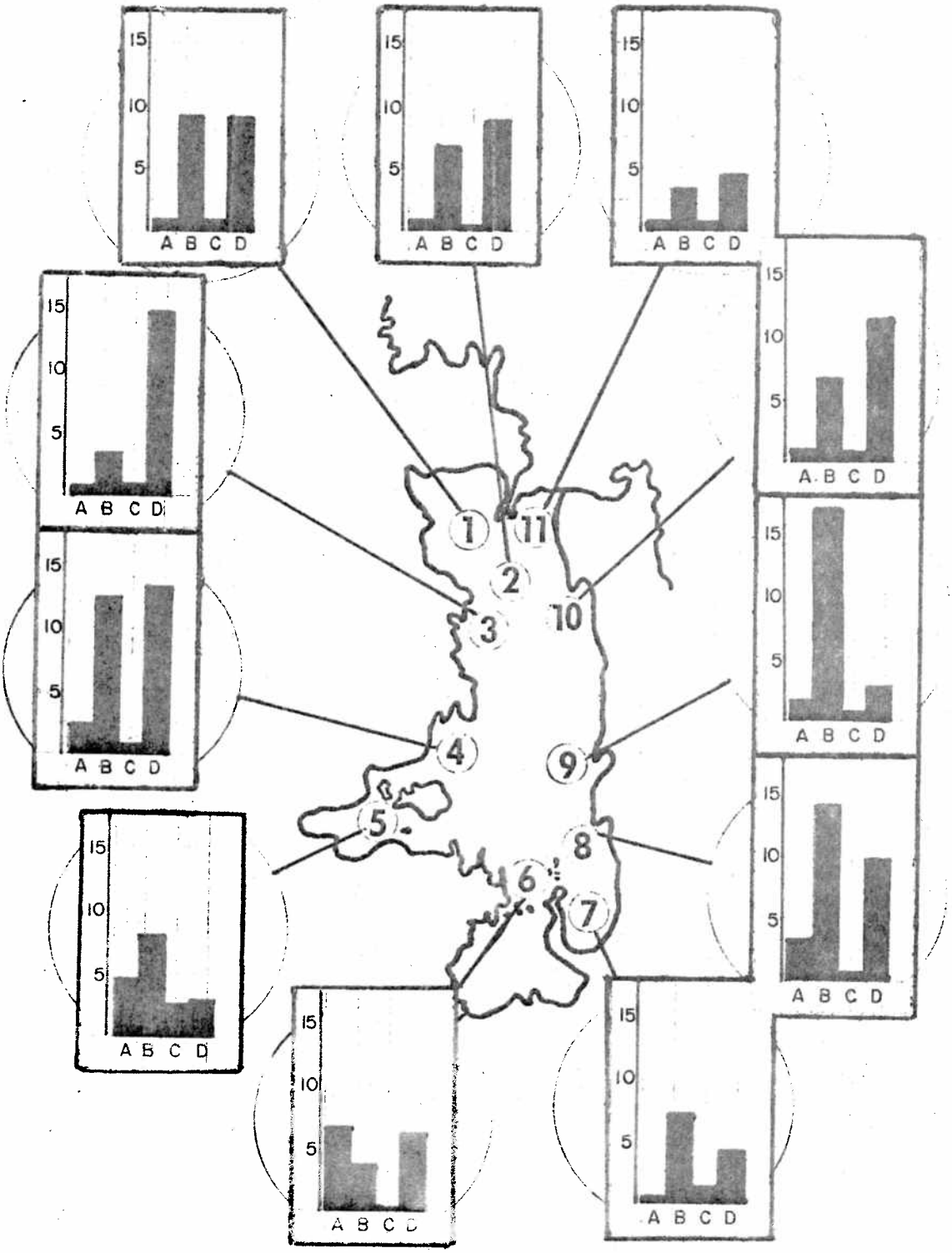

Figure 10. Plankton concentrations (1,000 ml)/acre foot during sample Seasons A, B, C and D, in Flathead Lake.

