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Distribution and Movements of Some Fishes in Bear Lake, Utah-Idaho, 1958-59

Stanley K.Y. Loo
Utah State University

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DISTRIBUTION AND MOVEMENTS OF SOME FISHES
IN BEAR LAKE, UTAH-IDaho, 1958-59

STANLEY K. Y. LOO

1960
DISTRIBUTION AND MOVEMENTS OF SOME FISHES IN
BEAR LAKE, UTAH-IDAHO, 1958-59

by

Stanley K. Y. Loo

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Fishery Biology

Approved:

W. F. Sigler
Major Professor

W. F. Sigler
Head of Department

Dean of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

1960
ACKNOWLEDGMENTS

I wish to express my appreciation to Drs. William F. Sigler, Head of the Wildlife Management Department, Utah State University, and John M. Neuhold, Assistant Professor, Wildlife Management Department, for their advice and help during this study.

Sincere appreciation is given also to Thomas J. Hassler, Gar W. Workman, D. Wayne Linn, Joseph W. Angelovic, and other graduate students for their assistance in gathering of the data. The National Science Foundation, Utah Cooperative Wildlife Research Unit, and the Wildlife Management Department of the Utah State University, under whose finances this research was conducted are also acknowledged.

My thanks and sincere gratitude is also given to my wife, Kay, for her help in the completion of this study.

Stanley K. Y. Loo
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During the summer of 1958, a study of the "Population Question of the Smelt Species" of Bear Lake, Idaho and Utah, was sponsored in part by a National Science Foundation grant to the Wildlife Management Department of Utah State University. The study was designed to extend over a period of three years.

The collection of the material presented in this thesis was initiated in November, 1958, and terminated in October, 1959. Field work was carried out each weekend as weather permitted. Adverse winter conditions during January, February, and March of 1959 prevented field work.

This research was designed to study the distribution and movement of some species of fish in relation to (1) depth at 15, 30, 60, and 150 feet and (2) water temperature at these depths.
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INTRODUCTION

During the summer of 1958, a study of the "Population Dynamics of the Small Benthic Fishes of Bear Lake, Idaho and Utah," was sponsored in part by a National Science Foundation grant to the Wildlife Management Department of Utah State University. The study was designed to extend over a period of three years.

The collection of the material presented in this thesis was initiated in November, 1958, and terminated in October, 1959. Field work was carried out each weekend as weather permitted. Adverse winter conditions during January, February, and March of 1959 prevented field work.

This research was designed to study the distribution and the movement of some species of fish in relation to (1) depths at 15, 50, 100, and 150 feet and (2) water temperatures at these depths.
REVIEW OF LITERATURE

For many years Bear Lake has attracted many investigators as a site of fisheries research. Kemmerer, Bovard, and Boorman (1923) made a brief survey of Bear Lake as a part of a study of western states trout waters. Their three-year study (1911-1913) included soundings, temperature readings, water analysis for dissolved gases, and a few plankton collections.

In 1915, Snyder and Hubbs made a fish collection in Bear Lake. From this collection, three species of whitefishes were described by Snyder (1919).

Tanner, in 1930, collected peaknose cisco, Coregonus gmnifer (Snyder) for a food habit study by gill netting in the Lake (Tanner, 1936).

A. S. Hazzard (1935) briefly investigated the Lake in 1933.

From 1938 through 1941, Stillman Wright and L. Edward Perry and personnel of the Fish and Game Departments of both Utah and Idaho made extensive fisheries studies at Bear Lake (Perry, 1943). Perry collected data on the peaknose cisco in fulfillment of his doctoral research.

A bulletin, Bear Lake, Its Fish and Fishing, was compiled by McConnell, Clark, and Sigler (1957). This publication summarized the federal aid programs which were carried out at Bear Lake by the Utah and Idaho Fish and Game Departments and Utah State University.

Smart (1956) continued the research on Bear Lake with a bottom fauna study. He found in general that the morphometric factors of the Lake
and the fluctuations of the lake level drastically affected the bottom fauna population.

