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RESEARCH

REPORT 89

OCT. 1976

Winter Observations on the Age and Growth of the Burbot in Lake Winnebago, Wisconsin

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ABSTRACT

Age and growth characteristics of the burbot, Lota lota (Linnaeus), in Lake Winnebago were described from a collection of 951 fish taken in fyke nets set under the ice during winter netting operations from 1969 through 1971. Age determinations were made from counts of the opaque zones on otoliths for 308 fish. Resolution of otolith zones, particularly with older individuals, was enhanced by staining otoliths in a concentrated solution of fluorescein dye. Otolith margins were opaque and considered incomplete during the February collection period, and the degree of opaqueness varied with age. The average growth in length of burbot from Lake Winnebago was below that reported for burbot from large lakes in North America. The hypothesis that relatively high summer water temperatures in this shallow, eutrophic lake may exert an influence on differential seasonal growth would require more definitive work during the entire year. All males were mature at age-group III; all females were mature at age-group IV. The length-weight relationship for the population was described as log W = -5.3436 + 3.1031 log L where W = weight in grams and L = total length in millimeters.

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INTRODUCTION

Winter studies on the spawning populations of the burbot, *Lota lota* (Linnaeus), were conducted during February 1969, 1970, and 1971 to describe the age structure and general growth of this species in Lake Winnebago. Life history and age-growth information on burbot are limited for inland waters in Wisconsin, perhaps because of its obscure, little known habits and availability. Bailey (1972) has reported on the age, growth, reproduction, and food of the burbot from the Wisconsin boundary waters of Lake Superior.

The burbot is abundant and widely scattered in Lake Winnebago, (Priegel 1967), and it ranks third in the commercial fishery (Priegel 1971). The only time burbot are catchable in significant numbers is during January and February when they congregate on rock and gravel reefs to spawn. During this period, personnel of the Wisconsin Department of Natural Resources engage in extensive beneath-the-ice fyke netting of burbot as part of the fish control program on the lake. From 1961 through 1971, the total harvest of burbot was 114,952.7 kg (253,427 lb). The annual harvest ranged between 3,334.4 and 16,624.2 kg (7,351-36,650 lb). The variation reflected the fishing effort which is determined by winter ice conditions on the lake. The burbot is classified as a rough fish in Wisconsin. It has low prestige and is not recognized as a desirable food fish by winter sport anglers on Lake Winnebago (Weber 1971).

Lake Winnebago is one of the largest glacial lakes in the United States and is the largest inland lake in Wisconsin. This roughly rectangular-shaped lake has an area of 55,772 ha (137,708 acres), is 45 km (28 miles) long, and is 17 km (10.5 miles) wide at its widest point. The lake has a maximum depth of 6.4 m (21 ft) and an average depth of 4.7 m (15.5 ft). The confluence of two large river systems -- the 172.2 km (107 mile) long Fox River and the 347.6 km (216 mile) long Wolf River -- enters Lake Winnebago (Priegel 1969). The lake is eutrophic, and temporarily stratifies in midsummer during periods of peak blue-green algae production. Long term, average June-September water temperatures in the lake (1959-1973) were 20.0° C (68° F), 23.4 (74), 22.2 (72) and 18.9 (66), respectively. Maximum temperatures reaching 25.6° C (78° F) are common during July and August.

MATERIALS AND METHODS

Determinations of age, growth, length-weight, and maturity were made on a total winter collection of 951 burbot. All fish were captured by 0.9 m (3 ft) fyke nets, with 38 mm (1.5 inch) stretch mesh, set under the ice on reefs along the west shore of Lake Winnebago during February netting periods from 1969 through 1971. Burbot used in this study were taken from a random sample of fish that had been placed in holding cribs after they were removed from the nets.

The total length of all fish was recorded to the nearest 0.1 inch and later converted to millimeters. Sex and state of maturity were determined by examination of the gonads since there were no external, dimorphic characteristics differentiating sex.

