



Initial Insights on the Thermal Ecology of Lake Whitefish in Northwestern Lake Michigan

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Introduction

Lake whitefish (LWF) *Coregonus clupeaformis* are a coldwater species native to the Great Lakes that support important fisheries in many parts of the basin. Sustainability of LWF stocks may be threatened by climate-induced changes in thermal habitat availability. Potential loss of thermal habitat could be particularly important in the warm, shallow waters of southern Green Bay, Lake Michigan. Current predictions of how LWF may respond to changes in water temperature are based on temperature ranges defined from laboratory studies. Prior research describing the temperature use of LWF outside of the laboratory setting has been limited.

Objectives

1. Provide baseline data on temperatures occupied by LWF in northwestern Lake Michigan.
2. Determine if temperature use varied for LWF inhabiting different areas within northwestern Lake Michigan.
3. Compare temperatures experienced by LWF during the summer with the laboratory derived optimal temperature range¹ (OTR; 10-14 °C) and broad thermal niche² (BTN; 7-17 °C).

Methods

Study Area

- Northwestern Lake Michigan, including Green Bay (Fig. 1)

Sampling and Tagging

- LWF ≥ 400 mm total length (N=400) were collected by electrofishing and commercial trap nets in Nov. 2017 and were surgically implanted (Fig. 2) with acoustic transmitters and iButton temperature loggers (Fig. 3)
- Data collection: 1 Dec. 2017 – logger death (7 Nov. 2018), recorded temperatures (°C) every 4 hr

Acoustic Telemetry & Temperature Data Processing

- Data from temperature loggers (n=13) returned by fishers were categorized into seasons
- Fish were assigned to geographic zones (southern Green Bay – SGB, northern Green Bay – NGB, Lake Michigan – LM) based on where they spent a majority of their time during a specific season using acoustic tag detections (Fig. 1)

