Time-scale specific (a)synchrony between Walleye and Yellow Perch dynamics across the Great Lakes

Kaitlyn McKnight[1], Lauren Shoemaker[2], David Fielder[3], Monir Hossain[4], J. Randy Jackson[5], Marten Koops[4], Lars Rudstam[5], Troy Zorn[6], William Fetzer[7]

University of Wyoming

1 – Program in Ecology, University of Wyoming, Laramie, WY. 2 – Department of Botany, University of Wyoming, Laramie, WY.
3 – Alpena Fisheries Research Station, Michigan Department of Natural Resources, Alpena, MI.4 – Fisheries and Oceans Canada, Burlington, ONT.
5 – Department of Natural Resources, Cornell University, Ithaca, NY. 6 – Marquette Fisheries Research Station, Michigan Department of Natural Resources, Marquette, MI.
7 – Department of Zoology and Physiology, University of Wyoming, Laramie, WY.

INTRODUCTION

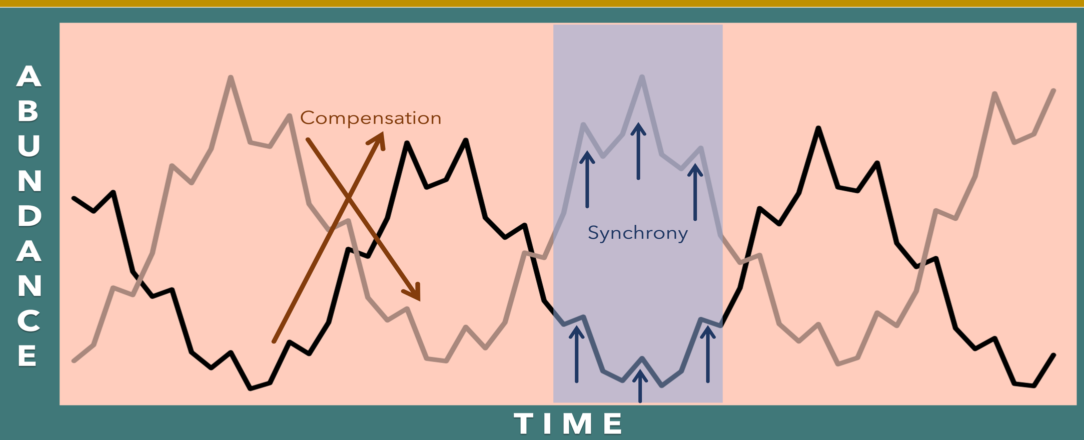

Figure 1. Conceptual figure depicting synchronous (highlighted in blue) and compensatory (highlighted in orange) dynamics through time. Notice how over the long-term these species are compensatory, with offsetting populations, but in the short-term these species are synchronous, and increase and decrease together.

- Synchronous (positively correlated) and compensatory (negatively correlated) dynamics between species are thought to be important factors driving resilience of fisheries productivity.
- The classic variance ratio $\boldsymbol{\varphi} = v_{total} / \boldsymbol{\Sigma}_i v_{ii} = \boldsymbol{\Sigma}_{i,j} v_{ij} / \boldsymbol{\Sigma}_i v_{ii}$ is a well-known metric used to quantify the extent to which population fluctuations of different species impact one another through synchrony ($\varphi > 1$) or through compensation ($\varphi < 1$; Schluter 1984, Zhao et al. 2020).
- Walleye *Sander vitreus* and Yellow Perch *Perca flavescens* support important fisheries across the Great Lakes.
- They are both cool water, moderately eutrophic tolerant species that inhabit similar environments and likely respond similarly to environmental change (Fetzer et al. 2017) .
- Predator-prey interactions between these species will often drive opposite population fluctuations.

Hypothesis

Environmental change → (Long-term) → Synchrony

Species interactions → (Short-term) → Compensation

OBJECTIVES

1. Apply a timescale-specific variance ratio to long-term gill net catch data at four separate sites within the Great Lakes basin.
2. Assess whether synchronous (variance ratio > 1) or compensatory (variance ratio < 1) dynamics are timescale dependent.
3. Develop further hypotheses to test how environmental changes and species interactions drive community dynamics.