A subsample of 750 burbot collected in 1969-1970 was used for describing the length-weight relationship. Weights were recorded to the nearest 0.01 pound and later converted to grams.

For a second subsample of 308 burbot collected in 1970-1971, age was determined by examination of otoliths extracted with forceps after a large pair of tin snips was used to make a median incision in the skull from the tip of the snout to a point behind the eyes. Paired otoliths were removed from each fish, but damaged or highly irregular otoliths that would preclude accurate age determinations were discarded. Otoliths were stored dry in small envelopes and examined within six months after removal. No significant deterioration of these otoliths was evident even after two years of dry storage.

To determine age, otoliths were placed concave side up in a watch glass containing water and examined under a binocular microscope at 10X magnification, using a blackened background on the stage and direct light reflected from the concave surface. Age interpretations were based on duplicate counts of opaque zones observed on the concave surface of the otoliths. Where possible, paired otoliths were used. Resolution of otolith zones, particularly with older individuals, was enhanced by staining the otolith in a concentrated solution of water-soluble fluorescein dye. The couplet of an alternating clear and opaque concentric band on an otolith represents one year's growth (Martin 1941). The number of opaque bands were regarded as annuli, and ages were expressed in roman numerals. A fish assigned to age III was considered to be at or near the end of its third growing season.

The limitations of this study were recognized, with particular reference to the potential biases inherent to obtaining data from the spawning segment of the population: (1) the segregation of the sexes that may occur, and (2) the selectivity of mature individuals over immature individuals in the population. Gear mesh selectivity was not considered to be limiting to the capture of size classes available in the spawning aggregation. However, the winter netting season is the only time of the year that the burbot is accessable in sufficient numbers to make any assessment of the biological characteristics of the population.

OTOLITH ZONES AND GROWTH

Since this study was restricted to winter collections, the relationships between patterns of growth and the formation of clear (hyaline) and opaque zones could not be determined. Martin (1941), and Clemens (1951), Bailey (1972), and Muth and Smith (1974) generally agree that the clear zone is formed in early summer and continues through late fall (November) when opaque zone formation begins. Bailey (1972) indicated that it is uncertain whether growth of Lake Superior burbot stops during the formation of the opaque zone.

The margins of the otoliths used in this study were opaque in early February, and these observations are consistent with otolith edge characteristics for burbot in winter described in studies previously cited. The degree of opaqueness on the otolith edge varied with age. Fish at age V and

younger exhibited greater deposits of opaque materials on their otolith margins than older individuals. The formation of the opaque margin was regarded as incomplete at the time of collection. In otoliths from Lake Winnebago burbot, the width of the opaque zones was considerably wider than the width of the translucent zones, especially during the first through fifth years of growth. Bailey (1972) found otoliths from Lake Superior burbot to have clear and opaque zones of nearly equal width. Otoliths from burbot in Lake of the Woods exhibited a wide hyaline zone (summer growth) and a slightly narrower, opaque winter growth zone (Muth and Smith, 1974).

The variable width of otolith zones in this study may be related to differential summer and winter growth. The relatively high summer water temperatures in Lake Winnebago appear to negatively influence the feeding behavior of this species. Burbot have been observed actively feeding in the lake only when water temperatures drop below 12.8° C (55° F) -- generally from late October through April. From cursory observations that have been made during the open-water sampling periods, May-September, the feeding activity of burbot does not approach the intensity that has been seen at other times of the year. It is possible that the warmer, summer water temperature reduces feeding activities that could cause a differential summer (hyaline zone) and winter growth (opaque zone) in Lake Winnebago burbot. More definitive investigation of the seasonal growth and feeding behavior of this species in Lake Winnebago would be required to support this hypothesis.