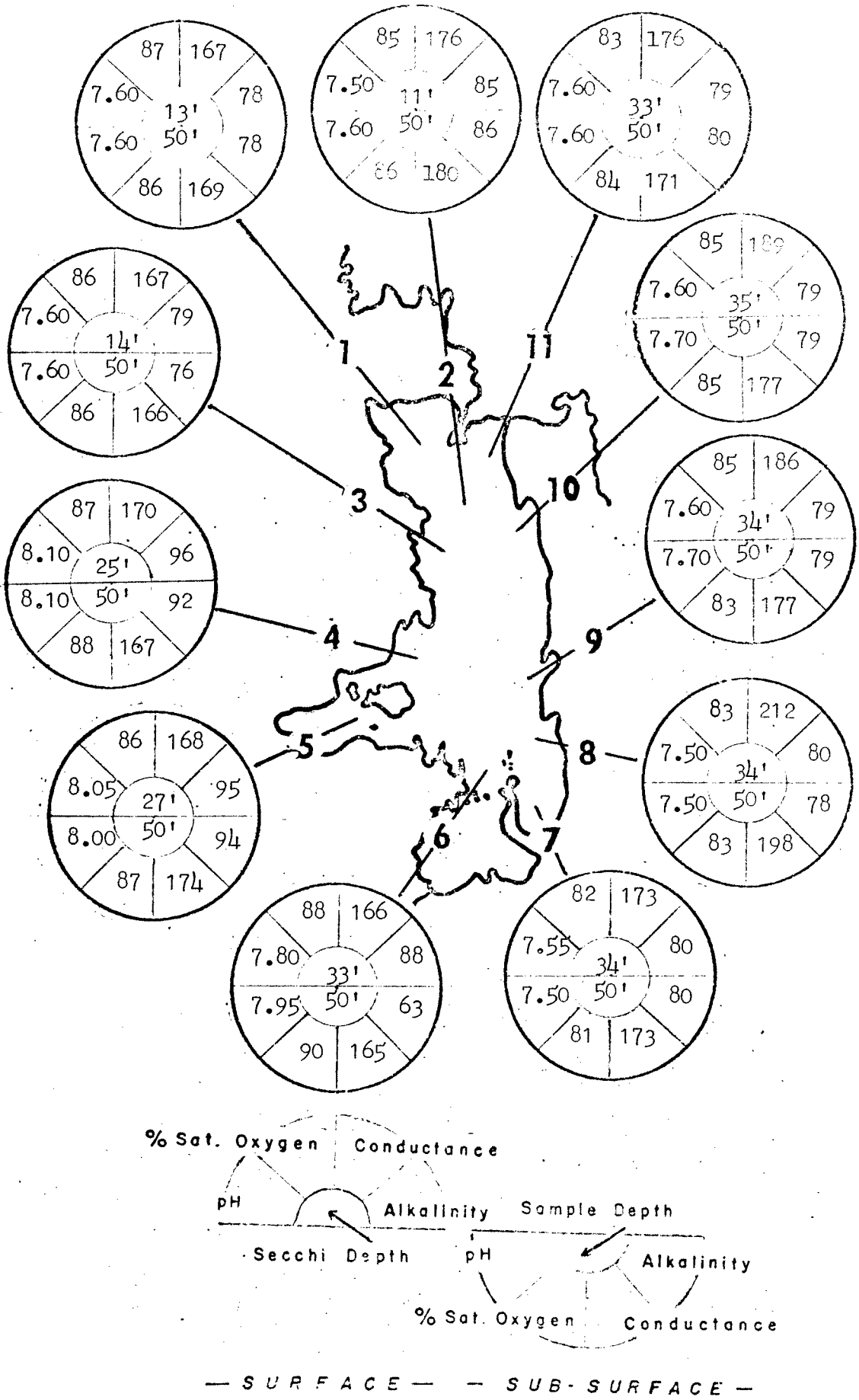

Figure 11. Basic water chemical measurements taken at the eleven lake areas, surface and sub-surface samples, during sampling Season A. (November 1967 through March 1968).

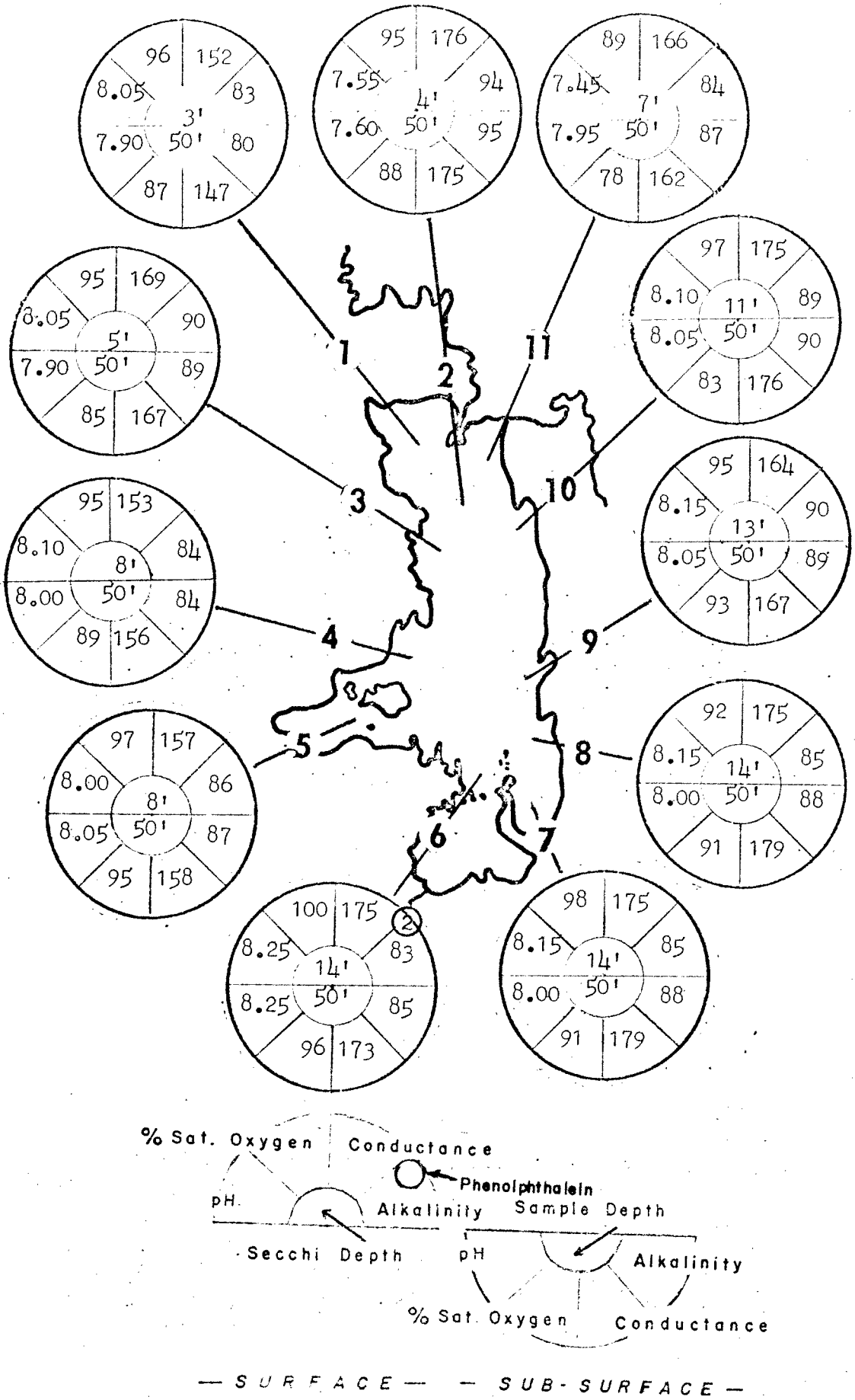

Figure 12. Basic water chemical measurements taken at the eleven lake areas, surface and sub-surface samples, during sampling Season B. (May through June 1968).

