

Winter Flounder *Pseudopleuronectes*
americanus Abundance in Rhode Island Coastal
Ponds

RI DMF Fyke Survey 2023-2024

Bryan P. Galligan M. Conor McManus
Richard G. Balouskus

2025-04-07

To do

- add language about how to interpret pd and ale plots
- change temp to ALE and probably remove the scatter plot
- add summary stats table at beginning
- add tables for rfm performance compared to the Galligan et al baseline
- change maps of station effects to compare 1999-2024 with the most recent year
- update Galligan et al citation with publication info

Introduction

This report uses data from the Rhode Island Division of Marine Fisheries fyke survey and statistical models developed by Galligan et al. (n.d.) to generate a summary of Winter Flounder *Pseudopleuronectes americanus* abundance in Rhode Island coastal ponds. The fyke survey is conducted annually in three ponds: Point Judith Pond, Potter Pond, and Ninigret Pond (Galligan et al. n.d.). The survey collects data on Winter Flounder abundance, water temperature, and other environmental variables (Balouskus et al. 2024; Galligan et al. n.d.). The statistical models use random forest machine learning to evaluate catchability and derive a fishery-independent abundance index for Winter Flounder in each pond (Breiman 2001; Galligan et al. n.d.).

The software that generates this report is intended to be run annually. In addition to updating the models presented by Galligan et al. (n.d.), it also provides a summary of Winter Flounder abundance and other relevant data for the most recent survey year.

This report highlights data from survey year:

[1] "2023 - 2024"

In what follows, we present an overview of Winter Flounder abundance in Rhode Island coastal ponds, focusing on the most recent survey year. We begin with a fishery-independent abundance index derived from data collected in all three coastal ponds, which is followed by specific abundance indices for each pond. We then examine the relationship between Winter Flounder abundance and water temperature. Finally, we explore the effects of fyke station on Winter Flounder catch probability (the probability of occurrence in the fyke survey catch).

Winter Flounder Abundance

The Southern New England/Mid-Atlantic (SNE/MA) Winter Flounder *Pseudopleuronectes americanus* population experienced a severe decline through the 1990's, and current estimates place stock biomass at less than 15% of its observed peak in 1982 (NEFSC 2022). Despite significant reductions in fishing effort, Winter Flounder show no signs of recovery (NEFSC 2022).

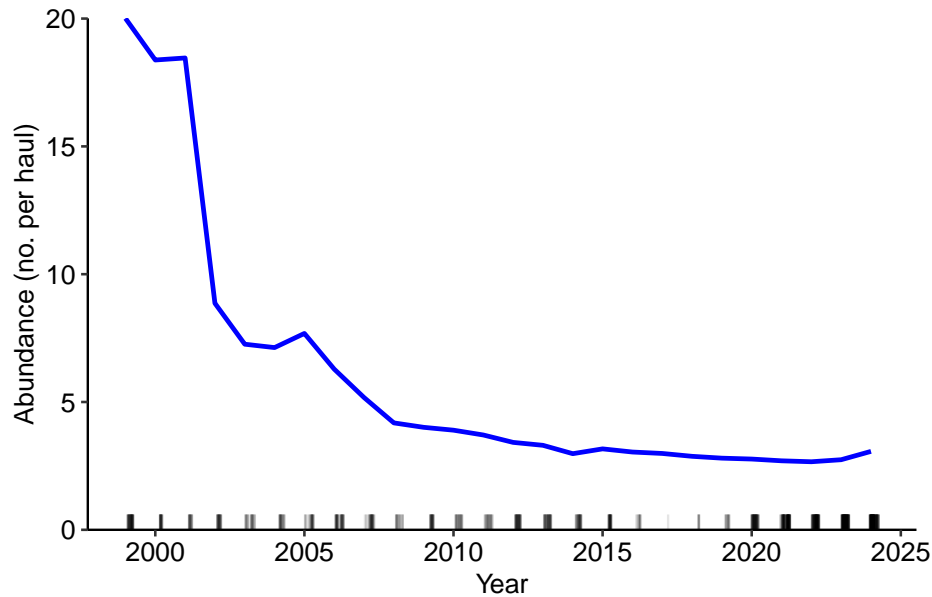


Figure 1: Fishery-independent abundance index for Rhode Island Winter Flounder in Rhode Island coastal ponds. The blue line is a partial dependence plot of Winter Flounder abundance on year.

