Biology of the Utah chub in Hebgen Lake, Montana
by Richard J Graham

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management at Montana State College
Montana State University

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An investigation was made on the biology of the Utah chub, Gila atraria, in Hebgen Lake, Montana, 1953-1954. Results from a preliminary study made in 19b8 on abundance and food habits are also presented. The chub was probably introduced into the lake by bait fishermen. Random sets (49) of gill nets in 1948 caught 708 Utah chubs, 147 whitefish, 79 brown trout, 31 rainbow trout, 6 cutthroat trout, 3 grayling and 2 suckers.

Gill nets set specifically for chubs in 1953 and 1954 took 1,030 and b,595 chubs respectively. Chubs appeared to be concentrated in shallow areas in the spring, widely distributed around the lake in summer and fall, and concentrated in deeper waters in winter. Stomach analyses were made on 55 rainbow trout, 70 brown trout and 165 chubs collected during the summer of 19U8. By volume the foods of chubs were 48.2 percent algae, 21.1 percent higher aquatic plants and 24.3 percent microcrustaceans. Analysis of 209 chub stomachs in 1953-1954 showed that insects comprised 36 percent of the total volume, microcrustaceans 36 percent, higher aquatic plants 19 percent, and debris 9 percent. Diptera larvae and pupae constituted about 75 percent of the volume of insects. The peak of the spawning season for 1953 and 1954 occurred during late June and early July. A rise in the percent of spent females captured was associated with a rise in air and water temperatures. Most spawning occurred in water temperatures above 54° F.

Eggs were found on various kinds of bottoms but most were recovered from sand and gravel. The average number of eggs per female was 40,750. Fry occurred along most of the shallow protected shorelines. A sample of fry captured on July 7, 195b averaged 0.3 inch in total length. Young taken October 31, 1953 averaged 1.3 inches. No mature males less than 3 years old or mature females less than b were aged. The calculated total lengths for each year of life based on b75 specimens were as follows: first-1.6 inches; second-3.5; third-6.1; fourth-8.2; fifth-9.7; sixth-10.9; seventh-12.b; eighth-13.6.

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Approved:

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

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ABSTRACT

An investigation was made on the biology of the Utah chub, Gila atraria, in Hebgen Lake, Montana, 1953-1954. Results from a preliminary study made in 1948 on abundance and food habits are also presented. The chub was probably introduced into the lake by bait fishermen. Random sets (49) of gill nets in 1948 caught 708 Utah chubs, 147 whitefish, 79 brown trout, 31 rainbow trout, 6 cutthroat trout, 3 grayling and 2 suckers. Gill nets set specifically for chubs in 1953 and 1954 took 1,030 and 4,595 chubs respectively. Chubs appeared to be concentrated in shallow areas in the spring, widely distributed around the lake in summer and fall, and concentrated in deeper waters in winter. Stomach analyses were made on 55 rainbow trout, 70 brown trout and 165 chubs collected during the summer of 1948. By volume the foods of chubs were 48.2 percent algae, 21.1 percent higher aquatic plants and 24.3 percent microcrustaceans. Analysis of 209 chub stomachs in 1953-1954 showed that insects comprised 36 percent of the total volume, microcrustaceans 36 percent, higher aquatic plants 19 percent, and debris 9 percent. Diptera larvae and pupae constituted about 75 percent of the volume of insects. The peak of the spawning season for 1953 and 1954 occurred during late June and early July. A rise in the percent of spent females captured was associated with a rise in air and water temperatures. Most spawning occurred in water temperatures above 54° F. Eggs were found on various kinds of bottoms but most were recovered from sand and gravel. The average number of eggs per female was 40,750. Fry occurred along most of the shallow protected shorelines. A sample of fry captured on July 7, 1954 averaged 0.3 inch in total length. Young taken October 31, 1953 averaged 1.3 inches. No mature males less than 3 years old or mature females less than 4 were aged. The calculated total lengths for each year of life based on 475 specimens were as follows: first-1.6 inches; second-3.5; third-6.1; fourth-8.2; fifth-9.7; sixth-10.9; seventh-12.4; eighth-13.6.

INTRODUCTION

The Utah chub, Gila atraria (Girard), is native to the Bonneville Basin of Utah and the upper Snake River drainage of Wyoming and Idaho (Simon, 1946). It is presumed that this species was accidentally introduced into Hebgen Lake, Montana by live-bait fishermen. Local residents report that schools of minnows, believed to be Utah chub, were first observed during the mid-thirties (1935-1937). The chub increased rapidly and probably reached its maximum abundance about 1948. It has remained at a relatively high level since that time.

Chubs have been collected in tributaries several miles above Hebgen Lake. Their known range below the lake includes all of the Madison River and the upper 85 miles of the Missouri River (to Hauser Dam). They may also be present in tributaries of these rivers. Bait fishermen recently introduced the chub into Cliff Lake which lies in an isolated basin about 12 miles west of Hebgen Lake.

The Utah chub is not a good food fish and is a nuisance to the fishermen because it readily takes most trout baits. It is so abundant that it may be contributing to a decline of the trout fishery but the limited data secured on Hebgen Lake do not necessarily indicate this. Davis (1940) and Sigler (1953) report that a decline of the trout fishery in Fish Lake, Utah appeared to be associated with an increase in the abundance of the Utah chub.

Information on the biology of the Utah chub seemed imperative in the development of a fisheries management program for Hebgen Lake. A pre-

liminary investigation on abundance and food habits was made in 1948 by R. A. Hays and C. G. Bishop of the Montana Fish and Game Department. A more intensive study on the biology of the chub was conducted during 1953-1954 by the writer. The results of both studies are presented.

Description of Hebgen Lake

Hebgen Lake is an artificial impoundment (Fig. 1) located on the Madison River within Gallatin County, approximately 1 mile west of Yellowstone National Park. The principal tributaries are; Madison River, South Fork of Madison River, Grayling Creek and Duck Creek. All of these arise in Yellowstone National Park. The dominant plant within the area is lodgepole pine (Pinus contorta) - the immediate shoreline of Hebgen Lake supports approximately equal amounts of lodgepole pine and grassland-sagebrush types. Most of the land around the lake lies on the National Forest and is used principally for recreation. About 75 summer homes and four resorts are on lands leased from the National Forest Service and several homes and resorts are on private lands.

The dam which impounds Hebgen Lake was completed in 1914 and is owned and operated by the Montana Power Company. The spillway lies at an elevation of 6,544 feet m.s.l. The reservoir has a capacity of 344,730 acre feet, a surface area of 13,700 acres and a maximum depth of 61.5 feet. The maximum recorded water temperature at the surface was 76° F. Ice usually forms during the latter part of October or early November and disappears in late April or early May. The methyl orange alkalinity was 77 p.p.m. and pH was 7.2 (November 11, 1954).