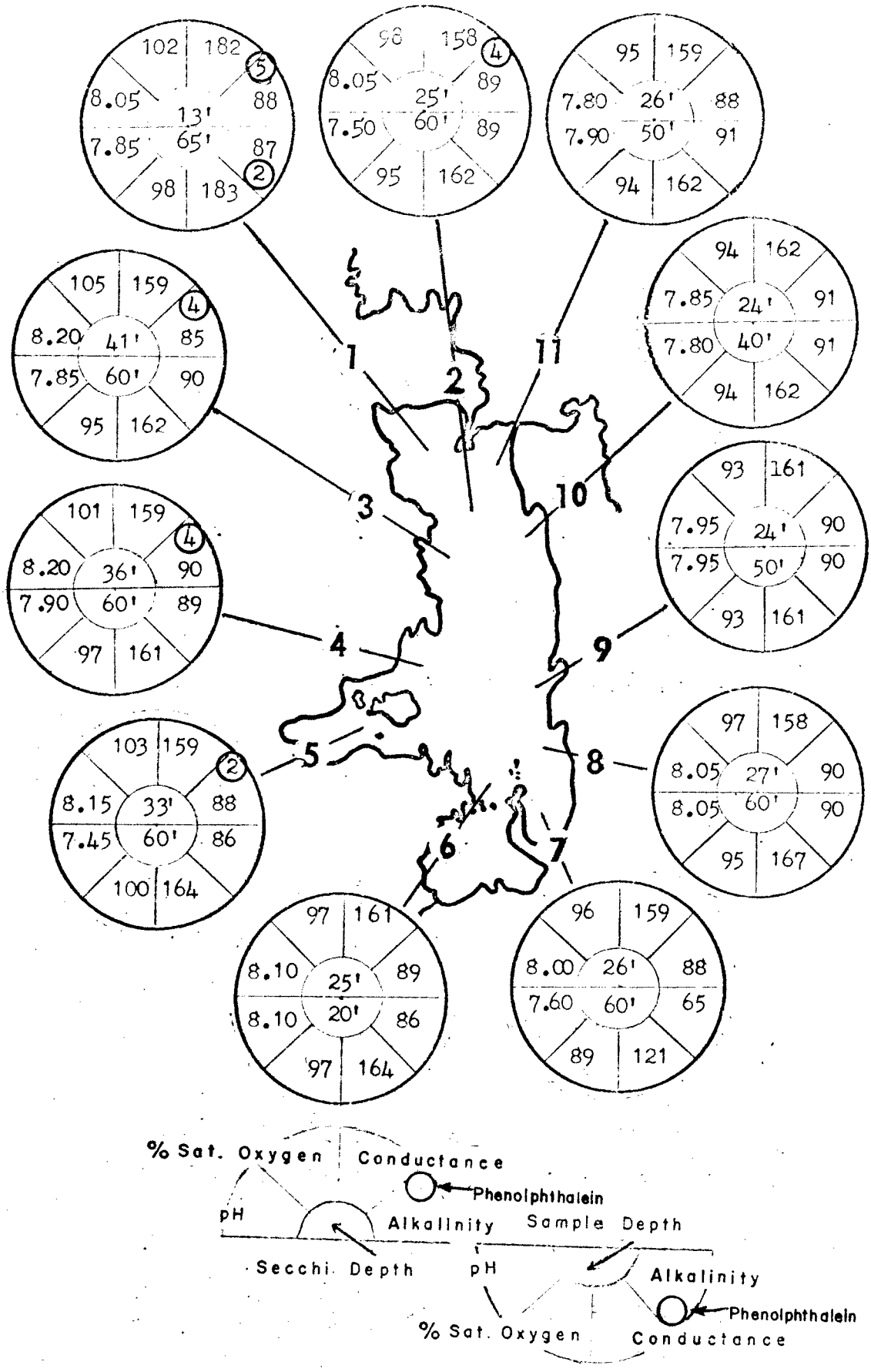

Figure 13. Basic water chemical measurements taken at the eleven lake areas, surface and sub-surface samples, during sampling Season C. (August through October 1968).

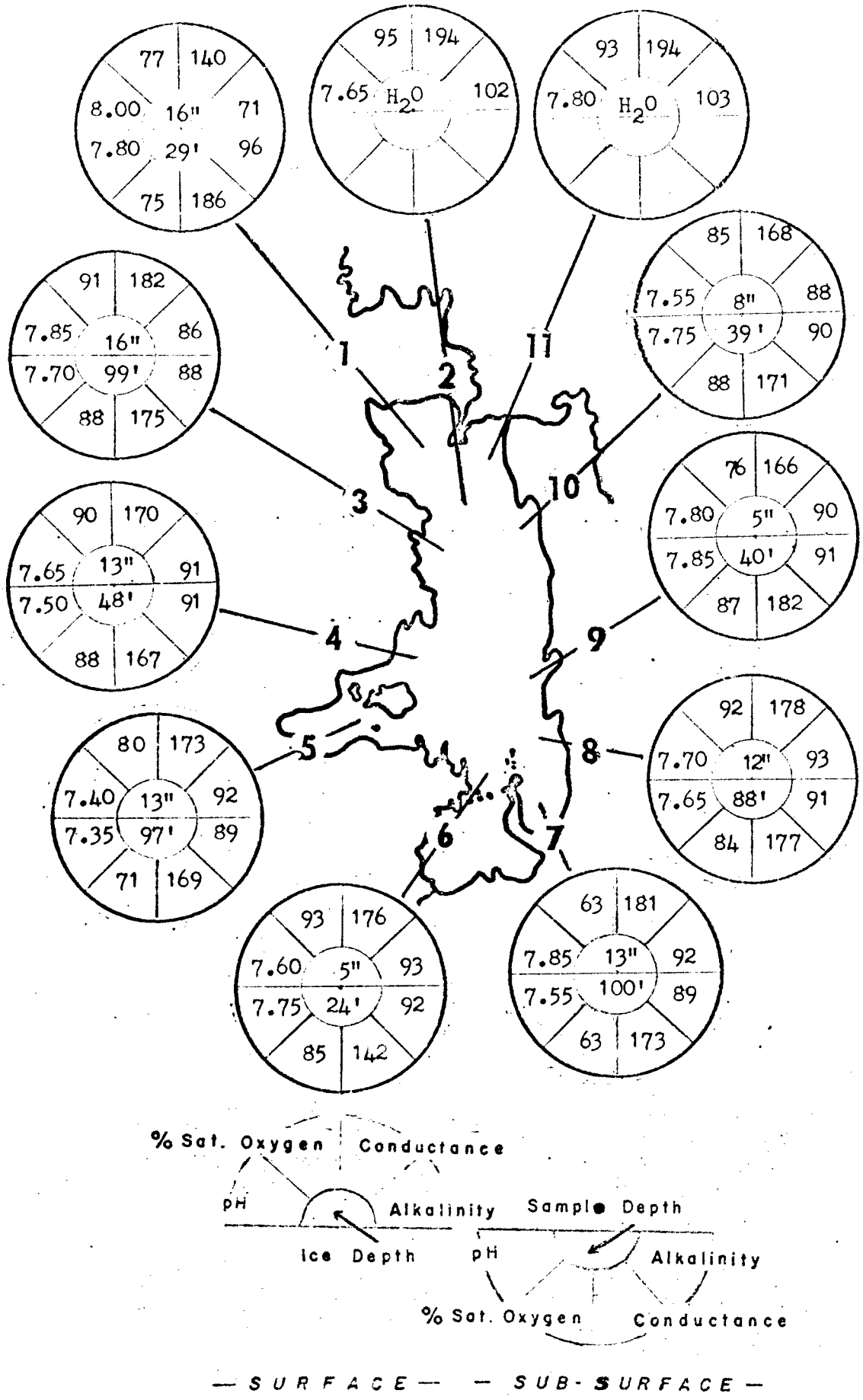

Figure 14. Basic water chemical measurements taken below the ice cover on Flathead Lake at the eleven lake areas, surface and sub-surface samples, during March 1969.

