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AGE AND LENGTH AT SEXUAL MATURITY OF BURBOT IN THE TANANA RIVER, ALASKA[1]

By

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ABSTRACT

A total of 351 burbot *Lota lota* were collected in the Tanana River between early November and mid-February. Length, age, sex, and maturity of these fish were determined. Ages ranged from 4 to 18 years and lengths ranged from 368 to 1,076 millimeters total length. Onset of sexual maturity was first noted at age 4 and 452 millimeters total length for males and age 6 and 498 millimeters total length for females. Burbot not in spawning condition were found in almost all age classes and length categories within the sample. These data and those from other authors indicate that burbot residing in moderate to extreme northern latitudes exhibit intermittent or nonconsecutive spawning. Probit analysis was used to model age and length at maturity. The age at which 50 percent of the females reached maturity was estimated to be 5 years (95 percent fiducial limits were 3 to 7 years). The length at which 50 percent of the females reached maturity was estimated to be 480 millimeters total length (95 percent fiducial limits were 363 to 543 millimeters total length). Due to the high proportions of immature male burbot in most age and length categories, the Probit model was unable to estimate similar statistics for males.

KEY WORDS: Burbot, *Lota lota*, sexual maturity, AM_{50}, LM_{50}, intermittent spawning, nonconsecutive spawning.

INTRODUCTION

The size and age at which a population of fish attains sexual maturity are often important considerations in the management of sport and commercial species (Taube 1976). Available data concerning the age and length at sexual maturity for populations of burbot *Lota lota* are variable in their findings (Table 1). Chen (1969) indicated a general trend for later maturation at higher latitudes. Hewson (1955), Williams (1972; 1976), and Chen (1969) suggested that burbot may not spawn every year after attaining first maturity. In order to better assess the impacts of a sport fishery for burbot in the Tanana River, a study was initiated by the Alaska Department of Fish and Game, Division of Sport Fish, using burbot carcases provided by local anglers. The objectives were: (1) to supplement information provided by Chen (1969) concerning age and length at first maturity; (2) to determine AM_{50} (the age at which 50% of the burbot are sexually mature); (3) LM_{50} (the length at which 50% of the burbot are sexually mature); and, (4) to determine if burbot were spawning on an intermittent annual basis.

METHODS

During the winters of 1987-88, 1988-89, and 1989-90, 339 filleted burbot carcasses with skeletons and entrails intact were collected from anglers fishing in the Tanana River near Fairbanks, Alaska (65° N). Most burbot were collected from anglers using baited set-lines with a minimum hook size of 19 mm (3/4 inch). Twelve burbot were collected using baited hoop traps (described by Evenson 1989) set through the ice. All burbot were collected between 1 November and 15 February. This is the peak period of the winter set-line sport fishery and prior to most spawning. Gonadal growth begins to increase in August for Tanana River burbot stocks (Chen 1969), and by November both sex and stage of maturity can be easily determined. Sex was determined by visual inspection of the gonads as described by Hewson (1955). A burbot was described as mature if the relative size of its' gonad indicated that it would spawn the season of collection. A burbot was described as immature if the relative size of the gonad indicated that it would not spawn the season of collection. Thus, no distinction was made between those fish which were immature (had never spawned) and those which had spawned in previous years but were not in condition to spawn during the season of collection.

All burbot were measured to the nearest millimeter in total length (TL). The age of each burbot was estimated by visual examination of the surface whole otolith (sagittae bones). Both otoliths were examined. Otoliths were stored in a 2:3 glycerine:alcohol medium for approximately two weeks prior to examination to enable better resolution and counting of annuli. Otoliths were viewed with a dissecting microscope using moderate power (12x - 50x) under reflective light.

The percent of mature burbot in each of several 25 mm length categories and in each of several age classes was calculated. Probit analysis was used to estimate the LM_{50} and AM_{50} (Finney 1971). The procedure PROBIT from SAS Institute Inc., Cary, North Carolina, was used for this analysis.

Table 1. Length and age at onset of sexual maturity for varius populations of burbot.