LENGTH-FREQUENCY DISTRIBUTION

Of the 951 burbot sampled from Lake Winnebago, 55.7 percent were between 348 and 437 mm (13.7-17.2 inches in total length) (Fig. 1), with an average total length for the sexes combined of 427 mm (16.8 inches). The sample consisted of 549 males and 402 females. Males ranged between 241 and 688 mm (9.5-27.1 inches) in total length, with an average length of 417 mm (16.4 inches). The average length of females was 439 mm (17.3 inches), with a range in length of 236-678 mm (9.3-27.7 inches).

Winter nets are strategically placed on reefs where burbot presumably spawn, and the fish are highly vulnerable to capture at this time. The length-frequency distribution curve is skewed to the left. The small number of fish present in the larger size classes could be related to intensive selective harvest of younger burbot that enter the catch soon after sexual maturity or may simply reflect natural mortality. Burbot within the 348 to 437 mm (13.7-17.2 inches) size range are in their third through fifth years of life.

AGE AND GROWTH

A subsample of 308 burbot was used to describe their growth in Lake Winnebago during the winter prespawning periods of 1970 and 1971. Females grew slightly faster than males at ages III, V, VI, VII, and X; however, fish of both sexes were combined to derive the general growth curve (Fig.2). The rate of growth was based on the average total lengths of fish from each age group rather than back calculations from otolith measurements. The

average length at each year for ages II through X was 269, 312, 361, 421, 505,546,584,592, and 622 mm (10.6, 12.3, 14.2, 16.6, 19.9, 21.5, 23.0, 23.3, and 24.5 inches), respectively.

The average total lengths of each age group were compared to determine the annual increment of growth. It is apparent that the greatest growth occurs during the first and second years of life; 43.2 percent of the average length at age X is attained during this growing period. The annual increment of average lengths for ages III-X was 43, 49, 60, 84, 41, 38, 8, and 30 mm (1.7, 1.9, 2.4, 3.3, 1.6, 1.5, 0.3, and 1.2 inches), respectively. Growth steadily increased between the third and sixth growing seasons, and decreased from the seventh through tenth. The relative decrease in growth increment during the third and fourth years and subsequent increase between the fifth and sixth years cannot be completely explained, but could be related to stages of maturity and/or changes in food habits. Clemens (1951) found the growth increment of Lake Erie burbot to decrease from the second to tenth year, and observed relatively smaller growth increments during the third and fourth years. The data from Lake Erie suggested that burbot show two types of growth, that of immature and mature life stages.

The average growth in length of burbot from Lake Winnebago was below that reported for burbot from Lake of the Woods (Muth and Smith 1974), Ocean Lake (Miller 1970a), Boysen Reservoir (Miller 1970b), Lake Winnipeg and the Mukutawa River (Hewson 1955), Lake Simcoe (McCrimmon and Devitt 1954), and Lake Erie (Clemens 1951). Lake Winnebago burbot were faster growing than burbot from Torrey Creek (Miller 1970a), Ring and Trail Lakes (Miller 1970b), Heming Lake (Lawler 1963), The Susquehanna River (Robins and Deubler 1955), and Lake Opeongo (Martin 1941). Growth of Lake Winnebago burbot at ages II throug IV was below that reported for fish from western Lake Superior (Bailey 1972) in these age groups, but exceeded the growth of Lake Superior burbot from the fifth through tenth years.

LENGTH-WEIGHT RELATION

The relationship between length and weight of burbot in prespawning condition was based on a subsample of 750 mature fish (sexes combined) grouped by 10 mm total length intervals (Fig. 3). The length-weight relation of Lake Winnebago burbot is expressed by the regression:

$$\text{Log } W = -5.3436 + 3.1031 \text{ Log } L$$

where W = weight in grams and L = total length in millimeters. The greatest differences between calculated and observed weights were among fish in the larger size groups for which sample size was small.