One of the most significant factors that affect the distributions of fish is temperature. According to Brett (1956):

Temperature constantly conditions the fish through acclimation while governing the scope for metabolic rate; performance is best in the region of the preferred temperature; and a sensitivity to small gradients of temperature may act as a directive factor.

It is generally known that each species of fish has a certain optimum temperature for activity.

The selected or preferred temperatures for the carp, *Cyprinus carpio* (Linnaeus), was determined in Canada for six acclimated temperatures by Pitt, Garside, and Hepburn (1956). They found 90° F. was the final preferendum of carp. The final preferendum is defined as the point at which a preferred temperature equals the acclimation temperature. This is the temperature which fish eventually select regardless of their previous thermal experiences.

Sigler (1958) believed that 90° F. was obviously above the temperature that carp can either reproduce or survive in for a long period of time on short rations. He added, however, they could probably live at this temperature for long periods, if sufficient food were available.

Sigler (1958) speculated that the average optimum temperature for carp was 68° F. This appeared to be the maximum temperature at which carp will spawn. Sigler added that this was only a hypothetical situation since probably no constant temperature of carp habitat exists. Sigler's report mentioned that a report by Moen suggested the possibility
that there is a threshold of temperature involved that functions above 72° to 75° F., at which point the metabolism causes the fish to move about more rapidly, to feed more, and to die quicker in the absence of food with excessive movement.

In general, cold water fishes have a lower level of thermal tolerance than inhabitants of warmer waters (Brett, 1956). Thermal receptors possessed by fish are found in their lateral-line system. This permits them to respond quickly to temperature differences (Hoagland, 1933). It was found in Norris Reservoir that water temperature was a major factor in fish distribution when a wide range in temperature was available to fish in summer and early fall (Dendy, 1945; Eschmeyer, 1945; and Cady, 1945).

Fry (1937) observed a spring migration of cisco, Coregonus artedi (Le Sueur) to deeper water in Lake Nipissing, Ontario. He interpreted this movement as selective responses to escape the influence of the warm surface temperature. Perry (1943) claimed that the peaknose cisco in Bear Lake sought temperatures below 59° F. during the summer and distributed themselves to all depths during the rest of the year.

The yellowbelly sunfish, Lepomis auritus (Linnaeus) was observed in laboratory experiments to seek deep water during the cold season and remained there until the water warmed sufficiently in the summer at which time it began to move about (Breder and Mighelli, 1935). Eschmeyer (1945) found in Norris Reservoir spring fishing began earlier in the upstream areas than in the region near the dam. The condition there was attributed to differences in water temperatures.
According to Collins (1952), there is a possibility that the response of migrating anadromous fishes to temperature differences may be a family characteristic. He added that many factors which may have a directional influence upon migrating fish must be considered.

Data collected from Norris Reservoir showed that temperature was more significant than depth in the distribution of fishes (Dendy, 1946). In their study of depth distribution of fishes, Hile and Juday (1941) failed to find a relationship among temperature, dissolved gases, and bathymetric distribution of fishes in Wisconsin lakes.

Odell (1932) observed in New York that the common sucker, Catostomus commersoni (Lacepede) and yellow perch, Perca flavescens (Mitchill) were found over a wider range than other species and were not restricted to the shallow areas.

Available data indicate that fish movements do follow trends or patterns. A striking demonstration of such a movement trend was shown by Dendy (1945). For many years there were various attempts to improve the sport fishery in TVA impoundments. Dendy found that fish distribution in any two reservoirs could not be expected to remain similar because of changes of thermal stratification and of differences in dissolved gases. Widespread publications of predictions made by Dendy of depth distribution of different species in certain reservoirs were presented for the benefit of sport fishermen. These predications were based on three years of accumulated data and helped to increase fishing in the storage reservoirs. Research of this type had gained public satisfaction and support for more of this kind of research.
DESCRIPTION OF THE LAKE

Bear Lake is located in northcentral Utah on the Utah-Idaho state line (Figure 1). Approximately half of the lake is located in Utah and half in Idaho. It spans 20 miles from north to south and varies in width from four to eight miles. The widest point is at the vicinity of the Utah-Idaho state line. It is deepest (208 feet) at the east side, north of the South Eden delta. The surface area of this oval shaped lake is approximately 110 square miles and its shore line is approximately 48 miles. The shore line is uniformly regular with no coves or bays. About 15 per cent of the lake is 25 feet or less in depth. The total area in excess of 100 feet is around 52 per cent. The Lake has a maximum level of 5,923.6 feet above sea level (Smart, 1958).

