PRELIMINARY OBSERVATIONS AND EXPERIMENTAL STUDY OF THE LING, *LOTA MACULOSA* (LESUEUR), IN WYOMING

EUGENE E. BJORN

Wyoming Game and Fish Commission, Cheyenne

INTRODUCTION

The ling (also called lake lawyer, burbot, or eel pout) has long been regarded highly in Wyoming as a source of food by those living in the localities where it is found. In recent years the interest of the sportsmen of this state and adjoining states has been so aroused that "ling fishing" has become one of our outstanding winter attractions. It was estimated that over 15,000 fish, averaging about 2 pounds in weight, were taken from a single lake last season, and since specimens weighing as much as 24 pounds have been taken, the interest is further stimulated by the possibility of landing a "big one."

Not only does the ling appeal to residents of the state because of its excellence as a food, but it also provides a source of revenue by attracting fishermen to the central part of the state at a time when there is a lull in other forms of sport. The open season for ling is during the months of December, January and February after the big-game hunting seasons are over and before the spring fishing seasons have begun. Many "dude" ranchers, who ordinarily have no business at this time, benefit by accommodating visiting fishermen.

The ever-increasing demand for the ling threatens to make serious inroads upon the supply, and consequently, steps have been taken to protect the species against a rapid decrease in numbers. After the 1939 Legislature had adjourned, the ling held the legal designation of a "game fish" and now receives protection along with other game species.

The Game and Fish Commission sent a party into the field during February, 1939, to study the habits of the ling and determine the possibilities of its artificial propagation. The investigation was conducted over a period of two weeks during which time two lakes were visited and approximately one hundred specimens were examined. Due to the limited extent of the study and the lack of proper hatchery facilities, the results of these preliminary observations cannot be considered conclusive. However, the work will be continued.

The results of the present investigation show something of the feeding and breeding habits of the ling in Wyoming, and demonstrate that the species can be propagated artificially. Special attention has been given to the types of food taken, the season during which the ling spawns in different lakes, the size of the eggs and number of eggs produced per fish, the collecting of eggs and their hatching under artificial conditions.

Materials and Methods

Most of the fish examined were taken through holes in the ice by means of short set lines baited with live minnows; others were taken in a gill net stretched across a small stream tributary to one of the lakes.

The fish used in the spawn-taking experiment were transported in fish cans to the Dubois Hatchery, where they were held in tubs until the experiment was completed. The eggs were stripped into a dry spawning pan and the milt from the male added immediately. The two were mixed thoroughly with the fingers until the eggs became cohesive; water was then added to cover the eggs and the pan set aside for five minutes to permit the completion of fertilization. The excess milt was then washed from the pan and the eggs placed in water for thirty minutes to water-harden; after water-hardening they were measured and placed on trout hatchery trays, the screens of which were replaced with muslin cloth to hold the small ling eggs. The trays were not disturbed during the entire process of incubation.

A stage micrometer was used to measure the diameters of the eggs which had been preserved in 2 per cent formalin until the measurements could be completed in the laboratory.

The number of eggs per fish was determined by counting the eggs in several small unit volumes, then multiplying the average by the total volume.

The stomach analyses were conducted to determine the types of food present, but little attention was given to the volume. Bait minnows taken from the hooks were not included in the analyses of the stomach contents. In determining the percentage of fish feeding on specific forms, specimens with empty stomachs were disregarded.

Spawning Season and the Number of Eggs per Female

The spawning season of the ling continues over a period of three months, beginning in December and extending through February, as indicated by the condition of fish from two lakes, Ocean and Ring. Sixty-three specimens were taken from Ocean Lake during a period of four days, from February 6 to 10. Examinations revealed that only four of them had not spawned, and that many of the spent fish had spawned some time previously. The residents near the lake reported that milt flowed freely from the males taken in December and the first part of January. Obviously the spawning season was practically terminated at this lake in early February. Thirty-four specimens were examined from Ring Lake from February 15 to 18. Milt could be taken from nearly all of the males. One of the females had spawned, three were ripe and were stripped of their eggs, and it was estimated that the remaining females would spawn within two weeks. Sportsmen in the vicinity reported that they had observed fish on the spawning beds from about the middle of February to the first part of March.

The differences in the time of the spawning seasons in the two lakes can possibly be attributed to the different environmental conditions. Ocean Lake is located in the open foothills at an altitude of 5,214 feet. It has a surface area of 4,061 acres and a maximum depth of 18 feet. The lake is supplied by seepage from summer irrigation water, and has no definite inlet or outlet. The surface temperature is comparatively high in the summer (68° F. on September 9, 1938), but doubtless drops quickly with the advent of cold weather. Ring Lake is located in the mountains at an altitude of about 7,000 feet. It has a surface area of 94 acres and a maximum depth of 34 feet. The lake is supplied with a fairly large permanent inlet and obviously has a more constant temperature than Ocean Lake.