METHODS

Data
- Annual gill net survey data coalesced for four sites across the Great Lakes basin ranging from 1959 – 2019.
- Total catch of Walleye and Yellow Perch summed per year.

Analysis
- Graphed log – transformed abundance through time for both species at all four sites (Figures 3-6).
- Calculated classic variance ratios for each site using the *tsvr* software package in R (Zhao et al. 2020, Figure 7).
- Calculated timescale specific variance ratios for each site for short (<4 years) and long (>4 years) timescales using the *tsvr* software package in R (Zhao et al. 2020, Figure 7).

PRELIMINARY RESULTS

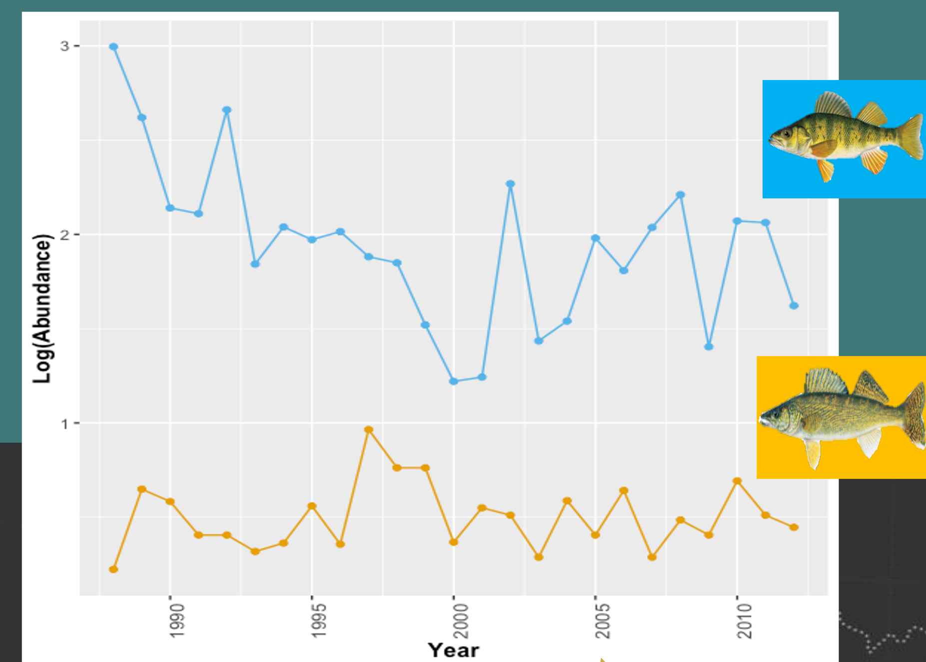

Figure 3. Walleye and Yellow Perch abundance graphed through time to display community dynamics in Bay de Noc over 24 years.

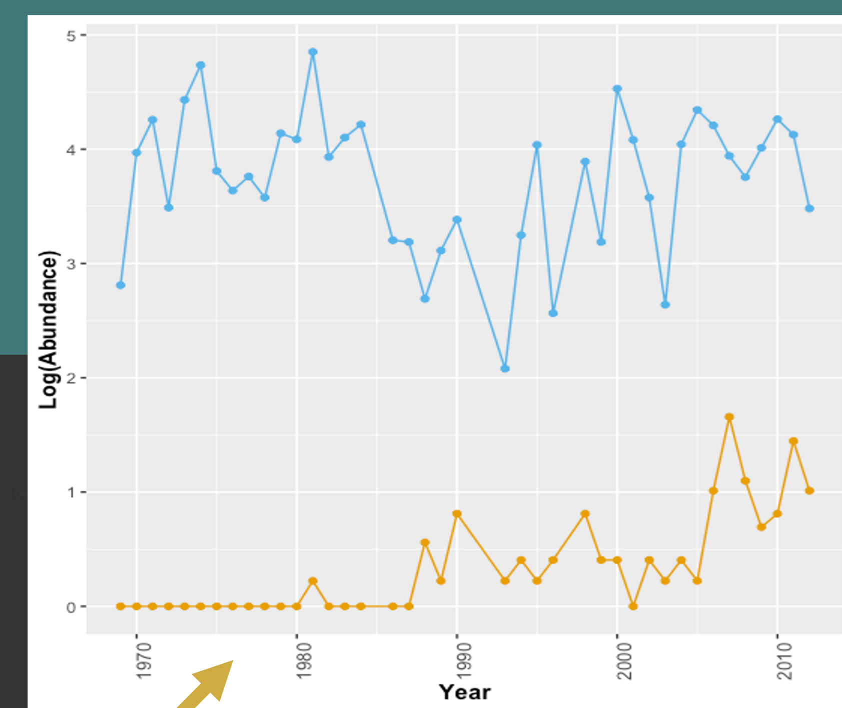

Figure 4. Walleye and Yellow Perch abundance graphed through time to display community dynamics in Les Cheneaux Islands over 43 years.