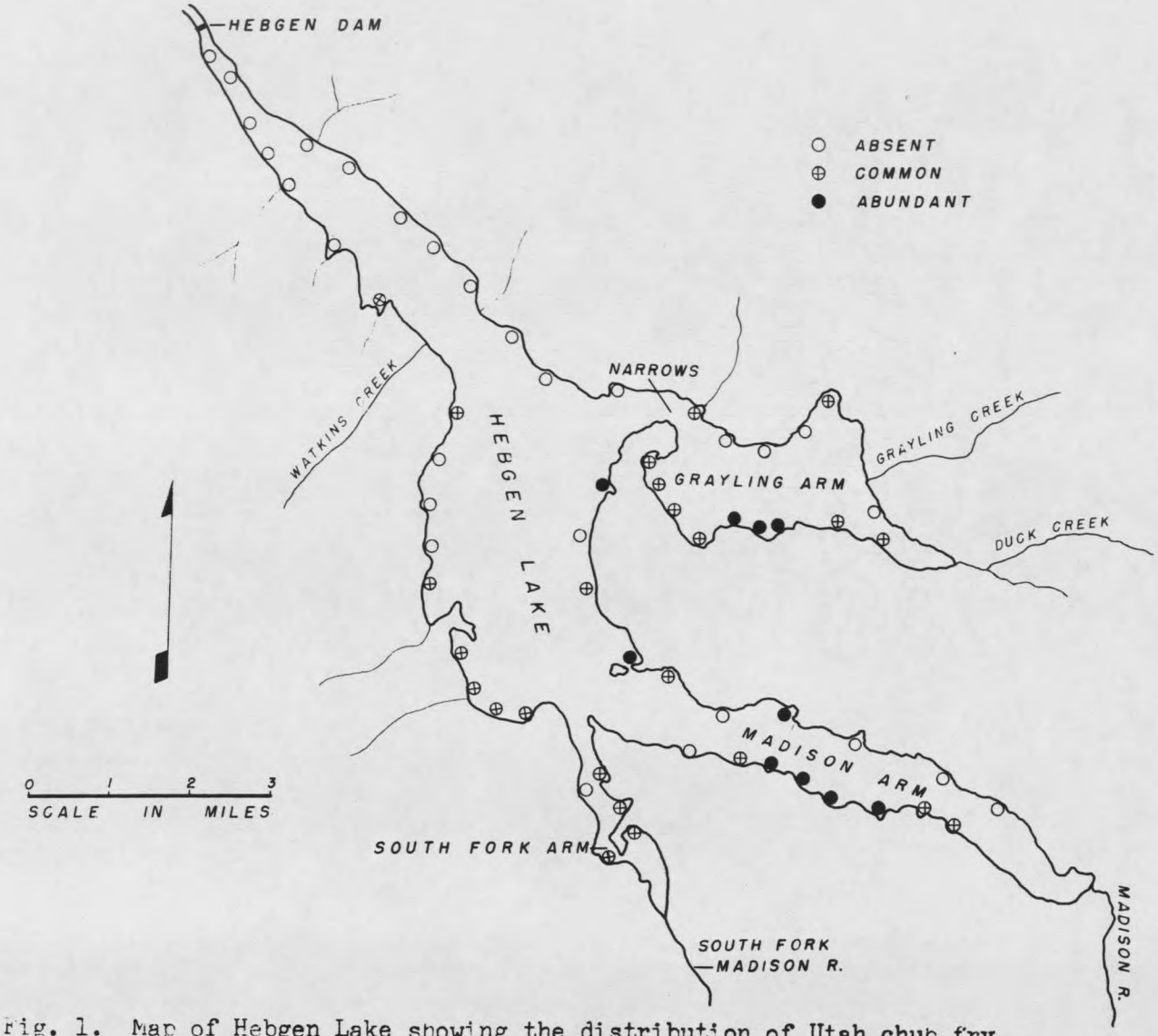

Fig. 1. Map of Hebgen Lake showing the distribution of Utah chub fry in 1953-1954.

Hebgen Lake is used to store water for downstream power units. Before 1953 the policy was to store water during the spring and summer and to release it as needed in the fall and winter. Since 1953 water has been released sharply in the fall so that the minimum level is usually reached in November. In a normal year the lake level is lowered about 17 feet and the volume reduced to 160,000 acre feet.

Fish Associates

The chub is the most abundant fish in Hebgen Lake. Brown trout (Salmo trutta) and mountain whitefish (Prosopium williamsoni) rank next followed by rainbow trout (Salmo gairdnerii). Cutthroat trout (Salmo clarkii), eastern brook trout (Salvelinus fontinalis), American grayling (Thymallus signifer), longnose sucker (Catostomus catostomus), longnose dace (Rhinichthys cataractae), and Rocky Mountain sculpin (Cottus bairdi) are also present in limited numbers.

Sampling Areas

Most observations and collections were made in the shallow areas of the lake, particularly the Grayling and Madison arms. The Grayling arm is connected to the main lake by a short channel called "The Narrows" (Fig. 1). Most of the arm has a depth of less than 15 feet and during the winter it is almost completely drained. The principal bottom material is muck although sand and gravel areas are present along the southern shoreline. The entire arm supported an extensive growth of aquatic vegetation in 1948. Pondweeds (Potamogeton gramineus, P. pectinatus, P.

richardsonii), water ladys thumb (Polygonum amphibium), water crowfoot (Ranunculus acquatalis), American milfoil (Myriophyllum spicatum), and several species of algae were common. Local residents report that aquatic vegetation became much reduced during the following two years. By 1953 only scattered patches were found, mainly along the southern shoreline.

The Madison arm is about 5 miles long and 1 mile wide. More than one-half of the arm has a depth of less than 15 feet. The bottom is primarily of sand and gravel. All plant species listed above were present but pondweeds were most abundant.

ABUNDANCE AND DISTRIBUTION

Fish collections, except for fry and fingerlings, were made with graded gill nets (square mesh 3/4 - 2 inches). In 1948 gill nets were set at random throughout the lake from July 13 to September 21. The relative abundance of the various species was estimated from these collections (Table I). The netting operations of 1953 and 1954 were selective for chubs in that the sets were confined to areas where this species was known to be abundant. Over 75 percent of the 1953-1954 sets were made in the Madison and Grayling arms during June and July and at depths of less than 10 feet. The collections were not comparable between any two years with respect to catch per hour or species composition.

The Utah chub was the most abundant species in the 1948 collections. In 1953 and 1954 the percentage of chubs was considerably greater but this was undoubtedly due to the selective setting of nets. The catch per hour

Table I. Fish captured in Hebgen Lake by 125-foot gill nets set at random in 1948, set selectively in 1953-1954.