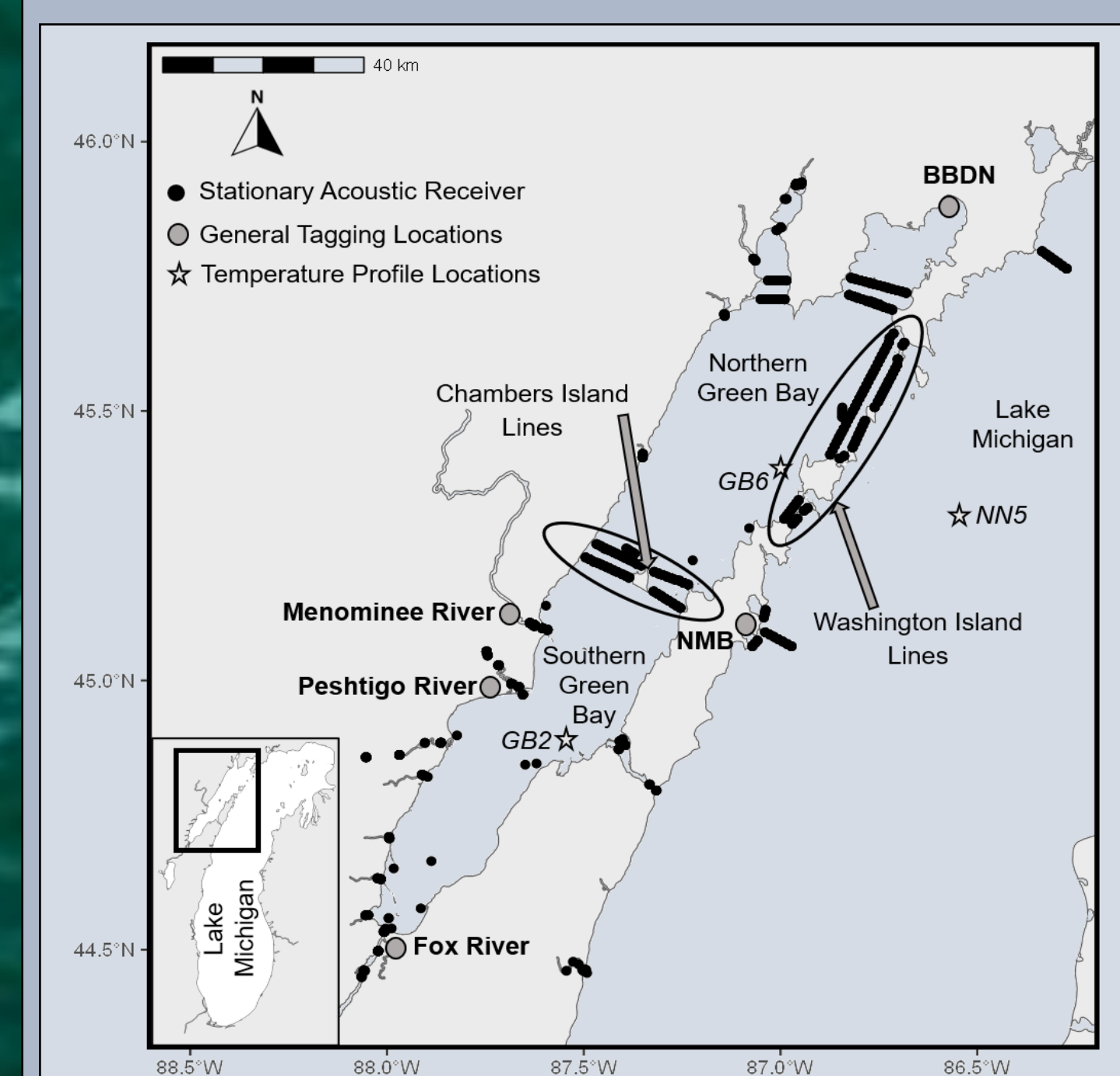


Figure 1. Study area in northwestern Lake Michigan, USA, which includes Green Bay. Locations of the stationary acoustic receivers deployed (N = 225), tagging locations (N = 5), and locations where temperature profiles were taken (N = 3) are shown.