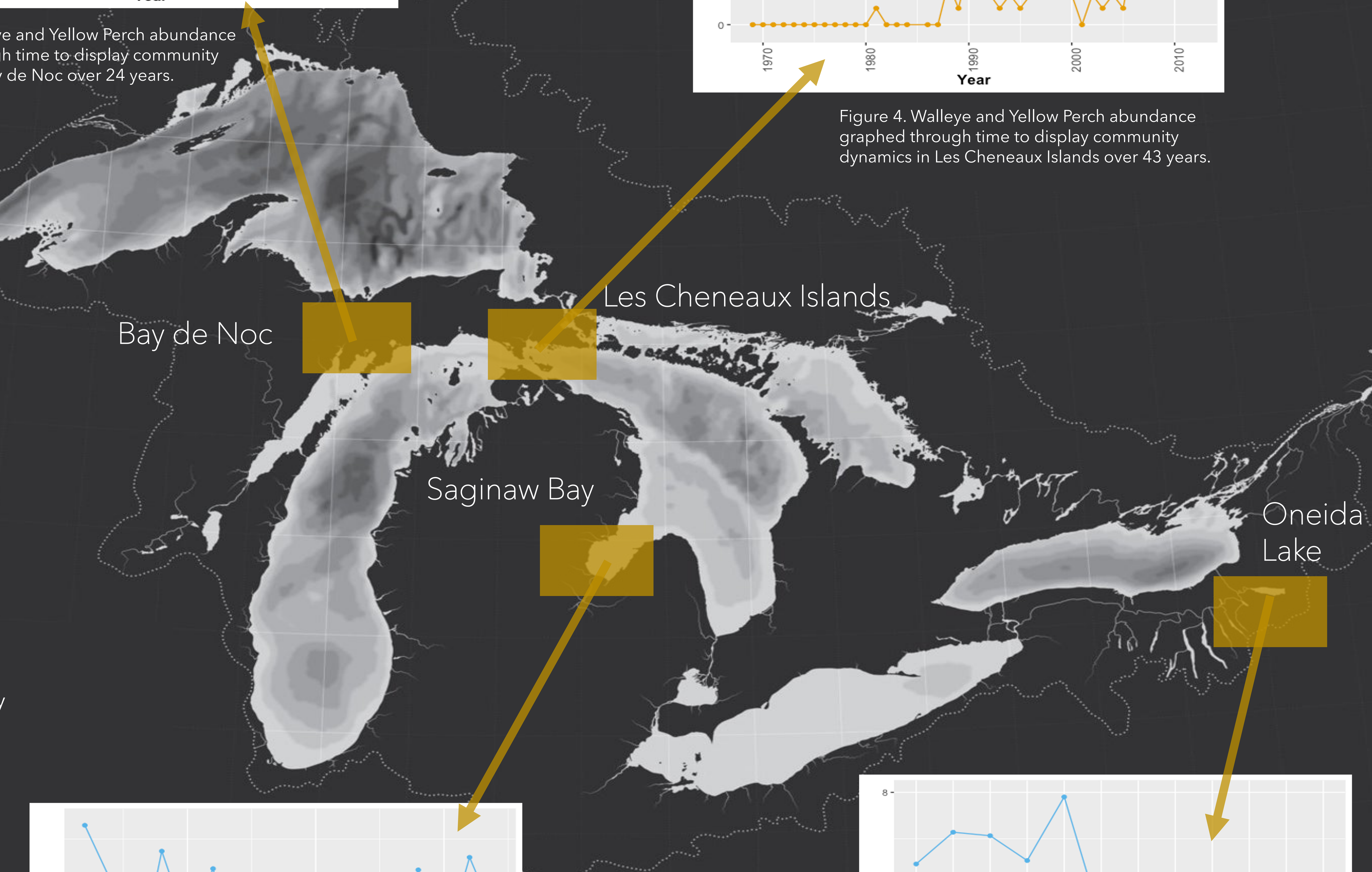

Figure 2. Map of the Great Lakes Basin, highlighting 4 study sites; Bay de Noc (BDN), Les Cheneaux Islands (LCI), Saginaw Bay (SAG), and Oneida Lake.