Our model-based abundance index for all three subpopulations shows a slow but continuing decline since 2007 that is not apparent in the raw survey data (Figure 1). Like our index, the 2022 stock assessment for SNE/MA Winter Flounder showed a significant drop in spawning stock abundance in the early 2000's, with 10,005 mt in the year 2000 and 4,648 mt in 2005 (NEFSC 2022). However, the assessment's increase in spawning stock biomass from 2005–2013 and the subsequent decrease to ~3,500 mt are not reflected in our index (NEFSC 2022).

Point Judith Pond showed a steep decline from 1999-2002, followed by a more gradual but steady decline until 2012, after which abundance remained low for the remainder of the survey period Figure 2. Potter Pond and Ninigret Pond both showed relatively stable abundance for the years in which they were surveyed Figure 2. Ninigret Pond had the highest modeled abundance of the three ponds, but also displayed a slight decrease in abundance in the last few years of the survey Figure 2.

Station

The following figures show the accumulated local effects (ALE) of station on catch probability for (1) the period from 1998-2019 and (2) the most recent five survey years. Station and pond are both influential drivers of Winter Flounder

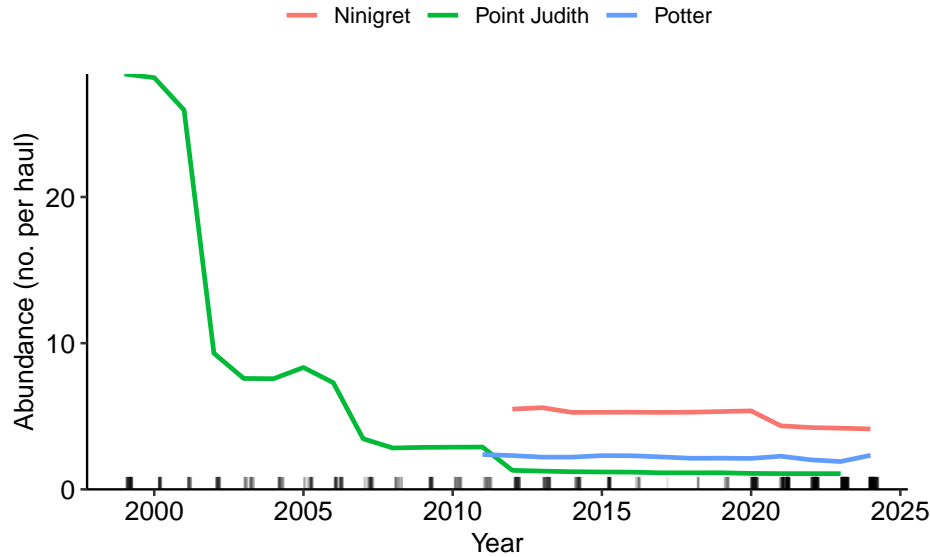


Figure 2: Fishery-independent abundance indices for Winter Flounder in Point Judith Pond, Potter Pond, and Ninigret Pond. Each line is a partial dependence plot of Winter Flounder abundance on year.

catch rates in the fyke survey (Galligan et al. n.d.). Effects are estimated for Point Judith Pond (Figure 3), Potter Pond (Figure 4), and Ninigret Pond (Figure 5). Notably, Potter Pond had no sites with a positive effect on occurrence or abundance, and Ninigret Pond displayed the strongest positive effects (Galligan et al. n.d.).