Spawning fish were taken near the inlet of Ring Lake during their migration to the spawning bed, which is a large hole in the creek bed about one-half mile above the lake. Examinations revealed that female ling in Ring Lake spawn when about 12 inches in length and that males are sexually mature when 9 inches in length.

It will be noted from Table 1 that there is a great variation in the number of eggs per unit volume. This circumstance can be attributed to the fact that the eggs varied considerably in the extent of their development; that is, some were very green and some were nearly ripe. Furthermore, some of the more nearly developed eggs may have begun to water-harden during the measuring process. In any event, the samples to be counted were taken immediately after the total volume had been determined, thus eliminating, as nearly as possible, the chance for error due to the change in the eggs while being measured. The information presented in Table 1 indicates that the female ling produces approximately 175,000 eggs per pound of fish.

TABLE 1. ESTIMATE OF THE NUMBER OF EGGS PRODUCED PER FISH

Weight of fish in pounds	Total length of fish in inches	Volume of eggs in cubic centimeters	Average number of eggs per cubic centimeter	Total number of eggs per fish
⅝	12	29.6	2,179	64,408
2¾	22½	285.0	1,578	451,473
3½	24⅝	211.0	2,477	522,385
8	33	540.0	2,674	1,444,122

Artificial Propagation

The fully developed eggs are of a clear light yellow color, are semi-buoyant, and have a diameter of slightly over 1 millimeter. The eggs that were measured were taken from a 20-inch fish that weighed 1½ pounds. The average diameter of the eggs was found to be 1.041 millimeters after fertilization and water-hardening and 1.084 millimeters four days before hatching. There were 1,118 unfertilized, water-hardened eggs in a cubic-centimeter sample, and 33,093 in a fluid ounce.

The first eggs were taken February 16. After they had water-hardened and had been poured into the trays, they showed no signs of sticking together and moved freely when the flow of water in the trough was properly regulated. However, after two days the free movement ceased, and the water was forced up among the small clusters of eggs which had formed. The water remained at a constant temperature of 43° F., and the eggs began to hatch thirty days after incubation had begun. On February 18, the survey party left the field, and the experiment was placed in the hands of the superintendent of the State Hatchery. Every four days a sample was sent to the Department office for further investigation.

Fungus was first noticed in the trays after twelve days of incubation. Since the eggs were too small to be "picked" and were not treated, the fungus spread rapidly. The eggs and newly hatched fry showed an unusual resistance to the attack of the fungus, though undoubtedly many were killed. It was not uncommon to find living eyed eggs in a solid growth of fungus, and the hatchery superintendent reported that when the eggs began to hatch many small fish were seen emerging from within heavy growths of fungus. No attempt was made to hold and feed the young fish in the hatchery.

Winter Food of the Ling

Food samples taken from Ocean Lake revealed that Amphipoda, Zygoptera nymphs, and Diptera larvae were particularly abundant. The extent to which these forms are utilized for food by the ling may be seen in Table 2. Since Diptera larvae were not contained in specimens over 22 inches in length, the information indicates that the larger fish show a preference for the larger types of food. This point is further illustrated by data (also obtained in February) from Ring Lake. Diptera larvae were represented in 40 per cent of the stomachs examined from fish that ranged from 9 to 18 inches in length, and were not present in the stomach contents of the larger fish.

TABLE 2. SUMMARY OF STOMACH EXAMINATIONS OF THE LING

Item	Percentage of ling from Ocean Lake containing the food indicated	Percentage of ling from Ring Lake containing the food indicated	Percentage of ling containing the food indicated
Number and size of fish	**38 specimens 18 to 25 inches long**	**34 specimens 9 to 33 inches long**	**72 specimens 9 to 33 inches long**
Plecoptera; stonefly nymphs	0.0	33.0	11.5
Trichoptera; caddisfly larvae	19.0	8.5	14.5
Ephemeroptera; mayfly nymphs	14.0	0.0	8.6
Diptera; larvae	9.5	16.5	11.5
Zygoptera; damselfly nymphs	90.5	8.5	58.5
Anisoptera; dragonfly nymphs	23.8	0.0	14.5
Amphipoda; scuds	74.0	25.0	55.8
Mollusca; snails	9.5	8.5	9.0
Vegetation; higher plants	23.8	16.5	20.5
Fish	47.5	66.8	56.0

Summary

1. The ling spawns in Ocean and Ring Lakes during the months of December, January and February. Due to differences in environmental conditions, the spawning period is earlier in Ocean Lake than in Ring Lake.

2. Female ling are sexually mature when 12 inches in length, and males when 9 inches in length.

3. The female ling produces approximately 175,000 eggs per pound of weight.

4. The average diameter of water-hardened eggs from a ling 20 inches in length and 1½ pounds in weight was 1.041 millimeters.

5. Ling eggs can be taken, fertilized, and hatched under artificial conditions. The incubation period is 30 days at a temperature of 43° F.

6. In winter the food consists of aquatic insects, Amphipoda Mollusca, and fish. The extent to which ling feed on fishes is inversely related to the accessibility of other types of food. Small ling feed extensively on Diptera larvae and other small food organisms.