Authority	Locality	Latitude	Sample Size	Age	Length (mm TL)
Robins and Deubler (1955)	Susquehanna River	42°- 43°N	175	3 - 4	240 - 265
Clemens (1951)	Lake Erie	42°- 44°N	2,329	3 - 5	300 - 480
Weber (1976)	Lake Winnebago, Wisconsin	44°N	ND	2 - 3 3	277 (male) 361 (female)
Bjorn (1940)	Ring Lake, Wyoming	43°N	ND	ND	229 (male) 305 (female)
Miller (1970)	Ocean Lake, Wyoming	43°N	101	3 - 4	ND
McCrimmon and Devitt (1954)	Lake Simcoe, Ontario	45°N	130	3 - 4	ND
Bailey (1972)	Lake Superior	46°N	349	1 - 4	246 (male) 272 (female)
Muth and Smith (1974)	Lake of the Woods, Ontario	46°N	5,454	3 - 5	400 - 500
Hackney (1975)	Lake Opeongo, Ontario	47°N	377	3	274 (male) 318 (female)
Hewson (1955)	Lake Winnipeg, Manitoba	50°- 54°N	303	2 - 6	ND
Odenwall (1927)	Lake Lappajavi, Finland	63°N	ND	4 - 5	ND
Williams and Potterville (1983)	Hudson Lake, Alaska	62°N	83	4 - 6	ND
Kirvlov (1962)	Vilyui River, Russia	63°- 66°N	ND	6 - 7	560 - 630
Chen (1969)	Tanana River, Alaska	65°- 66°N	38	6 - 7	400 - 500
Bendock (1979)	Colville River, Alaska	69°- 70°N	33	7	ND

ND = no data

RESULTS AND DISCUSSION

A total of 351 burbot were used in maturity analysis. Of these, 184 (52%) were females and 167 (48%) were males. Ages ranged from 4 to 18 years, while lengths ranged from 368 to 1,076 mm (TL). Onset of sexual maturity was first noted at age 4 and 452 mm TL for male burbot, while first maturity for females was not noted until age 6 and 498 mm TL. Nearly 80% of the burbot examined were in spawning condition, however 95% of the burbot sampled were age 7 or older and 500 mm TL or larger. Burbot not in spawning condition were found in almost all age classes and length categories within the sample (Tables 2 and 3).

The estimate of age at which 50% of female burbot mature in this population was 5 years (95% fiducial limits were 3 to 7 years), while the estimate of length at which 50% of female burbot mature was 480 mm TL (95% fiducial limits were 363 to 543 mm TL). Due to variability, and lack of trend in this variability in the proportions of male burbot which were judged to be in spawning condition within each age and length category (Figure 1), the Probit model did not provide estimates of AM_{50} or LM_{50} for males.

The results of this study concerning age and length at first sexual maturity are similar to those of other studies in northern latitudes (see Table 1) in that males matured between age 4 and 6 and females between age 6 and 8. The later age and length at first maturity of Tanana River burbot and other stocks of moderate northern latitudes is most likely a result of the slower growth rates and greater longevity exhibited by these stocks (Chen 1969). Unfortunately, no burbot younger than age 4 or smaller than 350 mm TL were collected and only 12% of the total sample were between the ages of 4 and 6, and only 4% were smaller than 450 mm TL.

This investigation revealed that 15% of the female burbot and 17% of the male burbot age 7 and older in this sample were not judged to be in spawning condition at the time of collection. Chen (1969) reported Tanana River burbot as old as 11 years as having unripe gonads. Hewson (1955) estimated that 5% of a Lake Winnipeg (50° - 54° N) burbot population was composed of fish believed to be mature in previous years, but which were not in spawning condition at the time of collection (during the spawning period). Only five of 15 prespawning female burbot, between the ages of 7 and 14, from Susitna Lake, Alaska (62° N), were in spawning condition. Williams (1976) further reported that 43% of the female burbot between the ages of 8 and 20 and 37% of the male burbot between the ages of 8 and 16 collected from a winter sample just prior to the spawning period in Hudson Lake, Alaska (62° N), were not in spawning condition. Other studies in lower latitudes (42° N to 47° N) with substantial sample sizes (Clemens 1951; Bailey 1972; Muth and Smith 1974; and Hackney 1975) did not observe the occurrence of immature burbot in the older, larger, segments of their samples.

The high proportion of immature (not in spawning condition) male and female burbot observed in older age classes and in larger length categories suggest four possibilities. First, these fish may have been sexually mature in

Table 2. Age at maturity for female and male burbot, Tanana River, Alaska.

FEMALES

Age	Sample Size	Percent	Number Mature	Percent Mature	Number Immature	Percent Immature
4	1	0.5	0	0	1	100.0
5	3	1.6	0	0	3	100.0
6	15	8.2	10	66.7	5	33.3
7	18	9.8	13	72.2	5	27.8
8	18	9.8	13	72.2	5	27.8
9	25	13.6	18	72.0	7	28.0
10	24	13.0	22	91.7	2	8.3
11	24	13.0	23	95.8	1	4.2
12	19	10.3	17	89.5	2	10.5
13	12	6.5	10	83.3	2	16.7
14	10	5.4	9	90.0	1	10.0
15	7	3.8	7	100.0	0	0.0
16	5	2.7	4	80.0	1	20.0
17	2	1.1	2	100.0	0	0.0
18	1	0.5	1	100.0	0	0.0
Totals	184	100.0	149	81.0	35	19.0

