ASPECTS OF THE BEHAVIOR AND BIOLOGY OF THE LONGEAR SUNFISH, *LEPOMIS MEGALOTIS* (RAFINESQUE), IN TWO ARKANSAS RESERVOIRS

By

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PREFACE

The objective of this study, conducted during the spring and summer months of 1967 and 1968, was to gather information on the life history of the longear sunfish in White River reservoirs. This was to be accomplished through: (1) a description of the behavior of longear sunfish in selected habitats in Beaver and Bull Shoals Reservoirs; (2) a determination of size, age, and seasonal gonadal-body weight relationships of longear from selected habitats in Beaver and Bull Shoals Reservoirs; and (3) a determination of seasonal changes occurring in the ovaries of female longear through examination and enumeration of oocytes and ova.

Thanks are due to the U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, South Central Reservoir Investigations of Fayetteville, Arkansas for providing the opportunity and financial support necessary for this research to be conducted. The use of their research facilities and equipment throughout the study is appreciated.

Members of the staff of South Central Reservoir Investigations who contributed substantially to the completion of this study were: Mr. Daniel Nelson, who assisted in the field work; Mr. David Morais, who constructed figures 1, 3, 4, 5, 15, 16, 17; Mr. Thomas Duncan, who photographed figures 19 and 20; Mr. Robert Jenkins, who offered suggestions in the preparation of the text; and Mr. Louis Vogele, who generously gave his assistance and suggestions throughout the study. To these staff members, especially to Mr. Vogele, I express my thanks.

Members of my advisory committee at Oklahoma State University who gave helpful criticism in the preparation of the text were: Dr. Arthur Harriman, of the Department of Psychology; Dr. Rudolph Miller, of the Department of Zoology; and Dr. Robert Summerfelt, of the Department of Zoology and leader of the Oklahoma Cooperative Fishery Unit, who served as committee chairman.

The Oklahoma Cooperative Fishery Unit provided a research assistantship and financial support for the construction of several figures, and multilithing of the thesis. Funds for this support were provided by the Oklahoma Department of Wildlife Conservation, Oklahoma State University Research Foundation, and the Bureau of Sport Fisheries and Wildlife.

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CHAPTER I

INTRODUCTION

Objective and Scope of Study

The objective of this study, conducted during the spring and summer months of 1967 and 1968, was to gather information on the life history of the longear sunfish (Lepomis megalotis [Rafinesque]) in reservoirs. This was to be accomplished through: (1) describing the behavior of longear sunfish in selected habitats of Beaver and Bull Shoals Reservoirs; (2) determining size, age, and seasonal gonadal-body weight relationships of longear from selected habitats in Beaver and Bull Shoals Reservoirs; and (3) determining seasonal changes occurring in the ovaries of female longear through examination and enumeration of oocytes and ova.

Literature Review

The longear sunfish is widely distributed and frequently abundant in streams and ponds of the central and south-central United States. Blair et al. (1957) described their range as including Minnesota east to Ontario, Ohio and Western Pennsylvania; southward from this area through the Mississippi Basin to the Gulf States and as far north on the coast as South Carolina.

Nesting behavior of longear in streams in Indiana was studied by Kirsch (1895) and in Illinois by Hankinson (1919). Data on the behavior of this sunfish and other members of the family Centrarchidae were summarized by Breder (1936, 1966). Gerking (1950, 1953), Gunning (1959), and Gunning and Shoop (1963) have investigated home range in the longear sunfish and the phenomenon of homing in streams and ponds. Witt and Marzolf (1954) gave a detailed description of an instance of longear spawning in Lake of the Ozarks. Miller (1963) investigated the behavior of longear in aquaria. Huck and Gunning (1967) studied agonistic and spawning behavior in aquaria and in nature. Further investigations of longear agonistic behavior in aquaria are being made by W. Hadley, an Oklahoma State University graduate student. Age and growth of longear have been investigated by Creaser (1926), Hubbs and Cooper (1935), Jenkins, Elkin, and Finnell (1955), and Bacon (1968).

The various aspects of longear sunfish behavior in man-made reservoirs have not been previously investigated. In addition, the author is aware of no prior studies dealing with the food habits of longear while engaged in reproductive activities or studies concerned with longear fecundity and spawning periodicity.

The longear sunfish appeared to be a highly successful competitor in the impoundments in which research was conducted for this study. Cove rotenone samples conducted by South Central Reservoir Investigations and the Arkansas Game and Fish Commission (personal communication) showed that the standing crop of longear in Bull Shoals Reservoir in 1967 was more than three times that in 1952 when the reservoir was new. During this same time period, the standing crop of other sunfishes decreased to less than one-tenth of the standing crop present in 1952. Cove rotenone samples in Beaver Reservoir during 1967 showed all sunfishes to have increased about one-third in standing crop since 1963.

CHAPTER II

METHODS AND MATERIALS

Description of the Reservoirs and Study Coves

Beaver and Bull Shoals Reservoirs are impoundments of the White River in Arkansas and are typically narrow and deep with steep rocky sides. Bull Shoals Reservoir, the lowermost impoundment on the White River, was filled in 1952 and has a surface area of 18,400 hectares (45,400 acres) at power pool. It has a shore development factor of 24.8 and a mean depth of 20.4 meters (67 feet). Beaver Reservoir, the youngest and uppermost impoundment on the White River, began filling in December 1963 and reached power pool level in February 1968. At power pool elevation it has a surface area of 11,420 hectares (28,200 acres), a mean depth of 17.7 meters (58 feet), and a shoreline development factor of 19.1 (Mullan and Applegate 1966). Both reservoirs are characterized by relatively high transparency with maximum secchi disc readings during the study of 8 meters (26 feet) and 7.4 meters (24 feet) in Beaver and Bull Shoals, respectively.

Selection of study areas within reservoirs was made from among coves in which it was thought that longear spawning could be observed. Other considerations were water clarity and ease of access to the area. No attempt was made to select directly comparable coves in each reservoir or coves representative of the whole lake.

Shady Grove Cove, the study area selected in Beaver Reservoir, is located on Rambo Creek near mid-reservoir (Figure 1 A). It has a surface area of 17.4 hectares (43 acres) at power pool level and a maximum depth of 27.7 meters (91 feet). Depending on lake level, much of the shoreline of this cove is formed by a thick limestone layer rising at the waters edge. Due to the newness of the reservoir much of the remainder of the shoreline of more gentle slope is covered by scattered underbrush and second growth timber. In 1967, the lake substrate was generally covered with a coarse silt interspersed with patches of gravel that were lightly silt covered. In 1968, following a 7 meter (23.0 foot) rise in water level, almost all the substrate in the cove was blanketed with approximately one centimeter of coarse silt.

The study cove in Bull Shoals Reservoir, Northwest Cyclone Cove, is located on the mainstem of the reservoir and has a surface area of 8.9 hectares (21.92 acres), and a maximum depth of 37 meters (121 feet) at power pool level (Figure 1 B). This cove has a well-weathered gravel shoreline at the normal lake level and little silt deposition is apparent until the 8 meter (26 foot) depth. In 1968, with a 6.7 meter (22.0 foot) rise in water level, the newly inundated substrate in the uppermost 6 meters (19.7 feet), was covered with dense weedy undergrowth and second growth timber.

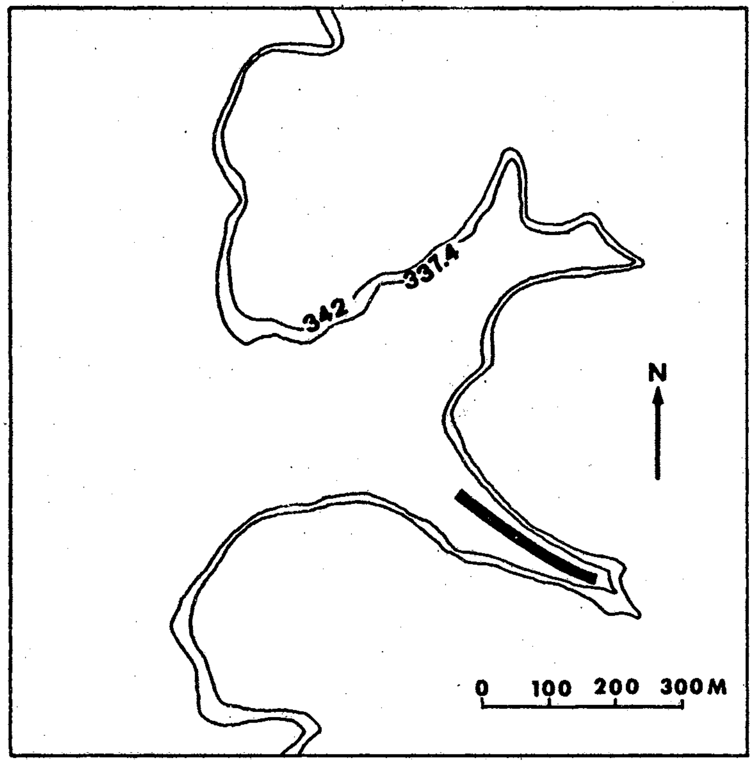
Behavior Studies

Trapping and Fin Clipping

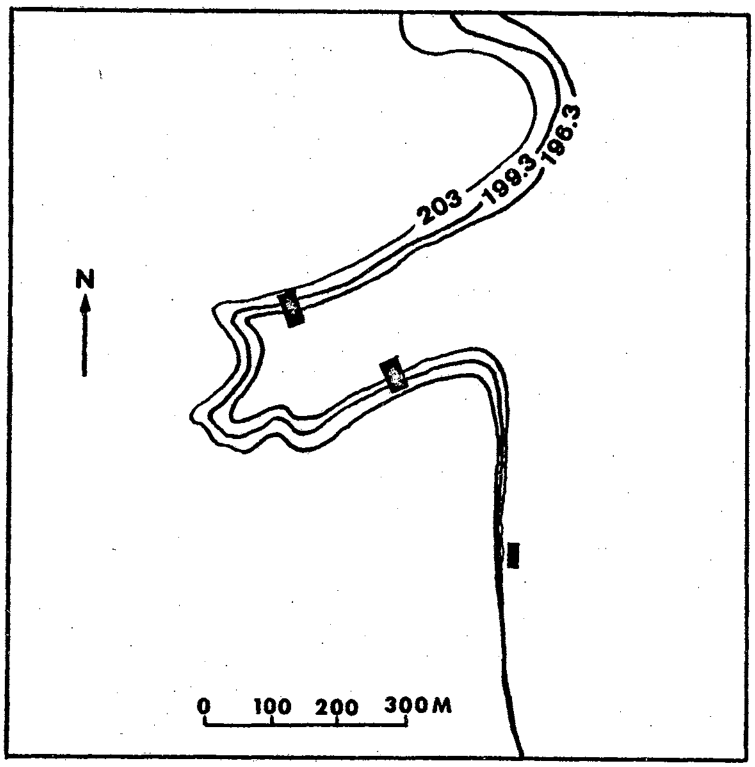
Collapsible nylon, one-half inch bar-mesh "barrel traps" (Houser, 1960) were placed at different depths and locations in the study coves to provide measures of vertical and horizontal distribution and movements of longear. In the Beaver Reservoir study cove, 4 barrel traps

Figure 1. - Study coves in Beaver and Bull Shoals Reservoirs:

A. Shady Grove Cove, Beaver Reservoir. Lower contour line represents power pool level; upper contour line lake level during spring and early summer, 1968. Shaded area indicates location barrel traps were set. B. Northwest Cyclone Cove, Bull Shoals Reservoir. Lower contour line represents lake level during spring and early summer, 1967; middle contour line power pool level; upper contour line lake level during spring and early summer, 1968. Shaded areas indicate locations barrel traps were set.



A



B

were set at 3.0 meter (10 foot) depth intervals from 3.0 meters to 12.2 meters (10 feet to 40 feet) and approximately 60 meters apart down the center of an arm of the cove (Figure 1 A). In the Bull Shoals study cove, 3 traps were set 400 to 500 meters apart in 3.0 meters (10 feet) of water. One trap was set on each shore of the cove and one was placed outside the cove on Cyclone Bluff (Figure 1 B).

The one-half inch bar mesh of the barrel traps was effective in capturing longear greater than 70 mm in total length. The average total length of longear beginning the second summer of growth in Beaver Reservoir was probably greater than 70 mm. In Bull Shoals, the average total length of age I longear was probably less than 70 mm until the latter part of their second summer of growth. Also, male longear of spawning size were less frequently captured during the spawning season. Therefore, although the traps were highly effective in capturing longear, trap catches of longear probably did not represent the age I and older populations in their true proportions at all seasons.

In both coves, an attempt was made to maintain the traps at a constant depth while fluctuations in lake level were occurring. Captured fish were removed from the traps at approximately one-week intervals and given a specific fin clip and released, or were preserved in 10 % formalin for use in other parts of the study. A total of 4,225 longear were captured by trapping in the Bull Shoals study cove and of these, 3,270 were fin clipped and released. Shears were used to trim off either the upper lobe of the caudal fin, the lower lobe of the caudal fin, or the rayed portion of the dorsal fin. In the Beaver Reservoir study cove, 324 of 527 captured longear were fin clipped by removing either the upper portion of the caudal fin, the lower portion of the caudal, or the left or right pectoral fin.

Fish marked by fin clipping could be recognized fairly easily upon close examination. Most of the clips could be easily recognized underwater also and did not appear to significantly alter the behavior of the fish. As a case in point, males with the lower caudal fin clipped behaved similarly to unclipped males in constructing and guarding nests.

Longear marked in 1967 were often recaptured in 1968. Occasionally old clips may have been overlooked. However, they were usually not difficult to recognize due either to the small amount of new fin growth that had occurred or to the lack of pigmentation in the new portion. A more significant source of error in determining the number of tagged fish at large in the population was in the mortality from one year to the next. Some mortality occurred to fish captured in the deep traps of the Beaver Reservoir study cove due to gas embolism upon being lifted to the lesser pressure existing at the surface. Other mortality due to being held in traps or to the handling procedure appeared to be negligible.

Tagging

Longear captured in nests using hand-nets were tagged to allow recognition of individual fish. A 2.5 cm (1 inch) dart tag, having a 0.6 cm (1/4 inch) diameter numbered flag attached to the tip, was used. This tag was anchored into the flesh of the caudal peduncle directly behind the soft rayed dorsal fin. In 1967, a total of 95 fish from the Beaver Reservoir study cove and 88 fish from the Bull Shoals study cove were tagged.