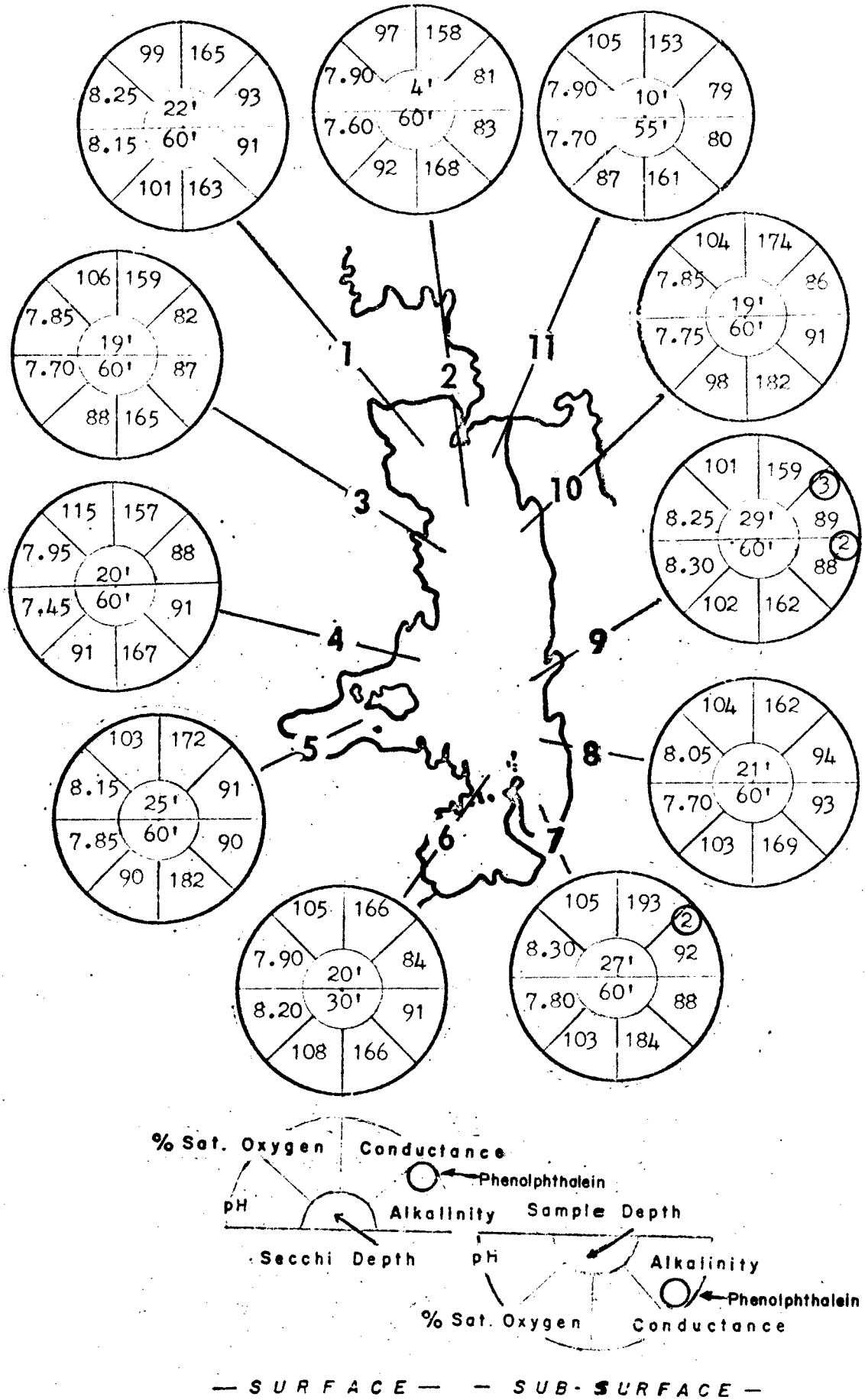

Figure 15. Basic water chemical measurements taken at the eleven lake areas, surface and sub-surface samples, during sampling Season D. (June through August 1969).

Mono-carbonates, as indicated by phenophthalein, in a range of 1 to 6 ppm were first calculated from samples taken in early July and generally persisted through September. Mono-carbonates were not recorded in Areas 8, 10 and 11.

Standard Conductance Standard conductance, as expressed in micromhos/cm and standardized to 77° F, showed little seasonal variation. Summer seasons (Seasons C and D) averaged about 10 micromhos/cm less than the other seasons sampled. High readings, 20 micromhos/cm higher than seasonal averages were found in Areas 8 and 9 during Season A; and in Areas 5 and 7 during Season D.

Dissolved Oxygen The concentration of dissolved oxygen ranged between 7.8 and 12.3 ppm during the sampling program. Further consideration of the oxygen concentration will be expressed in percent of saturation.

Oxygen concentrations prior to the establishment of the thermocline averaged 90 percent of saturation and were uniform to depths of 100 feet (maximum depth sampled). After thermal stratification, sub-surface concentrations (20 - 100 feet deep) were generally 5 - 8 percent less than the surface. This includes samples in Seasons C and D which were below the thermocline. By August, most areas in the lake were recording both surface and sub-surface saturations near or above the 100 percent level. The highest reading of oxygen was 115 percent and was found in Area 4 during July 1969.

Under the ice, oxygen concentrations averaged 85 percent at the surface and 79 percent in the sub-surface depths. The lowest saturation level, 63 percent, occurred during this ice-cover period in Areas 5 and 7.

Light Penetration

Secchi Disc Readings Light penetration, as determined by the secchi disc, ranged from 3 to 41 feet. The maximum occurred during mid-September in Areas 2 and 3. The low readings caused by sediment turbidity during the spring runoff, generally starts in mid-May and persists until June; thereafter, readings of 20 feet or more are common. Readings during other seasons ranged between 24 and 30 feet.

Water Temperatures

Thermal Patterns The thermal pattern of Flathead Lake follows that of most large deep lakes (Young, 1935). Specifically, as Flathead Lake surface waters start to warm a thermocline forms by early May and continues to expand and sink during the warm summer months which follow. The maximum depth of the upper limit of the thermocline found during the sampling was 90 feet in October. Violent winds can stir and rearrange the stratified layers during the summer months creating an unstable thermal pattern. As the epilimnion cools in the fall, the thermocline fades out when temperatures reach 46° F. Temperatures then continue to cool in a near isothermic state throughout the open winter period. An isothermic profile of 35° F. has been recorded to depths over 250 feet.

During the ice-cover period the temperatures assumed a pattern of most lakes; that is, with inverse stratification, but without a definite thermocline.

The basic temperature patterns found during the sampling season are described in the section "General Fish Distribution" and are also expressed in temperature profiles, Figures 16, 17, 18 and 19.

RECOMMENDATIONS

The major emphasis of research should continue to be directed toward the determination of the seasonal depth and area distribution of the fish with special consideration given to: (1) an intensive sampling program within small areas of the lake to determine the seasonal duration, extent and relative abundance of the fish; (2) to complete the analysis of the fish scales collected during previous sampling to permit correlation of age, growth, time of annulus formation and to compare growth rates between stations and the time of sampling; (3) to research new techniques of sampling juvenile kokanee populations for determining population trends; (4) to continue to measure water quality and to relate the causes and effects of significant changes in the water quality on the fish population, particularly age class strength.