MALES

Age	Sample Size	Percent	Number Mature	Percent Mature	Number Immature	Percent Immature
4	2	1.2	2	100.0	0	0.0
5	9	5.4	7	77.8	2	22.2
6	11	6.6	4	36.4	7	63.6
7	36	21.6	30	83.3	6	16.7
8	25	15.0	19	76.0	6	24.0
9	26	15.6	23	88.5	3	11.5
10	17	10.1	15	88.2	2	11.8
11	20	12.0	15	75.0	5	25.0
12	14	8.4	11	78.6	3	21.4
13	4	2.4	3	75.0	1	25.0
14	3	1.8	2	66.7	1	33.3
Totals	167	100.0	131	78.4	36	21.6

Table 3. Length at maturity for female and male burbot, Tanana River, Alaska.

FEMALES

Length[a]	Sample Size	Percent	Number Mature	Percent Mature	Number Immature	Percent Immature
350	1	0.5	0	0.0	1	100.0
400	1	0.5	0	0.0	1	100.0
450	6	3.2	1	16.7	5	83.3
500	13	7.0	7	53.9	6	46.1
550	22	11.8	17	77.3	5	22.7
600	20	10.8	14	70.0	6	30.0
650	19	10.2	17	89.5	2	10.5
700	17	9.1	15	88.2	2	11.8
750	27	14.5	25	92.6	2	7.4
800	20	10.8	18	90.0	2	10.0
850	24	12.9	21	87.5	3	12.5
900	11	5.9	9	81.8	2	18.2
950	2	1.1	2	100.0	0	0.0
1,000	2	1.1	2	100.0	0	0.0
1,050	1	0.5	1	100.0	0	0.0
Totals	186	100.0	149	80.1	37	19.9

MALES

Length[a]	Sample Size	Percent	Number Mature	Percent Mature	Number Immature	Percent Immature
450	7	4.2	4	57.1	3	42.9
500	18	10.8	13	72.2	5	27.8
550	41	24.6	32	78.1	9	21.9
600	28	16.8	25	89.3	3	10.7
650	20	12.0	17	85.0	3	15.0
700	14	8.4	13	92.9	1	7.1
750	21	12.6	15	71.4	6	28.6
800	12	7.2	9	75.0	3	25.0
850	4	2.4	2	50.0	2	50.0
900	1	0.6	0	0	1	100.0
950	1	0.6	1	100.0	0	0
Totals	167	100.0	131	78.4	36	21.6

[a] All lengths were recorded to the nearest millimeter in total length. Each number in the column represents the beginning of a 50 mm category.