Underwater Observations and Photography

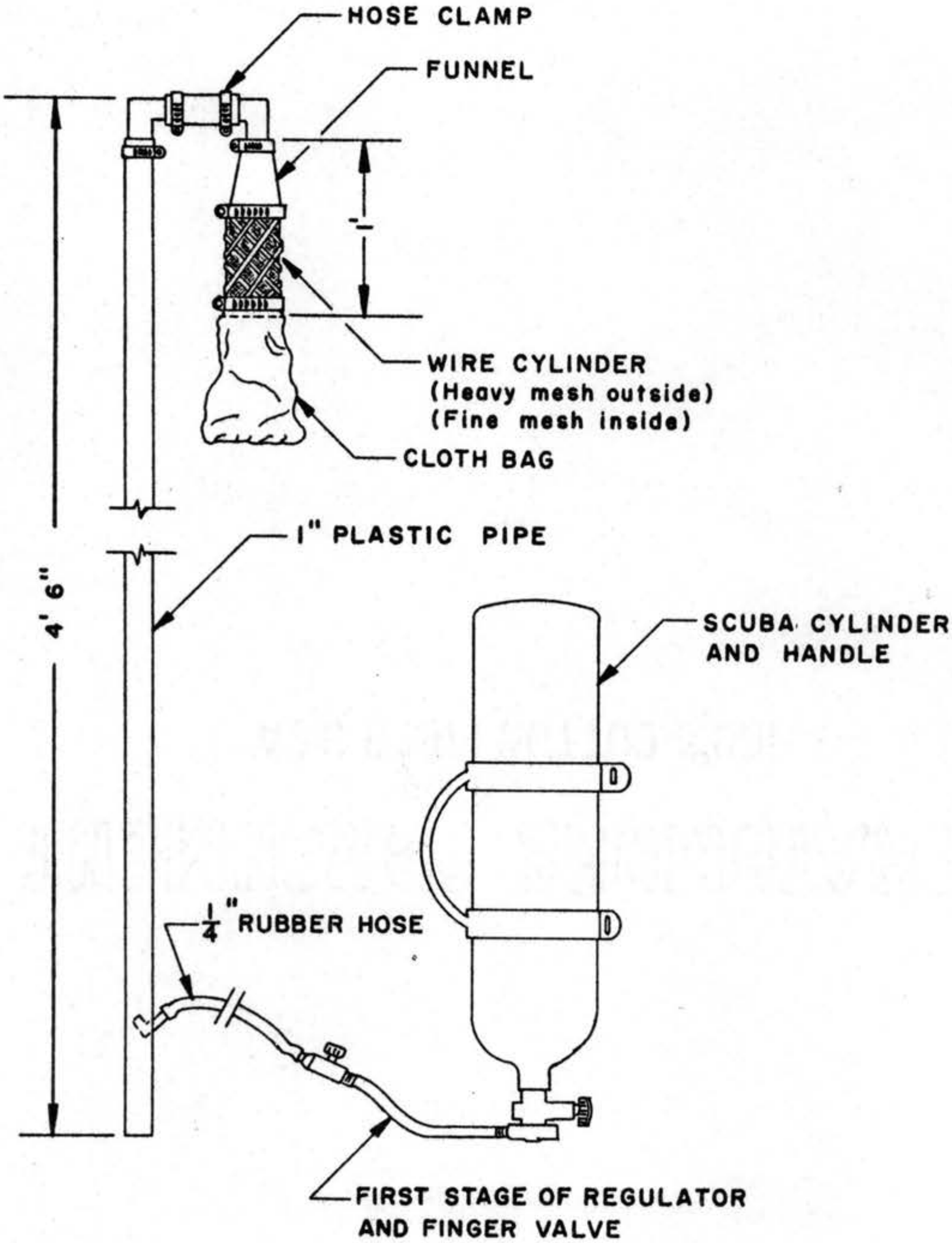
The water in both study coves was of sufficient clarity to enable the effective use of SCUBA (self-contained underwater breathing apparatus) in making prolonged underwater observations of longear activities. Diving was conducted both during the daytime and at night using underwater lights. Observations were recorded underwater with pencil on sheets of frosted acetate film fastened to a clipboard. SCUBA also aided in making collections of spawning fish.

Photographs were taken early in 1967 of a gravel shoreline which was later inundated and utilized by spawning longear. Underwater photographs of longear spawning activities were taken with a 35 mm underwater camera. In addition, approximately 1,000 feet of movie film was taken underwater with a 16 mm movie camera housed in an aluminum case. These films were then reviewed for a more detailed analysis of movements on a stop-motion cineprojector.

Nest Marking

The study of reproductive behavior was facilitated by marking nests with a 3.1 cm (1 1/4 inch) galvanized washer or a 2.5 cm (1 inch) aluminum square (Figure 13). These markers were stamped with a letter for nesting colony designation and with a number for individual nest recognition. In most cases, depth and diameter of a nest were recorded at the time of marking and nest contents were checked at one-week intervals throughout the spawning season. Collections of eggs, or eggs and larvae, were also made from 12 nests with an underwater vacuum unit that was designed by Mr. Louis Vogele and myself (Figure 2).

Figure 2. – Underwater vacuum unit used for collecting eggs from nests of longear sunfish.


HOSE CLAMP
FUNNEL
1'
WIRE CYLINDER
(Heavy mesh outside)
(Fine mesh inside)
CLOTH BAG
1" PLASTIC PIPE
4' 6"
SCUBA CYLINDER AND HANDLE
1/4" RUBBER HOSE
FIRST STAGE OF REGULATOR AND FINGER VALVE

Food Habits During Spawning

The stomach contents of 22 nest-guarding males and 4 females speared while spawning were examined to determine food habits of spawning longear. The contents were identified by microscopic examination and volumetric determinations were made in a graduated centrifuge tube. Percentage by volume for each major food item was then calculated

Ageing

Scale impressions were made for the fish collected in 1967 from barrel traps and by spearing. Age was determined by counting the number of annuli present on the scales as observed with aid of a microscale projector at a magnification of 40 X.

Gonadal Development Studies

Gonadal-body Weight Relationships

Gonadal-body weight relationships were determined from barrel trap collections of 276 and 410 longear sunfish made in the Bull Shoals study cove and 126 and 105 from the Beaver study cove in 1967 and 1968 respectively. Gonadal and body weights were determined in the laboratory from formalin (10 %) preserved fish. Forty-two longear participating in spawning activities were speared to determine gonadal condition at spawning and the effectiveness of barrel trap catches in representing the spawning population.

After blotting up excess moisture, the body weight of the fish was determined to the nearest 0.1 gram. The gonads were then removed, blotted dry, and weighed to the nearest 0.1 gram. The gonadal-somatic index was then calculated by expressing the ratio of gonadal weight to body weight as a percentage.

Stripping

Five ripe females were collected on June 11, 1968, to determine differences existing between eggs that could be stripped with gentle pressure on the abdomen and those that remained within the ovary. Ripe females were stripped in the field and preserved with their eggs in 10 % formalin. In the laboratory, the stripped eggs and the eggs remaining within the ovary were counted and measured to the nearest 0.5 mm. The diameters of these eggs were then compared with the diameter of fertilized eggs collected from longear nests.

Artificial Spawning

To aid in determining the effects of fertilization, water hardening and preservation upon egg diameter and adhesiveness, a ripe male and female were collected from Bull Shoals Reservoir and artificial spawning was attempted. The female measured 95 mm in length and was depositing eggs at the time of collection. The ripe male used was 73 mm in length and although not a nest-guarding male was collected in the colony. One hundred eggs emitted from the female by gentle thumb pressure on the abdomen were mixed in lake water with milt from the male using his tail as a stirring brush. The diameters of these eggs were measured after 40 minutes. One hundred and twenty-five ripe eggs were stripped into a Petri dish containing lake water without fertilization being attempted. After 40 minutes, the diameters of these eggs were measured. Eggs of all treatments were then preserved in 10 % formalin and after 45 hours were remeasured. Following this, the 125 unfertilized eggs first stripped into lake water were transferred from 10 % formalin to 40 % isopropyl alcohol. After 22 days the diameters of these eggs were measured again.

Intra-ovarian Ova and Oocyte Counts

From collections of females made during 1967 in both study coves, 3.1 % random samples, described below, of ova and oocytes were counted and measured. A total of 79 ovaries from the Beaver study cove and 84 from the Bull Shoals study cove were examined. After carefully teasing each ovary apart with dissecting probes, the formalin hardened ova and other ovarian tissue were stained in Alizarin Red and distributed uniformly in the counting dish.

The counting dish consisted of a Petri dish with a marked grid fastened beneath it. In developing the grid, the inside diameter of the Petri dish was determined and transferred to gridded paper. A field falling on the circumference of this circle was included if more than one-half of it was within the circle. Using this procedure, the area of the grid developed was 99.9 % of the area of the inside bottom of the dish. From the many fields on the grid, 9 were randomly selected by assigning each a number and drawing numbered slips of paper from a box. These 9 fields were 3.1 % of the inside dish bottom and were marked for easy recognition.

Ova and oocytes within the marked fields were counted and measured to the nearest .05 mm under a 40 X dissecting microscope with an ocular micrometer. The ova were not perfectly spherical, therefore measurements were made along a horizontal axis. This method was found to be unbiased by Clark (1931) and Carbine (1944). Only those ova one-half or more within each field were counted.

Females used in this study were grouped into arbitrarily selected size ranges for each month. In several cases, females within size groups and months were subdivided into smaller groups having similar size-frequency polygons and oocytes and ova of similar stages. A number of comparisons were made between these groups and the value obtained multiplied times the procedure expansion factor (31.02) to give the estimated number of oocytes and ova involved.

CHAPTER III

RESULTS

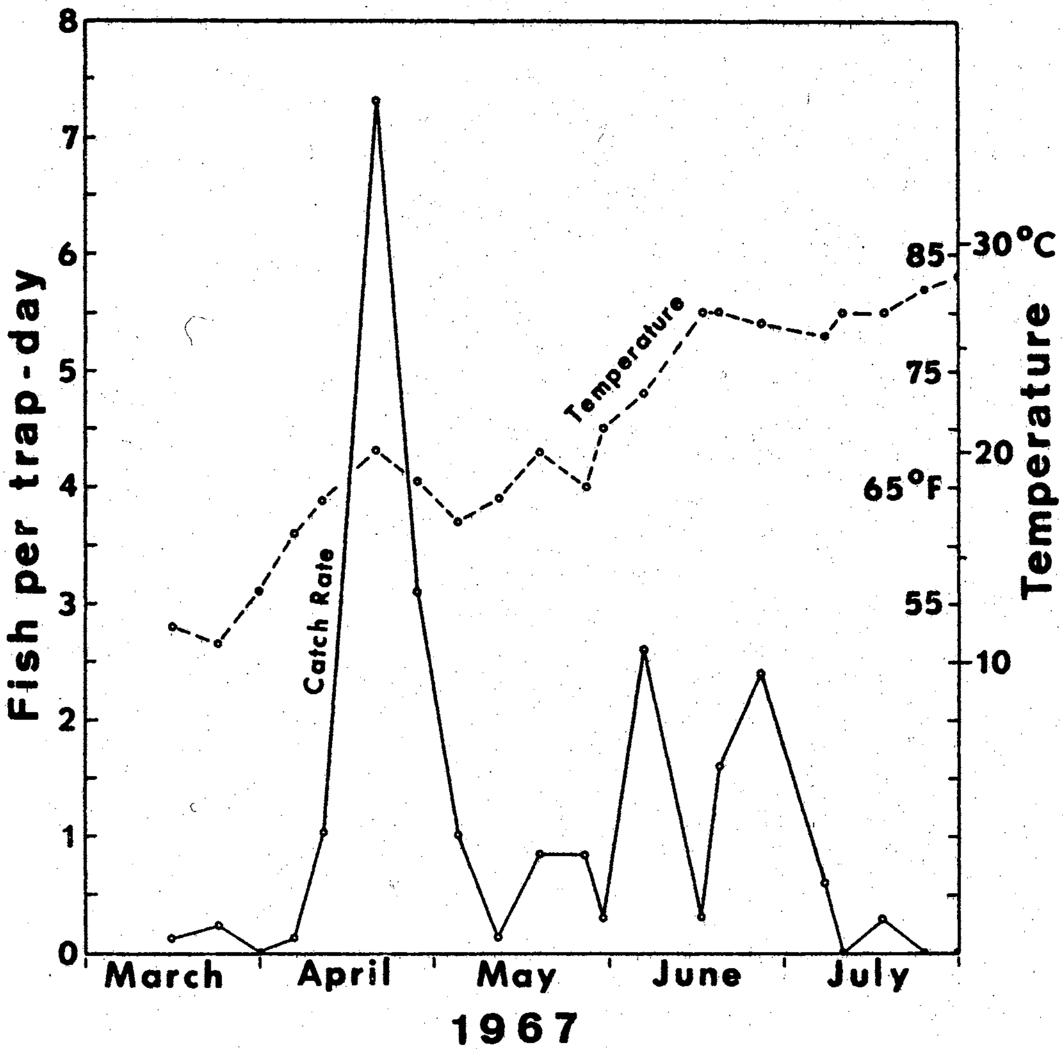
Behavior

Movements

Traps were first set in the Beaver study cove during mid-March in both 1967 and 1968. Catch rates at 3.0 meters (Figure 3, 4) were quite low at this time. Similar low catch rates in March were made from traps at 6.1 and 9.2 meters. However, in the trap at 12.2 meters a catch rate near the seasonal maximum in this trap was made during March 1967 (Figure 5). In observations made underwater in March 1967, longear were seen hiding singly or in small groups under rocks or stumps on the bottom. In early spring at water temperatures below about 12.8 C (55 F), longear appeared to be more easily startled by a diver than they were later in the spring and summer. Therefore, diving observations may not be representative assessments of the activities of longear in early spring.

Breder and Nigrelli (1935) reported decreased activity and aggregation of L. auritus as the water temperature was lowered to 16.1 C (61 F). Upon raising the temperature, they found that the fish became more active and dispersed from the aggregation at a temperature of 17.8 C (64 F). In the present study, trap catches of longear sunfish increased initially after the water temperature reached the 7.2 to

Figure 3. - Catch rate of longear sunfish and water temperature from 3.0 meters (10 feet) in the Beaver Reservoir study cove, 1967.



Fish per trap-day
8
7
6
5
4
3
2
1
0
Catch Rate
Temperature
85
75
65°F
55
30°C
20
10
Temperature
March
April
May
June
July
1967

Figure 4. - Catch rate of longear sunfish and water temperature from 3.0 meters (10 feet) in the Beaver Reservoir study cove, 1968.

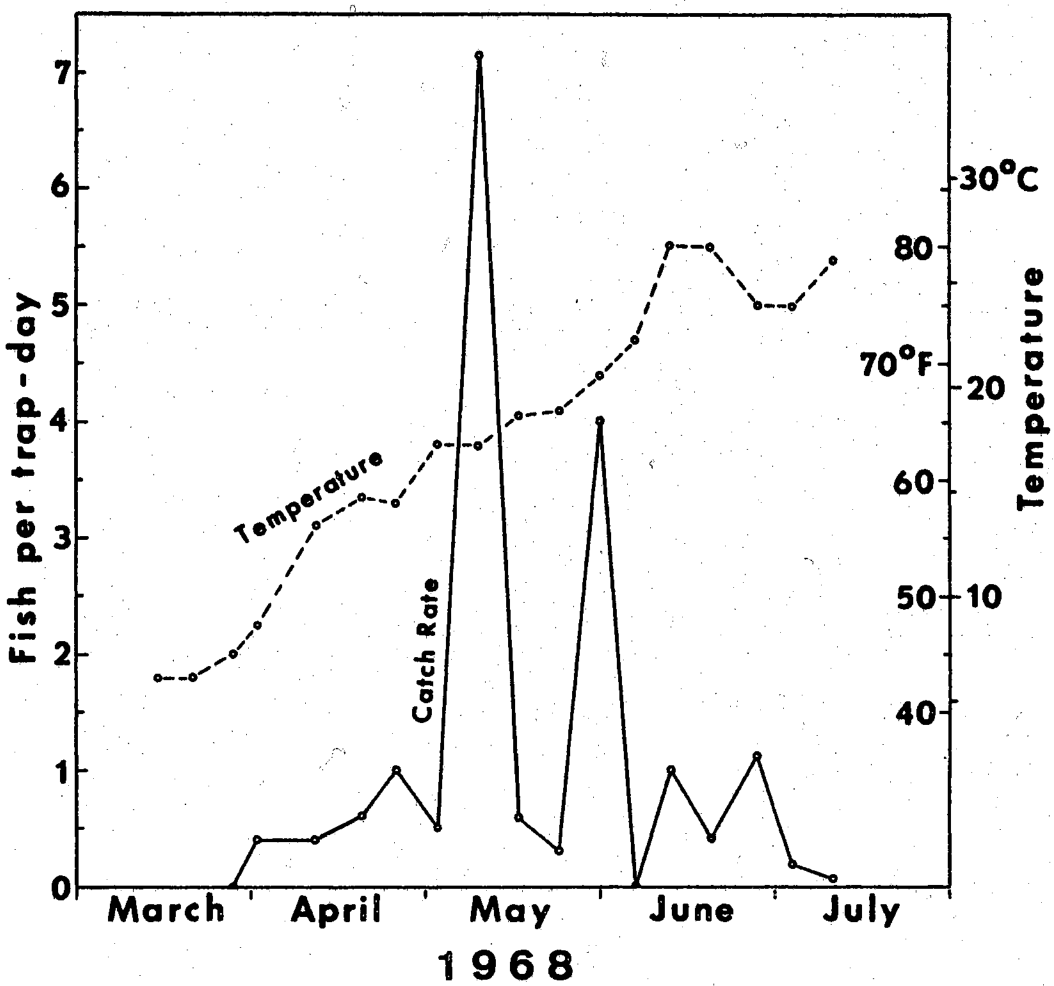
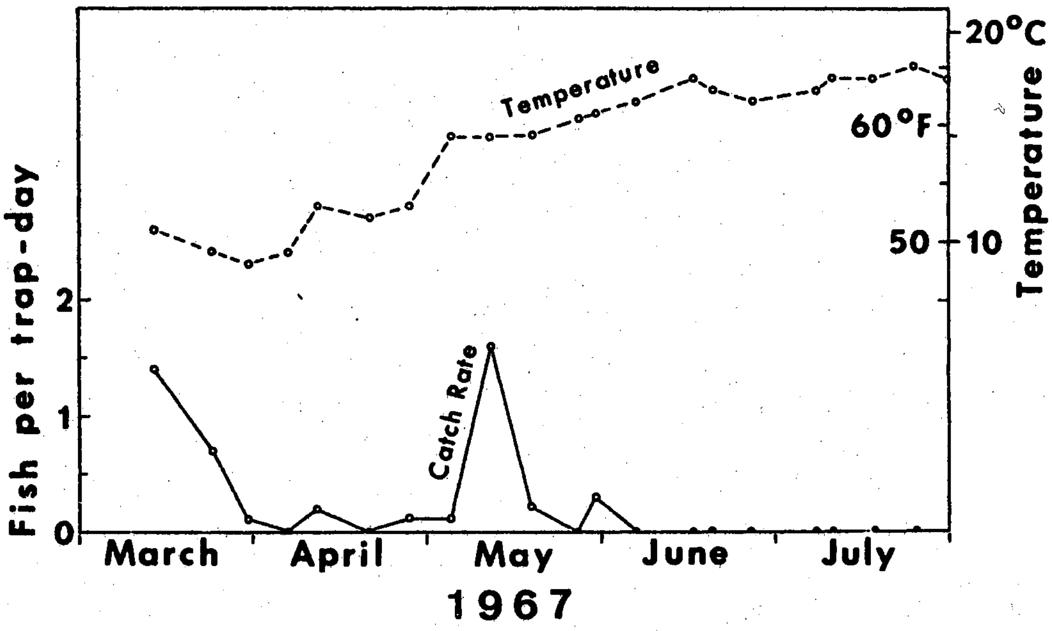