Fixed sampling stations within Point Judith Pond and Potter Pond have been surveyed at varying levels of effort since 1999 (Galligan et al. n.d.). Ninigret Pond was added to the survey in 2012 (Galligan et al. n.d.). Within each pond, between one and three fyke nets were set concurrently at any given time and then rotated haphazardly among fixed stations over the course of the winter.

Point Judith Pond

The historically productive Point Judith Pond has been surveyed since 1999 (Figure 3). The fyke survey has been conducted at 8 fixed stations within the pond, with varying levels of effort at each station. Notably, temporal changes have been observed in Point Judith Pond, with a narrower spawning window in more recent years (Balouskus et al. 2024).

Point Judith Pond is the easternmost of the surveyed salt ponds. Point Judith Pond has a surface area of approximately 6.58 km², a mean depth of 1.8 m, and is connected to Block Island Sound by an artificial breachway (Lee 1980). The Saugatucket River flows into the north end of Point Judith Pond, providing

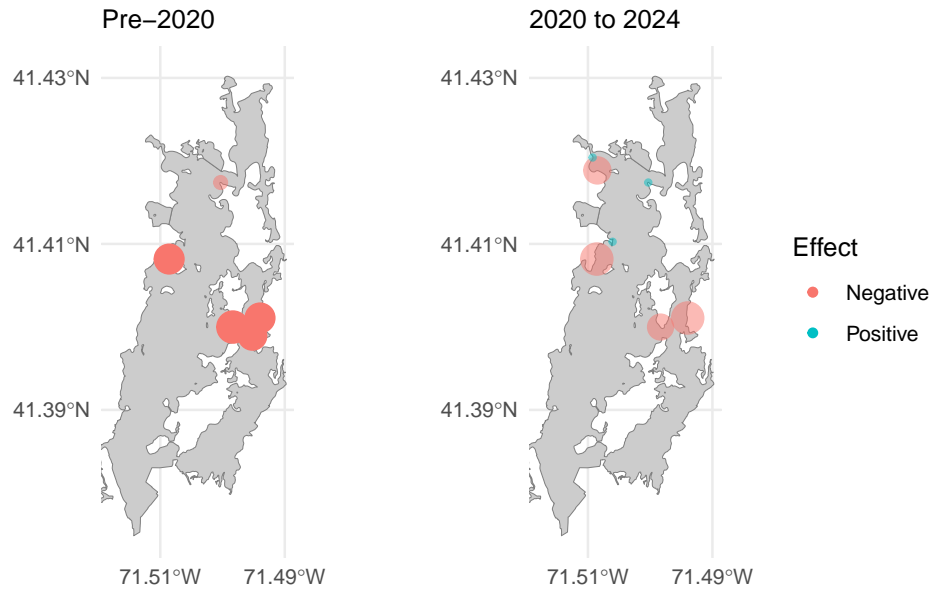


Figure 3: Accumulated local effects (ALE) of station on catch probability in Point Judith Pond. The left panel shows the ALE for all years prior to 2020, and the right panel shows the ALE for the last five years.

the greatest freshwater flow of any of the surveyed ponds. Salinity within the pond ranges from approximately 20 PSU in the northern reaches to full oceanic salinity at the breachway. Due to the developed watershed, shallow depths, and relatively low flushing rates, Point Judith Pond can experience eutrophication and increased growth of macroalgae (Lee and Olsen 1985; Meng et al. 2000). The pond is home to the largest fishing port in Rhode Island, the Block Island ferry terminal, and numerous marinas.

Potter Pond

Potter Pond has been surveyed consistently since 2011, with fyke nets set at 7 fixed stations within the pond Figure 4. Potter Pond has been characterized by a lack of positive effects on Winter Flounder occurrence or abundance, with the exception of a single station in the most recent survey years (Galligan et al. n.d.).