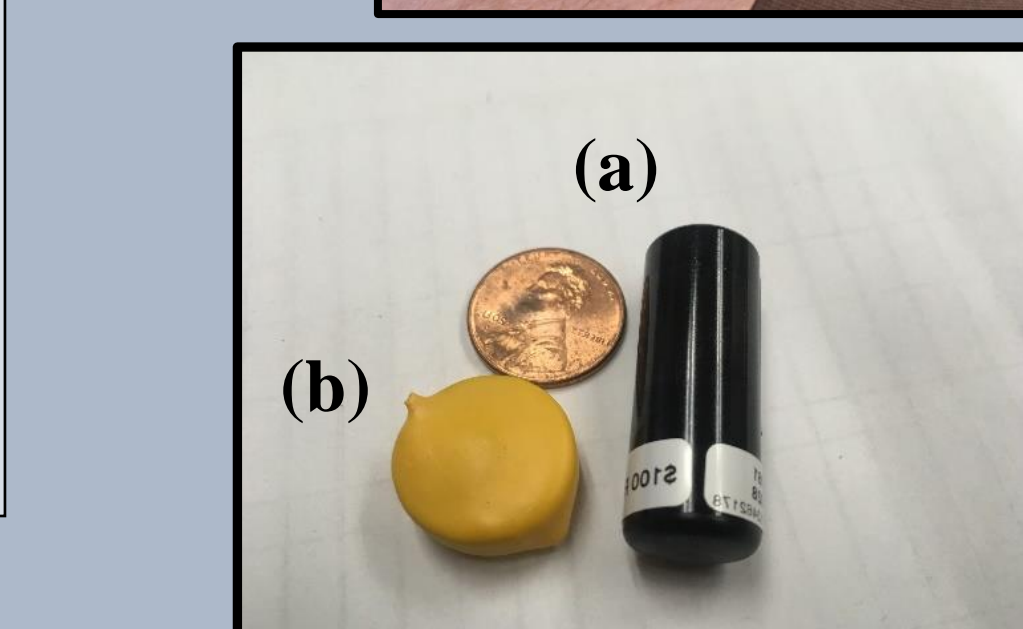
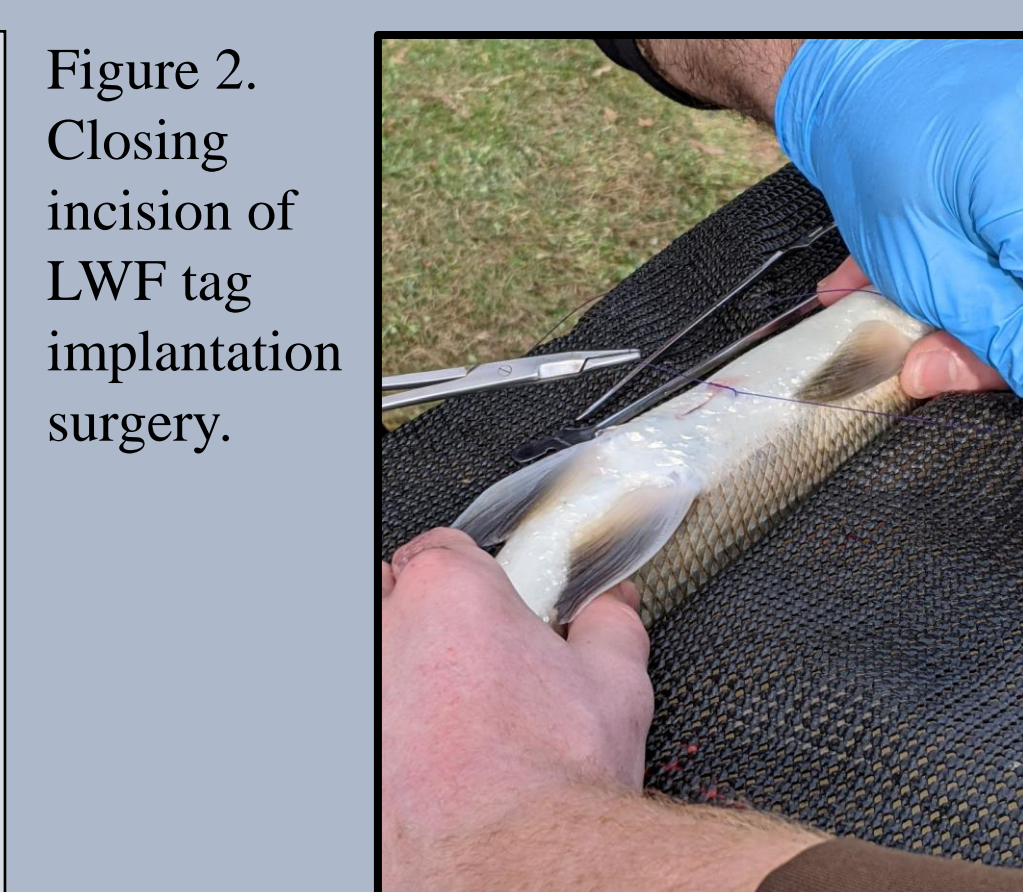


Figure 3. Acoustic transmitter (a) and iButton[®] temperature logger (b) that were used for this study.