Year	Species	Total number	Percent of total	Catch per hour
1948[1]	Utah chub	708	72.5	7.3
	Whitefish	147	15.1	1.5
	Brown trout	79	8.1	0.8
	Rainbow	31	3.2	0.3
	Cutthroat	6	0.6	-
	Grayling	3	0.3	-
	Sucker	2	0.2	-
1953[2]	Utah chub	1030	91.9	8.3
	Whitefish	26	2.4	0.2
	Brown trout	54	4.8	0.4
	Rainbow	10	0.9	0.1
1954[3]	Utah chub	4595	90.2	6.4
	Whitefish	210	4.1	0.3
	Brown trout	265	5.2	0.4
	Rainbow	25	0.5	-
	Grayling	1	-	-

[1] 49 sets, av. time per set 2.0 hrs.

[2] 48 sets, av. time per set 2.8 hrs.

[3] 90 sets, av. time per set 8.0 hrs.

for chubs was as follows: 1948, 7.3; 1953, 8.3; 1954, 6.4. The larger catch per hour in 1953 was probably due to selective gill netting. The average time for sets in 1954 was 3-4 times greater than in 1948 or 1953 and this probably accounts for the smaller catch per hour since nets set over-night frequently became so full of fish their efficiency was reduced.

The 1948 gill net sets indicated that the greatest concentration of chubs was in the Grayling arm. In 1954, a total of 44 gill net sets was made in the Madison arm and 39 in the Grayling arm. The catch per hour

for chubs was 6.0 and 7.3 respectively. Chubs were abundant in both arms but seemed to be somewhat more concentrated in Grayling arm.

No careful study was made on the seasonal distribution of the Utah chub in Hebgen Lake, however some general trends were discernible. The adult chubs apparently move from the deeper parts of the lake to the shallow areas with the disappearance of ice and the rise in water level. On May 5, 1954 an over-night set near the Narrows in Grayling arm caught only trout and whitefish. At this time most of the lake was covered with ice. On May 23, after ice had disappeared, nets placed in the same area took many chubs. Chubs were abundant in shallow areas throughout the summer but the catch showed a decline in early July, 1954. At this time most of the chubs had completed spawning and many small schools of adults were observed moving along the shorelines. Resort owners near the deeper areas of the lake report that chubs are seldom observed until early July. During mid-summer large schools were observed by the writer and reported by local residents in widely scattered parts of the lake. Chubs were present in shallow areas through September and October. On November 11, 1954 (ice was beginning to form) a net placed in the shallows of Grayling arm took no chubs but contained whitefish. These observations indicate that chubs are largely concentrated in deeper sections of the lake during the winter. A similar seasonal distribution was reported for the chub (Siphateles bicolor) in Eagle Lake, California (Kimsey, 1954).

FOOD HABITS

During the 1948 investigations stomach examinations were made on 55

rainbow trout, 70 brown trout and 165 Utah chubs. Specimens were collected by angling and gill netting at irregular intervals during June, July, August and September. Stomachs were removed from the specimens and immediately preserved in formalin. The contents from each stomach was sorted into taxonomic groups and their volumes were measured by displacement. The kinds, percentage of occurrence and percentage of volume of food of each species are given in Table II.

The 55 rainbow trout examined ranged in total length from 6.8 to 19.0 inches (14 under 12 inches). Aquatic insects made up the largest volume constituting 39.9 percent of the total. Diptera larvae and pupae made up about 64 percent of the volume of insects and Coleoptera about 35 percent. Other orders of insects found were Ephemeroptera, Hemiptera, Homoptera, Trichoptera, Lepidoptera and Hymenoptera. Cladocera (mostly Daphnia) ranked next in quantity, comprising 28.2 percent. Algae and higher aquatic plants constituted 2.4 and 2.0 percent of the volume respectively. Fish made up only 0.9 percent of the total volume and unidentified material and debris contributed 26.2 percent.

The 70 brown trout ranged in total length from 7.9 to 23.9 inches (2 under 12 inches). Fish made up the largest volume constituting 69.2 percent of the total. The kinds and percentages (by volume) of fish eaten were as follows: Utah chubs, 62; trout, 29; sculpins, 8; unidentified, 1. The combined volume of insects amounted to 9.9 percent of the total and Diptera (larvae and pupae) comprised about 88 percent of this. Cladocera constituted 8.0 percent of the volume. None of the stomachs examined con-

Table II. Percentage frequency of occurrence and percentage of total volume of food items eaten by 55 rainbow trout, 70 brown trout and 165 Utah chubs in Hebgen Lake, 1948.

	Rainbow trout		Brown trout		Utah chub	
Food organism	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume
Algae	4	2.4	-	-	31	48.2
Higher aquatic plants	6	2.0	2	0.4	29	21.1
Nematoda	-	-	-	-	1	Tr.
Mollusca	13	Tr.[1]	17	0.5	10	0.9
Hirudinea	-	-	2	Tr.	1	0.7
Cladocera	75	28.2	60	8.0	58	24.3
Copepoda	-	-	-	-	8	Tr.
Amphipoda	11	0.4	9	0.2	4	Tr.
Ephemeroptera	11	0.3	19	0.5	2	0.2
Trichoptera	13	Tr.	17	0.3	-	-
Diptera	93	25.6	75	8.7	60	0.5
Coleoptera	36	14.0	11	0.4	1	Tr.
Other insects	20	Tr.	4	Tr.	-	-
Arachnoidea	22	Tr.	16	Tr.	16	0.5
Fish	4	0.9	20	69.2	-	-
Unidentified and debris	67	26.2	61	11.8	41	3.6

[1]tr. equals trace.

tained algae. Higher aquatic plants amounted to only 0.4 percent of the total volume and unidentified material and debris made up 11.8 percent.

The range in total length of the 165 chubs used for stomach analysis was 5.3 - 14.5 inches. A comparison between the food of small (total length less than 9 inches) and large chubs showed it to be very similar. Algae (48.2%) and higher aquatic plants (21.1%) constituted 69.3 percent of the total volume for all chubs. Cladocera ranked next comprising 24.3 percent. The combined volume of insects amounted to only 0.7 percent of the total and unidentified material and debris made up 3.6 percent. Sigler (op. cit.) reported that the principal food items of 90 chubs from Fish Lake, Utah were Daphnia and Gammarus with algae ranking next.

Cladocera was the only item taken in quantity by both trout and chubs and while no definite conclusions can be drawn regarding the food competition between these species because of the small sample, there appears to be no serious conflict.

A total of 209 stomachs was examined from chubs collected during the summers of 1953-1954. Over 90 percent of the specimens was secured by gill nets. Stomachs were taken only from fish caught in sets of 2-hour duration or less. The kinds, percentage of occurrence and estimated percentage of volume of food of chubs are given in Table III.