Fluctuation of the lake level varies generally from three to four feet annually. Some lake water is removed for irrigation and hydro-electric power by means of a pumping station at the north end of the lake. Wave action and the fluctuation of the lake level make it difficult for plant life to survive in Bear Lake. In comparison to many lakes of similar size, Bear Lake is relatively unproductive of phytoplankton. Likewise, animal life is not abundant (McConnell, Clark, and Sigler, 1957). The shape of the basin has long been recognized as an important factor in limiting the production of plants and animals in a lake according to Rawson (1952).
MATERIALS AND METHODS

Types of nets

Two types of nylon gill nets were used in obtaining the fish specimens for this study. One type of net was 100 feet in length, six feet in depth, and composed of three-eighths inch mesh (bar measure). The other net was 125 feet in length, five feet in depth, and composed of meshes of three-fourths, one, one and one-fourth, one and one-half, and two inches (bar measure). Each mesh size made up a 25-foot panel. Only bottom set nets were used throughout this study. The catch of fish was within the layer of water five to six feet deep, immediately above the bottom.

Location of stations

Eight stations were established in regard to the relative uniformity and distribution of the depth areas of the lake. Two stations were located at each of the following depths: 15 feet, 50 feet, and 100 feet; and one station each at 125 feet and 150 feet (Figure 1). The stations formed a transect line parallel to the Utah-Idaho state-line. The transect line ran from the mouth of Swan Creek to the mouth of North Eden Creek (almost directly east-west). Since there was very little difference in water temperature and bottom type between the 125-foot and 150-foot contours, these two stations were considered as homogeneous and were grouped as one (150 feet) for the purpose of this study. The location of each station was determined by sounding with a weighted line and its position was marked permanently with an anchored buoy.
1 inch equals 2 miles

- station

Figure 1. Localities of stations at different depths, Bear Lake, Utah-Idaho (McConnell, Clark and Sigler, 1957; Smart, 1958)
Sampling

Each weekend throughout the year and four times a week during the summer months one gill net was set at each station. These nets were left overnight, the time averaged 15 hours. The type of net used at each station and the direction of the lay of the net (whether cross-wise or axis-wise to the lake), were essentially set to a predetermined random design. The direction of the fish traveling at the time they became entangled in the nets was noted when the nets were lifted. A water temperature profile at each station was recorded by a bathythermograph.

Data for the months of January, February, and March, 1959, were not obtained. Floating ice during these months prevented boating operations.

All fish captured that were in good condition were fin-clipped and returned at that time. The size of fish and direction of movement were recorded. All measurements were in total length in inches. Fish from each station were fin-clipped with a specified clip designated for that station. Fish movement from one area of the lake to another was verified by this method. The fins were clipped close to the base of the fin without undue injury to the fish. Regeneration of fins was not considered a problem because of the short time involved.
FINDINGS AND DISCUSSION

Abundance and species of fish in sample

The catch in 5,923 one hundred-foot net hours included 14 species of fish. A total of 3,191 fish were caught. This averaged 1.85 fish per 100-foot net hour. The species of fish included lake trout, *Salvelinus namaycush* (Walbaum); cutthroat trout, *Salmo clarki* (Richardson); rainbow trout, *Salmo gairdneri* (Gibbons); Bonneville (peaknose) cisco, *Coregonus gembifer* (Snyder); mountain whitefish, *Prosopium williamsoni* (Girard); Bonneville whitefish, *Prosopium spilonotus* (Snyder); Bear Lake whitefish, *Prosopium abyssicola* (Snyder); Utah sucker, *Catostomus ardens* (Jordan and Gilbert); Utah chub, *Gila atraria* (Girard); smallfin redside shiner, *Richardsonius balteatus hydrophlox* (Cope); Carrington's dace, *Rhinichthys osculus carringtoni* (Cope); sculpin, *Cottus species* (undescribed); carp, *Cyprinus carpio* (Linnaeus); and yellow perch, *Perca flavescens* (Mitchell).

