

*Assessment of the Burbot Population in Leech Lake, Minnesota*  
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*INTRODUCTION*

The Burbot (*Lota lota*) is the only freshwater member of the cod family (Gadidae; McPhail and Paragamian, 2000; Stapanian et al. 2010). Burbot have a wide, Holarctic distribution and prefer cold, deep-water lakes (McPhail and Paragamian, 2000; Stapanian et al., 2010; Bailey, 1972). Two distinct sub-species exist. *Lota lota lota* is found throughout Europe and Asia and in the Nearctic north of Great Slave Lake, Canada, whereas *Lota lota maculosa* is found in North America from the southern extent of Great Slave Lake, Canada to the upper Mississippi, Missouri, and Ohio Rivers (Figure 1; Stapanian et al., 2010; McPhail and Paragamian, 2000; Elmer et al., 2008).

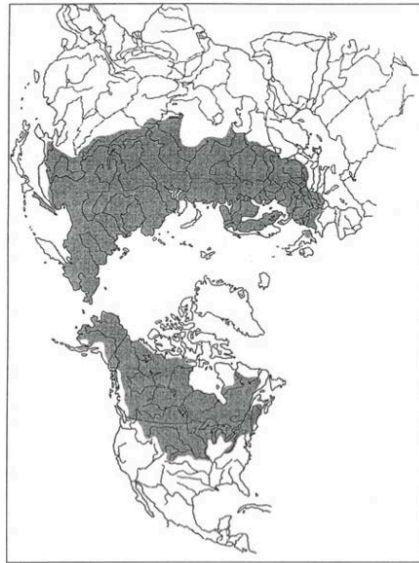


Figure 1. Holarctic distribution of Burbot (McPhail and Paragamian, 2000).

The maximum total length of adult Burbot ranges from 300-600 mm with weights ranging from 1-3 kg (McPhail and Paragamian, 2000). The life span of the Burbot varies from 7 years or younger in the southern extent of their range (near 45°N) to 8-12 years, with some fish reaching 20-22 years, of age for more northern populations (55°N; Guinn and Hallberg, 1990; McPhail and Paragamian, 2000; Worthington et al. 2011). In some North American populations, from 1.5% to 30% of adult Burbot, depending on location or climate and age or condition of the fish, may not spawn every year (McPhail and Paragamian, 2000, Worthington et al., 2011). Although many fish species are sexually dimorphic, Burbot are largely sexually monomorphic (McPhail and Paragamian 2000; Cott et al., 2013).

Burbot are not commonly harvested, either commercially or recreationally, throughout most of their range (Stapanian et al. 2010; Bailey 1972; Edwards et al. 2011). Thus, management actions are usually enacted in response to a population that is in critical condition and in need of restoration (Stapanian et al. 2010; Edwards et al. 2011). Low recruitment is a leading cause of decline in many populations including in Lake

Huron and Lake Erie (Stapanian et al. 2010; Edwards et al. 2011). Low levels of recruitment may be identified by examining the age distribution of a population over years (Polacek et al., 2006; Worthington et al., 2011). Changes in the average age or existence of year-classes (or cohorts) of young fish may indicate a recruitment problem (Edwards et al., 2011; Polacek et al., 2006; Worthington et al., 2011). Recruitment problems may also be evident in the relative condition of adult fish (Polacek et al., 2006; Fisher et al., 1996).

In contrast to most Burbot populations, the Leech Lake population may be the most exploited Burbot population in Minnesota. The International Eelpout Festival has been held each February since 1980 on Leech Lake. An average of 705 Burbot, or 2,474 pounds, are harvested during the Festival each year (Minnesota Department of Natural Resources, unpublished data).

High rates of exploitation may effect fish populations in a variety of ways. Fishing often removes the older, larger fish from populations causing population size to decline (mortality rate to rise) and life history traits to modify in order to compensate for the change. Reproduction and growth often increase under this circumstance (Rochet and Trenkel, 2003). The effects of high rates of exploitation on Burbot populations have been little studied (Stapanian et al. 2010). The primary objective was to compare key population parameters (i.e., size structure, relative condition, weight-length relationships, age structure, and growth dynamics) between the highly exploited Leech Lake population and the lowly exploited nearby Burbot population in Lake Superior.