Prepared by Delano A. Hanzel

Delano A. Hanzel

Date June 4, 1970

Waters referred to: 7-6400

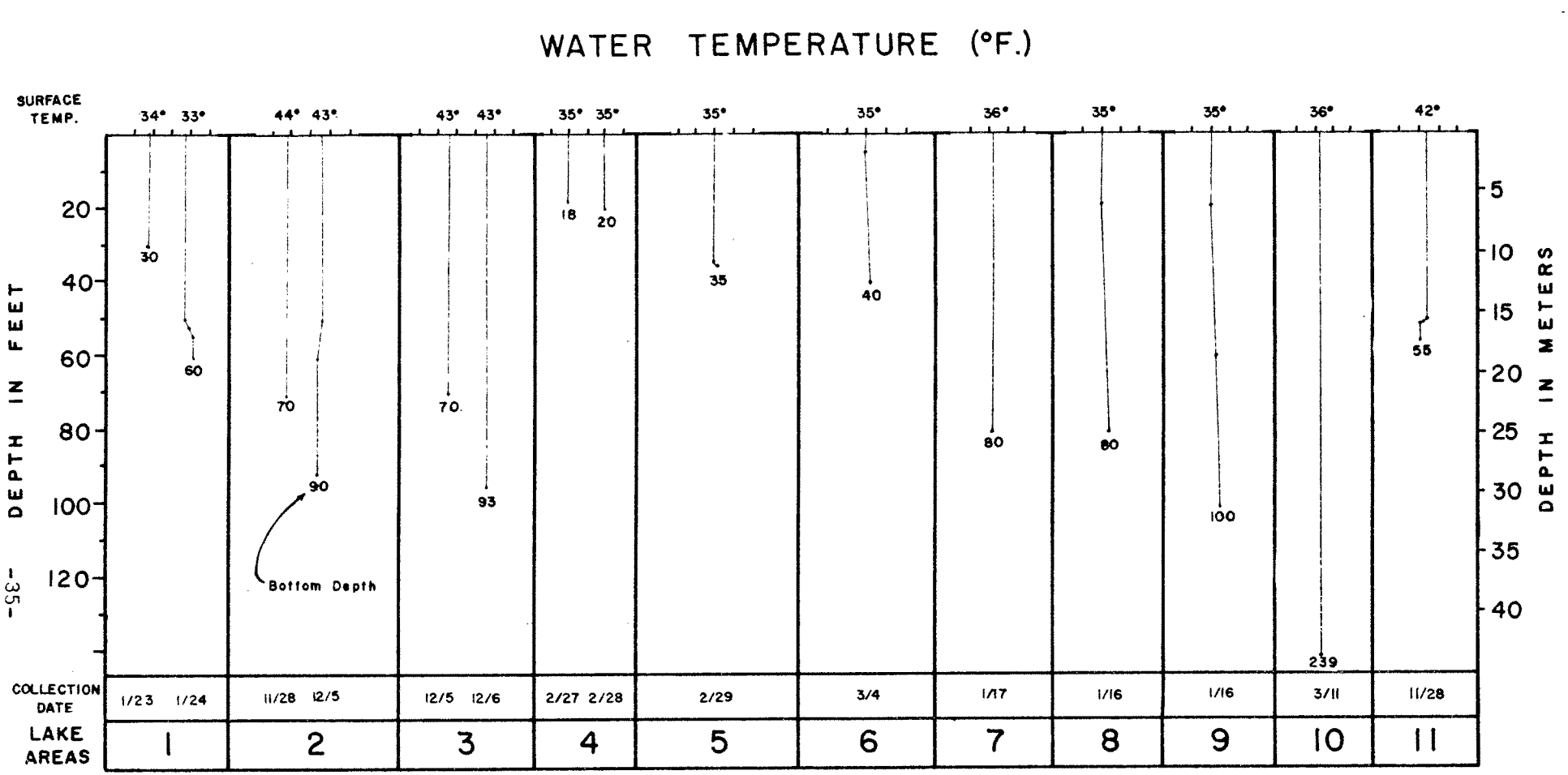

Figure 16. Selected water temperature profiles for sample stations in the eleven lake areas during Season A (November 1967 through March 1968).

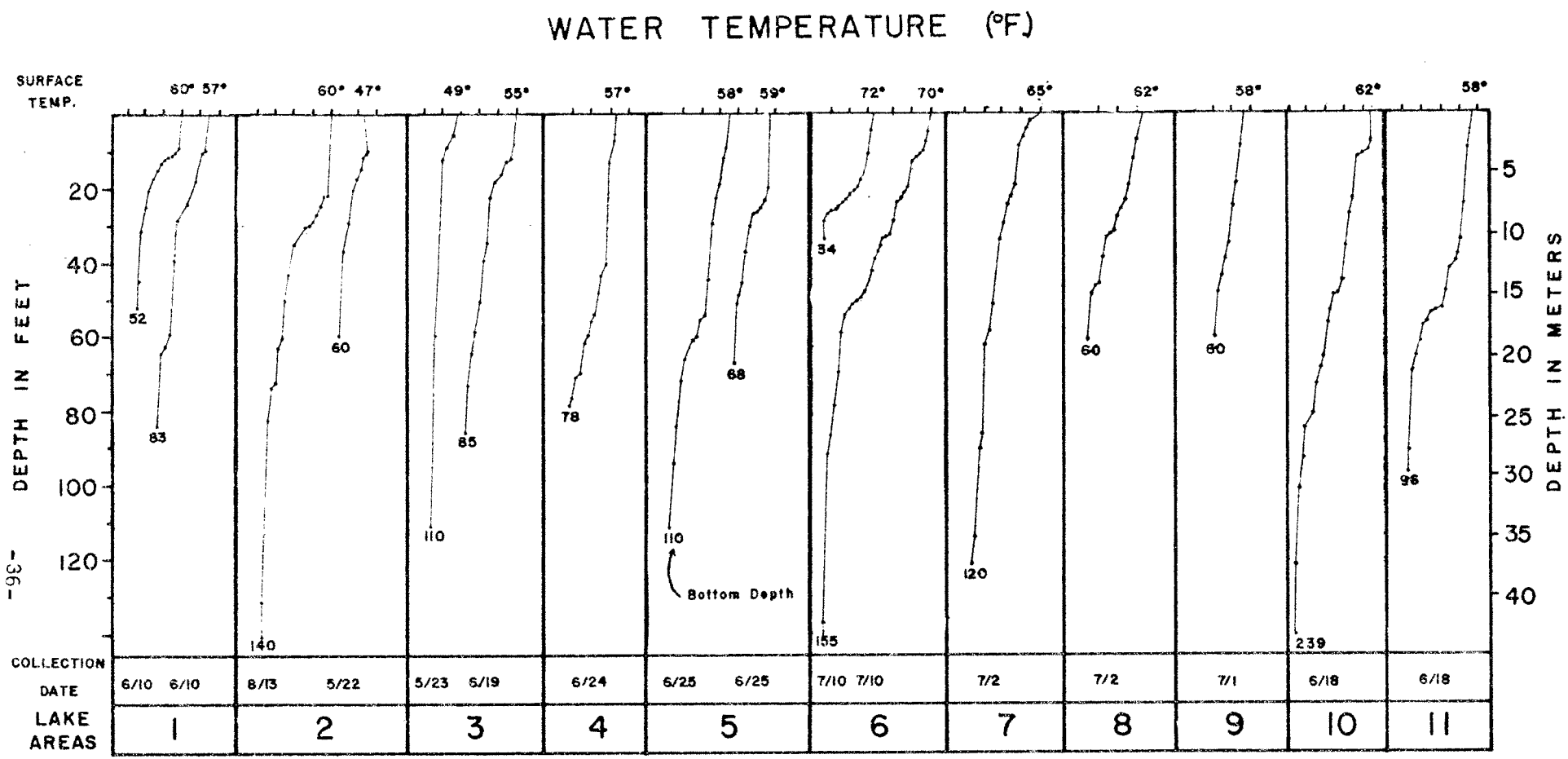

Figure 17. Selected water temperature profiles for sample stations in the eleven lake areas during Season B (May through June 1968).

