Oxythermal Stress of a Dimictic Lake
In Response to Changing Climate

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Lake Stratification

- **Ice Cover**

- **Spring Mixing**

- **Stratified**

- **Fall Overturn**
Oxythermal Stress (OTS)

Water Temperature (°C)

Dissolved Oxygen (mg/L)

Depth (m)

DO < 3 mg/L

Water Temp > 16°C

Cisco (Coregonus artedi)
Research Questions

*How does changing climate impact oxythermal stress?*

**Historical Climate**

**Projected Climate (WICCI)**

*How will the spatial distribution of OTS evolve?*

*How should we mitigate OTS effects due to climate change?*
Study Site - Fish Lake

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Depth (m)</td>
<td>6.6</td>
</tr>
<tr>
<td>Max Depth (m)</td>
<td>19.9</td>
</tr>
<tr>
<td>Surface Area (ha)</td>
<td>87.4</td>
</tr>
<tr>
<td>Groundwater Hydrology</td>
<td>Groundwater Flowthrough</td>
</tr>
<tr>
<td>Surfacewater Hydrology</td>
<td>Seepage</td>
</tr>
<tr>
<td>Percentage GW Input</td>
<td>6</td>
</tr>
</tbody>
</table>
1D Modeling

Temperature (°C) Dissolved Oxygen (mg/L)

Ice cover

Open water

SW LW SH LH

Aug Oct

Groundwater

H_{sed}

DYRESM – WQ - ICE
Historical Change in OTS

Summer Hypolimnetic DO Concentration

DO < 3 mg/L
Water Temp > 16°C

DO (mg/L)
A1B Scenario

- Spring: 3.3°C
- Summer: 2.7°C
- Autumn: 3.6°C
- Winter: 4.4°C

Historical Climate

- Depth (m)
- Dates: Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

A1B Scenario

- Frequency of Oxythermal Stress
- Days of Stress
- Number of Occurrences

Historical Climate

- Depth (m)
- Dates: Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Research Questions

*How does changing climate impact oxythermal stress?*

**Historical Climate**

*How will the spatial distribution of OTS evolve?*
3D Modeling

NHYS

Velocities
Temperature
turbulence

Dissolved Oxygen (mg/L)

Temperature (°C)

Depth (m)
Spatial Distribution of OTS

- April
- May
- June
- July
- August
- September
- October
Research Questions

*How does changing climate impact OTS?

*How will the spatial distribution of OTS evolve?

*How should we mitigate OTS effects due to climate change?
Mitigation/Adaptation Strategy

Option 1: Changing Water Levels

Lowering water levels
- More mixing → Higher DO

Raising water levels
- Larger spatial area for fish

Date
Depth (m)

Apr 0 2
May 2 4
Jun 4 6
Jul 6 8
Aug 8 10
Sep 10 12
Oct 12 14
Nov 14 16
Dec 16 18

Lower Water Level Scenario

Frequency of Oxythermal Stress

A1B Scenario

Days of Stress
Number of Occurrences

Frequency of Oxythermal Stress

Days of Stress
Number of Occurrences

Lower Water Levels

Mitigation/Adaptation Strategy
Mitigation/Adaptation Strategy

Option 2: Artificial Mixing

Gradual Entrainment Lake Inverter (GELI) (Crystal Lake Mixing Project – www.crystallakemixing.com)

Frequency of Oxythermal Stress

Delayed Stratification Onset

Higher Dissolved Oxygen

Gradual Entrainment

A1B Scenario

Mixing

Frequency of Oxythermal Stress Days

A1B Scenario

+ Mixing

(Crystal Lake Mixing Project – www.crystallakemixing.com)
Conclusions

*How does changing climate impact oxythermal stress?*

- **Air temp increases**
- **DO levels decrease**
- **Frequency of OTS increases**

*How will the spatial distribution of OTS evolve?*

- **April-July**
- **Aug + Sept**
- **low spatial OTS**
- **high spatial OTS**

*How should we mitigate OTS effects due to climate change?*

- **Artificial Mixing reduces OTS**
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