The identification of the whitefishes, excluding the peaknose cisco, proved uncertain, and the three species were considered as a single group as "whitefish." The catch of rainbow trout, sculpin, Carrington's dace, and smallfin redside shiner was too irregular and insufficient to warrant but a brief mention of their presence.

Returns of marked fish

A total of 1,440 fish was fin-clipped, of which four (or 0.28 percent were recaptured (Table 1). There was no individual fish that was recaptured and released a second time.
Table 1. Summary of the number and percentage of the species fin-clipped and recaptured in Bear Lake, 1958-59.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number captured</th>
<th>Number clipped</th>
<th>Number recaptured</th>
<th>Percentage recaptured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake trout</td>
<td>86</td>
<td>44</td>
<td>3</td>
<td>6.82</td>
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<tr>
<td>Cutthroat trout</td>
<td>18</td>
<td>12</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>16</td>
<td>7</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Whitefish</td>
<td>741</td>
<td>164</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Peaknose cisco</td>
<td>1,113</td>
<td>415</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Utah sucker</td>
<td>762</td>
<td>568</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Utah chub</td>
<td>347</td>
<td>181</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Carp</td>
<td>45</td>
<td>45</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Yellow perch</td>
<td>23</td>
<td>4</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,151</strong></td>
<td><strong>1,440</strong></td>
<td><strong>4</strong></td>
<td><strong>0.28</strong></td>
</tr>
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</table>
Forty-four lake trout and 12 cutthroat trout were fin-clipped. Of these, there were three (or 6.8 per cent) lake trout and one (or 8.3 per cent) cutthroat trout retaken. The sizes of the lake trout were 18 inches, 21 inches, and 27 inches. The cutthroat trout measured 19 inches.

In relation to the small returns, one point to consider is that the clipping of fish during this study was continued each week-end. The total number of clipped fish was accumulated over a period of nine months.

The percentage of return of the clipped fish was so small that only a brief review of the return is mentioned here.

Selectivity of gill nets

The probability of catching fish in gill nets depends upon the movements of the fish themselves. The more active fishes, especially those with a large cruising range such as lake trout and cutthroat trout, are likely to be more caught. These fish may have returned earlier but not yet entered the net. On the other hand, they may have avoided the nets after being captured once.

Several factors that influence the catchability of gill nets are:
(1) the size of the mesh, (2) the presence of appendages on the fish such as spines, (3) the element of time such as the time of the day and the season of the year. Therefore, through gill netting, it is possible that the relative abundance of fish of various species taken does not correspond to their relative abundance in the fish population. The limitation of gill netting should be understood more clearly when the factors of the selectivity of the nets are recognized.
Population densities

Lake trout.—The bulk of lake trout was netted from May through September, 1959. This species was present at all depths but was most frequent at the 50-foot and 100-foot contours. The size range taken was 10 inches to 38 inches, but more than 60 per cent of these were 18 to 21 inches long (Figure 8 and Table 3). On many occasions, the lake trout were believed to be "baited" into the nets by previous catches of small fishes such as sculpin, peaknose cisco, and whitefishes caught in the nets. This probably accounts for the large percentage of lake trout taken by the three-eighths inch mesh gill nets which also bagged the majority of the sculpins, peaknose cisco, and whitefishes (Table 2).

McConnell, Clark, and Sigler (1957) reported that the lake trout of Bear Lake were more active during the warmer months, frequenting the 25- to 75-foot zone during that period. The findings of this study agree with that report.

Smith and Van Oosten (1939) reported that lake trout and rainbow trout in Lake Michigan were extensive travelers. They obtained a 15.4 per cent recovery during an eight-year period from 1,416 tagged lake trout.

Eschmeyer et al. (1952) using pound nets obtained data from which he concluded that the lake trout in Lake Superior were extensive travelers. Conversely, Fry (1952) found that the lake trout population in South Bay, Lake Huron, were non-migratory.