The volumes of microcrustacea and insects were equal, each constituting 36 percent of the total. Daphnia was the most important crustacean. Diptera larvae and pupae made up about 75 percent of the volume of insects and Ephemeroptera nymphs about 20 percent. Other insects found were

Table III. Percentage frequency of occurrence and estimated percentage of total volume of food items eaten by 209 Utah chubs in Hebgen Lake, 1953-1954.

Food organism	Occurrence	Volume
Algae	7	tr.[1]
Higher aquatic plants	44	19.0
Nematoda	1	tr.
Mollusca	3	tr.
Cladocera	55	36.0
Amphipoda	tr.	tr.
Odonata	tr.	tr.
Ephemeroptera	18	8.0
Homoptera	2	1.0
Trichoptera	5	tr.
Diptera	64	27.0
Coleoptera	tr.	tr.
Arachnoidea	1	tr.
Unidentified and debris	59	9.0

[1]tr. equals trace

Odonata, Homoptera, Trichoptera and Coleoptera. Higher aquatic plants comprised about 19 percent of the total volume. Unidentified material and debris made up the remaining 9 percent.

A comparison between the foods of chub taken in 1948 and those taken in 1953-1954 indicated a change in diet. Approximately 65 percent of the stomachs examined in 1948 were collected in Grayling arm and in the vicinity of the Narrows. During 1953-1954 approximately 70 percent of the stomachs were collected in these areas. In 1948 algae occurred in 31 percent of the stomachs and constituted about one-half of the volume while in 1953-1954 algae was found in 7 percent of the stomachs and amounted to only a trace of the volume. Insects (principally Diptera larvae and pupae) replaced algae in volume as they increased from 0.7 percent in 1948 to 36

percent in 1953-1954. The change in diet probably resulted from a reduction of aquatic vegetation which occurred in these areas between the two study periods.

Contrary to Jordan and Evermann (1896) who characterized the Utah chub as "extremely destructive of other fishes, especially to young trout", no fishes of any kind were found in the stomachs of the 374 chubs studied.

SPAWNING

Season

All Utah chubs collected in 1953-1954 were opened and the gonads examined to determine maturity and sex. Depending upon the condition of the ovaries the mature females were classified as follows: (1) spent - ovaries with very few or no eggs; (2) partially spent - ovaries containing about one-half their egg capacity; (3) full - ovaries full of eggs. Some very ripe females may have lost eggs while struggling in gill nets but this probably had little effect on the findings since these females would have spawned within a few days.

A total of 304 mature female chubs was collected May 30-July 12, 1953. These were classified as to the condition of their ovaries and grouped into periods (Table IV). All females collected on May 30 were full. The spent females increased from about 33 percent (June 15-28) to about 76 percent (June 29-July 12) while the full females decreased from about 50 percent to 6 percent during this period. Approximately 20 percent of the females taken were partially spent.

The 1954 collection of female chubs totaled 1,666 and all except 27

Table IV. Ovary condition of chubs captured during 1953 in Hebgen Lake.

Period	Number of Females	Percent		
		Full	Partially Spent	Spent
5/30	16	100	-	-
6/15 - 6/21	55	45.5	23.6	30.9
6/22 - 6/28	34	50.0	14.7	35.3
6/29 - 7/5	59	5.0	17.0	78.0
7/6 - 7/12	140	6.4	18.6	75.0

of these were taken by gill nets. The females were classified and then grouped into periods extending from May 23 to August 6 (Fig. 2). During the first collection period (May 23-30) only one percent of the captured females was spent. The spent females taken May 31-June 20 remained at a low level (13.5 percent) but increased to about 63 percent for periods extending June 21-July 11. Over 95 percent of the females collected July 12-August 1 were spent, and during the last period (August 2-6) all were spent.

The high rate of increase in spent females with a corresponding decrease in full females indicates that the peaks of spawning for 1953 and 1954 occurred during late June and early July. In 1954 the largest percentages of partially spent females occurred between June 21 and July 11, and this is further evidence that the peak of spawning occurs at that time. The beginning and ending dates of the 1953 spawning season were not determined. The 1954 season apparently began in May and extended into August.