Fish per trap-day
7
6
5
4
3
2
1
0
Temperature
Catch Rate
30°C
80
70°F
20
60
50
10
40
Temperature
March
April
May
June
July
1968

Figure 5. - Catch rate of longear sunfish and water temperature from 12.2 meters (40 feet) in the Beaver Reservoir study cove, 1968.


Fish per trap-day
0
1
2
Temperature
Catch Rate
20°C
60°F
50
10
Temperature
March
April
May
June
July
1967

12.8 C (45 to 55 F) range (Figure 3, 4).

Peak catch rates, in the trap at 3.0 meters depth in the Beaver study cove occurred at 19.4 C (67 F) in April, 1967, and at 17.2 C (63 F) in May, 1968. In June of both study years, as definite thermal stratification began to occur, catch rate at 12.2 meters, then at 9.2 meters, declined to low levels (Figure 5). In late June and early July, catch in traps at 6.1 and 3.0 meters also dropped to low levels. The temperature at 3.0 meters at the beginning of the late June decline in catch rate at 6.1 and 3.0 meters ranged from 25 to 26.7 C (77 to 80 F).

In experiments by Brett (1956) significant mortality of sunfishes occurred at temperatures over 32.2 C (90 F). He found that even at near-lethal high temperatures, sunfish were not reduced to complete inactivity as they were at low temperatures. This was corroborated in the present study by the fact that some longear were captured in traps at water temperatures above 26.7 C (80 F).

Trap catch rate at 12.2 meters during March through May 1967 was .42 fish per trap day. In 1968 during the same time period, catch rate was .01 fish per trap day. The average secchi reading before definite thermal stratification in 1968 (1.94 meters), was less than one-half the average secchi reading over the same period in 1967 (4.1 meters). Underwater visibility by divers was zero at the 12.2 meter depth under conditions of similar turbidity. Clarke (1936) found that visual sensitivity of sunfish was similar to that of man. Because longear primarily feed by sight, it seems likely that turbidity may have limited their distribution to the upper more-lighted depths. Changes in turbidity may have influenced secondarily the depth distribution of longear by influencing the depth distribution of organisms on which the longear fed

It appeared that longear trap catches varied with water temperature. Catch rates in traps at 3.0 meters declined, in most cases, when the ambient water temperature showed an increase over the one-week trapping periods (Figure 3). After declines in catch rate, there appeared to be a period in which the fish adapted to or moved back into that level.

Trap catch rates declined with decreases in water temperature at the 12.2 meter (40 foot) depth during March and April, 1967 (Figure 5). This may have been a direct effect of temperature upon the activity level of fish residing at this depth or a result of fish moving into and out of this level as temperature changes occurred. Temperature changes probably influenced activity because fish marked at depths less than 12.2 meters were not recaptured in the trap at 12.2 meters during this time.

Gunning and Shoop (1963) estimated the home range of longear sunfish in a Louisiana stream as approximately 70 linear feet of stream. In the present study, limited movement of longear was indicated in 1967 at near-normal lake level. During 1967, many recaptures were made of fish marked from the same trap while few recaptures were made of fish marked from other traps (Table I). Gunning and Shoop (1963) suggested that the longer a fish is at large, the greater will be the probability of its straying outside a restricted area. In the present study, the rate of capture increased in 1968 while the total number of recaptures decreased. However, the number of recaptures of fish marked from other traps increased. These results indicated that longear strayed to a much greater degree in 1968 at high lake level than at near-normal lake level in 1967.

TABLE I

CATCHES OF LONGEAR SUNFISH FROM THREE BARREL TRAPS

IN THE BULL SHOALS STUDY COVE, 1967 AND 1968

Statistic	South shore trap 1967	South shore trap 1968	North shore trap 1967	North shore trap 1968	Bluff trap 1967	Bluff trap 1968
Total captured	280	913	307	1374	693	658
Fish marked from this trap	137	720	207	1124	494	488
Total fish marked from this trap	137	857	207	1331	494	982
Average catch per trap day	2.5	10.0	2.8	15.1	6.2	7.2
Deaths in trap	8	12	4	21	3	14
Recaptures from south shore trap	52	22	0	12	1	10
Recaptures from north shore trap	0	10	48	29	0	6
Recaptures from bluff trap	1	11	2	9	104	30

Feeding

Applegate, Mullan and Morais (1965) found the food habits of longear in Bull Shoals varied with body length. In their study, the diet of longear from 0.0 to 1.9 inches (0 to 48 mm) in length was predominately aquatic insects and Entomostraca, while fish eggs made up the remainder. Approximately one-half the diet of longear from 2. to 3.9 inches (41 to 99 mm) was aquatic insects. The remainder was fish eggs, bryozoa and terrestrial insects. Longear from 4.0 to 7.9 inches (102 to 102 mm) consumed mainly terrestrial insects, fish, and aquatic insects. Filamentous algae, bryozoa and detritus made up most of the remainder.

Underwater observations of longear feeding were made at different times of the day. Near dusk, especially in the spring, longear were seen to ingest terrestrial insects from the water surface. Several times, individuals were seen feeding in mid-water. Sometimes in feeding longear would spit out or reject an object at close range. At other times, they made short forward movements as if feeding on zooplankton. Longear were seen feeding with similar short forward movements on zooplankton attracted by a dock light. Occasionally a longear would take a bite of the lake substrate, masticate it a moment and then expel much of it through their opercular openings. Guarding males were often seen feeding in and around their nests.

The diet of longear while engaged in spawning and nest defense has not been previously studied. The results of stomach content analysis of 22 guarding male longear and 5 spawning female longear taken by spear are in Table II. Longear males did not stop feeding while defending nests, but included in their diet food items available in or adjacent to the nest. Female longear, however, consumed little food immediately

TABLE II

FOOD HABITS OF TWENTY-TWO NEST-GUARDING LONGEAR AND FIVE FEMALE LONGEAR SPEARED WHILE SPAWNING

Statistic	Spawning female	Guarding male
Average length (mm)	87	143
Average gonadal-somatic index	4.75	1.19
Number examined	5	22
Number with food	5	22
Total volume (cc)	.04	8.43
Percent of total volume:		
Longear eggs	25.0	32.43
Aquatic insects	25.0	22.17
Terrestrial insects	0.0	4.24
Entomostraca	T[1]	.24
Detritus	50.0	31.49

[1]Entomostraca present in trace quantities.

before and during spawning.

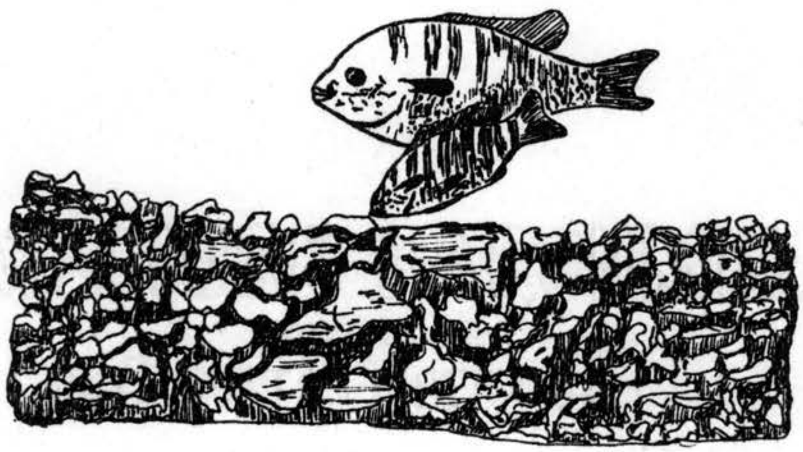
Huck and Gunning (1967) described longear following and feeding with hog suckers (Hypentelium nigricans). Longear were also attracted by a diver kicking up bottom silt, suggesting that this method of feeding is widespread.

Longear frequently ingested eggs from nests of other species. Nest-guarding bass (Micropterus spp.) or crappie (Pomoxis spp.) often were frightened a short distance from the nest by the appearance of a diver. Waiting longear then converged on the abandoned nest in large numbers and rapidly ate eggs. It was very difficult for a diver to drive them from a nest when they were in such a feeding frenzy. In fact, they were not disturbed if one of their number was captured and killed by the diver. The parent bass or crappie usually resumed defensive measures and chased out the intruding longear as soon as the diver left. Rushes by the guarding male bass or crappie often resulted in audible contact with the intruding longear.

A spawning or prespawning female longear sometimes made a peculiar movement upon entering a nest before beginning to circle with a male. The movement involved substrate biting followed by turning on one side and darting away. In turning on the side, the dorsum was directed either toward or away from the pursuing male. At other times, a female entered a nest and bit the substrate and immediately began circling with the male (Figure 6). This movement might be interpreted as being a feeding behavior becoming ritualized into a display having signal value to the male.

Feeding of longear on eggs in longear nests was similar to that described for bass nests except that the guarding male longear sometimes

Figure 6. - Female longear sunfish biting nest substrate prior to circling with male.



could not regain the advantage and subsequently began eating with the others. When such feeding occurred, adjacent males abandoned their nests and participated. Once this began, the fish were not easily distracted even by such things as an observer stirring up silt or making noise.

Guarding male longear often bit the substrate in their own nests. In several instances, eggs were seen to be consumed. Males on adjacent nests sometimes interrupted their displays by biting the substrate and spitting out gravel. Substrate biting was also often seen when a diver approached and observed a nest at close range. Some substrate biting may be displacement feeding produced by conflicting tendencies to flee and attack or remain on the nest. Substrate biting seemed to elicit attack by neighboring males.

Sleeping

Night observations of longear activities were made many times. Activity apparently varied with light because longear became inactive when it became quite dark. Surface feeding was observed in late summer under bright moonlight. In intense darkness longear rested on the bottom in much the same manner as was described for L. gibbosus and L. humilis (Miller, 1963). In the resting position, the fins were spread maximally with the pelvic fins and the midventral line forward to the chin touching the substrate. The pectoral fins were spread at right angles to the body. Body color appeared darker at night than in daytime and vertical barring characteristic of fish in daylight was nearly obscurred. Fish observed immediately after dark were more alert and more easily startled than fish approached late at night.

Comfort Movements

Comfort movements observed included chafing, coughing, body bending fin flicking, and twitching. These movements were rarely seen even while watching fish congregated in an active longear spawning colony. Miller (1963) reported that these activities were thought to occur with greater frequency when animals were under stress from social or other environmental conditions.

Chafing was the comfort movement most frequently seen. It involved brushing the side or belly along the substrate or a protruding stick. Repeated body bending, which involved several sharp turns with movements in the opposite direction, was seen a few times in association with chafing of the belly. Convulsive coughing occurred occasionally in individuals rapidly eating eggs from a nest. Coughing resulted, in these instances, in gravel being ejected from the mouth. Fin flicking was observed rarely and in the cases seen involved only the spined portion of the dorsal fin. A guarding male that was carrying an identification tag in its caudal peduncle went through a series of movements which may be called twitching. This included spreading and folding the spined dorsal fin several times in succession, accompanied by a slight forward movement and a jerking of the head to the side.

Agonistic Behavior

Agonistic behaviors occurred in dominance encounters, border disputes between territorial males, and between spawning males and females within a nest. These normally resulted in one fish being displaced or otherwise indicating a submissive appearance. At other times, such encounters ended with the establishment of a definite boundary between adjacent territories.

Lateral threat displays occurred between males near spawning colonies and between males guarding adjacent nests (Figure 7). A very weak lateral display was seen when a spawning female quickly spread and folded the dorsal spines upon re-entry of the male into the nest after chasing out excess females.

Circling lateral threat displays occurred between nest-guarding and challenging males not defending nests. In this display, much circling and changing of direction by both participants occurred. The nest-guarding male responded quickly to the movements of the challenger and swam forward or backward in a circle of a diameter approximately equal to the body length of the male. The challenger usually swam above the guarding male and in turning faced either toward or away from him. Both participants in this display had all fins spread except the spiny dorsal fins and the pectoral fins; the latter being used in maneuvering. One such display ended with the nest-guarding male becoming more darkly barred and darker on the erected anal and pelvic fins while the challenger became noticeably lighter in these same areas. In the latter part of this display, the pelvic fins of the challenger were folded. The challenger then slowly left the nest site and moved to another where he began displaying in a similar fashion.

The frontal threat in its various forms was the most frequently occurring type of agonistic behavior. It was particularly common and vigorous during reproductive activities. The most lengthy such displays involved males on adjacent nests (Figure 8). Fins were spread except the spiny dorsal fin and alternate short thrusts forward followed by backing into a lateral position were made by each male. While in the

Figure 7. - Lateral threat display between two guarding male longear on adjacent nests.