Results

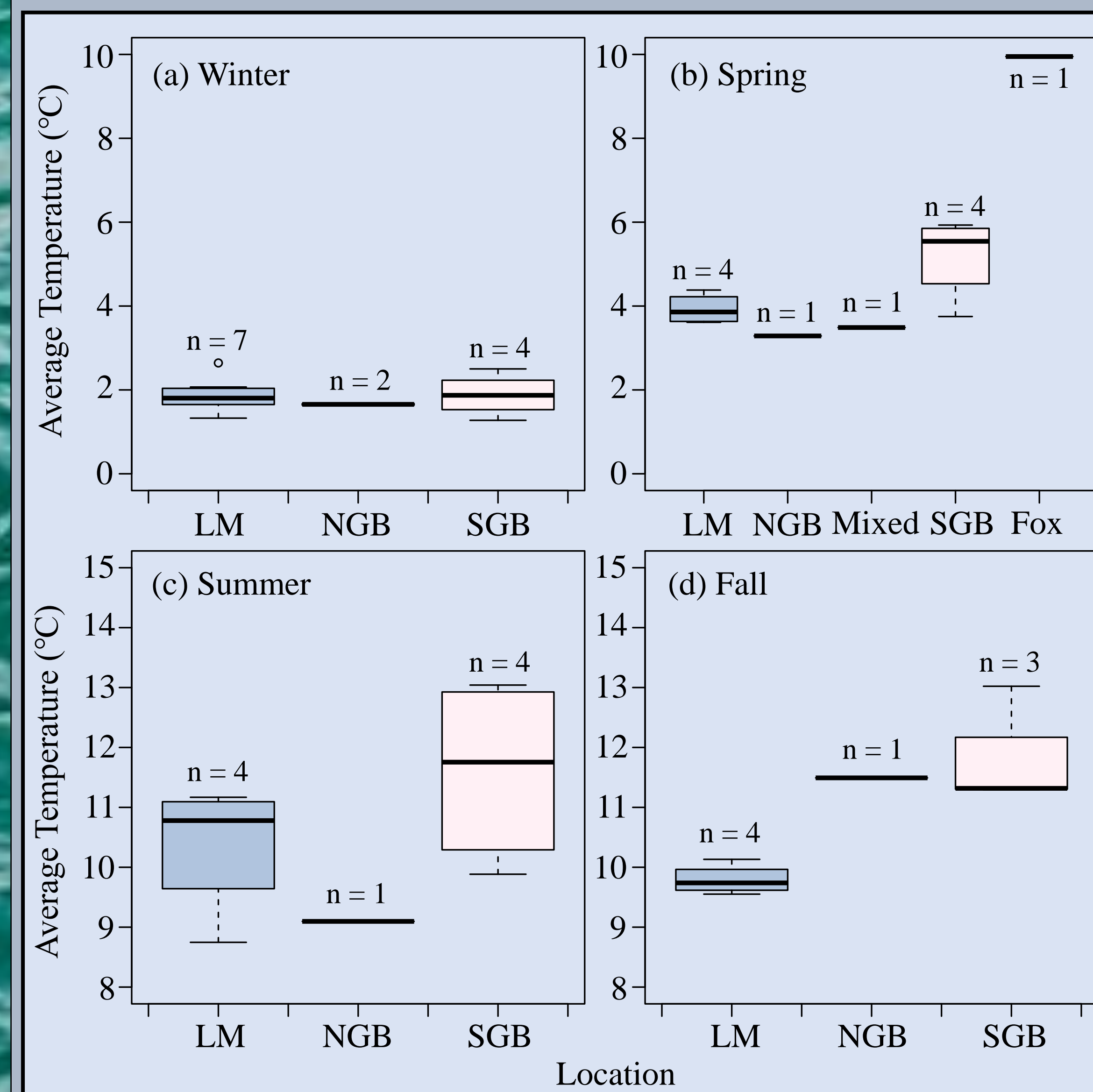


Figure 4. Average temperatures (°C) inhabited by LWF. The horizontal black line in each box represents the median of averages calculated for individual LWF. LM = Lake Michigan, NGB = northern Green Bay, SGB = southern Green Bay, MIXED = even amount of time spent in both NGB and SGB, FOX = Fox River.

Table 1. Water temperature ranges and means that LWF experienced during the seasons.

	Season			
	Winter	Spring	Summer	Fall
Range (°C)	0 - 8.0	0 - 20.0	4 - 21.5	4 - 21.0
Mean (°C)	1.8	4.8	10.8	10.8

- During the winter, LWF in all zones inhabited areas with similar average temperatures (Fig. 4)
- In spring, summer, and fall, fish in SGB inhabited higher average temperatures compared to fish in NGB and LM (Fig. 4)