AGE AT MATURITY

The state of maturity for burbot for which age data were available showed males to mature during their second and third year. All age II and III males were mature at average lengths of 277 and 310 mm (10.9 and 12.2 inches),

respectively. The combined sample size for males in these age groups consisted of only 28 fish, which was probably insufficient to accurately describe age at maturity. Females matured during their third and fourth years. Forty percent of female burbot were mature at age III, and all were mature at age IV at an average length of 361 mm (14.2 inches).

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ACKNOWLEDGMENT

This study was supported in part by funds supplied by the Federal Aid to Fish Restoration Act under Dingell-Johnson project F-83-R.

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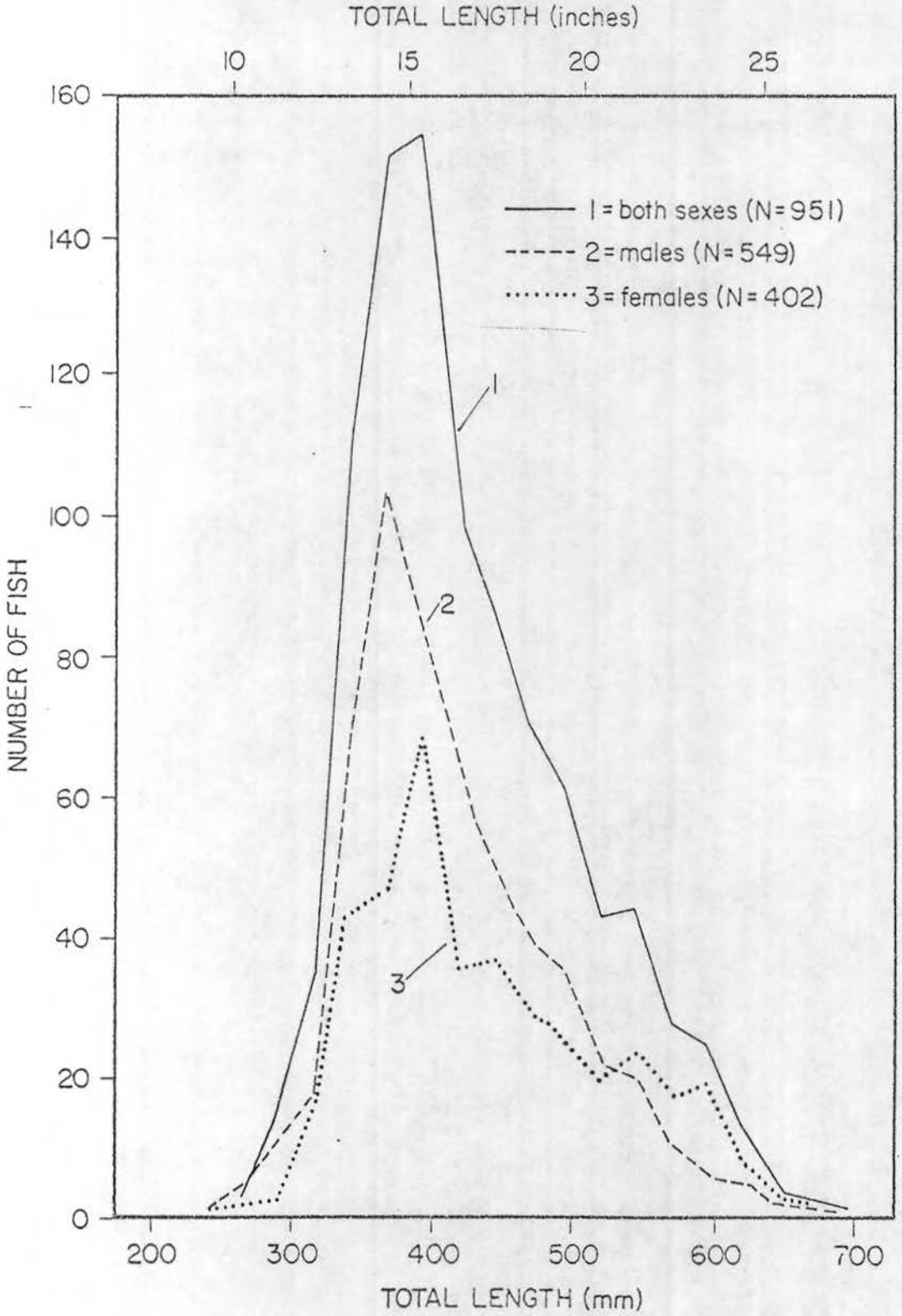