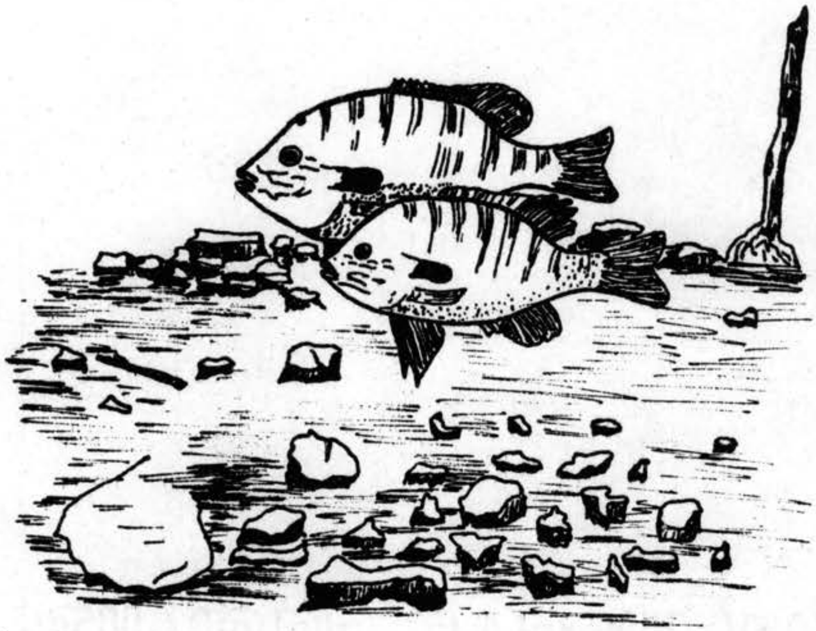
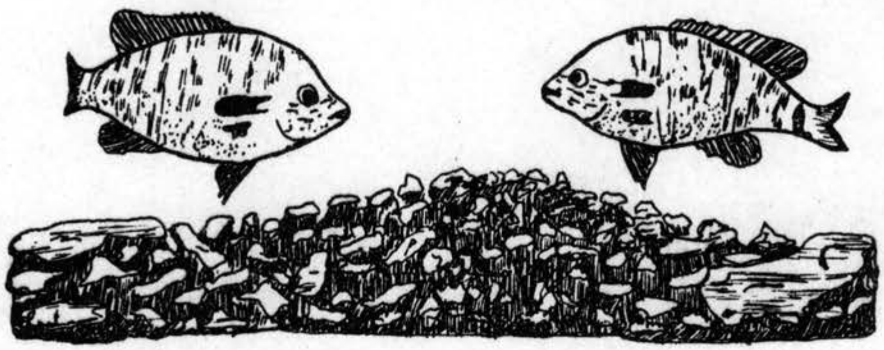


Figure 8. - Frontal threat display between two guarding male longear sunfish on adjacent nests.



lateral position, the rayed portion of the dorsal fin often was quivered repeatedly. This appeared to be an intention movement for the thrust which followed shortly.

In one instance, several lengthy frontal threats occurred as I closely approached a group of nests. My movement apparently frightened away a guarding male, whereupon adjacent males then alternately occupied the vacant nest with one male finally establishing dominance after a series of frontal threats. When I again moved closer to the nest, the guarding male left its newly acquired nest and returned to its old nest where it stayed even when approached very closely. When I moved from the nests, the dominant guarding male returned to occupy the nest. When the original guarding male returned, the new occupant immediately returned to its old nest without the exchange of noticeable threats or displays.

Another form of the frontal threat, called the rush, involved only a short pursuit of fleeing fish. Biting or other contact between the combatants in the rush sometimes led to the more lengthy frontal threat described above. Occasionally, a rush was given by one female to a dark barred and dark eyed female spawning with a male. This darkened coloration together with contracted fins and leaning posture apparently indicated inferiority. Such a submissive appearance seemed to elicit attack especially by smaller fish.

The most commonly seen frontal threat was called the chase, in which the fleeing fish was pursued for a few meters. Contact occurred less frequently in the chase than in the rush. Guarding males often chased carp (Cyprinus carpio) when the latter attempted to enter a longear nest. Unlike carp, smallmouth bass (Micropterus dolomieui) did not elicit attack and frequently swam through longear nests in a head-down posture as though searching for larvae.

Chases given by guarding males usually extended through territories of other males. In these cases, aggressive activities appeared to be directed toward the fleeing fish rather than the intruding male.

Only once during the study was an opercle spread observed. This was given by a nest-guarding male soon after a colony was begun. The participants in this display were two highly aggressive males that had previously been engaged in mouth-to-mouth combat above the common border of their nests.

Aggressive encounters with contact, especially early in the nest building phase, probably accounted for superficial injuries observed on guarding male longear. The rayed portion of the dorsal fin of nearly every guarding male had been split and many other males had portions of their fleshy opercle lobe torn away. Aggressive encounters appeared to dwindle in frequency and intensity, along with dulling of male spawning coloration, as the nesting cycle progressed.

Reproductive Behavior

The spawning season of longear sunfish in 1967 began during the last week of May and continued through June and the first week of July. In the Bull Shoals study cove, a less extensive second spawning period began on July 19, two weeks after the first one ended. It lasted only about one week. A typical nesting cycle lasted approximately 12 days with all clutches appearing to be hatched in approximately 7 days.

The water temperature, at the 1.5 meter (5 foot) level, at the beginning of spawning, was from 21.6 to 22.8 C (71 to 73 F). In one case, at the beginning of the spawning season, males were seen guarding nests at least three days before spawning occurred. The second spawning period began when the temperature at 1.5 meters was 28.3 C (81 F). When the water temperature rose to 28.9 C (84 F), these nests were abandoned and no eggs were found in them.

In the Beaver study cove, males were first seen guarding nests in 1968 on May 31. This was at a temperature at 1.5 meters of 21.9 C (71.5 F). Two weeks later at 27.7 C (82 F), only one active nest remained in the colony. Judging from the early stage of the colony when first observed, abandonment of the nests coincided to the sharp temperature rise. Around mid-June, another colony was begun when the temperature at 1.5 meters was 26.9 C (80.5 F). This colony, too, was prematurely abandoned, and the nests silted over by the following week. A 3.1 C (5.5 F) drop in water temperature at the 1.5 meter level occurred over this same time span.

Nests were first observed in the Bull Shoals study cove in 1968 on July 8, when the temperature at 1.5 meters was 28.3 C (83 F). Due to the age of many of the nests in the colony, initial construction must have occurred when the water temperature was approximately 26.6 C (80 F).

The longear sunfish in the two study coves nested mainly in colonies, but some, usually smaller, males nested singly. Nests were usually shallow, roughly circular depressions rimmed by progressively finer materials toward the outside (Figure 6). The average nest size was approximately 50.8 cm (20 inches) in diameter, ranging from 33 cm to 88.9 cm (13 inches to 35 inches). Although chases of intruders by guarding males often extended through the territories of other males, the territory of a guarding male appeared to include only the nest area itself and the space above the nest to approximately 1 meter. Nest size seemed to depend mainly on the conformation of the substrate with the size of the male playing little or no part. Nests in colonies usually shared at least one border with an adjacent nest. Occasionally, two nests were incorporated into one large nest occupied by only one male.

During the 1967 spawning season, 143 nests were marked with metal nest markers in the Bull Shoals study cove. Only about 100 of these nests were used at the peak of spawning activity. Most nests were constructed early in the life span of a colony with fewer males coming in as the colony aged. In the Beaver study cove in 1967, 120 nests were marked and activity in them followed until the larvae and guarding male departed. Approximately 60 of these nests were guarded at one time. No widespread difference in colony size was seen between the two coves; the maximum in each case was about 45 guarding males. Occasionally, nests were utilized in a second or third spawning attempt and additional batches of larvae hatched from them. It was not known if these were the original owners spawning again or different males. A spawning male just entering a colony would probably utilize an old unoccupied nest if one was available. However, this might depend upon the position of the nest within the colony.

Nesting colonies were constructed in many different habitats. Generally, they were found in brush-free areas having a gradually sloping gravel substrate. Usually, they were located on some shoreline prominence or at the head of an arm of a cove. Such an area in the Beaver study cove was photographed prior to its inundation following spring rains (Figure 9).

As one might expect, nearness of the spawning habitat to the

Figure 9. - Exposed Beaver Reservoir littoral substrate utilized as longear sunfish nesting site following spring rise in lake level.

feeding or winter habitat seems to be a factor in nest site selection. At normal lake level, marked fish seen in colonies were usually those marked from the nearest trap. In Bull Shoals, at a time of high water level, a colony of longear was seen spawning in an unusual situation on a steep rocky bluff. These longear may have spawned in an atypical habitat because in 1968, typical longear spawning habitat was almost non-existent in both study coves. In the Beaver study cove, an old road bed which was within 50 meters of a 1967 colony site was heavily utilized.

Another factor which may have been of importance in site selection was the availability of food to guarding males. One large nesting colony was formed under a cliff directly beneath a group of nesting cliff swallows (Petrochelidon pyrrhonota). Bird lice (probably Eureum malleus) heavily infested the nests and the face of the cliff. Perhaps these lice fell into the water and provided a food source for the longear colony. A colony of longear also was seen near the ramp leading to a boat dock where tame ducks were frequently fed.

The degree and duration of nest exposure to incident sunlight had no obvious effect on colony site selection. The colonies under the cliff and along the boat dock, were generally in the shade while most other colonies received direct sunlight throughout the day.

Nest depths in both study coves ranged from only 0.2 to 3.4 meters (.7 to 11 feet) with the average being about 1.5 meters (5 feet). The average nest depth of a newly constructed colony seemed to be related to light penetration only in the lower transparency range. Extremely shallow colonies were recorded only when secchi readings were very low. No relationship between colony depth and water transparency could be seen at normal water transparency (3 to 6 meters).

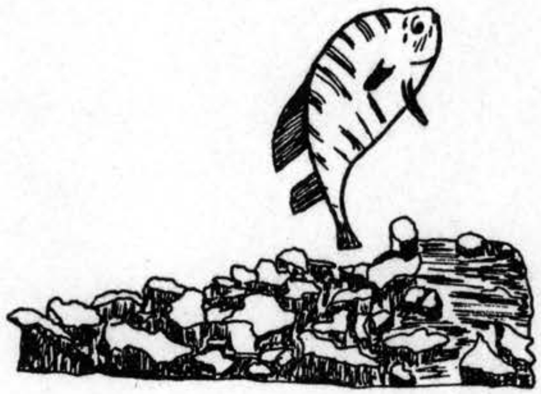
Nest depth seemed to be related to the depth of brush-free, gently sloping gravel substrate. In 1968 in the Bull Shoals study cove, the average depth of 4 colonies was about 2.6 meters (8.5 feet). At this depth, nests were just above the normal lake shoreline where the brush and weeds began to thin out. It appeared that the longear spawned deeper than normal but within the range observed in 1967, in order to take advantage of more preferred substrate.

Nest-building and Care of Young

Male longear constructed their nests by an activity called sweeping This movement involved repeated undulations of the tail with the caudal fin contracted and in contact with the substrate. When sweeping, the spined portion of the dorsal fin was contracted, the soft rayed portion of the anal fin and soft rayed portion of the dorsal fin opposed the sweeps of the tail, while the pectoral fins swept forward (Figure 10). Sweeping began as vigorous fanning which sped up into rapid undulations of the tail. These undulations became slower and finally ceased as the fish reached an angle of near 85 degrees with the substrate. Up to 38 sweeps have been observed in one session.

Sweeping appeared to occur with less frequency after initial nest construction and ceased along with fanning about the time the eggs hatched. Besides its value in cleaning and aerating the eggs, sweeping functioned in driving the adhesive eggs between and under the gravel. This afforded them some protection from nest-robbing longear and from the guarding male himself. When sweeping stopped, the nest became silty and overgrown with periphyton composed of diatoms and colonies of uni-

Figure 10. - Longear sunfish male sweeping nest.



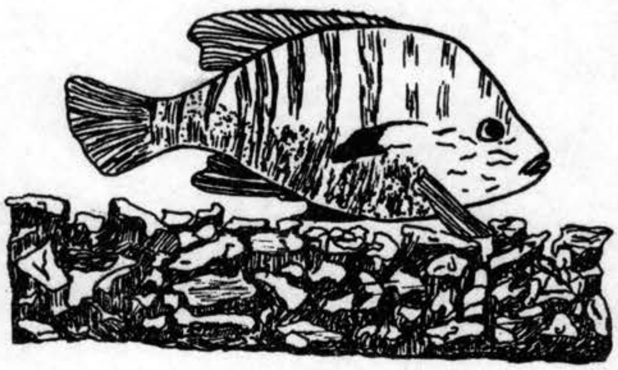
cellular bluegreen algae. This probably had survival value for the larvae who remained hidden in the periphyton until they were large enough to leave the nest.

Fanning involved movements of the tail which were opposed by differently timed movements of the rayed portions of the dorsal and anal fins. The pectoral fins swept alternately forward and maintained the horizontal position of the fish slightly above the nest bottom (Figure 11). Witt and Marzolf (1954) observed fanning immediately after a spawning female left a nest. However, other activities such as sweeping often occurred after spawning but before fanning was seen. Fanning was observed only when eggs were in the nest and was frequently interrupted by agonistic behaviors. Fanning in the male three-spined stickleback was released by stimuli provided by the respiratory activities of the eggs (Iersel, 1953). Longear sunfish were not observed fanning when their nests contained only larvae. Larvae as well as eggs could provide stimuli as a result of their respiratory activities. This suggests that other stimuli in the nesting cycle must be used by longear in determining at what time fanning ceases.

Spawning Behavior

As the spawning season approached, the coloration of the longear sunfish became more brilliant; the female slightly less so than the male. In the male, as the orange-yellow undercolor brightened, this color spread to all fins except the pectoral fins. After the first appearance of males on nests, the 9 to 11 dark lateral bars became noticeably more conspicuous. Along with this barring, the rayed fins and the caudal peduncle became darker, but this darkening was more evi-

Figure 11. - Longear sunfish male fanning nest containing developing eggs.



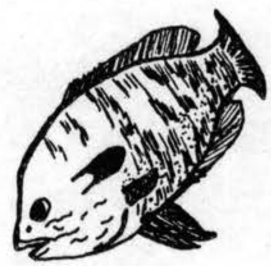
dent in some fish than in others. At some point in the nesting cycle the dark body color and dark rayed fins began to lighten. Most of this dark color was absent by the time the male was guarding larvae and the colony had begun to thin out. By that time, the brilliance of other body colors appeared to be fading to former levels.

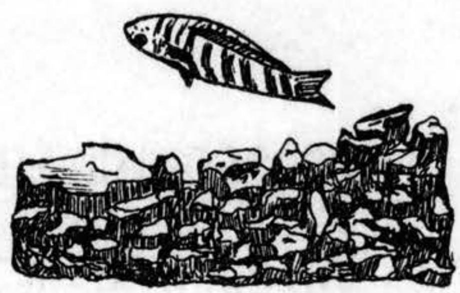
Spawning occurred throughout the day when a female (or usually a group of females) began swimming rapidly about the colony. Spawning females had conspicuous dark bars, dark eyes, and folded fins (Figure 12). The change to submissive coloration and posture sometimes occurred within a few seconds. Smaller females did not necessarily change to a darker color than did much larger ones, indicating that spawning coloration was not strictly dependent on dominance ranking.

At the time the females were seen entering the colony, the males began leading. Leading involved spreading the fins, except the spined portion of the dorsal fin, which was sometimes spread briefly, swimming straight toward the female, and then returning directly to the nest. If the female followed, the male swam in a descending spiral, with one side tilted inward, toward the side of the female (Figure 12). The male and female then began moving close to the substrate in a circle, approximately a diameter equal to the body length of the male, with the female close on the inside of the circle. Circling was frequently interrupted when males chased intruders from the nests. During these chases, the females remained in the nest until the male returned.

The male went directly to the side of the female after returning to the nest whereupon they began circling again. The female sometimes interrupted the circling by leaning on its side, biting the substrate and darting ahead of the male. A male would chase and attempt to lead

Figure 12. - Longear sunfish male swimming a descending spiral to the side of a female that had just entered his nest.





back to his nest a female which left. Generally, a female in a nest would lean on its side after one or two circuits of the nest and would quiver and emit ova (Figure 13). In the egg-laying position, the vertical orientation of the female changed from an angle of 70 degrees to an angle of approximately 15 degrees to the horizontal. The caudal peduncle was swung slightly to the side and in contact with the male, bringing the genital opening near that of the male. The duration of these spawning movements and intervals between them, as measured by cinematography, seemed to be about constant for each female yet different between females.

Several abortive spawning efforts sometimes occurred during which females left and then reentered a nest within a few minutes. From 7 to 20 eggs have been observed to be emitted in one spawning movement, although early spawning movements within a spawning bout appeared to produce fewer eggs. Fertilization probably took place as the eggs were being deposited. Miller (1963) suggested that males, like females, may not shed sex products with each spawning movement. To closer examine this point, water samples were collected from various locations in a nest immediately after a female was seen emitting eggs. No sperm were seen upon microscopic examination of prepared slides of these samples. However, when another spawning pair was interrupted after several spawning movements, the freshly emitted eggs were thought to have become fertilized because within 30 seconds they adhered to the rocks in the bottom of the nest.