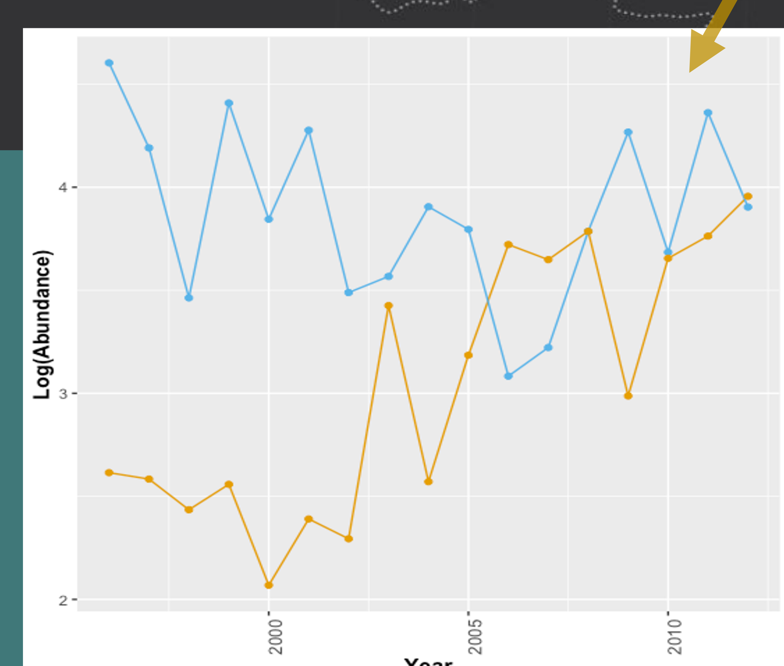

Figure 5. Walleye and Yellow Perch abundance graphed through time to display community dynamics in Saginaw Bay over 16 years.

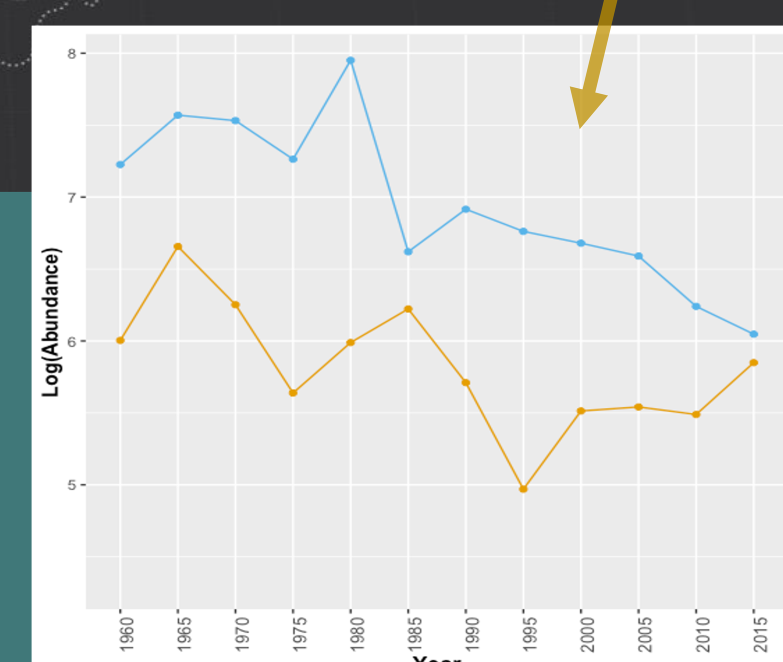

Figure 6. Walleye and Yellow Perch abundance graphed through time to display community dynamics in Oneida Lake over 55 years.

