The Hidden World of Overwintering Fish: How Cold Water Species Benefit From Winter

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Background

- Freshwater fish are most commonly understood to be active in the spring, summer, and fall, and dormant in the winter.¹
- For overwintering fish, winter is typically defined as a period of ice cover and short day lengths.¹
- Winter is associated with negative growth and high mortality with few studies focusing on the potential benefits of winter.¹
- This study highlights how size and ice cover influence the outcome of cold-water overwintering freshwater fish.



- Explore how winter can be both positive and negative for cold-water freshwater fish.
- Understand the different ways size and ice cover can impact overwintering fish.
- Predict how climate change will impact these fish.

Methods

- Google Scholar was used to search key terms such as "fish AND winter AND mortality" or "fish AND winter AND size".
- Key findings from the studies were organized into a spreadsheet with the most common categories and species studied, which was used to find out which species were most successful under specific conditions.

Ice Cover			
.abel	Reference	Species	Focus of Study
4	Amundsen & Knudsen, 2010	Arctic Charr, Brown Trout	Arctic charr interaction with brown trout
3	Byström et al., 2006	Arctic Charr	Starvation mortality

- Ice cover and size were found to be the most positive topics with cold water species being the most popular for overwinter studies (fig. 1).
- Data was extracted from Atlantic salmon studies that reported mean monthly wet weight and compared against each other.
- All studies were narrowed down until connections could be made between them regarding the overwinter outcomes of fish under the same conditions.
- Studies that involved both size and ice cover were identified, then connected through outcomes on a flowchart.

Definitions:

Positive: Maintained or gained mass or energy, high survival **Negative:** Lost mass or energy, low survival, increased aggression or competition **Mixed:** Maintained or gained mass or energy, high survival





Fig 3. The effect of size and ice cover on fish species with a cold thermal preference based on lipids, survival, energy, growth, and condition

Fig 1. (A) Number of studies with positive, negative, or mixed overwinter results by species organized by mean optimal growth temperature. (B) Number of studies with positive, negative, or mixed results by topic

- Factors that can make ice cover beneficial:
 - Continuous feeding throughout winter, especially in small fish.³
 - Provides protection against aerial and terrestrial predators.⁴
 - Ice cover reduces resting metabolism and promotes proper energy budgeting.⁴

Factors that can make ice cover disadvantageous:

- Competition: Heightened competition under ice cover.⁵
 - Predator: Piscivorous feeding can be less efficient.⁵
 - Prey: Enhanced predation risk after moving to new feeding zones.⁵
- Visual foraging: Ambient light conditions are darker under ice cover.⁵

Size







Conclusions

- Overwinter success is highly dependent on the complicated interactions of overwinter conditions.
- Ice cover is often crucial for overwinter survival and positive outcome.
- Despite having synthesized the impacts of size and ice cover on overwintering fish, there are still many factors that remain unknown. Future studies should focus on how size and ice cover influence overwinter success paired with other common overwinter conditions.
- Winter is not an inherently negative period of time for freshwater fish as there are many benefits of the season that various species have evolved to take advantage of.
- Large fish often had higher survival and more positive outcomes than small, however mass seemed to decrease more in large fish than small.
- Energy stores decreased while there was little change in mass.²
- Mass alone may not be a good indicator of overwinter success due to factors such as underlying physiological outcomes.²

New Questions:

- How can we identify size-dependent success under unifying conditions?
- What are the drivers for success and what are the outcomes we can evaluate success with?

• Climate change is causing warmer, shorter winters with less ice cover which will be detrimental for these cold water fish that benefit from ice cover.⁶







Future Directions

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- Draw connections between other factors identified in warm water species.
- Synthetize more topics into unifying winter outcomes and add more conditions to the flow chart.

References:

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