A spawning session usually ended immediately following a spawning movement, when the female darted from the nest with the male chasing. A female leaving one nest after only a few spawning movements often

Figure 13. - Female longear sunfish tilting on side in a spawning movement while circling on inside of male. Rectangular metal object is stamped nest marker.


A
27

went immediately and spawned in another nest. Two or more females often were present in a nest at one time. Two females were frequently observed circling on the inside of a single male. No spawning contact could be received by the male in such spawning attempts because only the outside female exhibited a spawning movement (Figure 14). The male usually forced out one female (usually the one farthest to the inside) limiting occupancy of the nest to only one female at a time. However, the males' threats seemed less vigorous toward excess females than toward other intruders.

In two separate instances, egg laying occurred in which females were the only participants. The first instance occurred after I had frightened away a guarding male in a nest with two females. Two females remained in the nest and they circled with each other in much the same manner as in a normal spawning. They often changed the direction of their circling, with each female, in turn emitting eggs while circling on the inside of the other female. When the male returned, this activity was stopped and the male attempted to chase one of the females from the nest. In a second case, there were four fish in a nest with a male and the male interrupted its circling with one female to rush two fish beginning to circle with each other. Apparently, these circling fish were both females because they were dark barred and were difficult for the male to rout from the nest.

Tagging

Spawning periodicity was to be studied through the use of flag tags. Several underwater sightings were made of tagged longear with two observations being made of tagged males guarding nests. However, these tags

Figure 14. - Male longear sunfish circling in nest with two females.

were retained only a short time by longear sunfish. Longear were occasionally seen nipping the tags attached to other fish and several discarded tags were found lying on the lake bottom.

Observations on Nest Contents

Collections of longear eggs and larvae from 12 nests using an underwater vacuum device (Figure 2) yielded from 608 to 2,756 eggs or eggs and larvae per nest. These nests were probably in various stages since egg deposition by different females ocurred during a period of up to one week. The lowest nest egg count (608) was greater than the average number of freely-flowing eggs (414) that were stripped from a collection of ripe females (Table III). This indicated that several females probably spawned in one nest. Underwater observations substantiated this, because several females were seen spawning in one nest within a few minutes of each other. Females might spawn only part of their currently ripe ova in any one nest. Spawning females were often observed which deposited eggs in one nest and shortly thereafter moved to and deposited eggs in another nest.

From the enumeration of longear nests and the recording of their contents, success of reproduction was compared in the two study coves. Spawning attempts were considered successful if at least a partial hatch of eggs occurred. Several times nests were utilized by the same or a different male in a second spawning attempt. A few nests were constructed which were never utilized in spawning. The highest percent of successful spawning attempts occurred in the Bull Shoals study cove during both study years (Table IV).

Larvae appeared to remain in the nest for about one week after

TABLE III

NUMBER AND MEAN DIAMETER OF OVA STRIPPED FROM RIPE FEMALES COMPARED WITH OVA RETAINED WITHIN THE OVARIES

Statistic	Female number 1	2	3	4	5
Age	II	III	II	III	II
Length of fish (mm)	89	95	92	98	83
Gonadal-somatic index	21.1	11.4	10.1	9.9	8.3
Number of free ova	717	370	372	432	177
Mean diameter of free ova (mm)	1.89	1.90	1.77	1.74	1.76
Number of retained ova	123	289	48	151	59
Mean diameter of retained ova (mm)	1.91	1.89	1.82	1.66	1.80

TABLE IV

NUMBERS AND SUCCESS OF LONGEAR NESTS OBSERVED IN THE BEAVER AND BULL SHOALS STUDY COVES, 1967 AND 1968

Statistic	Beaver Study Cove 1967	Beaver Study Cove 1968	Bull Shoals Study Cove 1967	Bull Shoals Study Cove 1968
Number of nests with viable fry from the:				
First spawning attempt in nest[1]	41	9	96	20
Second spawning attempt in nest	0	0	3	0
Total number spawnings yielding viable fry	41	9	99	20
Number of nests constructed and abandoned without receiving eggs	0	0	11	0
Number of nests observed with eggs which produced no viable fry from the:				
First spawning attempt in nest	69	65	48	31
Second spawning attempt in nest	6	0	8	0
Percent total number nests observed which produced viable fry	35	12	64	39

[1]A "spawning attempt" here refers to activities immediate to the deposition of eggs in a longear nest by one or more females and the nest-guarding activities of the male which followed.

hatching. During this time, smallmouth bass apparently preyed heavily on the larvae because longear nests were not defended against them. Larvae apparently left the nest as each clutch developed rather than all at one time. The lengths of 70 advanced larvae collected from a nest ranged from 5.8 to 7.5 mm. The average length was 6.9 mm. The lengths of 22 longear fry collected from a school ranged from 9.5 to 12.3 mm with an average of 11.0 mm. This indicated that larvae left the nest at a length of from 6.9 to 11.0 mm.

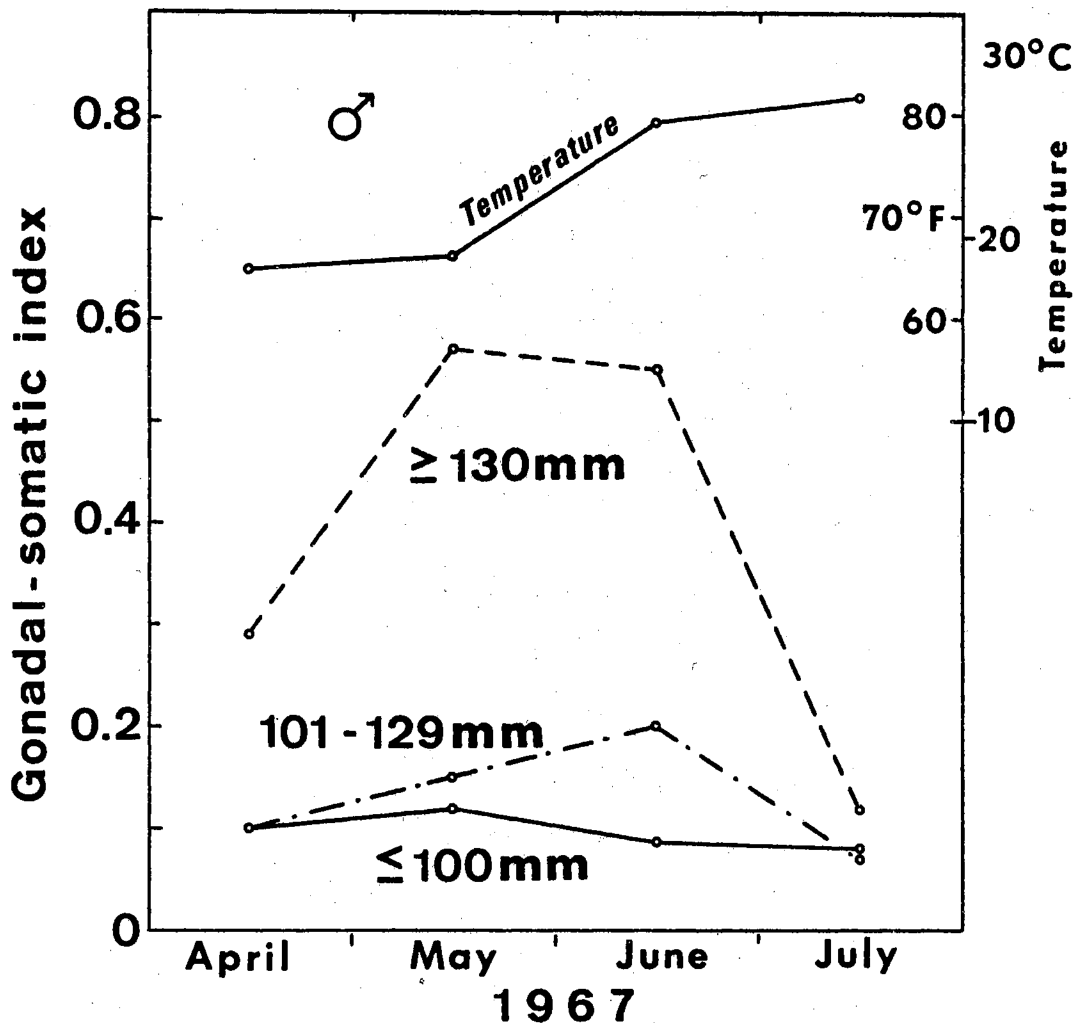
After leaving the nest, fry from several nests gathered in large schools. These schools were usually found around cover such as submerged bushes. Young black bass and other predators preyed heavily upon them at this time. Later, after the schools broke up, the young longear occurred singly or in small groups close to the substrate at shallow depths.

Gonadal Development

Gonadal-body Weight Relationships

The seasonal cycle of gonadal-somatic indexes for males in the Bull Shoals study cove was similar for both study years. The length groups for which curves were plotted were arbitrarily chosen but represented groups of males fairly well. The smallest size class, fish less than or equal to 100 mm ($\leq$ 100 mm), remained at low gonadal-somatic indexes throughout the spring and summer (Figure 15). The slight drop seen from May to July resulted from increment in somatic tissue occurring over the summer rather than a decrease in gonadal weight. Twenty-eight percent of the males captured in the traps of this size range were age I, 56 % were age II, and 14 % were age III. Some of the age III males together with an occasional age IV male of this size category had a

Figure 15. - Seasonal changes in average gonadal-somatic index for three length groups of longear sunfish males in the Bull Shoals study cove, 1967. Temperature is an average temperature reading at two meters depth for the months shown.



♂
Temperature
≥130mm
101-129mm
≤100mm
Gonadal-somatic index
0.8
0.6
0.4
0.2
0
30°C
80
70°F
20
60
10
Temperature
April
May
June
July
1967

gonadal-somatic index of up to 5.62 %. Small ripe males were seldom captured in barrel traps but were often taken by spear or hand-net around nesting colonies.

The gonadal-somatic index of the 101 to 129 mm size group showed a slight increase toward mid-summer. The apparent drop during July may have been partly due to growth of some members of the $\leq$ 100 mm category into the 101 to 129 mm range. During the trapping season, 39 % of the males taken 101 to 129 mm in length were age II, 51 % were age III, and 13 % were age IV. The smallest nest-guarding male speared was 126 mm in length. Usually, nests of small males were not seen in colonies but were found by themselves. The extremely high gonadal-somatic index noted in some small males was not found in members of the 101 to 129 mm size category.

The $\geq$ 130 mm size category of males showed a rapid increase in gonadal-somatic index during April and May. The barrel traps were not completely successful in sampling these large males in June 1967. The average gonadal-somatic index of 20 guarding males speared in the first part of June was 1.21 %. The sharp July decline of the gonadal-somatic index for males $\geq$ 130 mm was partly due to growth of non-spawning males into this size range. Twenty-four percent of males of this size captured in barrel traps were age III, 45 % were age IV, and 32 % were age V. No males were examined older than age V. Of the guarding males speared from nests, 11 % were age III, 56 % were age IV, and 33 % were age V.

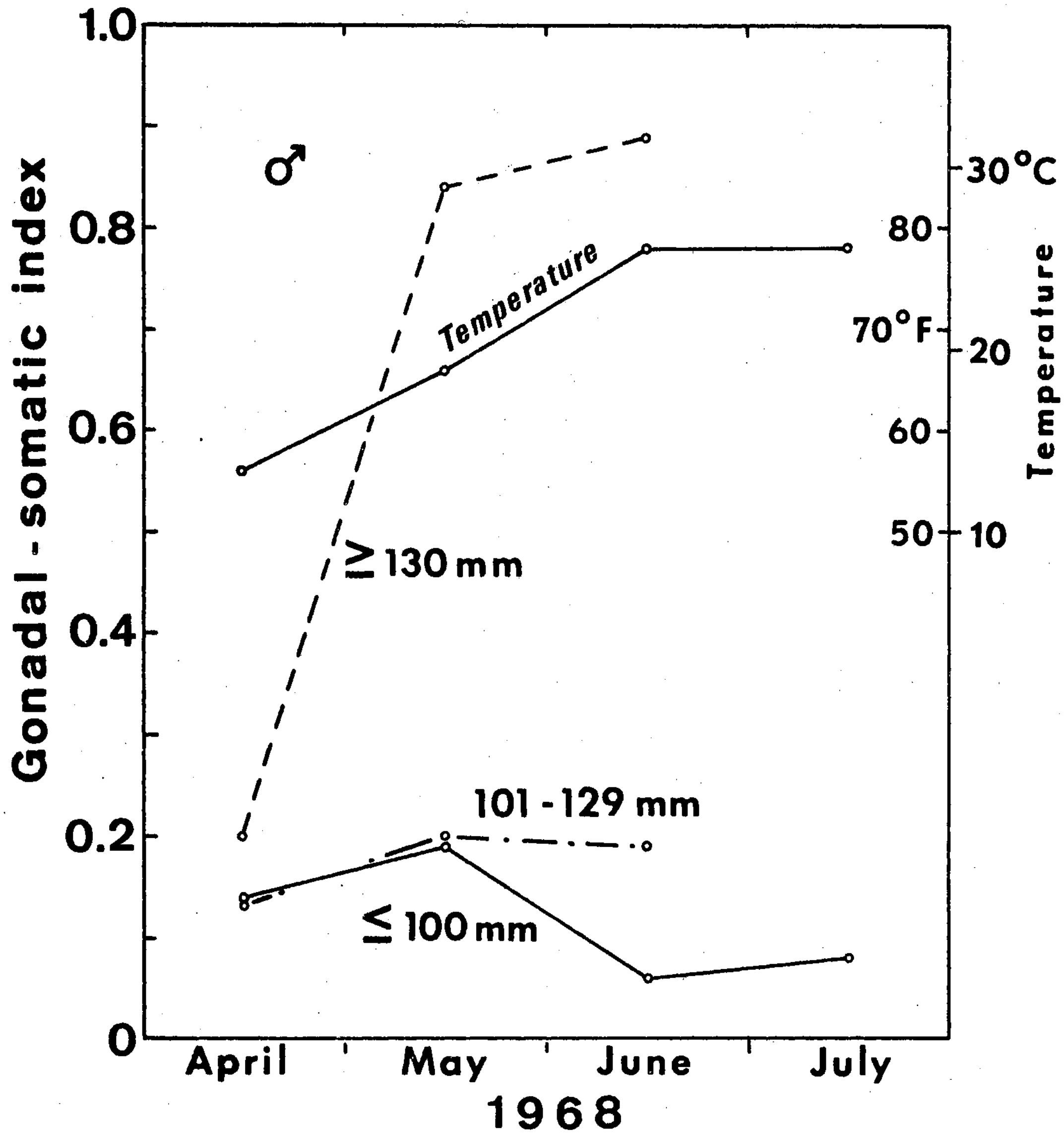
In 1968, in the Bull Shoals study cove, males in the $\geq$ 130 mm size group were more vulnerable to traps in June and July than they were in 1967. This was probably due to a greater degree of movement of longear at high lake level. The gonadal-somatic indexes of these males were much lower than those of spawning males. Perhaps a large portion of the males of spawning size did not mature and spawn in 1968. Only 20 nests were observed in 1968 relative to 96 examined in 1967. There was an obvious reduction in availability of suitable spawning substrate in 1968.

Seasonal variation in gonadal-somatic indexes for males of the Beaver study cove in 1968 (Figure 16) were similar to that of 1967. The males of the ≥ 130 mm category are somewhat misrepresented by the May average. Average gonadal-somatic index for an early May collection was .65 % and 1.20 % for a late May collection. Representative data on males of this size range may be difficult to obtain from barrel traps. However, collections made by spearing nest-guarding males indicated that gonadal-somatic indexes for males were very similar in the two study coves.

The smallest nest-guarding male taken from the Beaver study cove was 142 mm in length. No ripe males of less than 100 mm in length were captured in this cove as they were in the Bull Shoals study cove. The percentage age composition of males of the ≥ 130 mm category was 23 % age II, 46 % age III, 26 % age IV, and 4 % age V. Males 101 to 129 mm in length were 58 % age I, 25 % age II, and 17 % age III. All males of the ≤ 100 mm group were of age I. Of 3 guarding males collected, 1 was age III and 2 were age IV.