A variety of bony structures within fish can be examined to determine age (Pawson, 1990). Scales, fin-rays, and spines are common structures that can be extracted without sacrificing the fish, but generally underestimate the true age of long-lived specimens (Guinn and Hallberg, 1990). Burbot age is best assessed from examination of sagittal otoliths, as the scales are small and inadequate for aging (McPhail and Paragamian, 2000; Bailey, 1972; Edwards et al., 2011). The opaque and clear growth sections of Burbot otoliths are often difficult to distinguish, likely due to the continued growth of Burbot throughout the winter (Boag, 1989; McPhail and Paragamian, 2000). Edwards et al. (2011) strongly suggested the use of thin-sectioning methods to age Burbot otoliths, along with noting the inability to age whole otoliths past about age 7, which is consistent with Polacek et al. (2006) who used whole otoliths only up to age 5. However, Polacek et al. (2006) preferred the crack-and-burn method applied to otoliths for aging older fish. In addition, some studies have shown a strong relationship between the size (weight or length) of the otolith and the age of the fish (Pawson, 1990). Thus, pursuant to our primary objective, our secondary objective is to describe the relationships between otolith size and fish size and fish age to attempt to discern fish age from both fish length and otolith size (Pawson, 1990).

## *METHODS*

### *Sampling and Data Collection*

Burbot were sampled from fish caught by anglers as part of the Eelpout Festival from 19-22 February 2015. When given permission by the angler, we measured total length (TL,  $\pm 1$ mm), weighed (W,  $\pm 10$ g), identified sex by visual examination of the gonads, and removed sagittal otoliths from each fish. Precision of weights was low due

to cold temperatures and strong winds in the field. Sagittal otoliths were originally taken from six fish per 25 mm TL category for each of male, female, and unknown sex fish. However, a narrow range of sampled lengths led us to ultimately target removing otoliths from 150 fish. In the end, sagittal otoliths were removed from 173 Burbot.

In the laboratory, all otoliths were rinsed with warm water and dried. For the first fifty fish, both the right and left whole otoliths were weighed ( $\pm 0.001$  g) and placed on a black background with a ruler, immersed in bamboo oil, and photographed under a Nikon SMZ745T™ dissecting microscope. The longest length of the otolith was measured from each photograph using ImageJ64 (Schneider et al., 2012). For all remaining fish, the left otolith, unless it was broken or missing, was weighed, photographed, and measured using the same procedure.

### *Statistical Analysis*

An indicator variable regression (IVR) was used to determine if the relationship between  $\log_{10}(\text{length})$  and  $\log_{10}(\text{weight})$  differed between female and male Burbot. The relative weight for each Burbot greater than 200 mm was computed using the standard weight equation developed by Fisher et al. (1996). A one-way ANOVA was used to determine if the mean relative weight differed between female and male Burbot.

The 50 fish with lengths and weights for both the left and right otoliths were used to identify any differences between the left and right otoliths. A paired t-test was used to determine if the mean length or mean weight of the paired otoliths differed. An indicator variable regression (IVR) was used to determine if the relationship between otolith weight and length differed between left and right otoliths. The relationship between otolith length and weight, fish length and otolith size (length or weight) was described for all fish with simple linear regressions.

All statistical analyses were performed using the R environment (R Core Team, 2005) using a 5% rejection criterion.

### *RESULTS*

Burbot sampled ranged from 190 to 780 mm (Figure 2). Approximately 44% more male Burbot were sampled than female Burbot. The mean length of male Burbot was 534 mm (range from 291 to 768 mm), whereas the mean length of female Burbot was 562 mm (range from 295 to 780 mm). Fish of an unknown sex spanned the length range, largely due to difficulties identifying the sex of both frozen and spent fish.