Numerous ripe males were observed throughout the 1953 collecting

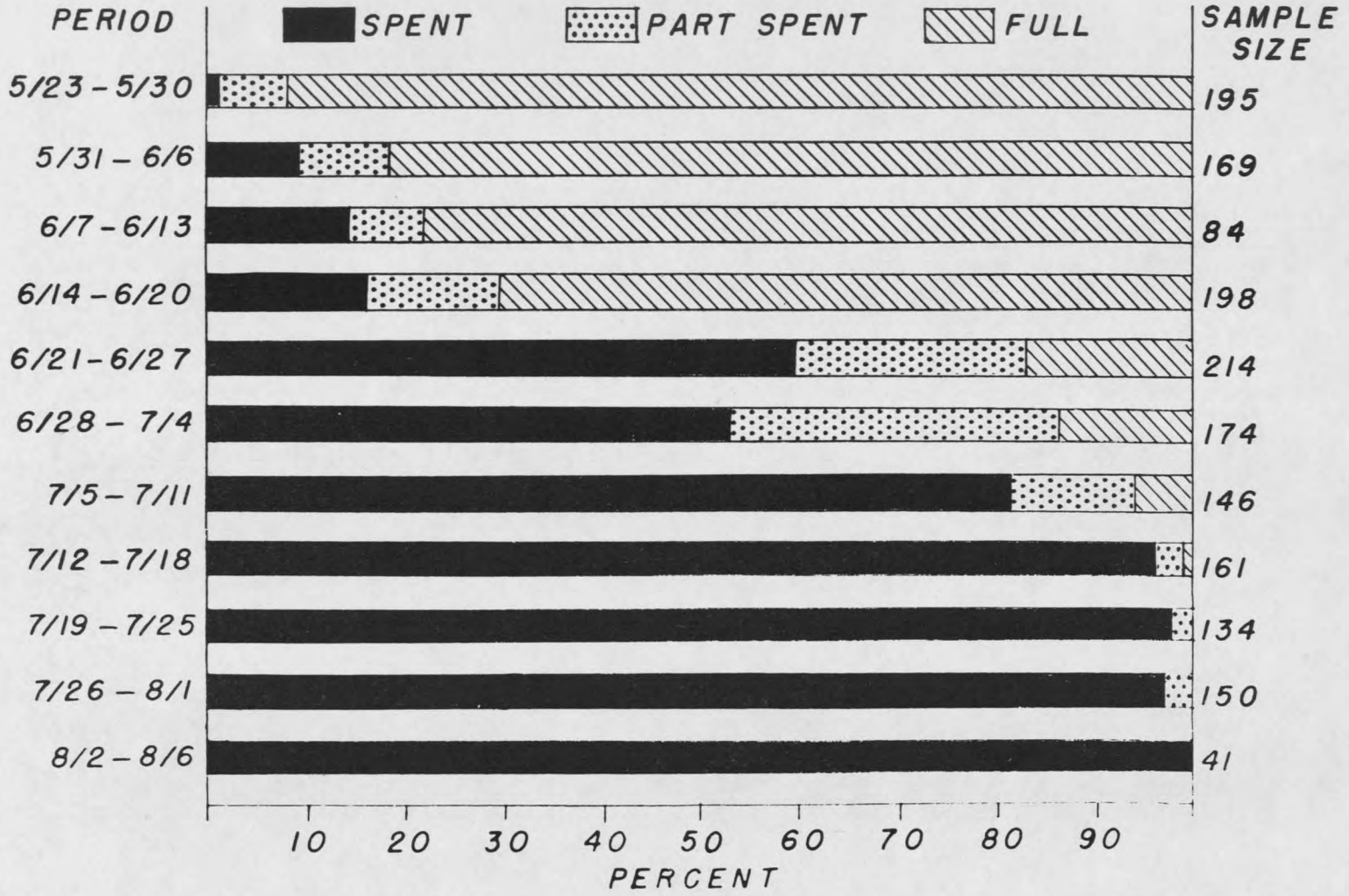

Fig. 2. Ovary conditions of 1,666 chubs captured during the spring of 1954.

period (May 30-July 12). In 1954, ripe males were abundant from the earliest collections (May 23-30) until mid-July. There was some indication that males ripened sooner than females.

Air temperatures for 1953-1954 were obtained from the United States Department of Commerce weather station at Hebgen Dam. Two water temperature stations were established in Hebgen Lake, one in the Madison arm and the other at the Narrows. Maximum-minimum thermometers were placed about 2½ feet below the surface and readings were taken at irregular intervals during collecting periods. The average air temperature (40.4° F.) for May, 1953 was 4.6° below normal. The average temperature for June (52.1° F.) was normal and the July average (62.9° F.) was 2.8° above normal. The water temperature during the peak of spawning (June 17-July 9) averaged 60.2° F. with a maximum of 68° and a minimum of 54°.

In 1954 the average air temperatures for May (46.9° F.), June (50.1° F.) and July 63.0° F.) were 1.9° above, 2.0° below and 2.9° above normal respectively. Average air and water temperatures were determined for periods corresponding to chub collecting periods and then compared with the incidence of spent females (Fig. 3). The 1954 spawning season probably began during the warm weather of mid-May. On May 26 the weather turned cold and low temperatures prevailed until June 20. The average water temperatures between May 30 and June 21 were below 55° F. and the occurrence of spent females during this time remained below 20 percent. The marked increase in air and water temperature for the period June 21-27 was associated with an increase in the percent of spent females. Most spawn-

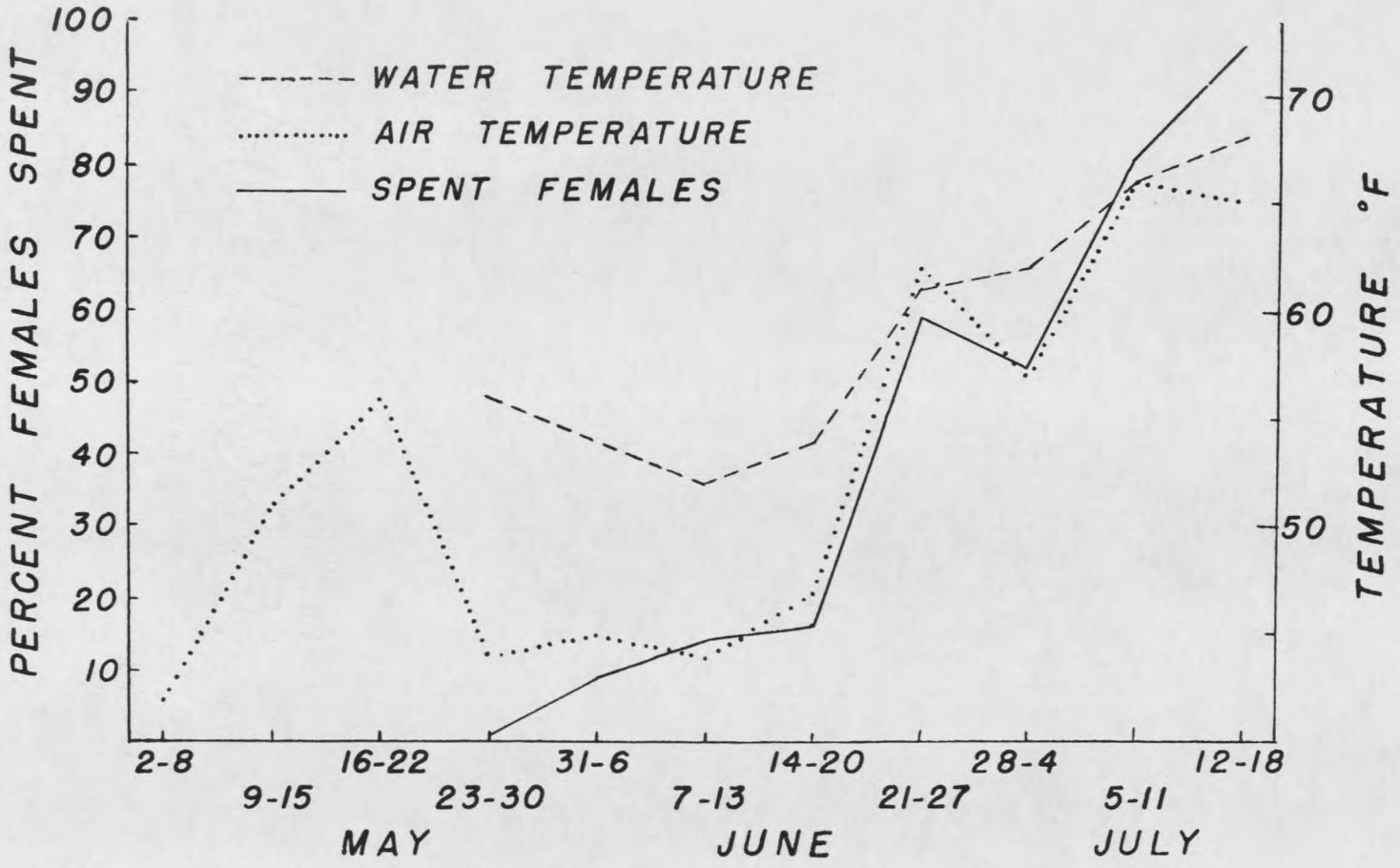

Fig. 3. Relationship between air and water temperatures, and the percent of spent females occurring in periodic collections in Heogen Lake, 1954.

ing occurs in water temperatures above 54° F.