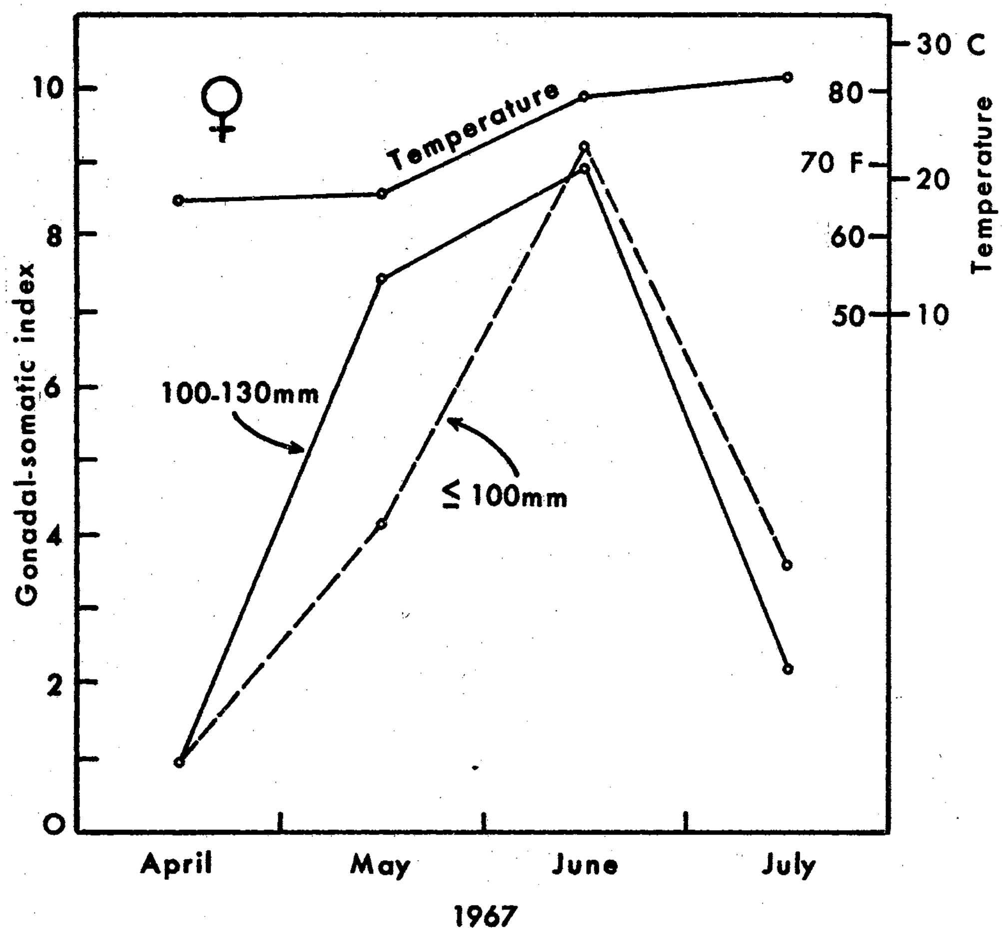
The seasonal pattern of gonadal-somatic indexes for females captured in the Bull Shoals study cove in 1967 (Figure 17), reached a peak in June. A sharp decline in gonadal-somatic index occurred over the time in which spawning was known to have occurred. Several females speared while spawning in a second spawning period July 20, had gonadal-

Figure 16. - Seasonal changes in average gonadal-somatic index for three length groups of longear sunfish males in the Beaver Reservoir study cove, 1968. Temperature is an average temperature reading at two meters depth for the months shown.



1.0
0.8
0.6
0.4
0.2
0
Gonadal - somatic index
♂
Temperature
≥ 130 mm
101 - 129 mm
≤ 100 mm
30°C
80
70°F
20
60
50
10
Temperature
April
May
June
July
1968

Figure 17. – Season Changes in average gonadal-somatic index for three length groups of longear sunfish females in the Bull Shoals study cove, 1967. Temperature is an average temperature reading at two meters depth for the months shown.



♀
Temperature
100-130mm
≤ 100mm
Gonadal-somatic index
0
2
4
6
8
10
30 C
80
70 F
20
60
50
10
Temperature
April
May
June
July
1967

somatic indexes as low as 2.0 %.

The age composition in 1967 for the ≤ 100 m size group was 28 % age I, 44 % age II, 25 % age III, and 3 % age IV. The 101 to 129 mm size group was 10 % age II, 56 % age III, and 34 % age IV. Females captured during the spawning period with gonadal-somatic indexes larger than 2.0 % were assumed able to spawn. The age composition of spawning females was 4 % age I, 35 % age II, 41 % age III, and 20 % age IV. The highest gonadal-somatic index recorded in the study was 21.0 % for an 89 mm female.

The 1968 gonadal-somatic index curves for females of the Bull Shoals study cove are shown in Figure 18. An additional curve is plotted here for a few females of the ≥ 130 mm category. Females of this size were probably age IV. Some age IV females might not have participated in spawning as indicated by the low index values in June. The index values for the ≤ 100 mm and the 101 to 129 size groups increased more slowly to a June peak in 1968 than in 1967. The index values declined sharply in June even though no nesting was observed until July 8, at the time the last collection was made. Decline of ovary size without spawning can result from atresia and metabolic resorption of oocytes and ova. Several females from barrel trap catches during this time emitted a yellow yolk-like fluid upon gently pressing the abdomen. These females did not always appear gravid and had gonadal-somatic indexes from 2.8 % to 6.8 %. Ovaries of these fish had a slight orange coloration rather than the yellow color of a ripe ovary. They also appeared compressed or hardened (Figure 19). The ova within these ovaries were of slightly smaller diameter and were of more irregular shapes than that characteristic of ripe ova (Figure 20). Their color was

Figure 18. - Seasonal changes in average gonadal-somatic index for three length groups of longear sunfish females in the Bull Shoals study cove, 1968. Temperature is an average temperature reading at two meters depth for the months shown.

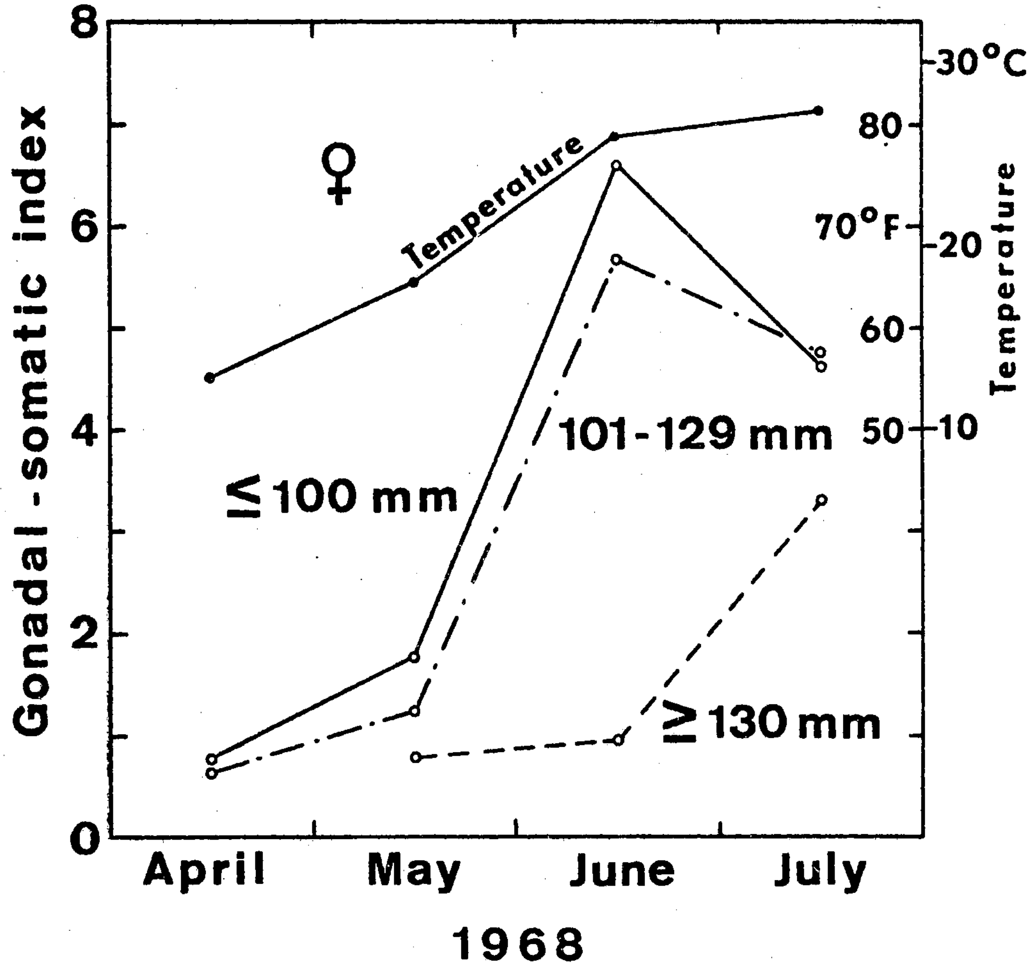

8
6
4
2
0
Gonadal - somatic index
♀
Temperature
≦100 mm
101-129 mm
≧130 mm
30°C
80
70°F
20
60
50
10
Temperature
April
May
June
July
1968

Figure 19. - Ovary of a ripe longear sunfish showing resorption of ova and oocytes. Female was age III and 100 mm in length and had a gonadal-somatic index of 2.73 %.

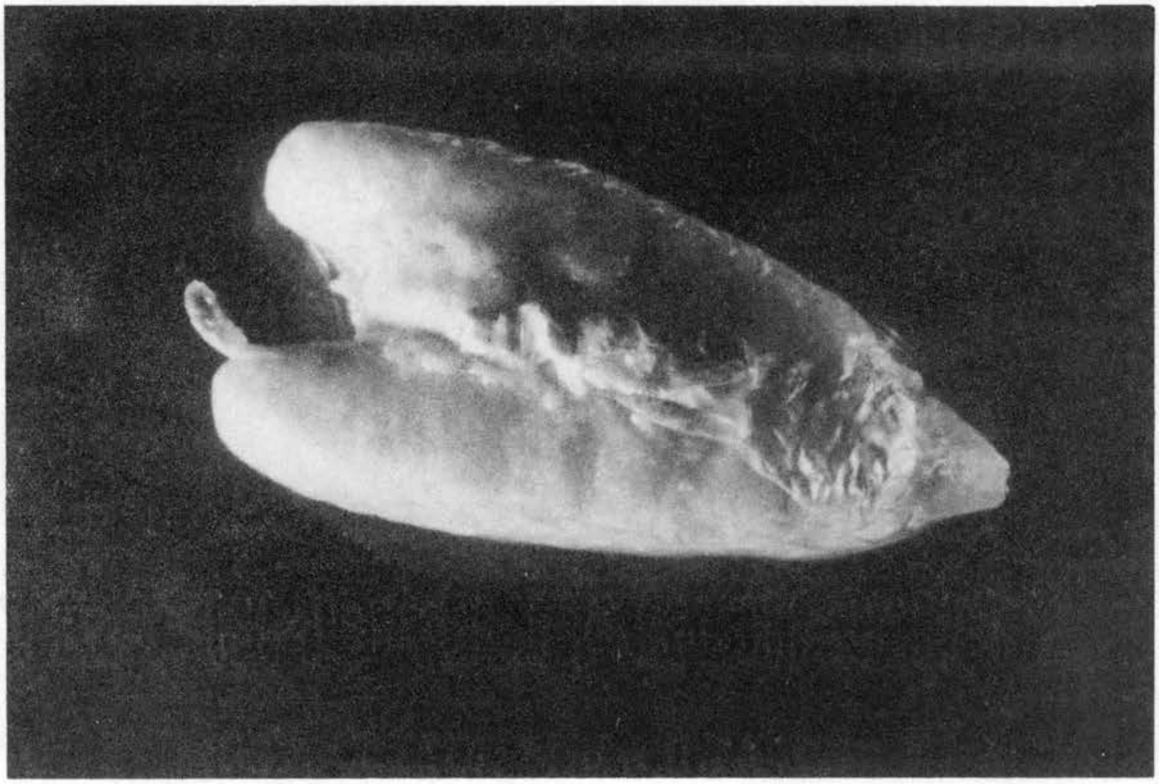
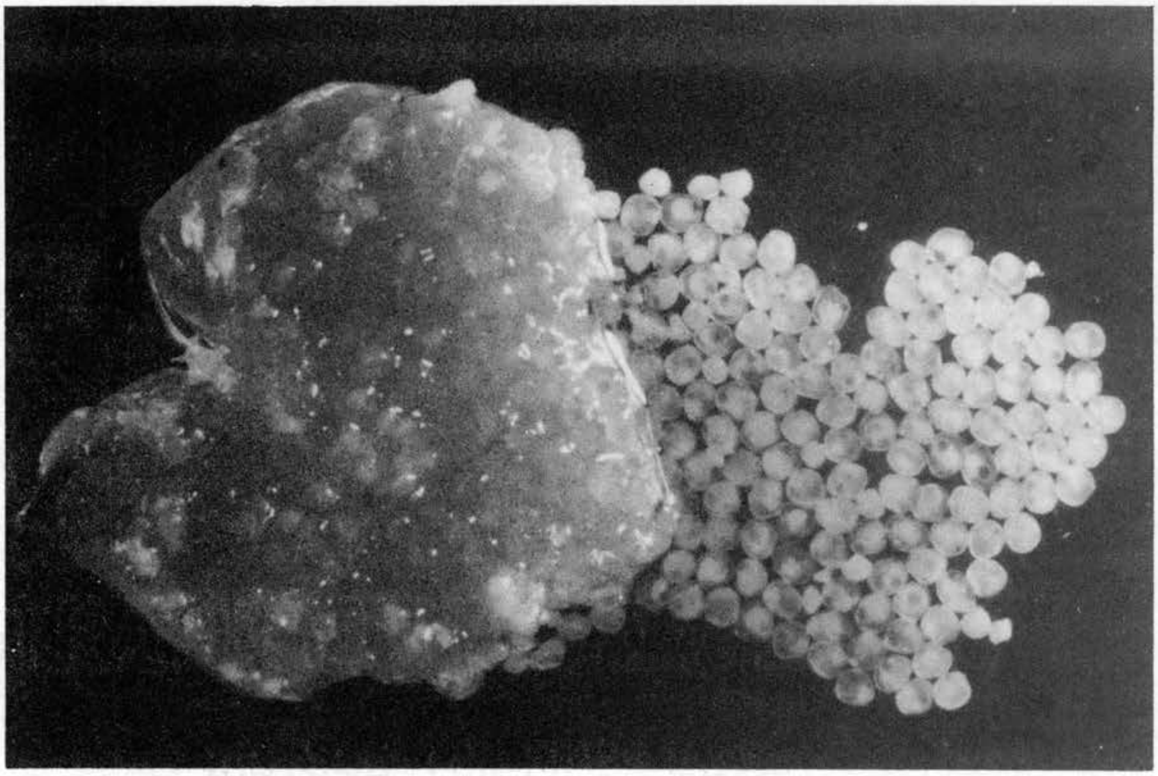


Figure 20. - Ovary of a ripe longear sunfish showing freely-flowing ova. Female was age III and 106 mm in length and had a gonadal-somatic index of 6.78 %.