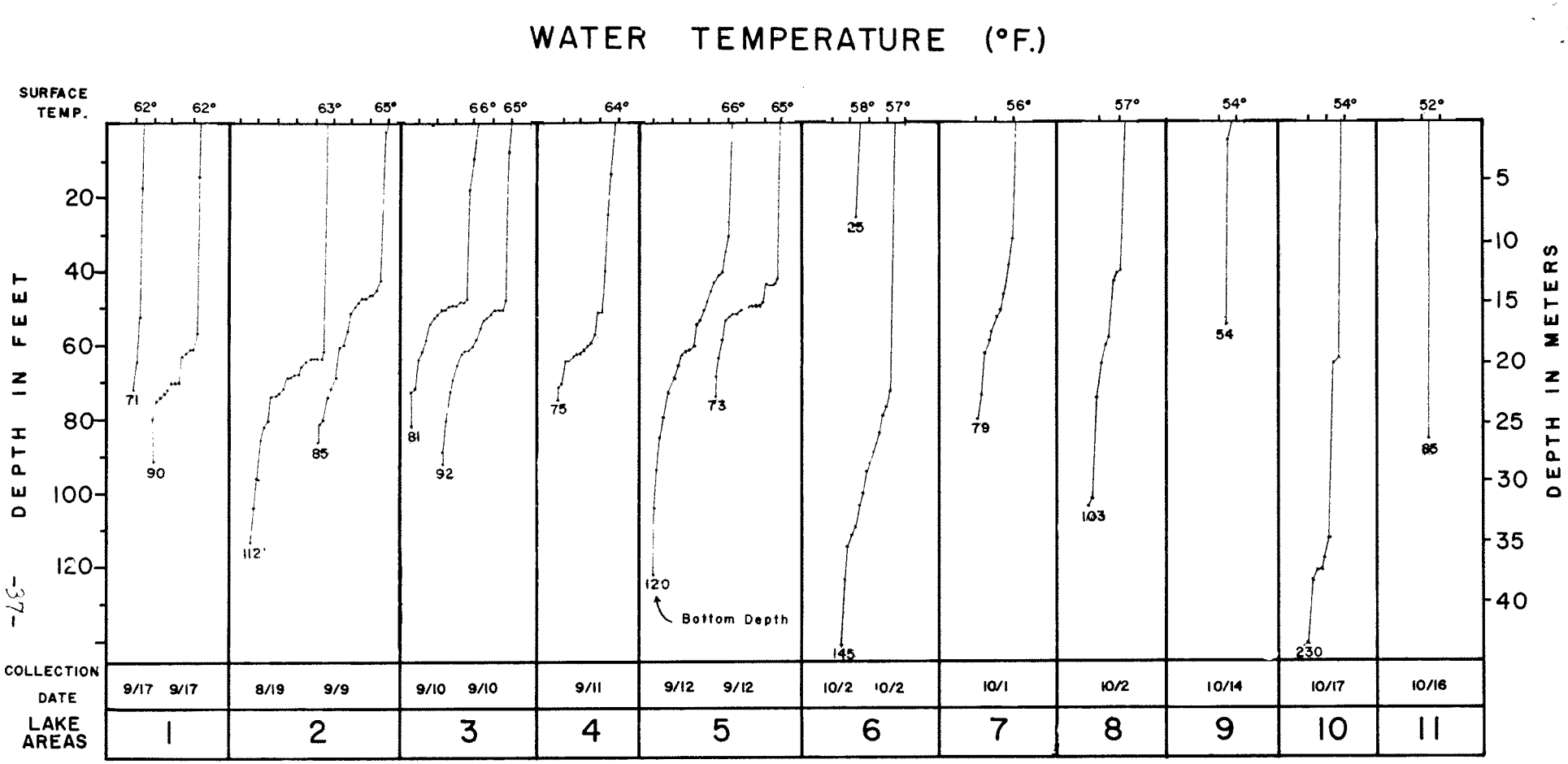

Figure 18. Selected water temperature profiles for sample stations in the eleven lake areas during Season C (August through October 1968).