Cutthroat trout.—Ten (or 55 per cent) of the cutthroat trout were caught at the 50-foot contour. Only one cutthroat trout was taken at the 100-foot depth; the others were caught at the 15-foot contour.
Table 2. Fish taken by two types of bottom set gill nets in Bear Lake, 1958-59

<table>
<thead>
<tr>
<th>Species</th>
<th>Experimental net</th>
<th>3/8 inch net</th>
<th>Both nets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number caught</td>
<td>Percentage of total</td>
<td>Number caught</td>
</tr>
<tr>
<td>Lake trout</td>
<td>25</td>
<td>29.07</td>
<td>61</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>12</td>
<td>75.00</td>
<td>4</td>
</tr>
<tr>
<td>Cutthroat trout</td>
<td>13</td>
<td>72.22</td>
<td>5</td>
</tr>
<tr>
<td>Whitefish</td>
<td>284</td>
<td>38.32</td>
<td>457</td>
</tr>
<tr>
<td>Peaknose cisco</td>
<td>175</td>
<td>15.72</td>
<td>933</td>
</tr>
<tr>
<td>Yellow perch</td>
<td>19</td>
<td>82.61</td>
<td>4</td>
</tr>
<tr>
<td>Carp</td>
<td>34</td>
<td>75.56</td>
<td>11</td>
</tr>
<tr>
<td>Utah sucker</td>
<td>741</td>
<td>97.24</td>
<td>21</td>
</tr>
<tr>
<td>Utah chub</td>
<td>286</td>
<td>82.42</td>
<td>61</td>
</tr>
<tr>
<td>Sculpin</td>
<td>2</td>
<td>5.26</td>
<td>36</td>
</tr>
<tr>
<td>Carrington's dace</td>
<td>0</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Richardsonius sp.</td>
<td>1</td>
<td>100.00</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>1,592</td>
<td>1,599</td>
<td>3,191</td>
</tr>
</tbody>
</table>
According to McConnell, Clark, and Sigler (1957), the degree of movement of the cutthroat appeared constant at all seasons and was most abundant from shore to the 75-foot contour. The catch of cutthroat trout during this study verifies this statement. They also said that inshore movement occurred in spring and a minor but definite offshore movement appeared in the fall. An insufficient number of cutthroat trout was taken during this study which appeared to demonstrate the movement pattern previously described.

The Utah cutthroat trout was the only trout native to Bear Lake. This subspecies is believed to be extinct. The present-day cutthroat trout is considered a mixture of several subspecies of cutthroat and rainbow trout. It is also believed that most of the fish that appear to be hybrids are taxonomically closer to cutthroat than to rainbow trout (McConnell, Clark, and Sigler, 1957).

Rainbow trout.—Rainbow trout was concentrated in the shallow waters during the summer months. Only 16 trout were caught but more than half of these were taken in 15 feet of water. It is the common practice of the Utah Fish and Game Department to stock this species during the summer. Three freshly clipped trout from the State hatchery plus the presence of 8- to 12-inch trout taken in the nets suggest that hatchery-stocked rainbow trout do not wander far from shore. Rainbow trout planted in Bear Lake were known to disperse widely along the shore not long after being released (McConnell, Clark, and Sigler, 1957). This preference for the shallow waters is speculated to be a feeding reaction rather than a preference for depth or temperature.

Carp.—Thirty-one carp were caught during the months of July, August, and September. Fourteen were taken during the remainder of
the year. All of the carp were taken in waters of 15- and 50-foot depth. Large schools of 50 to 100 carp were frequently observed on the surface throughout the lake in August and September. Their relative abundance at the surface during this time of the year is probably correlated with the warm surface water. The carp is a widespread traveler in Bear Lake during the summer months (McConnell, Clark, and Sigler, 1957). Although this species is almost exclusively a bottom feeder and an extensive traveler, there were relatively few carp taken. The depth distribution data suggest that the carp tolerates colder temperature, but tended to be near shore and at the surface in deep water.

Utah chub.—All of the Utah chub were obtained at the 15- and 50-foot zones through a wide range of temperature. Eighty-two per cent (or 283) of the chub catch were netted in the 15-foot zone. Most of the young chubs (four to six inches) were caught in water temperatures ranging from 52° to 62° F. As the season progressed, larger sized chubs (10 to 11 inches) were more commonly caught in colder waters (43° to 49° F.).