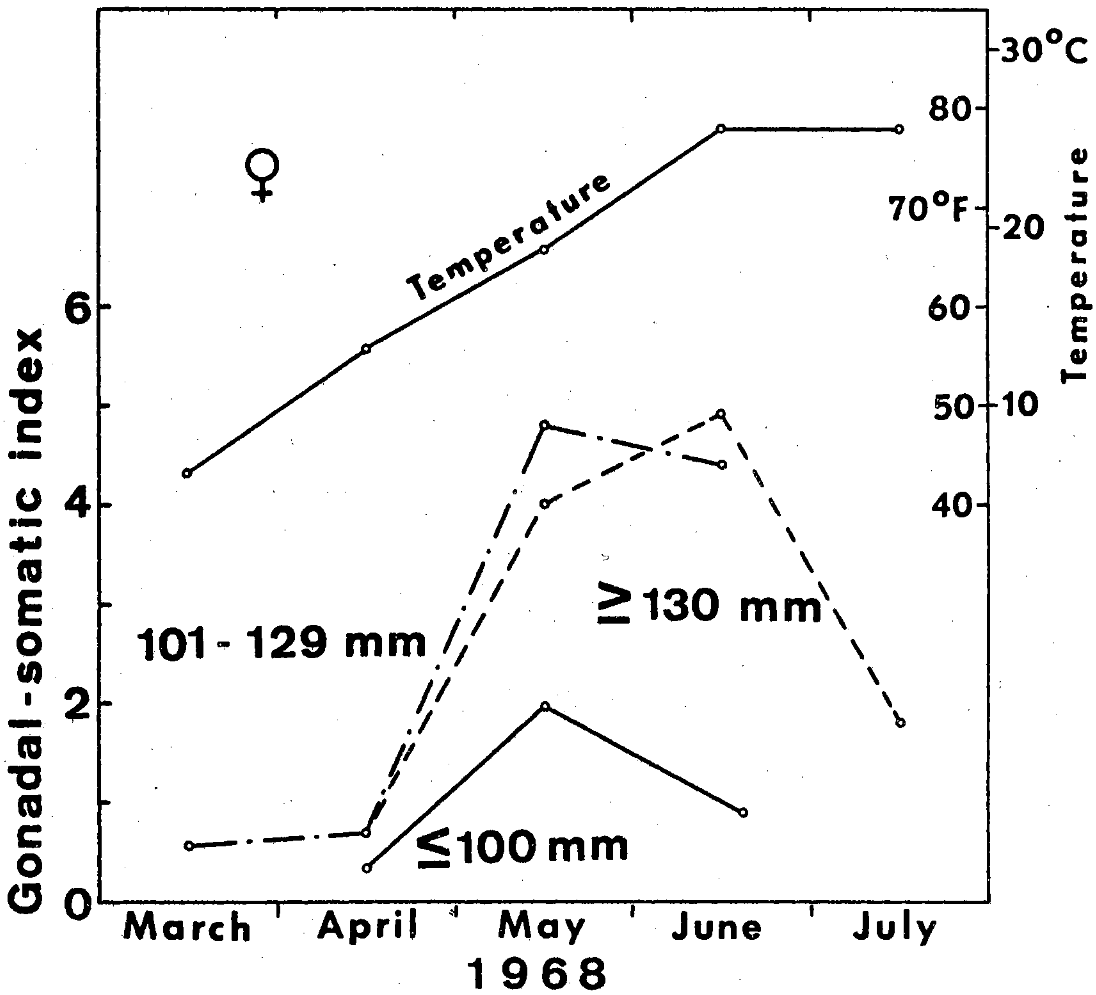
opaque yellow rather than the clear yellow of ripe ova.

The gonadal-body weight relationships of females collected from the Beaver study cove in 1968, are shown in Figure 21. Only 1 of 8 females collected in May of the ≤ 100 mm group had a gonadal-somatic index within the spawning range. Eighty-six percent of the females of the ≤ 100 mm group in 1967 were of age I and 14 % were of age II. Females of the 101 to 129 mm group reached their peak index in late May when spawning was first observed. Two percent of the females collected in 1967 in the 101 to 129 mm size class were age I, 57 % were age II, and 41 % were age III. In 1968, the ≥ 130 mm size class did not reach their peak index until June. The age composition of these females was 22 % age II, 56 % age III, and 22 % age IV. Overall, the age of females spawning in the Beaver study cove in 1967 was 17 % age I, 42 % age III, 33 % age III, and 8 % age IV.

Sex Ratios

The Bull Shoals study cove had a much lower male to female ratio of longear sunfish than the Beaver study cove population (Table V). The Bull Shoals study cove has been inundated several years longer than the Beaver study cove. Selectivity of a predator for the smaller members of the prey species would put greater predator pressure on females than males. Longear are more abundant and grow more slowly in Bull Shoals than in Beaver Reservoir. Female longear in Bull Shoals perhaps receive more predator pressure than do males. In a food habits study conducted by Applegate, Mullan and Morais (1965) on centrarchids in Bull Shoals, longear were found to be important in the diet of largemouth bass. Young-of-the-year longear were particularly important in the diet

Figure 21. - Seasonal changes in average gonadal-somatic index for three length groups of longear sunfish females in the Beaver Reservoir study cove, 1968. Temperature is an average temperature reading at two meters depth for the months shown.



♀
Temperature
101 - 129 mm
≥130 mm
≤100 mm
Gonadal - somatic index
0
2
4
6
March
April
May
June
July
1968
80
70°F
60
50
40
30°C
20
10
Temperature

TABLE V

SEX RATIO OF LONGEAR COLLECTED FROM THE

BEAVER AND BULL SHOALS STUDY COVES

Collection	Males	Females	Sex Ratio Males:Females
Bull Shoals Study Cove 1967	172	66	1 : .33
Bull Shoals Study Cove 1968	286	131	1 : .46
Beaver Study Cove 1967	44	81	1 : 1.85
Beaver Study Cove 1968	54	58	1 : 1.08

of 2.0 to 7.9 inch basses during the summer and fall.

Stripping

Ova stripped by gentle pressure from a collection of gravid female longear represented from 56 % to 85 % of the largest class of ova within the ovaries. Stripping was probably only a rough approximation of the number of ova which were ready to be spawned. However, this procedure suggested that all ova in the largest size class were not all ovulated and loose within the sac-like ovary at the same time (Table III). A hypothesis of equal mean diameters for stripped and retained ova was not rejected (t calc $<$ $t_{.50[50]}$) for any female. This showed that ovulation was not strictly dependent upon ova size. The average size of freshly stripped ova in lake water ranged from 1.68 to 1.93 mm. Eggs collected from a longear nest and measured in lake water ranged from 1.60 to 2.20 mm. Stripped ova then were within the size range of those found in nests. This indicated that little change in size occurred due to water hardening upon deposition in a nest.

Stripped eggs observed with a dissecting microscope were of a uniform spherical shape with a wide perivitelline space and with one to several large oil globules. Retained ova were less uniformly spherical with a narrow perivitelline space and scattered oil globules.

Artificial Spawning

A hypothesis of equal mean diameter for 100 fertilized ova after 40 minutes in lake water and 125 unfertilized ova stripped from the same female after 40 minutes in lake water was not rejected (t calc $<$ $t_{.50\,[200]}$. Most of the supposedly fertilized ova adhered to each other and to the bottom of the container within a few minutes. The unfertilized ova were adhesive to a much lesser degree and could be rolled around by moving the container. Assuming that fertilization had occurred in the eggs that became adhesive, it had no discernable effect upon egg diameter after 40 minutes in lake water.

<u>Effects of Preservation</u>

The total lengths of 200 longear taken in the field and again after preservation in 10 % formalin were compared and a shrinkage factor calculated. Preserved length was .989 fresh length. Because fish were not usually weighed in the field, only 3 fresh weights were available for comparison with preserved weights. From these, preserved weight was found to be 1.033 times fresh weight.

The effect of formalin (10 %) fixation and storage on egg diameter varied widely with the condition of the egg. Fertilized eggs swelled 2.41 % after 45 hours preservation while unfertilized ova swelled 1.05 %. Eggs collected from a longear nest swelled 10.12 % of their diameter at collection following 12 days in 10 % formalin. Unfertilized mature ova after hardening in 10 % formalin for 64 hours did not swell upon being placed in 40 % isopropyl alcohol.

Oocytes in the .45 to 1.40 mm size range swelled an average of 19 % of their original diameter after preservation in 10 % formalin. However, the largest oocytes in this size range did not appreciably change in diameter. This had the effect of grouping the oocytes into a much narrower size range giving the appearance that the ovary contained no oocytes of approximately .45 to .80 mm in diamter. Without knowledge of this differential effect of formalin upon ova and oocytes of different sizes, a more discontinuous process for oocyte maturation would be suggested.

Intra-ovarian Ova and Oocyte Counts

The five stages of ova development described by James (1946) for bluegill (L. macrochirus) and for the largemouth bass (Micropterus salmoides) were apparent in longear sunfish ovaries. They included:

Stage I: Youngest oocytes, they ranged from .05 mm to about .25 mm in diameter and contained a large nucleus. They were irregular in shape and numerous in immature and regenerating ovaries.

Stage II: Vacuolization of the cytoplasm, these oocytes ranged in size from about .25 mm to about .90 mm and appeared opaque due to the many small vacuoles in the cytoplasm. They were most numerous in ovaries in early stages of development.

Stage III: Beginning of yolk deposition, these oocytes ranged from .90 mm to about 1.55 mm and appeared yellow due to the presence of yolk material. They were most numerous in the late stages of ovarian development.

Stage IV: The mature ovum, these oocytes ranged in size from 1.55 mm to 2.20 mm and appeared translucent. Following ovulation, which occurred within this size range, these ova had a single large yellow oil globule and a wide perivitelline space.

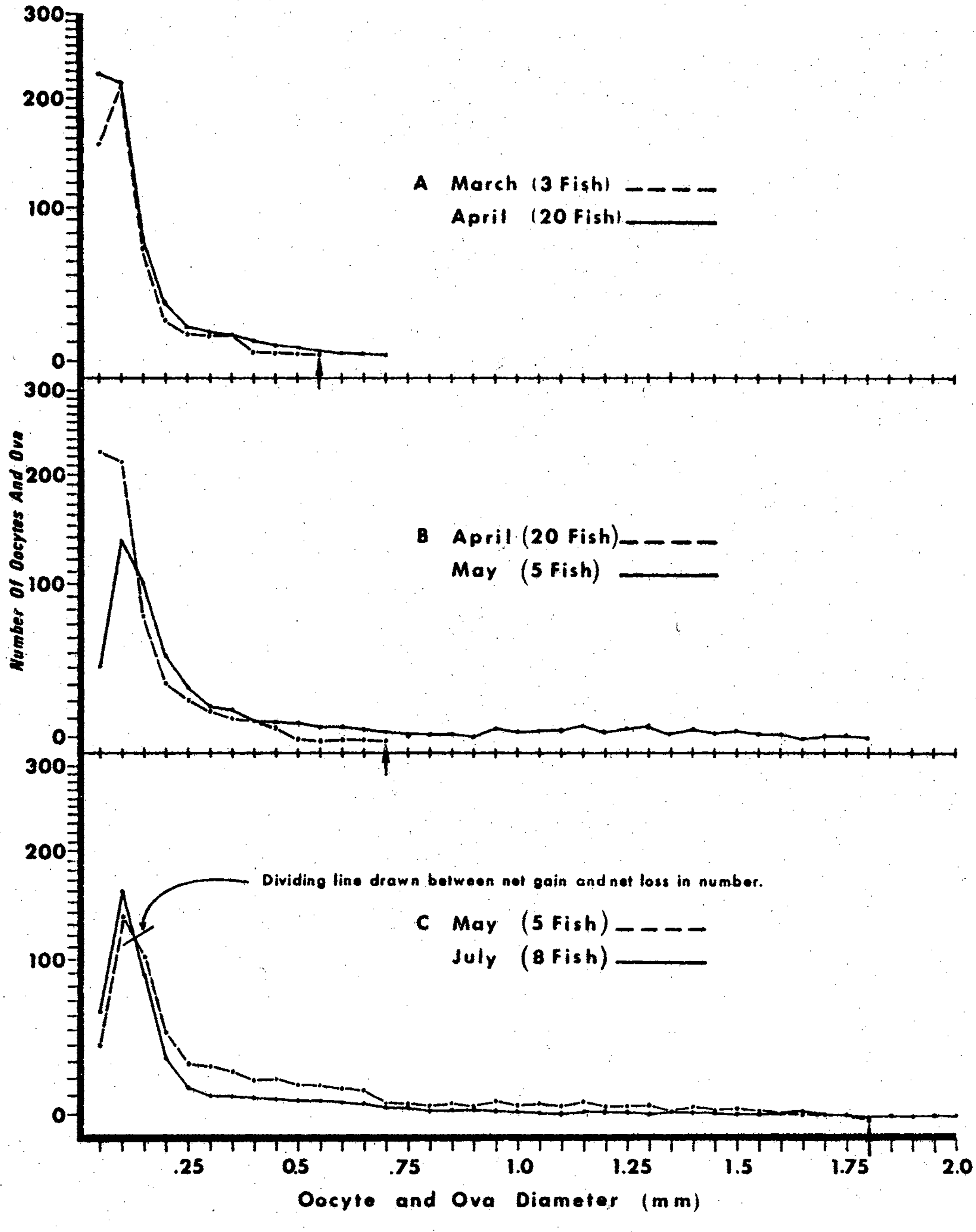
Stage V: Resorption, ova and oocytes in this stage often had irregular shapes and broke up easily while teasing the ovary apart. Atresia of maturing oocytes was significant in longear ovaries throughout all stages. Resorbing ova were usually found in post-spawning females. However, resorbing ova were found in longear ovaries before any spawning activity occurred and approximately two weeks after ripe females were first collected.

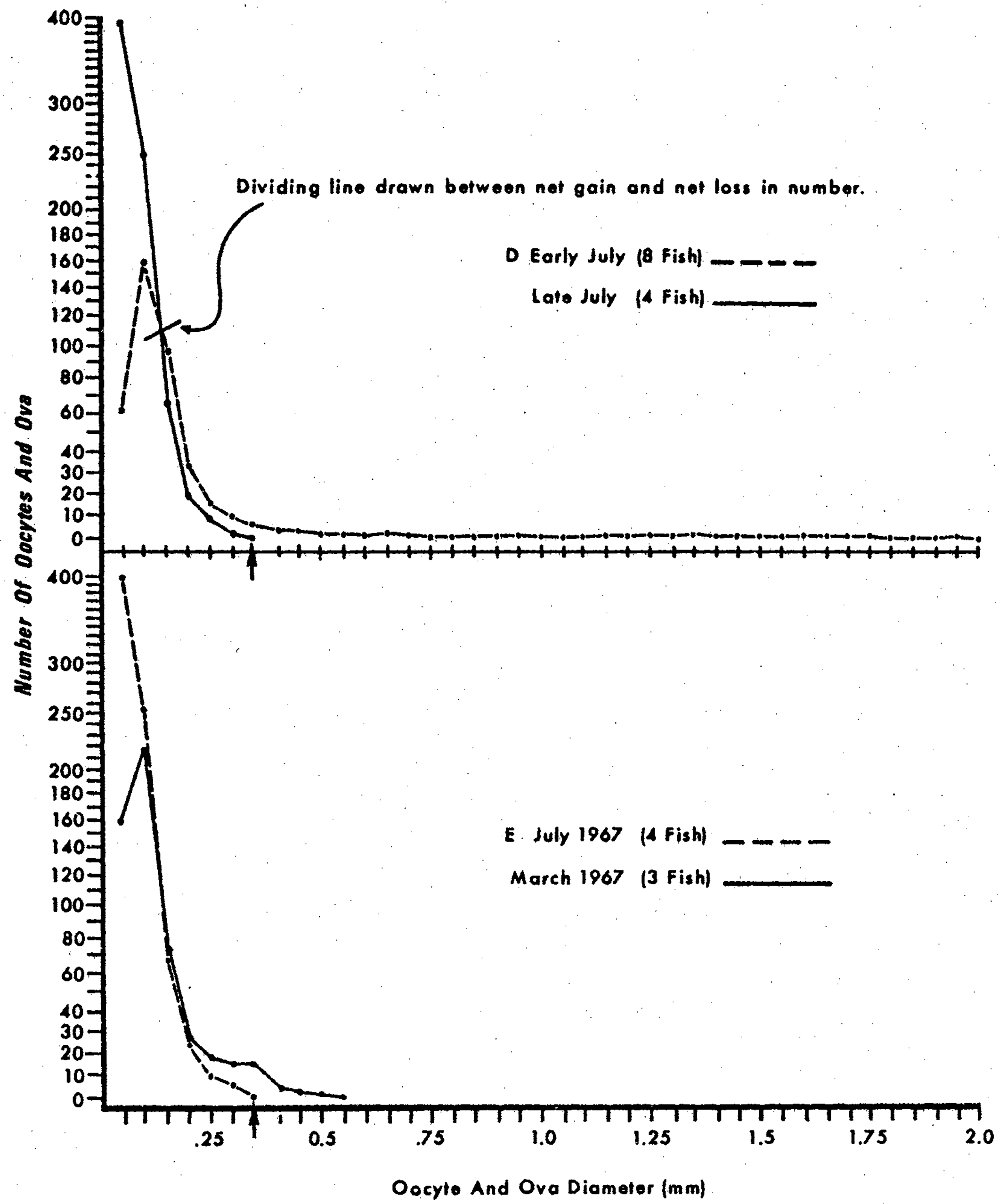
Oocyte size-frequency polygons for each size group of female through the season indicated that many small oocytes (stage I) were generated in early spring. Due to the late setting of traps in the Bull Shoals study cove and the few fish caught in the Beaver study cove in early spring, only one comparison of oocyte size-frequency polygons could be made. Twenty fish in the 101 to 129 mm length class captured in April, had about 3,300 more oocytes than 3 fish captured in March (Figure 22 A).