Areas

Two methods were used to locate chub spawning areas: (1) observing the distribution of fry which would indicate the location of spawning areas with respect to the lake shoreline; (2) selecting specific areas for bottom sampling to recover eggs.

The distribution of fry was obtained by surveying the lake shoreline during 1953-1954 (Fig. 1). Their presence was determined by seining and by direct observation. The length of shoreline surveyed at each sampling point varied from 75 to 3,500 yards.

The western part of the main lake from the dam to Watkins Creek is characterized by steep bottoms and no fry were found there. The shore from Watkins Creek to the South Fork arm has steep bottoms interspersed with shallow areas. Fry were locally distributed in protected areas but never abundant. A few fry were present in several shallow bays located in the South Fork arm. Fry were distributed in the numerous shallow areas along the southern shoreline of the Madison arm. Large numbers were observed in certain of these areas. Only one heavy concentration of fry was found along the northern shore of the Madison arm. This was in a protected shallow area. Fry were abundant in several protected shallow areas which occur along the shoreline from the Madison arm to the Narrows. Nearly all of Grayling arm is shallow and the principal bottom material is silt and muck although sand and gravel areas are present. Fry were found along most of the southern shoreline but heavy concentrations were con-

fined to areas which had bottoms composed of sand and gravel. Fry were seldom found along the northern shores of this arm. In 1948, when aquatic vegetation was abundant in Grayling arm, numerous fry were observed in certain areas which had bottoms of silt and muck. These same areas had few or no fry in 1953-1954 when vegetation was nearly absent. No information was obtained on the influence of vegetation on spawning or on the survival of eggs or fry. Few protected shallow areas occur between Grayling arm and the dam and no fry were found along this shoreline.

Southwesterly winds prevail during the summer which subject the northern shores to severe wave action. Fry were seldom found in exposed areas even though other factors seemed favorable for spawning. Fry occurred along most shallow, protected shorelines and heaviest concentrations of fry were found in the Madison and Grayling arms. The shallow areas where fry were most abundant had bottoms composed of sand and gravel.

In 1954, specific areas were selected for bottom sampling in an attempt to recover eggs. The initial effort was with a Petersen dredge. This method was abandoned because not enough area could be sampled in a reasonable time. Chub eggs were collected by removing the thin surface layer of the bottom with a flattened container, or by dragging a fine-mesh insect net through bottom material stirred up by kicking. Eggs were recovered from bottom materials by successive washings through graded screens. No quantitative samples were taken.

Eggs were recovered from 25 of 47 samples taken June 25-July 9. They

were found on various kinds of bottoms including gravel, sand, silt, muck and detritus, but most of them were recovered from sand and gravel. The depths at which eggs were found varied from 1 to 4 feet. They were undoubtedly present at greater depths but no samples were taken because of method limitations. The distance from shore where eggs were found varied from 2 to 150 feet.

Submerged plants were not abundant during the sampling period and those present had attained very little growth. No eggs were found adhering to plants. Numerous observations of submerged snags, stumps and brush in shallow water revealed no eggs. Two mats (3 by 4 feet) of woven willow branches, a piece of driftwood, and an iron pipe were placed at depths of 8-10 feet in areas where spawning was believed to occur. These were checked periodically during the spawning period but no eggs were found adhering to them. None were taken in surface plankton hauls over known spawning areas. Deposition and fertilization of eggs were not observed. No evidence was found of nest construction and the distribution of eggs indicates that they are broadcast over the bottom.

Until 1949, the Fish and Game Department maintained rainbow trout spawning stations on several tributaries to Hebgen Lake. Traps were operated during May and June, and very few chubs were taken. No movement of chubs into tributary streams was observed by the writer.

Number of Eggs

Approximate egg numbers were determined for 7 females (egg sacs still intact) collected during June, 1953 (Table V). These specimens ranged in

Table V. Calculated numbers of eggs for 7 Utah chubs collected in Hebgen Lake.

Total Length, inches	Weight, pounds	Number of eggs
8.8	0.34	15,900
10.3	0.61	32,300
10.4	0.57	21,300
10.9	0.74	47,500
11.7	0.83	47,400
13.4	-	58,500
13.8	1.57	62,400

total length from 8.8 to 13.8 inches. The volumetric method was used to calculate egg numbers. The average number of eggs per female was 40,750 with a minimum of 15,900 (8.8 inch fish) and a maximum of 62,400 (13.8 inch specimen).

AGE AND GROWTH

Fry and Fingerlings

The first fry were observed in 1953 on August 3. Their total lengths ranged from 0.4 to 1.3 inches with an average of 0.8. In 1954, fry were first observed on July 7 and these ranged in total length from 0.25 to 0.5 inches with an average of 0.3. Newly hatched fry were present in bank depressions, in well protected pockets created by driftwood and scattered through emergent vegetation. They were found within a few inches of the shoreline in areas where banks or other cover was lacking. As fry increased in size they were present at greater distances from shore, particularly if submerged vegetation was present.

Fry and fingerlings were collected at irregular intervals from August

to October in 1953 and in July and September in 1954 (Table VI). Fingerlings which averaged 1.3 inches in total length were collected on October 31, 1953. Sampling was limited to areas with depths that could be waded. During late September and October fingerlings became scarce in these waters. The average total length of young of the year during these months is probably greater than indicated in the samples since larger fish apparently move into deeper water.

Table VI. Size of Utah chub fry and fingerlings in collections from Hebgen Lake.

Period	Number	Total length (inches)[1]	
		Range	Average
Aug. 3-6, 1953	275	0.4 - 1.3	0.8
Aug. 27-28, 1953	345	0.6 - 2.1	1.0
Sept. 15-16, 1953	265	0.6 - 2.0	1.2
Oct. 10, 1953	62	0.8 - 2.0	1.3
July 7-9, 1954	224	0.25- 0.5	0.3
July 21-28, 1954	226	0.25- 0.7	0.5
Sept. 7-8, 1954	157	0.8 - 1.5	1.1

[1]Measurements from specimens preserved in 10% formalin

The presence of fry (0.8 inch in total length) in the collection of October 31, 1953 suggests that at least a few chubs may not form scales during their first year of life. Scales with one to three circuli were found on fish 1.0 inch in total length. Scales were not detected on fish 0.8 inch long but bony plates without circuli were found on several specimens with a total length of 0.9 inch. Kimsey (op. cit.) found scales forming in Siphateles bicolor which had standard lengths of 0.78-0.97 inches.