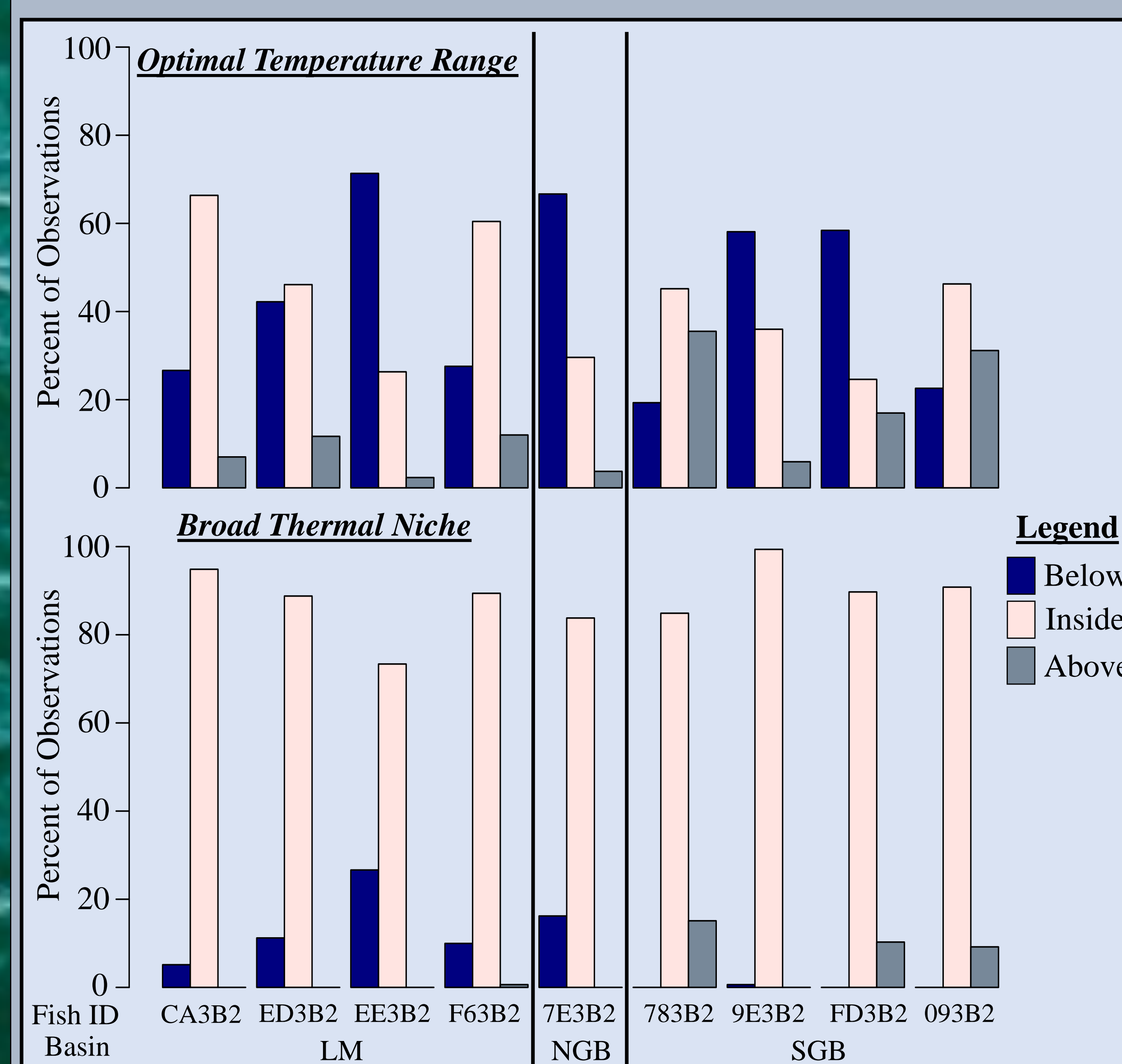


Figure 6. Percentage of observations during the summer where individual LWF in different locations were below, inside, and above the optimal temperature range¹ (OTR) and the broad thermal niche² (BTN).