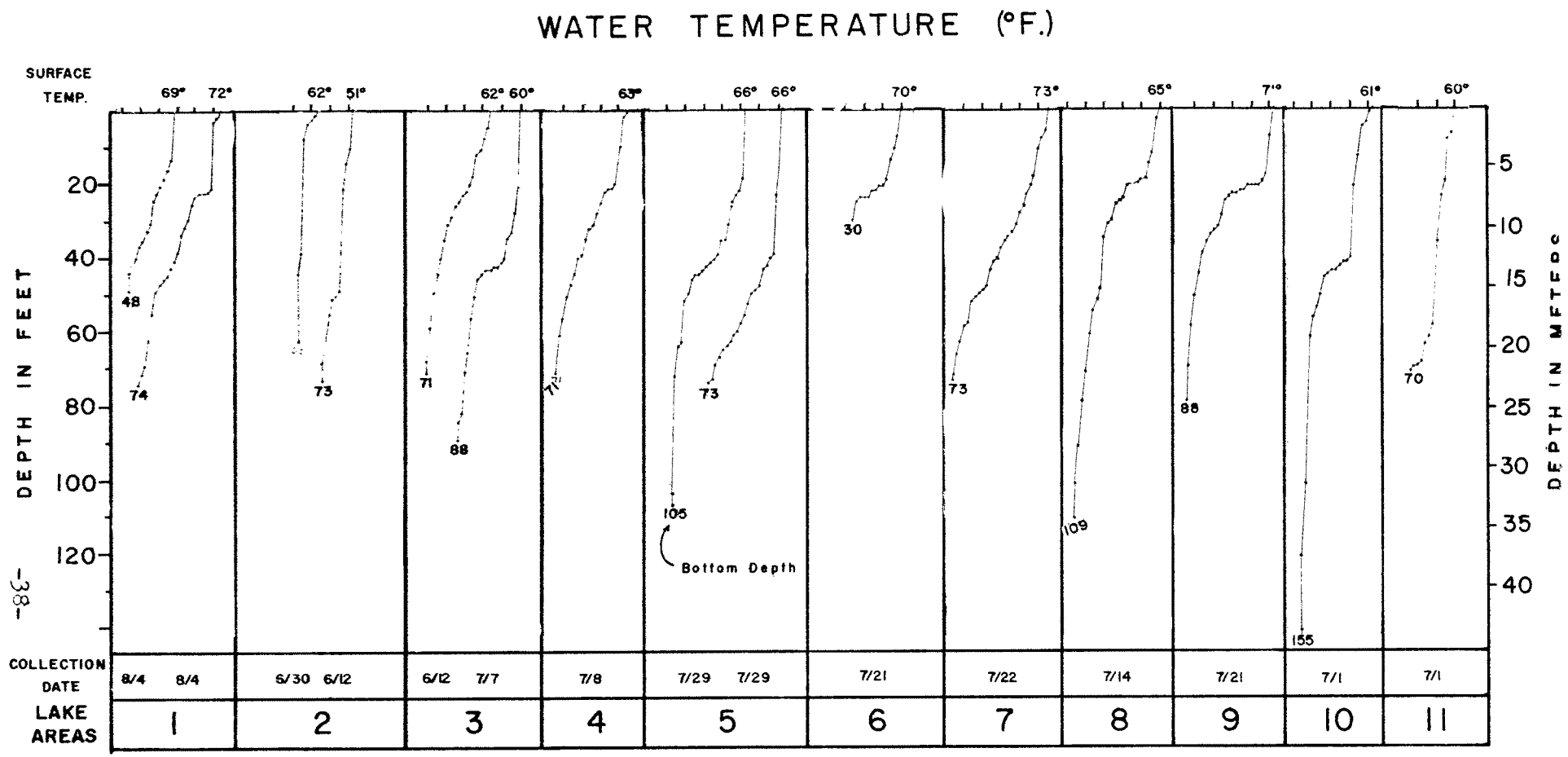

Figure 19. Selected water temperature profiles for sample stations in the eleven lake areas during Season D (June through August 1969).

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Appendix I. Number of fish collected by area in Flathead Lake, 1967-69

Season		Fish Species												Season Total
		LNf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PMf	
Area 1	A	149	31	3	-	3	7	1	24	2	18	-	3	241
	B	10	1	-	-	-	-	1	1	5	6	-	4	28
	C	43	23	-	-	2	-	-	10	1	11	4	31	125
	D	102	56	6	-	-	12	-	2	3	-	9	17	207
Species Total		304	111	9	-	5	19	2	37	11	35	13	55	601
Area 2	A	106	20	-	-	-	-	-	-	-	20	5	5	156
	B	21	2	-	-	-	-	-	1	-	1	-	3	28
	C	77	29	-	2	-	-	-	-	1	-	22	23	154
	D	62	14	-	-	-	-	2	15	4	9	2	15	123
Species Total		266	65	-	2	-	-	2	16	5	30	29	46	461
Area 3	A	25	1	-	-	-	-	-	2	-	3	-	4	35
	B	38	5	-	1	-	-	-	2	4	5	-	1	56
	C	43	15	-	2	-	-	-	-	3	3	6	-	72
	D	59	14	-	2	-	-	-	-	-	2	17	20	114
Species Total		165	35	-	5	-	-	-	4	7	13	23	25	277

Appendix I. (Continued) Number of fish collected by area, 1967-69

Seasons		Fish Species												Season Total
		LWf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PWf	
Area 4	A	8	1	-	-	-	4	3	1	-	1	-	-	18
	B	14	8	-	1	-	-	-	1	1	3	-	7	35
	C	20	25	1	2	-	-	-	-	-	5	14	34	101
	D	18	18	-	-	-	-	-	1	-	2	1	24	64
Species Total		60	52	1	3	-	4	3	3	1	11	15	65	218
Area 5	A	5	2	1	-	-	-	-	-	1	9	-	-	18
	B	24	14	1	3	-	-	-	3	-	8	7	1	61
	C	17	12	-	7	-	-	-	-	3	2	3	1	45
	D	30	16	-	1	-	-	-	-	-	-	1	8	56
Species Total		76	44	2	11	-	-	-	3	4	19	11	10	180
Area 6	A	5	1	-	-	1	-	-	39	1	23	-	-	70
	B	71	18	9	-	-	-	-	3	-	5	7	4	117
	C	21	-	-	-	17	-	4	29	-	37	1	-	109
	D	57	12	2	-	4	2	-	2	-	21	4	-	104
Species Total		154	31	11	-	22	2	4	73	1	86	12	[illegible]	400

Appendix I. (Continued) Number of fish collected by area in Flathead Lake, 1967-69

Seasons		Fish Species												Season Total
		LWf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PWf	
Area 7	A	5	2	3	-	1	-	4	1	-	1	-	3	20
	B	9	10	1	1	-	-	-	-	-	22	8	-	51
	C	11	8	1	1	-	-	-	-	1	2	4	-	28
	D	32	8	-	-	-	-	-	-	-	1	-	2	43
Species Total		57	28	5	2	1	-	4	1	1	26	12	5	142
Area 8	A	11	4	4	1	-	-	-	5	1	1	-	5	32
	B	4	4	-	1	-	-	-	-	-	8	9	-	26
	C	46	11	2	1	2	-	1	18	5	23	4	1	114
	D	69	19	4	2	-	-	3	-	1	8	2	32	140
Species Total		130	38	10	5	2	-	4	23	7	40	15	38	312
Area 9	A	2	2	1	-	-	-	-	-	-	-	-	-	5
	B	67	18	-	5	-	-	-	-	3	28	2	1	124
	C	19	12	-	1	1	-	-	5	3	17	18	2	78
	D	77	15	4	-	-	-	-	-	-	11	2	6	115
Species Total		165	47	5	6	1	-	-	5	6	56	22	9	322

Appendix I. (Continued) Number of fish collected by area in Flathead Lake, 1967-69

Seasons	Fish Species												Season Total
	LWf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PWf	
Area 10 A	8	10	2	-	-	1	1	3	3	1	14	-	43
B	12	12	5	-	-	-	-	-	-	1	4	-	34
C	1	14	-	-	2	-	1	7	3	23	124	1	176
D	38	4	-	2	-	-	-	-	-	9	-	-	53
Species Total	59	40	7	2	2	1	2	10	6	34	142	1	306
Area 11 A	50	11	-	-	-	-	-	-	1	-	1	1	64
B	9	2	-	-	1	-	-	-	-	-	-	3	15
C	43	9	-	-	-	-	1	2	3	15	11	2	86
D	36	7	-	-	-	3	-	-	1	-	75	6	128
Species Total	138	29	-	-	1	3	1	2	5	15	87	12	293
	1,574	520	50	36	34	29	22	177	54	365	381	270	3,512