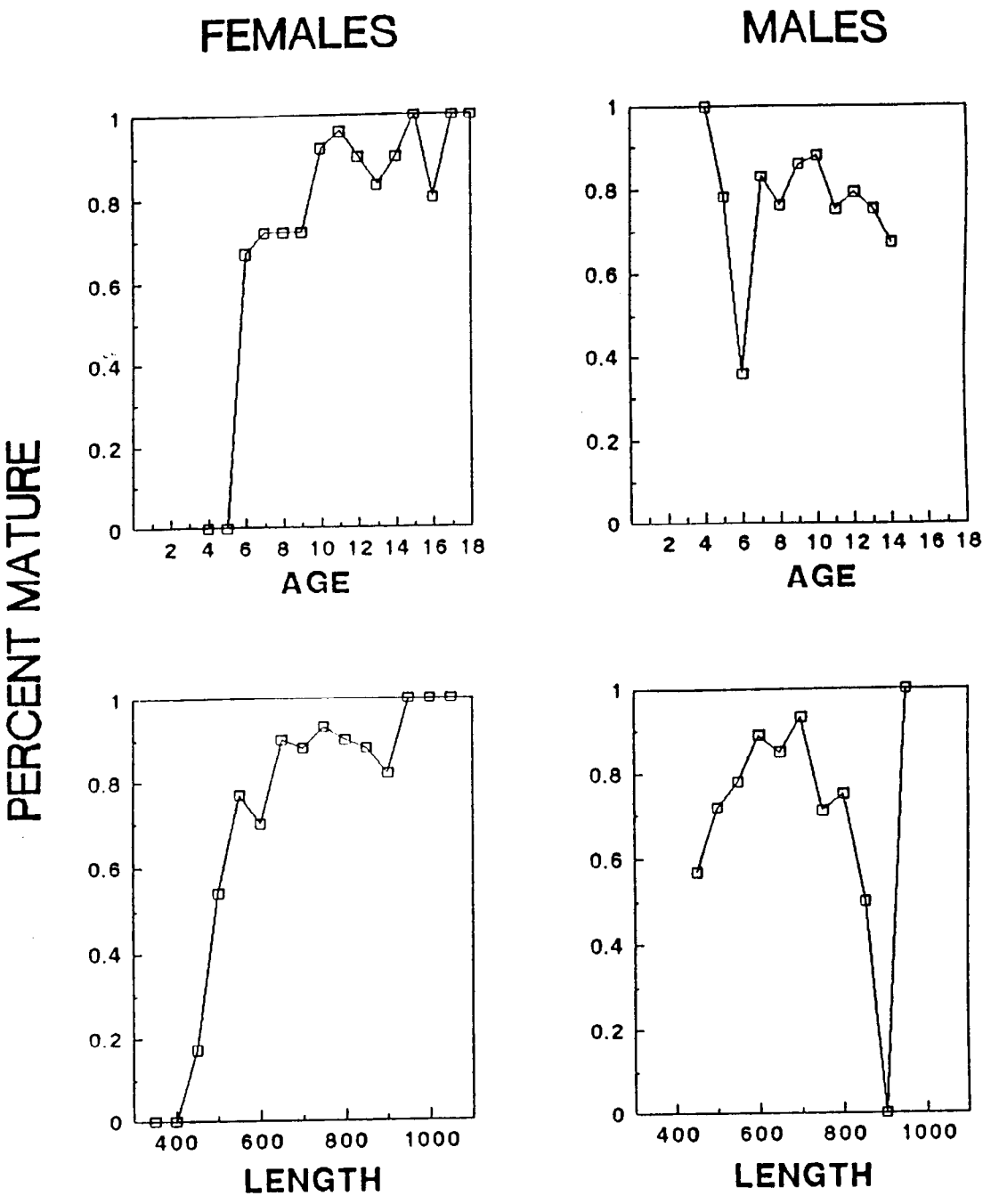

Figure 1. Proportions of sexually mature male and female burbot collected from the Tanana River by age and length category.

previous years, but did not develop gonads fully during the year of collection (nonconsecutive or intermittent spawning). Second, these fish may never have spawned in previous years (late maturation). Third, these fish, although immature at the time of collection, may have developed completely in the weeks following collection and spawned at a much later date in the spring (delayed maturation). And fourth, these fish were in fact mature, but were inaccurately categorized as immature (inaccurate judgement of maturity).

Fish examined that were not in spawning condition ranged from age 4 to 16, while burbot in spawning condition ranged from age 4 to 18. A prior sample of 480 burbot from the Tanana River revealed that 90% of the fishable population was age 12 or younger, with the oldest burbot being 20 years old (Evenson 1988). Late maturation seems an unlikely alternative given the documented variability in onset of sexual maturity and given that only a small portion of the population is composed of very old fish (over age 16).

The idea of delayed maturation also seems unlikely. It is not known exactly how long the spawning period lasts in the Tanana River, however it appears to begin around the first week of February. Two burbot collected in this study on 15 February were females which had already spawned. Chen (1969) captured spent females in the Tanana River during the first week of February, and observed ripe males in late January. Other authors found that spawning began as early as December in Ring Lake, Wyoming (43° N; Bjorn 1940), and as late as early April in Lake Erie (43° N; Clemens 1951). Some burbot collected in March in Susitna Lake and in Hudson Lake (both 62° N; Williams 1972; 1976) had not yet spawned. Burbot sampled included burbot of large size and old ages which were not in spawning condition. It is unlikely that these fish could have developed mature gonads within the next couple of months had they not been caught.

The probability that some fish were inaccurately judged immature is unlikely. Although no specific criteria concerning relative gonad size, weight, or volume to body length were used, conservative judgement in classifying a fish as immature was used. Only those fish with very small gonads (based on overall size) relative to body length were called immature. If those fish were indeed mature, then their gonadal production was miniscule as compared to other fish (judged to be mature) of similar length.

It is concluded that burbot in the Tanana River and in other populations of moderate northern latitudes (50° N to 65° N) exhibit some degree of intermittent or nonconsecutive spawning. Thus, the frequency of spawning as well as the age at first maturity of burbot populations may be influenced by their geographic location.

The phenomenon of intermittent spawning becoming more prevalent with increasing northern latitudes has been documented in various populations of lake trout *Salvelinus namaycush* (Martin and Olver 1980). These authors suggest that different patterns of light and darkness in high latitude areas may alter the reproductive cycle.

The Probit model was unable to predict AM_{50} and LM_{50} for male burbot. The sample sizes for male and female burbot were nearly equal as were the overall

percentages of mature fish in both samples. However, following first maturity, which appears to be earlier for males than females, the frequency of intermittent spawning is more prevalent with males than is the case for females. Chen (1969) observed that during the period of gonadal development (September to February), the male gonad comprised a greater percentage of total body weight than did the female gonad. He believed that intermittent spawning might be due partially to the failure to accumulate necessary nutrients for gonad development. This may be especially true for male burbot.

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