Potter Pond is situated immediately west of Point Judith Pond and joined to Point Judith by a permanent tidal channel. The surface area of Potter Pond is approximately 1.38 km². The primary source of freshwater into Potter Pond is from Fresh Pond, which empties into Potter's northern reaches. This northern section of Potter Pond is also characterized by a glacial kettle hole that reaches over 40 feet in depth, a unique feature among the RI coastal ponds. Potter Pond has no direct outlet to the ocean.

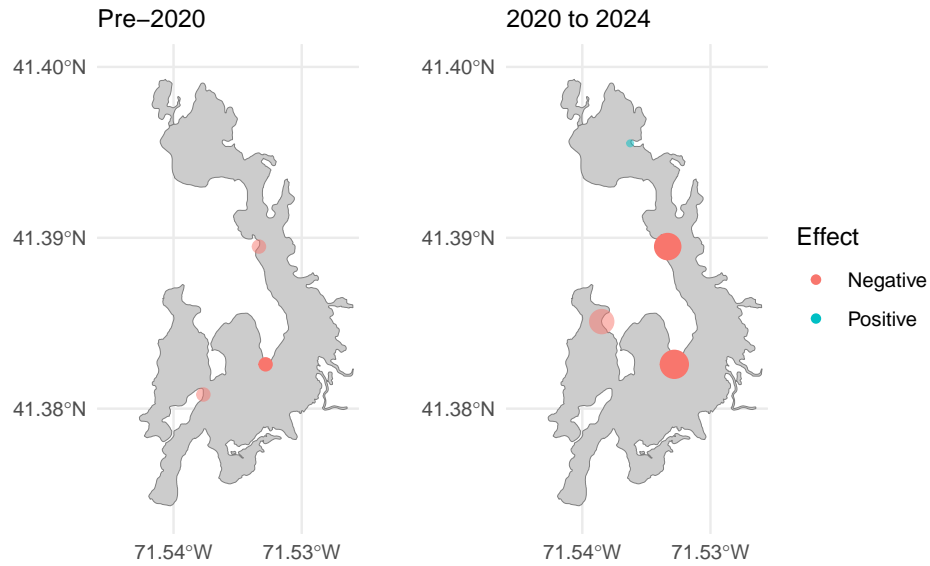


Figure 4: Accumulated local effects (ALE) of station on catch probability in Potter Pond. The left panel shows the ALE for all years prior to 2020, and the right panel shows the ALE for the last five years.

Ninigret Pond

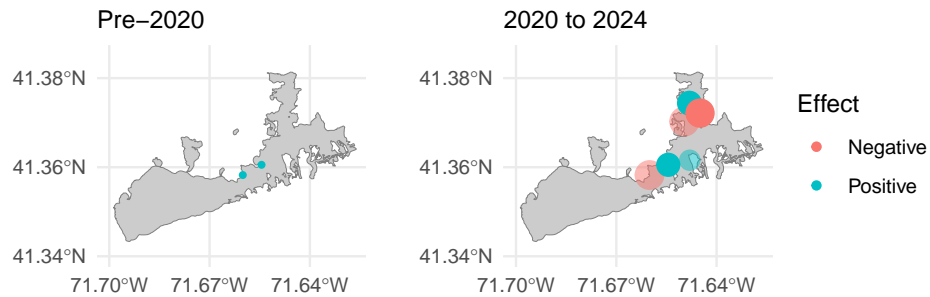


Figure 5: Accumulated local effects (ALE) of station on catch probability in Ninigret Pond. The left panel shows the ALE for all years prior to 2020, and the right panel shows the ALE for the last five years.

Ninigret Pond was added to the fyke survey in 2012 with 7 fixed stations Figure 5. The pond has been characterized by more positive effects on Winter Flounder occurrence and abundance and a higher abundance index than Point Judith or Potter ponds in recent years (Galligan et al. n.d.).