The average of the largest oocyte size category present in March in the ≤ 100 mm length group of the Beaver study cove was about .40 mm and in April was .45 mm. For the 101 to 129 mm group the March average of the largest size oocyte size group present was .43 mm and in April was .49 mm. The average of the largest size oocyte size category present in March for the ≥ 130 mm length group was .45 mm and in April was .50 mm. In the Bull Shoals study cove in April, the ≤ 100 mm length group had an average largest oocyte size group of .45 mm. The average largest oocyte size group in April for the 101 to 129 mm length category was .55 mm. The largest oocytes present in March and April were in oocyte stage II.

Large numbers of oocytes were resorbed during the weeks immediately preceeding spawning. In the ≤ 100 mm group in the Beaver study cove, females in May had about 5,500 fewer oocytes than they did in April. In the 101 to 129 mm group, this average loss amounted to about 4,500 oocytes (Figure 22 B). The ≥ 130 mm group lost an average of 15,600 oocytes during this period. In the Bull Shoals study cove, the April

Figure 22. - Average size-frequency polygons of ova and oocytes for longear sunfish, 1967. Comparisons illustrate seasonal phenomena found to occur in longear ovaries: A. spring increase in rate of oocyte generation; B. prespawning decrease in rate of oocyte generation and metabolic resorption of oocytes not accounted for by the number of maturing oocytes; C. decrease in numbers of ova and oocytes due to spawning; D. post-spawning resorption of ova and oocytes and period of intense rate of oocyte generation; E. over-winter decrease in rate of oocyte generation, and metabolic resorption of oocytes not accounted for by the number of maturing oocytes.


300
200
100
0
A March (3 Fish)
April (20 Fish)
300
200
100
0
Number Of Oocytes And Ova
B April (20 Fish)
May (5 Fish)
300
200
100
0
Dividing line drawn between net gain and net loss in number.
C May (5 Fish)
July (8 Fish)
.25
0.5
.75
1.0
1.25
1.5
1.75
2.0
Oocyte and Ova Diameter (mm)



Dividing line drawn between net gain and net loss in number.
D Early July (8 Fish)
Late July (4 Fish)
E July 1967 (4 Fish)
March 1967 (3 Fish)
Number Of Oocytes And Ova
400
300
250
200
180
160
140
120
100
80
60
40
30
20
10
0
.25
0.5
.75
1.0
1.25
1.5
1.75
2.0
Oocyte And Ova Diameter (mm)

to May changes were strikingly different. The average April to May loss was only about 478 oocytes for the ≤ 100 mm group. The 101 to 129 mm group gained about 358 oocytes from April to May. However, both of these length groups in the Bull Shoals study cove had low numbers of oocytes in April. Apparently there was little, if any, spring generation of oocytes in females from this cove.

Due to the continuous generation of small oocytes during the spawning season, the number of spawned ova could not be obtained by simply determining the difference between total oocyte and ova counts for two collections. Another complication was coincidence of growth and maturation of oocytes and multiple spawnings during the spawning period. This complication was partially eliminated by finding the difference in number of oocytes and ova above a certain size. This oocyte size was found by determining the point of intersection of the two size frequency polygons being compared (Figure 22 C).

Ova loss due to spawning was derived from oocyte and ova counts of fish taken immediately before spawning and after spawning. Samples of post-spawners were presumably taken before resorption of any left-over ova had occurred. Even though ova loss due to post-spawning rescrption was eliminated or minimized, these estimates still included oocytes resorbed over the spawning period. Kelly (1962) found that resorption did not significantly bias his fecundity estimates for the largemouth bass. For the longear sunfish, atretic oocytes appeared to be common at every stage of development. Therefore, the following estimates of spawned ova are likely to be somewhat larger than actual.

In the Beaver study cove, the number of spawned ova for the May to July period was 1,417 for the ≤ 100 mm length group, 3,440 ova for the

101 to 129 mm group, and 4,213 ova for the ≥ 130 mm group. In the Bull Shoals study cove, the number of ova spawned was 3,600 for the ≤ 100 mm group and 4,136 ova for the 101 to 129 mm group.

Post-spawning resorption of ova and post-spawning regeneration of oocytes were found to occur simultaneously and quantitative estimates of each were made from the same ovaries. Females used in this comparison were collected immediately after the spawning period but before resorption of left-over ova and oocytes and females collected later having all these ova and oocytes resorbed (Figure 22 D). The critical oocyte size used was again the dividing line drawn between net gain and net loss in ova and oocytes over the period in question.

In the Beaver study cove, females of the ≤ 100 mm group following spawning resorbed 412 ova and oocytes and retained oocytes no larger than .30 mm (early stage II). The 101 to 129 mm group (Figure 22 D) resorbed 2,903 ova and oocytes and retained oocytes up to .30 mm in diameter. The ≥ 130 mm group resorbed 1,510 ova and oocytes during this time and the maximum size retained was .35 mm. The Bull Shoals study cove females of the ≤ 100 mm length class resorbed about 134 ova and oocytes following spawning and retained oocytes up to .35 mm in diameter. Females of the 101 to 129 mm group resorbed 1,861 ova and the maximum size oocyte retained was .30 mm.

Post-spawning regeneration by individuals of the ≤ 100 mm group of the Beaver study cove amounted to 8,709 oocytes. For the 101 to 129 mm group, regeneration was 12,966 oocytes. The ≥ 130 mm group regenerated about 16,058 oocytes during this time. Post-spawning regeneration of oocytes for females of the ≤ 100 mm group in the Bull Shoals study cove was 6,495 oocytes and 13,370 oocytes for the 101 to 129 mm group.

Because ova and oocyte counts were made only for females collected in 1967, counts were not available for the spring of 1968. A hypothetical comparison was made between regenerating ovaries from late July 1967 and ovaries from females collected in early spring 1967 (Figure 22 E). Although conditions are likely to vary from year to year, this comparison does indicate that some resorption of oocytes may occur over the winter period.

In the Beaver study cove the hypothetical winter resorption for the ≤ 100 mm group was about 4,818 oocytes. For the 101 to 129 mm group, it was 6,995 oocytes, and for the ≥ 130 mm group only 1,055 oocytes. In the Bull Shoals study cove the hypothetical winter resorption for the ≤ 100 mm group was about 2,877 oocytes and for the 101 to 129 mm group was 8,866 oocytes.

CHAPTER IV

SUMMARY

The longear sunfish is of particular importance in the White River reservoirs of Northern Arkansas and Missouri because they are abundant and because they are predators upon the nests of other centrarchids. Longear are also important competitors for food and serve as forage for bass until the longear reach a length of at least 107 mm.

Longear spawning was observed in coves in Beaver and Bull Shoals Reservoirs. The water was of sufficient clarity to enable the effective use of SCUBA in making prolonged underwater observations of longear activities.

One-half inch bar mesh barrel traps were used to study horizontal and vertical distribution and movements of longear. Traps in Beaver Reservoir were set at 12.2, 9.2, 6.1, and 3.0 meters (40, 30, 20 and 10 feet) in one arm of the study cove. The traps in Bull Shoals were set about 500 meters apart at a depth of 3.0 meters. Fin clipping for marking purposes did not appear to significantly alter the behavior of the fish. Low trap catch rates and diving observations in the early spring indicated that longear were moving little and hiding among rocks or stumps on the bottom. As the water warmed to about 7.2 to 12.8 C (45 to 55 F) trap catches increased. Catch rates in the traps at 12.2 and 9.2 meters declined with the onset of definite thermal stratification. Catch rates in traps at shallow depths dropped to low levels when the temperature reached about 25 to 26.7 C (77 to 80 F). Trap catch rates at all levels appeared to be markedly affected by changes in temperature at that depth.

In the Bull Shoals study cove at near-normal level, a high rate of recapture of fish marked from the same trap indicated a high degree of residency of the longear population. High lake level in 1968 apparently prompted a much higher degree of movement.

Male longear fed while defending their nests by including in their diet what food items were available in or adjacent to the nest. Spawning female longear apparently consumed little food immediately before and during spawning. In the presence of a diver, whose appearance initially frightened a guarding male bass or crappie, longear were observed to be voracious predators upon the eggs of other species.

In intense darkness, longear sunfish rested on the bottom with all fins spread maximally, and with the pelvic fins and chin touching the substrate. In mid-summer they remained active until it became quite dark and surface feeding was seen under conditions of bright moonlight.

Agonistic behaviors and comfort movements were observed, particularly in the context of reproductive activities. Agonistic behaviors probably accounted for many of the superficial injuries observed on guarding male longear and appeared to regulate the size of males nesting in colonies. Nests were observed to be vigorously defended against carp (*Cyprinus carpio*) but not defended against intruding smallmouth bass (*Micropterus dolomieui*).

The longear spawning season began in the two study coves during the last days of May when the water temperatures at nest depth were around 21 to 23 C (70 to 73 F). Initial nest construction occurred up to 3 days before any eggs were deposited. In some instances, newly constructed nests did not receive any eggs and the male soon departed. Intermittent spawning activity was observed throughout the spawning season at temperatures as high as 26.9 C (80.5 F). A temperature change of 3.1 C (5.5 F) in less than 7 days at the nest depth was generally accompanied by abandonment of the colonies.

Most nests were constructed early in the life span of a colony with fewer males coming in as the colony aged. A typical longear nesting cycle lasted almost two weeks. All clutches of eggs appeared to hatch within about one week. Guarding male longear remained at the nest until the larvae departed. Larvae were from 6.9 to 11.0 mm in length at the time they left the nest. Occasionally nests were utilized in a second or third spawning attempt by the original nest owner or other males.

Spawning occurred throughout the day and was begun when a female began swimming rapidly about the colony. A female might deposit all its currently mature ova in one nest but often spawned in several nests before leaving the colony. It was found that even the lowest nest egg count from 12 collected nests was greater than the average number of freely-flowing ova that were stripped with gentle pressure from a collection of ripe females. Fertilization probably occurred at the same time the eggs were deposited. Spawning attempts were often observed in which two females circled on the inside of one male.

Egg deposition was observed in which females circled with other females. Each female, in turn, emitted eggs while circling on the inside of the other female.

Sweeping occurred with less frequency after initial nest construction and ceased along with fanning about the time of egg hatching. Besides its value in cleaning and aerating the eggs, sweeping functioned in driving the adhesive eggs between and under the gravel.

Fanning was observed only when eggs were in the nest. Although fanning was never observed when the nest contained only larvae, the body movements of the male and the movements of the larvae themselves tended to keep the larvae free of silt.

The average size of longear nests was around 50.8 cm (20 inches) in diameter. Nest size appeared to depend mainly upon the conformation of the substrate with body size of the male playing little or no part. Nests in colonies usually shared at least one border with an adjacent nest.

Nest depth ranged from 0.2 to 3.4 meters (.7 to 11 feet) and the average was about 1.5 meters (5 feet). The average nest depth of a newly constructed colony was related to light penetration only in the lower transparency range.

Longear spawning colonies were found in a wide variety of habitats ranging from deeply shaded areas to solid rock ledges on a steep bluff. Generally, however, they were found in brush-free areas having a gradually sloping gravel substrate. Usually, colonies were located on some shoreline prominence or at the head of an arm of a cove.

A higher percent of nests having at least a partial hatch of larvae during the spawning season occurred in the Bull Shoals study cove in both years of the study.

The interpretation of the relationship of gonadal weight to body weight was complicated by the following: (1) all members of a spawning population might not mature at the same time; (2) more than one spawning period might occur for each individual; (3) spawning occurred at a wide range in gonadal-somatic indexes; (4) fish having a high gonadal-somatic index might not participate in spawning; (5) for each sex there was a broad overlap in size among age groups; and (6) the sampling gear was not completely successful in sampling the spawning populations.

In the Bull Shoals study cove, some of the males less than 100 mm in length that were ages III and IV had a gonadal-somatic index as high as 5.62 %. Most of the age III males and all males younger than age III in both study coves showed no appreciable increase in gonadal-somatic index over the spring and summer.

Some of the males of the 101 to 129 mm size group spawned in nests isolated from a colony. Males of this size group did not spawn in the Beaver study cove.

In the Bull Shoals study cove in 1967, most of the males of the ≥ 130 mm group spawned. The smallest nest-guarding male speared in this cove was 126 mm in length. Of 20 guarding males speared from nests in this cove, the average prespawning or early spawning gonadal-somatic index was 1.21 %. A large portion of the spawning size males did not mature and spawn in 1968, in this cove. It is thought that this was due primarily to the high lake level and resulting scarcity of spawning substrate of the type most often utilized. Many males were captured that were age V, but none were captured older than age V.

In the Bull Shoals study cove in 1967, gonadal-somatic indexes for females reached their highest point in June at about 9 %. Females in this cove were slower growing and reached higher gonadal-somatic indexes than did females in the Beaver study cove. Females were speared in mid-summer spawning periods with gonadal-somatic indexes as low as 2.0 %.

Females apparently spawned more than once in a season. Few longear females in the Bull Shoals study cove reached a length of 130 mm. Females attaining this length were generally age IV and may not have participated in spawning.

In the Bull Shoals study cove in 1968, female gonadal-somatic indexes reached a peak in June and began to drop even though no nesting was observed. Decline of ovary size without spawning represents atresia of ova and oocytes and metabolic resorption of yolk.

In the Beaver study cove, females spawning were younger, on the average, than in the Bull Shoals study cove. This was probably due to increased year class strength that developed in the early years of Beaver Reservoir.

There were 2 to 3 times as many males as females in the Bull Shoals study cove. Females apparently outnumbered males in the Beaver study cove. These observations suggested that sex ratio of longear populations may change in favor of the males as a White River reservoir ages.

Ova stripped from gravid female longear represented from 56 % to 85 % of the largest class of ova within the ovaries. This indicated that an individual female did not deposit, at any one time, all the ova which it was capable of producing during the spawning season.

The size of ova stripped from gravid females was within the size range of eggs collected from longear nests. Therefore, little change in egg diameter occurred due to water hardening upon deposition in a nest.

Effects of water hardening upon fertilized and upon unfertilized ova were not significantly different. Apparently fertilized ova adhered to each other and to the container to a much greater degree than did unfertilized ova.

Body length of longear preserved in formalin (10 %) was found to be .989 fresh length. Preserved weight was 1.033 times fresh weight. Preservation of ova and oocytes in 10 % formalin caused a varied amount of swelling depending upon their condition and age.

Phenomena apparent from an enumeration of 3.1 % random samples of ova and oocytes from 163 longear ovaries were: (1) the generation in spring of many small oocytes; (2) the metabolic resorption of oocytes in large numbers during the weeks immediately preceeding spawning; (3) ova loss due to spawning and its dependence upon a continuous maturation of oocytes during the spawning season; (4) the post-spawning resorption of all ova and oocytes above approximately .30 mm; (5) the post-spawning regeneration of great numbers of small oocytes; and (6)an over-winter resorption of many small oocytes.

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Master of Science

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