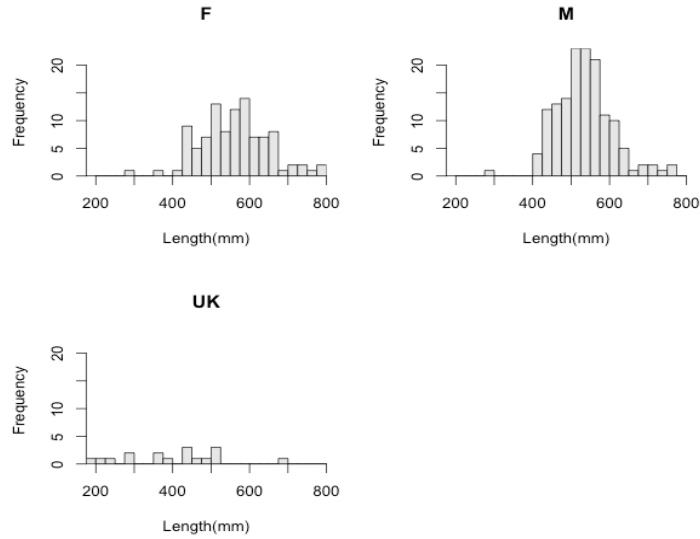


Figure 2. Length frequency histograms of Burbot collected at the 2015 Eelpout Festival separated by sex (F=female, M=male, UK=unknown sex).

The relationship between  $W$  and  $TL$  did not differ significantly between male and female Burbot (difference in slope  $p=0.9384$ , difference in intercept  $p=0.3382$ ; Figure 3). Thus, for all Burbot, there was a significant ( $p<0.00005$ ) relationship between  $W$  and  $TL$  as defined by the equation:  $W = 1.845 \times 10^{-6} * TL^{3.254}$ .

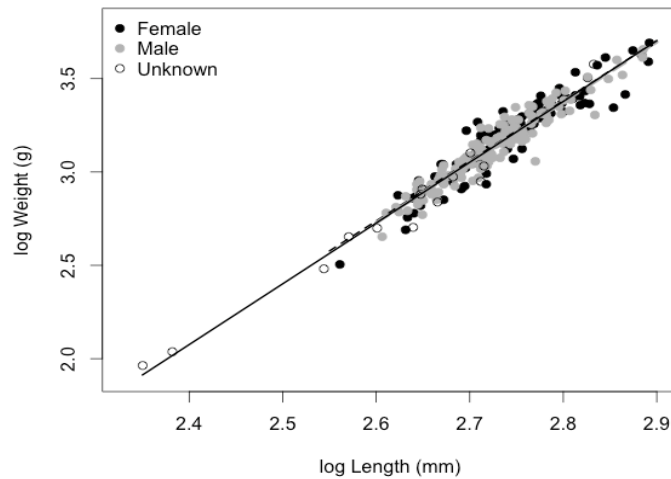


Figure 3. Linear regression of the log weight and log length of Burbot by sex collected at the 2015 Eelpout Festival.

There was a slight significant difference in the relative weight of male and female Burbot ( $p$ -value = 0.0461; Figure 4). Females had a mean relative weight of 133 ( $n=98$ ; CI= 129 to 137), while males had a mean relative weight of 128 ( $n=142$ ; CI= 118 to 137).

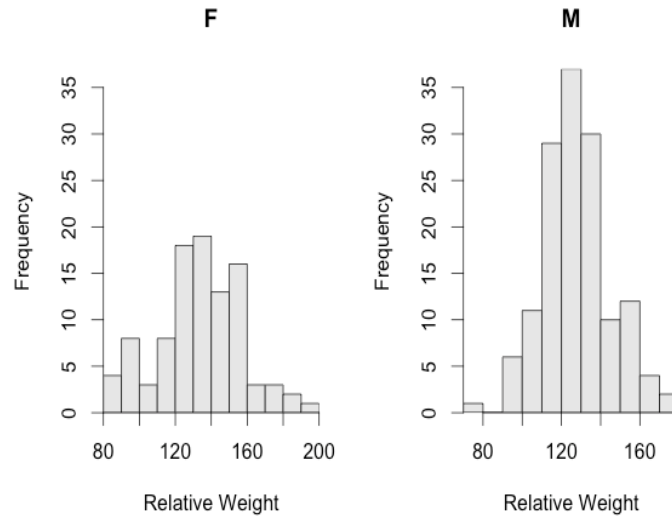


Figure 4. Histogram of the relative weights of female and male Burbot collected at the 2015 Eelpout Festival.