Ninigret Pond is the largest salt pond in Rhode Island with a surface area of approximately 6.74 km² and has a permanent, maintained breachway to the ocean. The mean depth throughout Ninigret Pond is approximately 0.4 m, and

it is connected to Green Hill Pond to the east by a tidal channel (Lee 1980). The watershed of Ninigret Pond includes residential housing, marinas, and the USFWS Ninigret Wildlife Refuge.

Water Temperature

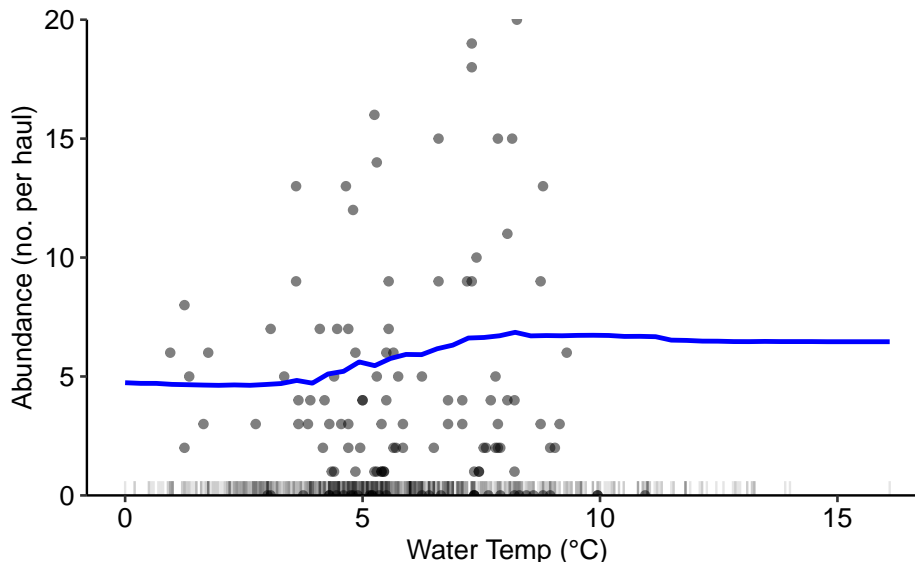


Figure 6: Partial dependence plot of Winter Flounder abundance on water temperature. The blue line is the partial dependence plot, and the gray rug shows the distribution of water temperatures in survey data. Scatter plot points represent the observations made in the most recent survey year.

Water temperature was the only environmental variable that predicted abundance (Figure 6). Below an $\sim 8^\circ\text{C}$ threshold, warmer temperatures were associated with increased abundance (Figure 3). This trend is consistent with observations of burrowing and/or inactivity at cooler temperatures, which would make Winter Flounder less available to fixed gears (Grothues et al. 2012; Ziegler and Frisk 2019). Above $\sim 8^\circ\text{C}$, the positive effect of temperature on abundance declined.

Winter Flounder display diverse temperature preferences throughout their range, and respond to shifts in temperature by managing depth, activity level, and burrowing behaviors (Klein-MacPhee 2002). Climate warming is believed to be a significant driver of Winter Flounder population dynamics, with increased temperatures exerting direct effects on early life stages and indirect effects through changes in niche availability (Bell et al. 2022; Langan et al. 2023). We also note the possible amplification of long-term warming in the study location (Oczkowski et al. 2015).