A length frequency polygon of 189 fry and fingerlings collected from one area on August 6, 1953 indicates two age classes were present (Fig. 4). The average total lengths of fish in the first and second groups were 0.9 and 2.8 inches respectively. A study of their scales showed the fish in the second group to be yearlings.

Size and Age at Maturity

Total lengths were taken on random samples of mature male, mature female, and immature chubs collected by gill netting in 1954 (Fig. 5). All fish with undeveloped gonads were classified as immature. These were not sexed. The 524 males in this sample ranged in length from 5.8 to 11.8 inches with an average of 9.4. The 284 females varied in length from 7.4 to 14.2 inches with an average of 10.6 or more than one inch greater than for males.

The length frequency of these fish suggests an age group between 5.0 and 7.5 inches and another between 7.5 and 9.0 inches. Scale studies show that fish in the first size group were nearly all 3 years old and those in the second were 4 years old. A total of 160 fish comprised the first group and 74.4 percent of these were immature, 25.0 percent were mature males and 0.6 percent were mature females. The second group totaled 182 fish and 29.1 percent of these were immatures, 57.1 percent were mature males and 13.8 percent were mature females. No mature males aged by the scale method were less than 3 years old and no mature females were less than 4. Most of the mature males and females were 5 or 6 years old. A few chubs with undeveloped gonads were aged at 5 years old.

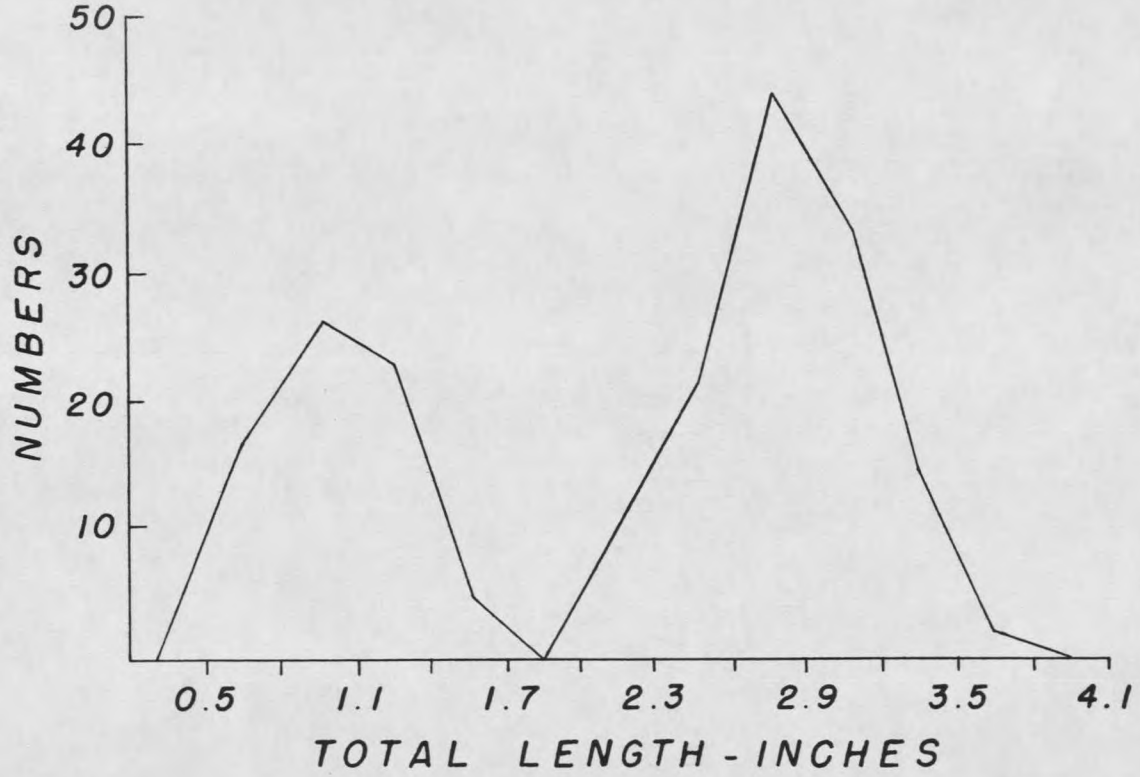

Fig. 4. Length frequency for 189 chubs collected on August 6, 1953 from one location in Hebgen Lake.