DISCUSSION

- Preliminary results for Oneida Lake support our a prior hypothesis that Walleye and Yellow Perch populations are compensatory in the short term and synchronous in the long term (Figures 6 & 7).
- Results for the other three sites do not support our predictions (Figures 3-5, 7). With several probable explanations for this, one is that these systems are open with close proximity to deeper waters.
- Oneida lake represents a closed population and has experienced dramatic environmental changes. It was extremely eutrophic in the 1950's and now is mesotrophic.
- These ecosystem changes were similarly observed in the larger Great Lakes but not as dramatic. Their overall size and other confounding factors could make them more stable on an interannual basis when compared to Oneida Lake.

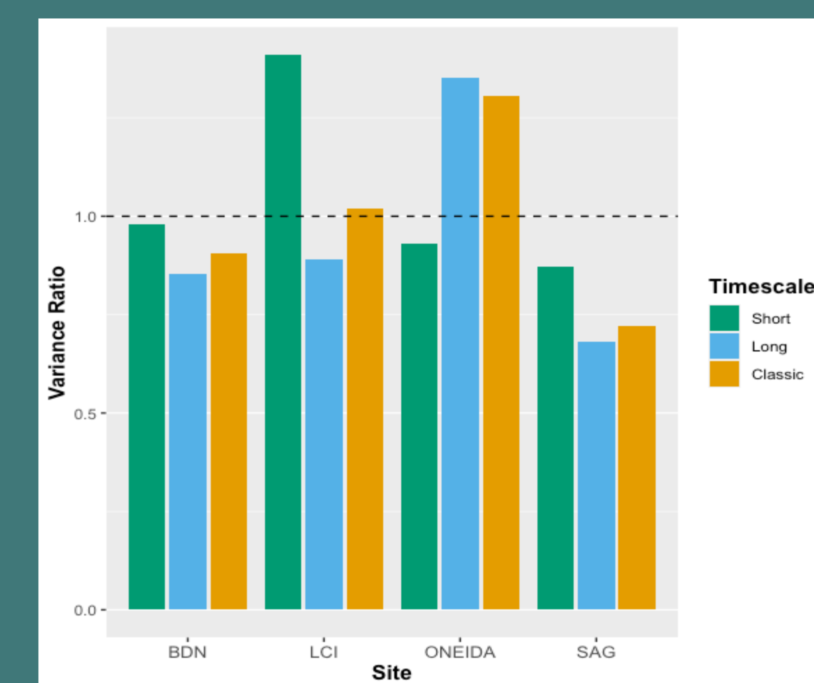

Figure 7. Short, long, and classic variance ratios (VR) calculated for Walleye and Yellow Perch populations across four sites. VRs greater than one (black dashed line) indicate the two species are more synchronous , or fluctuate together, and VRs less than one indicate the two species are more compensatory, or fluctuate opposite.

FUTURE RESEARCH

Big Questions

1. How does short term environmental variation interact with long term environmental change to drive time variant patterns of synchrony and compensation?
2. What role does evenness play in determining the relative importance of synchronous and compensatory dynamics on community stability?

Next Steps

- Incorporate additional sites across the Great Lakes Basin.
- Integrate environmental data, specifically changes in productivity and water clarity, to differentiate the role of abiotic and biotic drivers.
- Expand these methods by including additional species to evaluate the role of (a)synchrony on fish community stability and resilience.
- Utilize spatial scaling to assess synchrony among populations and communities within and across sites.

REFERENCES

Fetzer, W.W., Roth, B.M., Infante, D.M., Clapp, D.F., Claramunt, R.M., Fielder, D.G., Forsyth, D.K., He, J.X., Newcomb, T.J., Riseng, C.M. and Wehrly, K.E., 2017. Spatial and temporal dynamics of nearshore fish communities in Lake Michigan and Lake Huron. *Journal of Great Lakes Research*, *43*(2), pp.319-334.

Schluter, D. 1984. A variance test for detecting species associations, with some example applications. *Ecology* 65, pp.998–1005.

Zhao, L., Wang, S., Hallett, L.M., Rypel, A.L., Sheppard, L.W., Castorani, M.C., Shoemaker, L.G., Cottingham, K.L., Suding, K. and Reuman, D.C., 2020. A new variance ratio metric to detect the timescale of compensatory dynamics. *Ecosphere*, *11*(5), p.e03114.