Quantifying a potential mechanism between ice cover and cisco recruitment success: what role does light play in cisco embryonic development and larval survival?

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**ABSTRACT:**

**INTRODUCTION:**

*Coregonus* fishes play important economic and ecological roles throughout the northern hemisphere, “*but probably nowhere else do they attain so much importance in the fisheries as in the region of the [Laurentian] Great Lakes*” (Koelz 1929). Sadly, *Coregonus* recruitment has dwindled to unprecedented levels. *Coregonus* species are fall spawners whose embryos incubate under ice throughout the winter and hatch in spring. Recent changes in ice cover coupled with poor *Coregonus* recruitment (ciscoes in particular) has led to speculation about the relationship between ice cover and embryo and larval survival for more than a decade with limited rectification. Over the past 37 years in Lake Superior, 17 of 19 moderate- to high-recruitment years of cisco (*C. artedi)* occurred when January ice cover exceeded 15% lakewide and twelve of 18 years had no measurable recruitment when lakewide ice cover did not reach 15% by January (new analysis, MV/TS). All known cisco spawning areas are estimated to be covered at 15% lakewide ice cover (Figure 1a, Goodyear 1982). Potential mechanisms by which early ice cover might influence cisco recruitment success include the reduction of physical wave action, lower and more stable winter and spring water temperatures, and less sunlight reaching the lake bottom.

Why light?

* Ice-light relationship as experimental proxy

How does ice impact development?

* Hatching cues
* Yolk-feeding-survival relationship
* Spring zooplankton phenology

A larger yolk-sac at hatching increases time before exogenous feeding is required, which increases larval survival (Fuiman 2002).

Contrast between Lake Superior and Lake Ontario ice regimes

Lakes Superior and Ontario provide a contrast in ice cover and subsequent light attenuation.

Different incubation depths. Look at Lar’s lab for literature.

Identify to what extent light influences cisco incubation duration, embryo survival, larval yolk-sac volume at hatching, and larval growth and survival.

We will study cisco from Lakes Superior and Ontario under a common garden experiment to measure how cisco embryos respond to different ice regimes. We hypothesize that exposure to elevated light intensity (low ice cover) will accelerate cisco embryogenesis, resulting in smaller yolk-sacs and lower larval survival. Lake Superior cisco are expected to be adapted to lower light levels and thus will experience more negative impacts from increasing light intensity than Lake Ontario cisco. If these results hold up to more rigorous experimentation this would be a significant step towards understanding the recent high variability observed in *Coregonus* recruitment and help predict what the future of these species may look like under current climate trends to inform restoration efforts, particularly with respect to the selection of successful brood stocks.

**METHODS:**

Cisco will be collected from Lake Superior, near Bayfield, Wisconsin, and Lake Ontario, Chaumont Bay, New York, in December 2019 by the Wisconsin DNR and New York DEC, respectively. Eggs and milt will be stripped from 12 females and 16 males and artificially inseminated to create 48 families from each lake. Fertilized eggs will be transported overnight to the University of Vermont (UVM) where all laboratory work will be conducted. Fertilization success will be assessed within 48-hours post-fertilization and unsuccessful families removed. Embryos from successful families ﻿will be divided among three light treatments and individual embryos randomly distributed into three 24-well microplates. Light treatments will represent 90-100, 40-60, and 0-10% ice cover and follow daily photoperiods. Incubation light levels will be based on measured lakebed light intensity data collected by the proposal authors throughout the entirety of Lake Superior’s 2016 and 2017 ice seasons. Embryos will be incubated at a constant temperature of 2.0°C in climate-controlled chambers. This novel incubation method was tested at UVM on Lake Ontario cisco with unrivaled embryo survival (>80%) in 2018-19.

Newly-hatched larvae will be photographed, and the images then used to measure total length-at-hatch (mm) and yolk-sac volume (mm3). The relationship between embryonic life history traits (incubation period, length-at-hatch, yolk-sac volume) and incubation light treatments between lakes will be analyzed using linear mixed models and ANOVAs. A sib analysis (Falconer and Mackay 1996) will be used to assess the relative role heritability (variation within sibling families) and the common environment (light) played in effecting the measured life history traits.

Larvae will be moved from microplates to rearing tanks by lake and incubation light treatment and exposed to the same photoperiod cycle (*i.e.,*12-hr light, 12-hr dark) with gradual sunrise and sunset transitions. Larvae will be reared in 150-L oval recirculating tanks at 10°C and provided dry feed *ad libitum*. At three months post-hatch, total length and weight of all larvae will be measured. Mean daily growth increment will be calculated as (mean final length – mean length-at-hatch)/duration of the larval experiment to assess how incubation light intensity impacted subsequent larval growth.

**RESULTS:**

**DISCUSSION:**

**LITERATURE CITED:**

**TABLES:**

**FIGURES:**