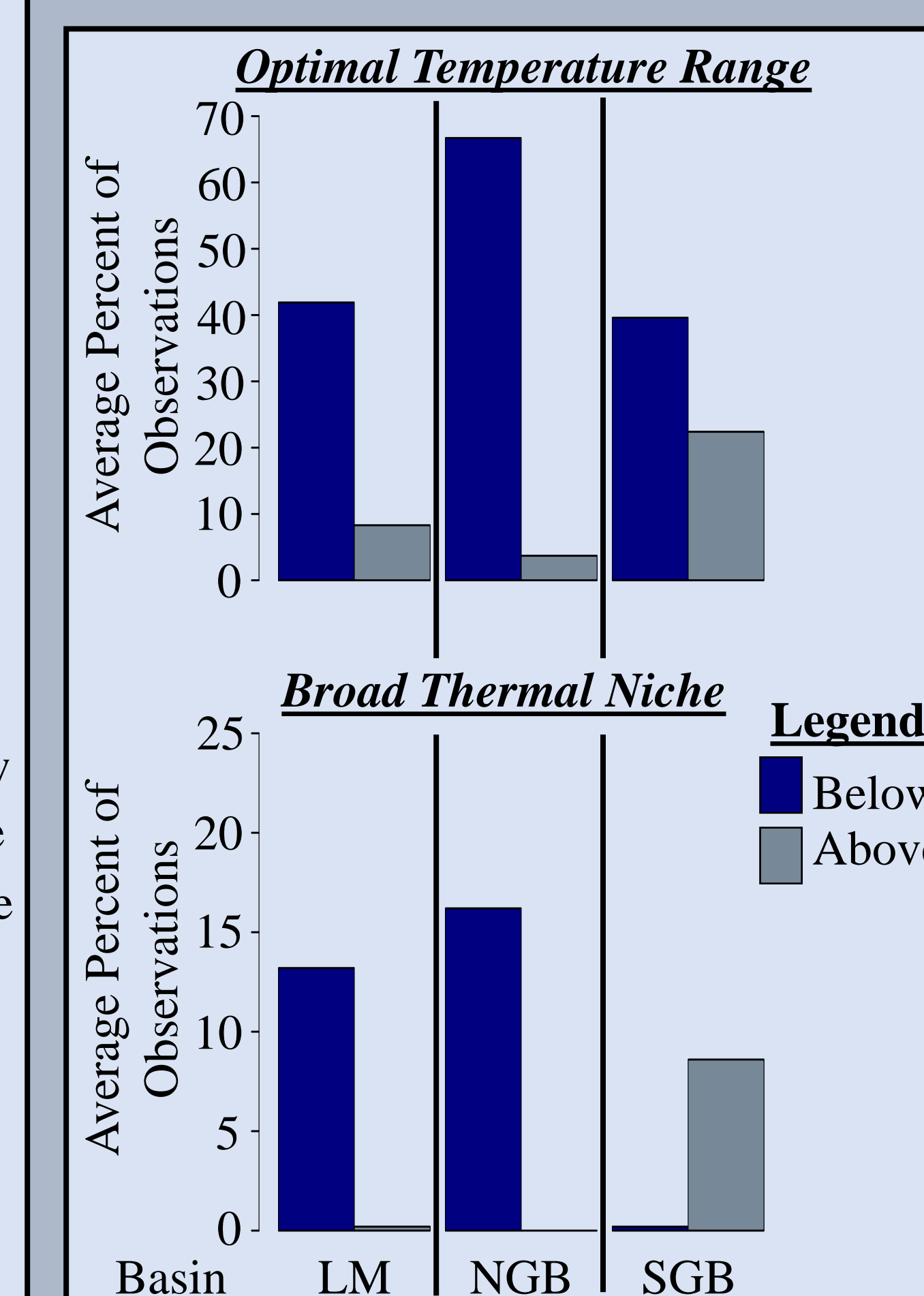


Figure 5. Average percent of observations during the summer where LWF in different locations were below and above the optimal temperature range¹ (OTR) and the broad thermal niche² (BTN).

Discussion

General Thermal Ecology

- LWF inhabited waters from 0 – 21.5 °C
- *Temperature Usage Varying Based on Location Inhabited*

- LWF in SGB during spring, summer, and fall generally inhabited warmer water than LWF in NGB and LM

Alignment of Observations to Previously Defined Thermal Ranges

- Our study is the first to document thermal ecology of LWF over all seasons in northwestern LM
- The OTR was meant to represent 2/3 of all thermal observations while the BTN was meant to represent all thermal observations by LWF
- Based on the results, the observed temperature use of LWF in northwestern LM was broader than both thermal ranges, even when those temperatures were available to them throughout the summer
- Based on the results, the thermal ranges as currently defined may not be appropriate for the species in all locations

Limitations

- This study had a sample size of n=13
- No statistical tests were conducted due to low sample sizes

Conclusions

- LWF may exhibit a local adaptation or flexibility to use warmer waters in certain populations due to inhabiting high productivity habitat regions
- This local adaptation/flexibility could be relevant in shallow areas of the Great Lakes where LWF populations reside, as more thermal habitat may be present than previously thought
- Our data provide an important starting point for understanding LWF thermal ecology in northwestern LM and how the species may respond to changing water temperatures in the Great Lakes



Figure 7. Lake whitefish (LWF).

Acknowledgements

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