Yellow perch.—Only two of the 23 yellow perch were found at the 50-foot contour. The rest were caught at the 15-foot zone during the fall. By means of gill netting, large-sized perch were found concentrated along the north shore in November, 1958. The water temperature in that area was 49° F. at that time. The sample indicates the perch inhabits shallow waters when the water temperature is cold. This preference is believed to be attributed to temperature rather than depth. The local residents of Bear Lake valley frequently fish at the north end of the lake for this species during the winter. McConnell, Clark, and Sigler (1957) mentioned that the perch in Bear Lake exhibited greater degree
of movement during the summer than in the remaining seasons. No evidence of this pattern of movement was observed by this writer, if the presence of this species by gill netting is indicative of such movement.

**Sculpin.**—The sculpin was scattered through a wide range of temperature and depth. As the depth increased, the catch increased. Thirty-nine per cent of this species were taken from the 150-foot depth as compared to 29 per cent taken from the 100-foot depth. Ninety-five per cent of the 38 sculpins were caught in the three-eighths inch nets (Table 2). Twenty-one of the sculpin catch averaged three to four inches in length. According to McConnell, Clark, and Sigler (1957), this sedentary species and the peaknose cisco are the two most numerous fish in Bear Lake. They found that large numbers of adult sculpins were collected by electro-fishing in shallow waters in April, 1952, while many young ones were collected by poisoning the shallow waters in October and November, 1953.

**Carrington's dace and smallfin redside shiner.**—Both of these species were taken at the 15-foot contour during June and August, 1959. The Carrington's dace was taken in June when the water was 60°F. The smallfin redside shiner was taken in 70°F. water in August. These species usually inhabit shallow, warm waters.

**Whitefishes.**—The whitefishes showed a wide range in depth and temperature distributions. The shallower water (15 to 50 feet) seemed to contain a denser concentration than the deeper water. More than 75 per cent of the catch were taken in the 15- and 50-foot contours, but there seemed to be a definite preference for the 50-foot contour (Figure 2).
While the best catch of whitefishes was obtained at the 50-foot contour, the east side of the lake contributed more of the whitefishes than the west side. At the east side of the lake, an inshore movement was noticeable at the 15-foot zone. This movement was believed to be due to the spawning run of the whitefishes at that area during December, 1958.

At the 50- and 100-foot contours, the fish movement was northerly-southerly. This latter movement may have been due to the whitefishes following the contour of the lake. An offshore movement was predominant over inshore movement at the 50-foot zone. There was no predominance of inshore-offshore movements at the 100-foot contour.

Offshore movement was dominant at the west side of the lake. This movement may be a desire to move into deeper water as daylight appeared.

Figures 2 and 3 show that more whitefishes were taken in deep, cold water (38° to 44° F.) by the experimental nets than by the three-eighths inch nets. The whitefishes taken in the three-eighths inch nets were five to seven inches in length and were caught mostly in the shallow water zones where the water temperatures were 46° F. or warmer.

In general, the depth distribution data suggest that there is a definite preference for the 50-foot zone. But the temperature distribution data suggest that the whitefishes concentrate in waters of different temperatures according to their size differences. Young whitefishes showed preference to water of warmer temperature than that preferred by the adults. This difference may be a species differentiation rather than difference in age class of one species.

According to McConnell, Clark, and Sigler (1957), the whitefishes in Bear Lake inhabit the 25- to 75-foot zones during the summer and early fall, and then they move to deeper water in the winter.
Figure 2. Percentage distribution by depth and temperature of whitefish taken in two types of bottom set gill nets in Bear Lake, 1958-59
Figure 3. Percentage distribution by temperature of three species of fish in two types of bottom set gill nets in Bear Lake, 1958-59
Figure 4. Percentage distribution by depth and direction of three species of fish taken in bottom set gill nets in Bear Lake, 1958-59
Budd (1956) worked with tagged whitefish of another species, lake whitefish, *C. clupeaformis* (Mitchill) in northern Lake Huron. He found that the lake whitefish in South Bay ranged widely, whereas those in Lake Huron and Georgian Bay showed no well defined migratory routes. He concluded that in determining the movements of this species in different areas it seems likely that the local hydrographic conditions were a major factor. Smith and Van Oosten (1939) found that the lake whitefish in Lake Michigan were non-migratory. Odell's study (1932) in New York showed that water deeper than 44 feet was the usual habitat for lake whitefish. He added that in every case of shallow water netting, whitefish and lake trout were caught only when the water was cold. The whitefishes in Bear Lake during this study were found in waters as warm as 70° F. at the 15-foot contour. The lake trout, however, were never caught in this study in water warmer than 57° F.