FIGURE 1. Length-frequency distribution of burbot from Lake Winnebago, 1969-71.

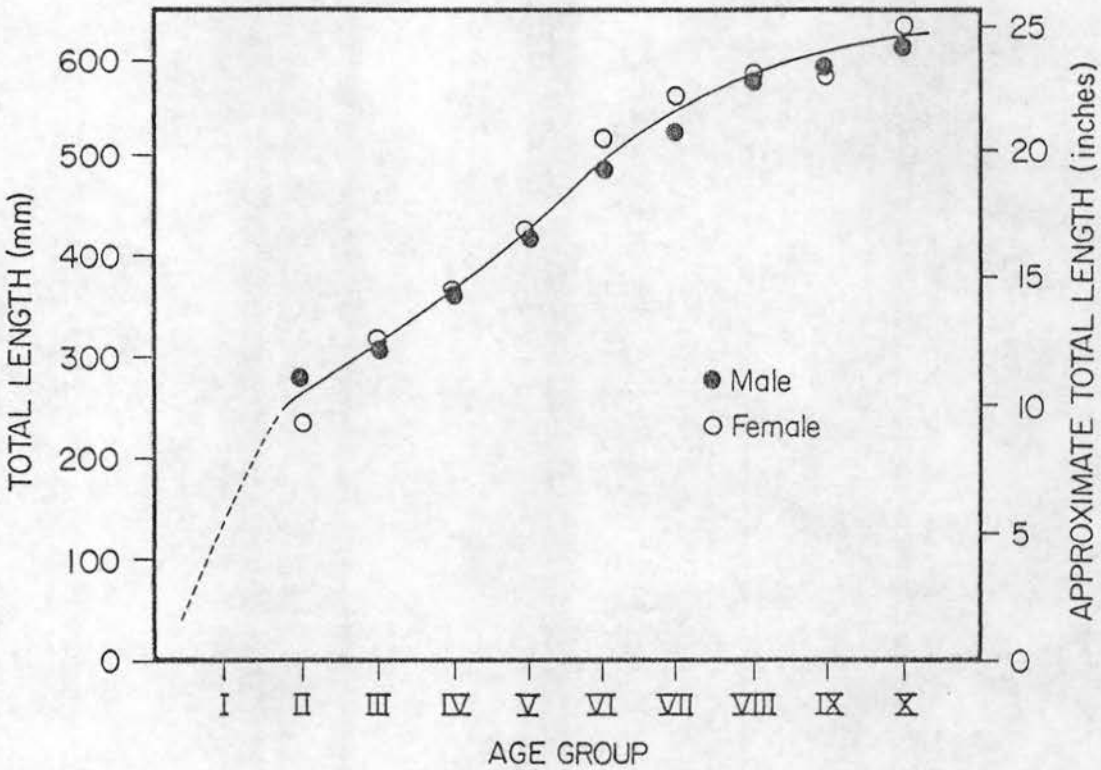

FIGURE 2. Average length to age relationship of 308 burbot from Lake Winnebago taken during winter prespawning periods, 1970-71. (General growth curve fitted by inspection to average lengths of each age group -- sexes combined.)