Appendix II. Percent of species composition of fish collected in each sample area during sample Seasons A, B, C and D in Flathead Lake

Sample Season A (November 1967 through March 1968)

Areas	Species and Percent of Catch											
	LWf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PWf
1	61.8	12.9	1.2	-	1.2	2.9	0.4	10.0	0.9	7.5	-	1.2
2	68.0	12.8	-	-	-	-	-	-	-	12.8	3.2	3.2
3	71.4	2.9	-	-	-	-	-	5.7	-	8.6	-	11.4
4	44.4	5.5	-	-	-	22.4	16.7	5.5	-	5.5	-	-
5	27.9	11.1	5.5	-	-	-	-	-	5.5	50.0	-	-
6	7.1	1.4	-	-	1.4	-	-	55.7	1.4	32.9	-	-
7	25.0	10.0	15.0	-	5.0	-	20.0	5.0	-	5.0	-	15.0
8	34.4	12.5	12.5	3.1	-	-	-	15.6	3.1	3.1	-	15.6
9	40.0	40.0	20.0	-	-	-	-	-	-	-	-	-
10	18.6	23.3	4.6	-	-	2.3	2.3	7.0	7.0	2.3	32.6	-
11	78.1	17.2	-	-	-	-	-	-	1.6	-	1.6	1.6

Sample Season B (May through July 1968)

1	35.7	3.6	-	-	-	-	3.6	3.6	17.9	21.4	-	14.3
2	75.0	7.1	-	-	-	-	-	3.6	-	3.6	-	10.7
3	67.9	8.9	-	1.8	-	-	-	3.6	7.1	8.9	-	1.8
4	40.0	22.9	-	2.8	-	-	-	2.8	2.9	8.6	-	20.0
5	39.3	23.0	1.6	4.9	-	-	-	4.9	-	13.1	11.5	1.6
6	60.7	15.4	7.7	-	-	-	-	2.6	-	4.3	6.0	3.4
7	17.6	19.6	1.9	1.9	-	-	-	-	-	43.1	15.7	-
8	15.4	15.4	-	3.8	-	-	-	-	-	30.8	34.6	-
9	54.0	14.5	-	4.0	-	-	-	-	2.4	22.6	1.6	0.8
10	35.3	35.3	14.7	-	-	-	-	-	-	2.9	11.8	-
11	60.0	13.3	-	-	6.7	-	-	-	-	-	-	20.0

Appendix II. (Continued) Percent of species composition of fish collected in each sample area during sample Seasons A, B, C and D in Flathead Lake

Sample Season C (August through October 1968)

Areas	Species and Percent of Catch											
	LWf	DV	Wf	LT	YP	Ct	CSu	PM	LNSu	SQ	Kok	PWf
1	34.4	18.4	-	-	1.6	-	-	8.0	0.8	8.8	3.2	24.8
2	50.0	18.8	-	1.3	-	-	-	-	0.6	-	14.3	14.9
3	59.7	20.8	-	2.8	-	-	-	-	4.2	4.2	8.3	-
4	19.8	24.7	1.0	2.0	-	-	-	-	-	5.0	13.9	33.6
5	37.8	26.7	-	15.6	-	-	-	-	6.7	4.4	6.7	2.1
6	19.3	-	-	-	15.6	-	3.7	26.6	-	33.9	0.9	-
7	39.3	28.6	3.5	3.6	-	-	-	-	3.6	7.1	14.3	-
8	40.3	9.6	1.8	0.9	1.8	-	0.9	15.7	4.4	20.2	3.5	0.9
9	24.3	15.4	-	1.3	1.3	-	-	6.4	3.8	21.8	23.1	2.6
10	0.5	8.0	-	-	1.1	-	0.6	4.0	1.7	13.1	70.5	0.5
11	50.0	10.5	-	-	-	-	1.1	2.3	3.5	17.5	12.8	2.3

Sample Season D (June through August 1969)

1	49.3	27.1	2.9	-	-	5.8	-	1.0	1.4	-	4.3	8.2
2	50.4	11.6	-	-	-	-	1.5	12.2	3.3	7.3	1.5	12.2
3	51.8	12.4	-	1.7	-	-	-	-	-	1.7	14.9	17.5
4	28.1	28.1	-	-	-	-	-	1.6	-	3.1	1.6	37.5
5	53.5	28.6	-	1.8	-	-	-	-	-	-	1.8	14.3
6	54.8	11.5	1.9	-	3.8	1.9	-	1.9	-	20.3	3.9	-
7	74.4	18.6	-	-	-	-	-	-	-	2.3	-	4.7
8	49.3	13.6	2.9	1.4	-	-	2.1	-	0.7	5.7	1.4	22.9
9	67.0	13.0	3.5	-	-	-	-	-	-	9.6	1.7	5.2
10	71.7	7.5	-	3.8	-	-	-	-	-	17.0	-	-
11	28.1	5.5	-	-	-	2.3	-	-	0.8	-	58.6	4.7

Appendix IV. Total volume of surface plankton collected at the eleven areas during the four sample seasons*

Areas	Season A		Season B		Season C		Season D	
	ml/AF	Date	ml/AF	Date	ml/AF	Date	ml/AF	Date
1	919	(1/24)	9,100	(6/10)	725	(9/17)	9,100	(6/12)
2	875	(12/05)	6,600	(5/22)	245	(9/09)	8,800	(6/12)
3	984	(12/05)	3,200	(5/23)	949	(9/10)	14,500	(6/18)
4	2,200	(2/22)	12,500	(6/24)	850	(9/10)	13,200	(7/08)
5	4,600	(2/29)	8,000	(6/25)	2,600	(9/12)	2,800	(7/28)
6	6,500	(3/04)	3,600	(7/10)	125	(10/02)	6,150	(7/21)
7	600	(1/17)	7,000	(7/02)	1,200	(10/01)	4,013	(7/22)
8	3,090	(1/16)	13,700	(7/03)	729	(10/02)	9,600	(7/14)
9	1,700	(1/15)	16,300	(7/01)	612	(10/16)	2,800	(7/21)
10	800	(1/10)	6,500	(6/18)	700	(10/16)	11,200	(7/01)
11	800	(11/29)	3,300	(6/18)	846	(9/16)	4,500	(7/01)
Rounded Average	2,097		8,164		871		7,878	

* Season A - November 1967 through March 1968
Season B - May through July 1968
Season C - August through October 1968
Season D - June through August 1969

Appendix III. Average monthly surface plankton concentrations taken from Flathead Lake (September 1967 through August 1969)

Date	Average	Number of Samples
1967		
September	284	1
November	815	3
December	929	2
1968		
January	1,210	11
February	3,042	3
March	6,548	1
May	4,834	3
June	8,453	9
July	10,822	6
August	2,260	1
September	952	11
October	668	7
November	434	1
1969		
April	2,491	1
May	2,893	4
June	1,037	6
July	7,859	14
August	2,644	2