During one occasion in December, 1958, a large number of whitefishes was taken at the 15-foot contour at the east side of Bear Lake. This catch made up 18 per cent of the total whitefishes (Figure 2). The water temperature at this time was 39° F. This concentration of whitefishes was due to their spawning behavior. The Bonneville whitefish spawn in shallow water in early December when the water temperature is in the low forties. These spawners average eight to nine inches in length (McConnell, Clark, and Sigler, 1957).

Movement of fish populations into spawning areas is often closely related to temperature changes and may be considered as dependent upon temperature. Cady (1945) revealed that in Norris Reservoir, spawning obviously influenced depth distribution of some fish for a short time.
at spawning time. This type of behavior was definitely demonstrated in Bear Lake by the whitefishes.

Peaknose cisco.—The peaknose cisco was commonly concentrated in the 50- and 100-foot zones (Figure 5). This species was seldom found in water less than 50 feet; only 19 of 965 peaknose ciscoes were caught at the 15-foot contour.

The peaknose cisco constituted 35 per cent of the total catch (Table 2). There were twice as many peaknose ciscoes caught at the east side of the lake as at the west side. This reaction may be due to the steeper slope of the lake floor on that side of the lake (Figure 1). According to Perry (1943) the wide dispersal of peaknose cisco in the spring and late winter and their preference for midwater rather than the bottom contribute to their low rate of catch in the bottom set nets.

The temperature preference of the peaknose cisco tended to be in the cold waters of 38° to 50° F. A striking feature shown in Figure 5 is the concentration of peaknose cisco in the 41° to 50° F. waters at the depths of 50 feet and more. This finding may be attributed to a reaction to the temperature of the water rather than depth.

The pattern of movement of the peaknose cisco did not follow the pattern of movement of the whitefishes. At the 15-, 50-, and 100-foot depths, the peaknose cisco tended to move parallel (north-south) to the shoreline at the vicinity of the study area (Figure 4). This direction of movement may be attributed to temperature preference. By swimming along the north-south axis of the lake, the peaknose cisco tended to distribute themselves within the desired temperature stratum. In regards
Figure 5. Percentage distribution by depth and temperature of peaknose cisco taken in two types of bottom set gill nets in Bear Lake, 1958-59
to the offshore-inshore movement, more peaknose ciscoes were caught at the west side of the lake moving inshore than offshore. This may mean an inshore feeding movement.

**Utah sucker.**—The Utah sucker was widely scattered at all depths but was found concentrated in the 15- and 50-foot contours (Figure 4). The west side of the lake contributed more suckers than the east side, except in the waters deeper than 100 feet. The number of suckers caught by gill netting decreased sharply as the depth of the water increased. Seventy-five per cent of the suckers were taken from the 15- and 50-foot zones, suggesting their preference for shallow water.

The suckers were caught in a considerable range of temperatures. This may be interpreted to mean the distribution of this species was not dependent upon the water temperature (Figures 3 and 6). More than half of the suckers caught were 12 to 19 inches long (Figure 8 and Table 4).

Only 21 (or 2.7 per cent) of all the suckers were taken by the three-eighths inch net (Table 2). They consisted of all sizes and were not taken at any particular water temperature or depth.

The activity patterns at 15 and 50 feet (Figure 4) show a northerly-southerly movement. It is believed that there is close correlation between the feeding behavior of the sucker and depth preference, fish distribution, and fish movement. The sucker tended to stay in the preferred depth for feeding and may have been following the contour of the lake.