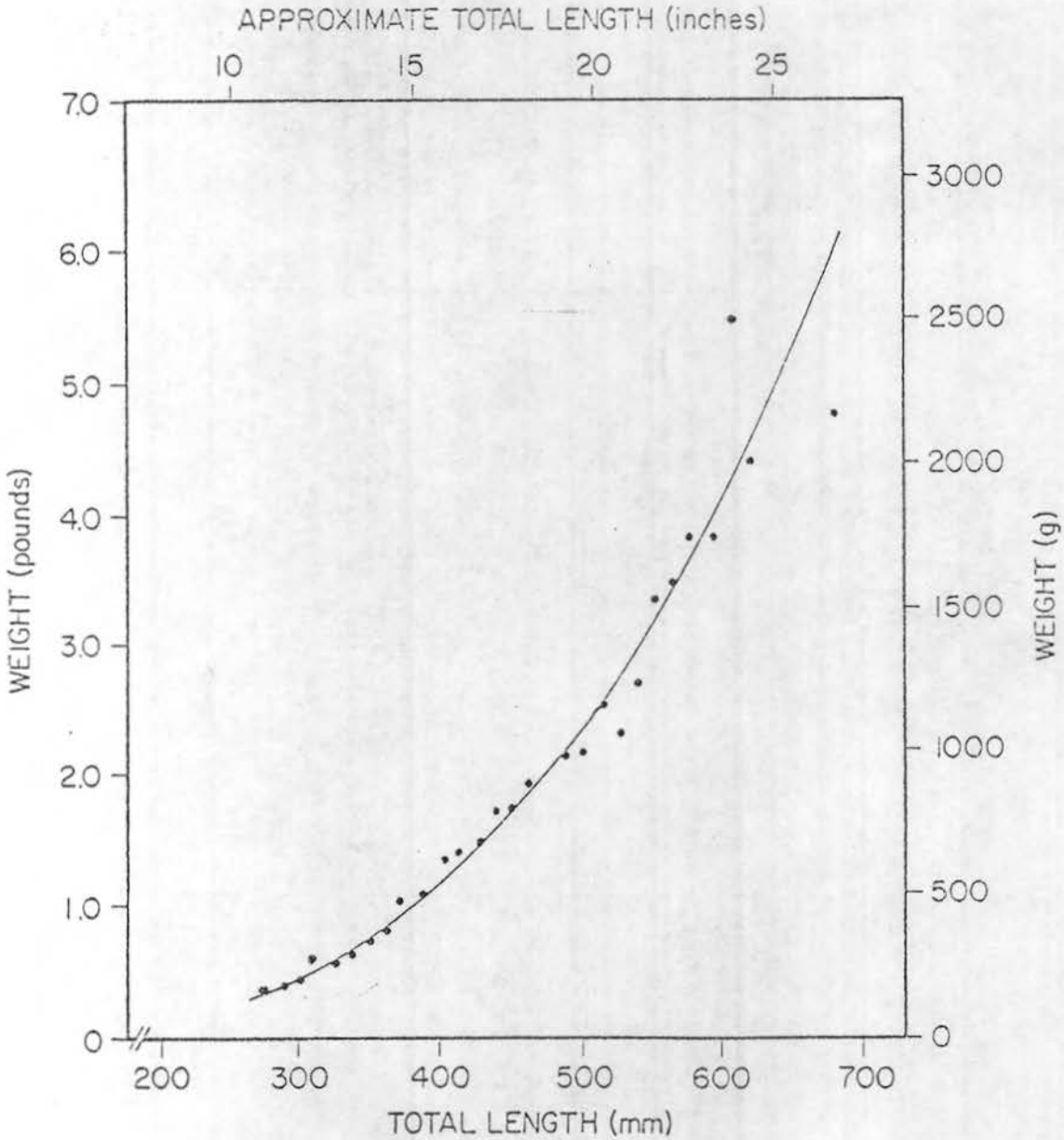

FIGURE 3. Length-weight relationship of 750 mature burbot (sexes combined) in Lake Winnebago, February 1969-70. (Solid dots indicate observed data from which curve was calculated.)

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