Historical Temperature Observations

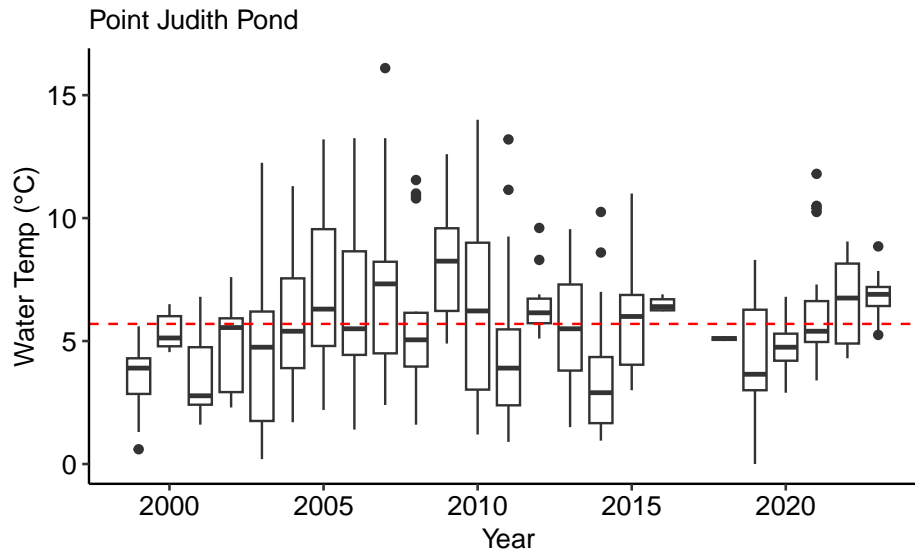


Figure 7: Boxplot of historical water temperature observations in Point Judith Pond. The dashed red line represents the mean water temperature for all years prior to 2020.

References

- Balouskus, R. G., J. M. Lake, K. E. Rodrigue, S. D. Olszewski, and M. C. McManus. 2024. [A coastal lagoon-spawning Winter Flounder subpopulation during ecosystem and fisheries shifts](#). *North American Journal of Fisheries Management* 44(6):1534–1551.
- Bell, R. J., B. Grieve, M. Ribera, J. Manderson, and D. Richardson. 2022. [Climate-induced habitat changes in commercial fish stocks](#). *ICES Journal of Marine Science* 79(8):2247–2264.
- Breiman, L. 2001. [Random Forests](#). *Machine Learning* 45(1):5–32.
- Galligan, B. P., M. C. McManus, and R. G. Balouskus. (n.d.). Drivers of Winter Flounder subpopulation catch rates in a fisheries-independent fixed gear survey. *Transactions of the American Fisheries Society*.
- Grothues, T. M., K. W. Able, and J. H. Pravatiner. 2012. [Winter flounder \(*Pseudopleuronectes americanus* Walbaum\) burial in estuaries: Acoustic telemetry triumph and tribulation](#). *Journal of Experimental Marine Biology and Ecology* 438:125–136.
- Klein-MacPhee, G. 2002. Righteye flounders. Family Pleuronectidae. Pages 560–586 in B. B. Collette and G. Klein-MacPhee, editors. *Bigelow and Schroeder's fishes of the Gulf of Maine*, 3rd edition. Smithsonian Institution, Washington, DC.

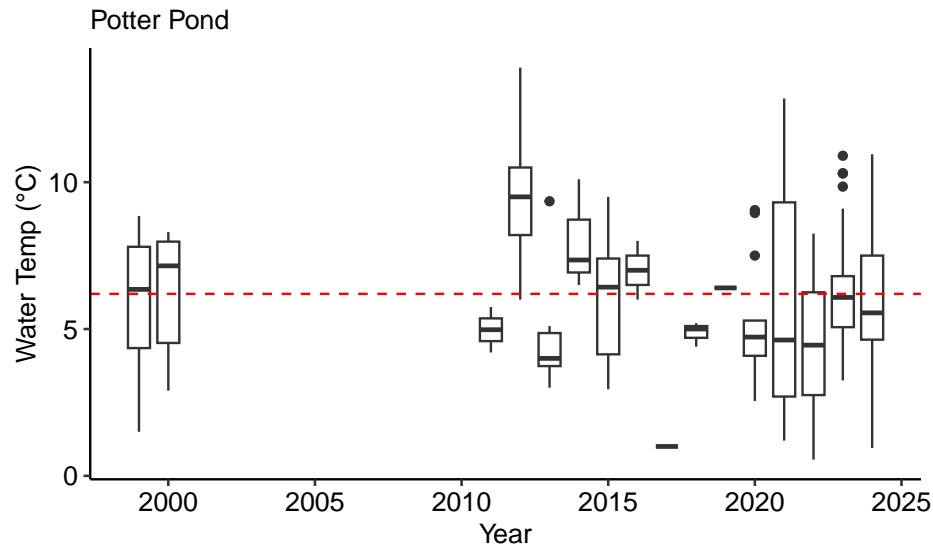


Figure 8: Boxplot of historical water temperature observations in Potter Pond. The dashed red line represents the mean water temperature for all years prior to 2020.