In comparing the west side of the lake with the east side, there appeared to be at the west side a similar number of suckers moving inshore
Figure 6. Percentage distribution by depth and temperature of Utah sucker taken in two types of bottom set gill nets in Bear Lake, 1958-59.
as there were moving offshore. At the east side, offshore movement was dominant.
CONCLUSIONS

In Bear Lake, it appeared that the deep water species required the lower temperature that was coexistent with deep water. The shallow water species were basically kept in their restricted area due to their need for warmer water and the greater availability of food found there. Species that were not affected by differences of temperature wandered over a greater range primarily to secure forage.

It is important to emphasize that the abundance of fish caught on certain fishing grounds do not necessarily mean greater activity, but may be suggestive of more fish being present in that area. Various conditions such as suitable spawning sites, attractiveness of habitat, preference of temperature, availability of food and other reasons are some of the factors that may cause more fish to be present in a particular area.
SUMMARY

1. This study was carried out under the sponsorship of the National Science Foundation and the Utah Cooperative Wildlife Research Unit, Utah State University. The data of this study were collected from November, 1958, through October, 1959, in Bear Lake, Utah-Idaho.

2. Eight permanent stations were established at four depths, 15, 50, 100, and 150 feet. These stations transected Bear Lake directly west to east from Swan Creek at Lakota.

3. Fish collections were made by nylon gill nets set on the floor of the lake each weekend at each station. The nets were set overnight (approximately 15 hours) before being picked up the following morning.

4. A total of 3,191 fish was taken in 5,923 one hundred-foot net hours. This averaged 1.85 fish per 100-foot net hours. Fourteen species of fish were caught.

5. An attempt to determine fish movement in the lake was carried out by fin clipping and releasing 1,440 fish in the lake. Only four (or 0.28 per cent) of these were recaptured. The recaptured fishes included three lake trout and one cutthroat trout. The percentage of return was considered to be inadequate to show any effect of fish movement.

6. The available data suggest that the water temperature and its relationship with depth played an important role in determining the distribution of fish in the lake.
7. Most of the fish in number and species were caught at the 15-foot depth. Yellow perch, rainbow trout, Carrington's dace, and the smallfin redside shiner were taken in largest quantity at this depth.

8. Lake trout, Utah sucker, Utah chub, and carp were caught in large numbers at both the 15- and 50-foot contours. More cutthroat trout and whitefishes were taken from the 50-foot depth than at the 15-foot depth.

9. The peaknose cisco was concentrated in moderately deep water of 50 to 100 feet in depth. This species was caught more often than any other fish during this study. It constituted 35 per cent of the catch.

10. The sculpin was taken at all depths and temperatures. Most of them, however, were taken in deep water—as the depth increased the rate of catch increased.

11. The distribution of the whitefishes was suggestive of a preference to depth rather than temperature. These fish were caught in a wide range of temperature. Young whitefish appeared to prefer warmer waters than adult whitefish.

12. The Utah sucker was taken in a wide range of temperature but 75 per cent of this species were caught in the 15- and 50-foot zones. Most of the suckers were taken at the west side of the lake.

13. Most of the peaknose cisco were taken at the east side of the lake where there is a steeper drop-off of the shoreline. It is believed by the writer that the concentration of the peaknose cisco was attributable to a reaction to temperature rather than depth. The
concentration of this species appeared at the 41° to 50° F. range of temperature.

14. In regards to movement of the whitefishes, peaknose cisco, and Utah sucker, it was generalized that these fishes traveled along the north-south axis of the lake. This is speculated to be a movement following the contour of the lake floor.
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Figure 7. Average depths of isotherms (degrees F.) in Bear Lake, 1958-59 (dotted line indicates upper limit of the thermocline)
Figure 8. Length-frequency distributions of the common species of fish caught in two types of bottom set gill nets in Bear Lake, 1958-59
Table 3. Length-frequency distributions of some common species taken in bottom set gill nets in Bear Lake, 1958-59

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Table 4. Length frequency-distributions of some common species taken in bottom set gill nets in Bear Lake, 1958-59

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Table 5. Length frequency-distributions of some common species taken in bottom set gill nets in Bear Lake, 1958-59

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