No significant difference was found between the lengths ( $p=0.0595$ ;  $r^2=0.9565$ ) or weights ( $p$ -value = 0.9879;  $r^2 = 0.9696$ ) of the left and right otoliths. Thus, all further analyses used the left otolith. A significant relationship between the weight and length of otoliths from individual Burbot exists ( $p<0.00005$ ). The relationship can be defined as the equation:  $otolith\ weight = 2.2029 \times 10^{-4} * otolith\ length^{2.568}$  (Figure 5).

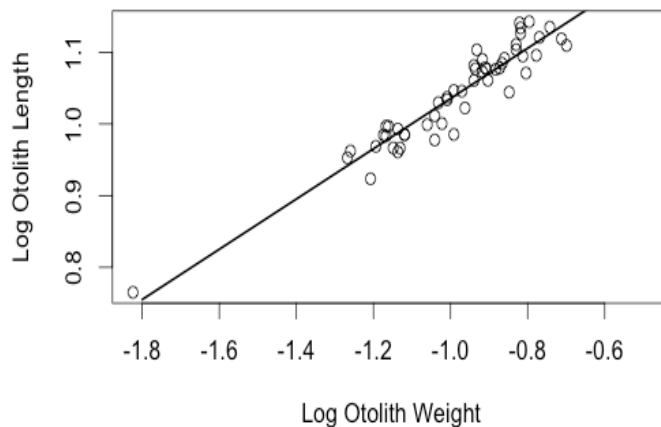


Figure 5. Linear regression of otolith length (mm) vs. otolith weight (g).

The significant relationship ( $p<0.00005$ ) between the length of the Burbot and the weight of its otolith is defined by  $TL = 10^{-6.8396} * otolith\ weight^{2.1530}$  (Figure 6).

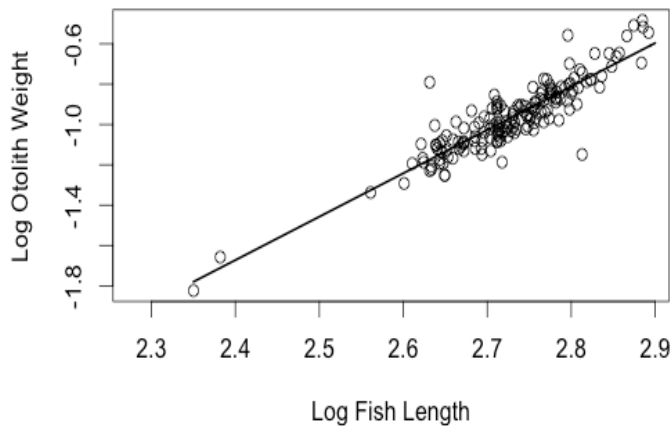


Figure 6. Linear regression of the log fish length and log left otolith weight from Burbot collected at the 2015 Eelpout Festival.

#### *Discussion*

Leech Lake Burbot were found to have a length distribution very similar, if not slightly larger, than other populations. Most Burbot populations are found to have an adult range of 300-600 mm (McPhail and Paragamian, 2000), whereas Leech Lake Burbot adults range around 400-675 mm (Figure 2).

The weight-length equation of Leech Lake Burbot will allow for the biologists at the Minnesota Department of Natural Resources to more efficiently assess the population during future surveys of the population. The equation will allow for the estimation of weights from lengths of the fish, saving time in the field. The assessment that there is no significant difference in the weight-length relationship between females and males is consistent with other populations (Bailey, 1972). Ultimately, we will compare this relationship to the same relationship for Burbot from Lake Superior to assess the impact of exploitation on relative condition of the fish.

Both female and male Burbot from Leech Lake were found to be in good overall condition with the mean relative weights much greater than 100, which represents the 75<sup>th</sup> percentile of weights from throughout the range of Burbot. The comparatively high relative weight (Figure 4) of Leech Lake Burbot is likely a result of the high exploitation of the population each year during the International Eelpout Festival. High harvest of fish populations can result in high condition factors by reducing the intraspecific competition and allowing for fewer fish to grow larger and more quickly. This claim will be further tested by comparing these relative weights with relative weights of Burbot from Lake Superior.

The equation used to compare the length of the Burbot and the weight of its otolith ( $TL = 10^{-6.8396} * otolith\ weight^{2.1530}$ ; Figure 6) will be tested in continuation of this study as a possible way to age fish based upon otolith size. We will also test the possibility of estimating fish age more accurately by comparing otolith size to age.

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