- Langan, J. A., R. J. Bell, and J. S. Collie. 2023. [Taking stock: Is recovery of a depleted population possible in a changing climate?](#) *Fisheries Oceanography* 32(1):15–27.
- Lee, V. 1980. [An elusive compromise: Rhode Island coastal ponds and their people.](#) Rhode Island Sea Grant, RIU-T-80-009, Narragansett, RI.
- Lee, V., and S. Olsen. 1985. [Eutrophication and management initiatives for the control of nutrient inputs to Rhode Island coastal lagoons.](#) *Estuaries* 8(2):191–202.
- Meng, L., C. Gray, B. Taplin, and E. Kupcha. 2000. [Using winter flounder growth rates to assess habitat quality in Rhode Island's coastal lagoons.](#) *Marine Ecology Progress Series* 201:287–299.
- NEFSC. 2022. Southern New England Mid-Atlantic Winter Flounder management track assessment report. NOAA Northeast Fisheries Science Center, Woods Hole, MA.
- Oczkowski, A., R. McKinney, S. Ayvazian, A. Hanson, C. Wigand, and E. Markham. 2015. [Preliminary evidence for the amplification of global warming in shallow, intertidal estuarine waters.](#) *PLOS ONE* 10(10):e0141529.
- Ziegler, C. M., and M. G. Frisk. 2019. [Flatfish utilize sediment blanket to facilitate thermoregulation.](#) *Marine Ecology Progress Series* 609:179–186.

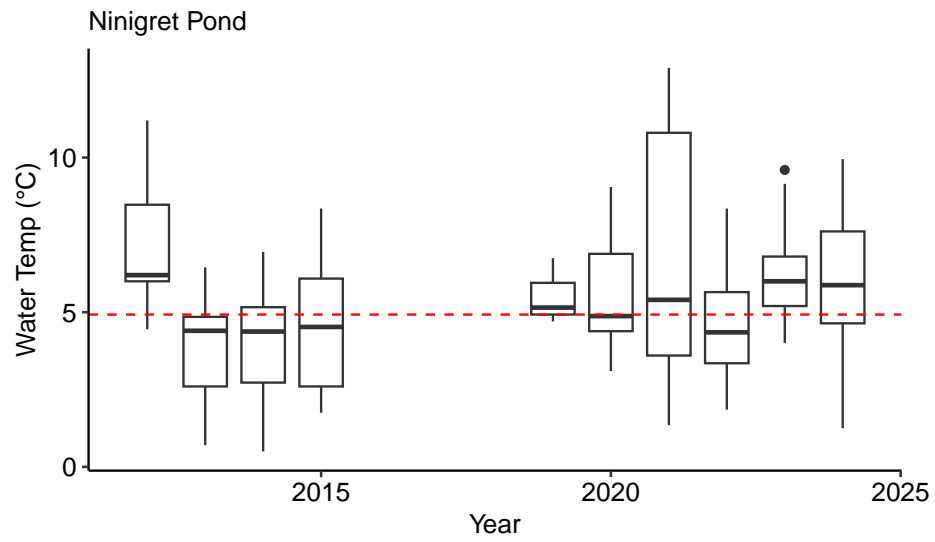


Figure 9: Boxplot of historical water temperature observations in Ninigret Pond. The dashed red line represents the mean water temperature for all years prior to 2020.