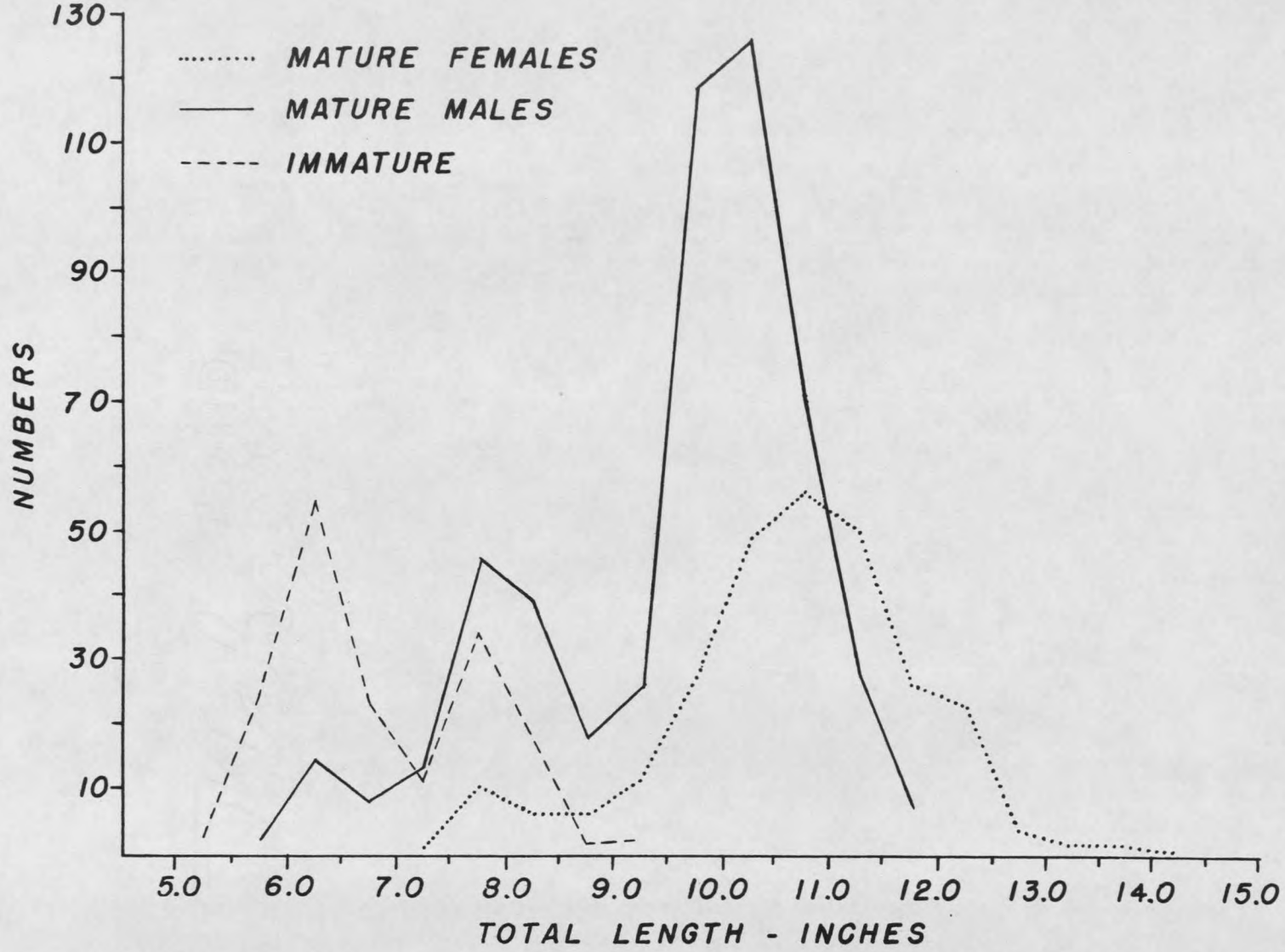

Fig. 5. Length frequencies for 524 mature male, 284 mature female and 175 immature chubs collected by gill nets in Hebgen Lake, 1954.

There is a considerable overlap between immature and mature chubs with respect to size and age. Males apparently mature a year younger than females.

Growth

The age and growth of the Utah chub in Hebgen Lake were based on 475 specimens (188 mature males, 183 mature females, 104 immatures) collected during 1953-1954. These fish ranged in total length from 2.2 to 14.5 inches and represented all of the age groups, I to VIII. Scales were taken from the left side of the body between the lateral line and dorsal fin. Annuli beyond the fifth year were, in general, difficult to detect because of their close proximity to one another. Scale measurements were made along the anterio-lateral radius. Uncorrected calculated total lengths were determined with a nomograph, assuming a linear relationship between scale and body growth. Because of obvious differences between the size of males and females the results were tabulated separately (Table VII).

The average calculated length at each annulus was consistently greater for females than for males. This difference gradually increased from 0.1 inch in the first year of life to 0.7 inch in the seventh. Twenty-seven females and 7 males were 7 years old, and 4 females and no males were 8 years old. This would indicate that females live to be older than males.

The average calculated length of all chubs at the end of each year of life follows: first-1.6; second-3.5; third-6.1; fourth-8.2; fifth-9.7;

Table VII Average calculated total lengths (inches) of Utah chubs collected in 1953-1954 from Hebgen Lake. (I - immature; M - mature males; F - mature females)

Age group	Number			Average total length (inches) at capture			Year of Life																	
							1			2			3			4			5			6		7		8
	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F	M	F	M	F	F
I	38			2.8			1.7																			
II	2			4.5			1.4			3.1																
III	38	15		6.2	6.2		1.6	1.6		3.4	3.7		6.2	6.2												
IV	24	22	7	7.6	7.7	7.6	1.4	1.6	1.4	3.0	3.4	3.2	5.4	5.7	5.4	7.6	7.7	7.6								
V	2	56	44	8.2	9.3	9.7	1.3	1.6	1.6	2.4	3.7	3.9	4.1	6.0	6.1	6.4	7.9	8.0	8.2	9.2	9.6					
VI		88	101		10.5	11.0		1.5	1.6		3.3	3.7		6.1	6.3		8.2	8.4		9.5	9.9	10.5	10.9			
VII		7	27		11.8	12.5		1.5	1.6		3.1	3.4		6.0	6.5		8.4	8.9		9.8	10.4	10.9	11.5	11.8	12.4	
VIII			4			13.6			1.4		3.0				5.7			8.4			10.7		11.8		12.8	13.6
Grand av. by sex	104	188	183					1.5	1.6		3.5	3.7		6.0	6.3		8.0	8.4		9.4	9.9	10.5	11.1	11.8	12.5	13.6
Grand av. all fish	475							1.6			3.5			6.1			8.2			9.7		10.9		12.4		13.6

sixth-10.9; seventh-12.4; eighth-13.6. Hazzard (1936) studied the growth of 26 Utah chubs from Fish Lake, Utah. Their average calculated total lengths at the end of each year of life for the first 5 years were 1.3, 3.5, 5.5, 6.6, and 7.4 inches respectively. The Fish Lake chubs were comparable in length at the second annulus with the Hebgen Lake specimens. Thereafter the Hebgen Lake specimens grew more rapidly.

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SUMMARY

1. The biology of the Utah chub in Hebgen Lake, Montana was studied in 1948 and in 1953-1954.

2. The chub was the most abundant species of fish in the lake.

3. General seasonal distribution of the chubs was; concentrated in shallow areas in the spring, widely distributed around the lake during the summer and fall, and concentrated in the deeper areas in the winter.

4. In 1948 stomach analysis was made on 55 rainbow trout, 70 brown trout and 165 chubs. The percentages of the principal food items by volume of each species were as follows: rainbow trout, insects-39.9 and microcrustaceans-28.2; brown trout, fish-69.2 and insects-9.9; chubs, algae-48.2 and microcrustaceans-24.3.

5. Stomach analysis was made on 209 chubs collected in 1953-1954. Their foods by volume were; 36 percent microcrustaceans, 36 percent insects, 19 percent higher aquatic plants, and 9 percent debris.

6. Diptera larvae and pupae made up about 75 percent of the volume of insects in 1953-1954 and mayfly nymphs about 20 percent.

7. Most of the spawning in 1953 and 1954 occurred during late June and early July.

8. The 1954 spawning season began in May and extended into August.

9. Most spawning occurred in temperatures above 54° F.

10. A rise in water temperatures was associated with an increase in the percent of spent females collected.

11. Fry were found along most of the shallow, protected shorelines.

12. Chub eggs were recovered on various kinds of bottoms including gravel, sand, silt, muck and detritus, but most were recovered from sand and gravel.

13. The number of eggs per female ranged from 16,900 to 62,400 and averaged 40,750.

14. The average total length of young chubs in 1953 increased from 0.8 inch in August to 1.3 inches in October.

15. Sexual maturity was attained by some males at the age of three years. A few females reached sexual maturity at the age of four years.

16. The average calculated total lengths for each year of life based on 475 specimens was: first-1.6 inches; second-3.5; third-6.1; fourth-8.2; fifth-9.7; sixth-10.9; seventh-12.4; eighth-13.6.

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