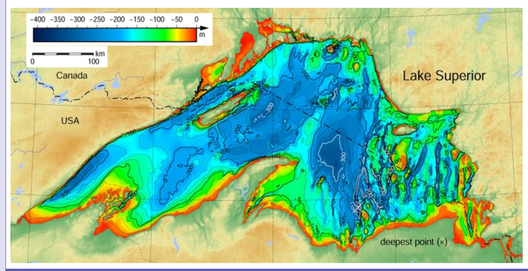
Introduced Salmonine Diet and Trophic Ecology in the Michigan Waters of Lake Superior

B. R. Vasquez[1] and B. S. Gerig[1*]

[1]Dept. of Biology, Northern Michigan University, Marquette, MI; [*]Faculty Advisor

Introduction

- Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*O. kisutch*) were introduced to Lake Superior in the 1960's following the widespread fishery collapse of Lake Trout (*Salvelinus namaycush).*
- Potadromous morphs of Brown Trout (*Salmo trutta*) and Rainbow Trout (*O. mykiss*) have been stocked at varying intensities prior to the Lake Trout's population collapse; Lake Trout have since stabilized.
- Splake (*S. fontinalis* × *S. namaycush*) are currently stocked in Lake Superior above their natural density, and function as an introduced Salmonine from a scientific management perspective.
- All of these Salmonines have become naturalized to the nearshore zone, yet few studies have attempted to determine the ecological niches and dietary overlap between them in the Lake Superior Basin.
- Stable isotopes of carbon and nitrogen provide information on energy source and relative trophic level, which in combination with diet analysis can inform fisheries managers of ecological trends.



Bathymetric relief map of Lake Superior. "Nearshore" is described as ≤ 100 meters. Unlike Lake Trout, introduced Salmonines are not encountered past this depth but instead predominantly cruise the epilimnion. Picture credit: NOAA.

Research Objectives

- Assess the dietary composition of introduced Salmonines in Lake Superior and determine common prey items between species.
- Collect preliminary isotope data on Salmonines occupying the nearshore zone to determine niche overlap.

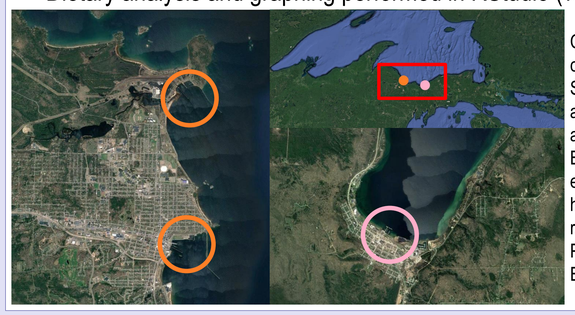
Approach and Methods

Sampling and Processing

- Fish were collected from the Michigan DNR Creel Survey at Upper / Lower Harbor (Marquette, MI) and Munising Harbor (Munising, MI).
- Muscle tissue and stomachs were removed from each sampled fish.
- Stomachs were opened, diet items were then counted and weighed.

Data Analysis

- Dietary analysis and graphing performed in RStudio (v. 3.4.3).



Creel Survey collections on Lake Superior were located at Marquette (orange) and Munising (pink). Both locations are embayments with high rates of recreational fishing. Picture credit: Google Earth Pro.

Results

Table 1. Percent dietary biomass of items found in sampled Salmonine stomachs (n=41 total). ANT = Formicidae, BET = Coleoptera, CIC = Cicadoidea, DIP = Diptera, HYM = Hymenoptera, LEP = Lepidoptera, MAY = Ephemeroptera, MYS = *Mysis*, NSS = Ninespine Stickleback, RAS = Rainbow Smelt, SSC = Slimy Sculpin, TSS = Threespine Stickleback, UFR = Unidentified fish remains, UTI = Unidentified terrestrial insect. Shading indicates higher percent dietary biomass for a given Salmonine.

Salmonine	ANT	BET	CIC	DIP	HYM	LEP	MAY	MYS	NSS	RAS	SSC	TSS	UFR	UTI
Brown Trout (BNT)	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.21	0.00	0.12	0.62	0.00	0.00
Chinook Salmon (CHS)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Coho Salmon (COS)	0.09	0.23	0.07	0.16	0.20	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.24
Lake Trout (LAT)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.77	0.00	0.04	0.01	0.00
Rainbow Trout (RBT)	0.04	0.08	0.00	0.34	0.06	0.00	0.01	0.00	0.00	0.00	0.00	0.35	0.00	0.13
Splake (SPL)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00

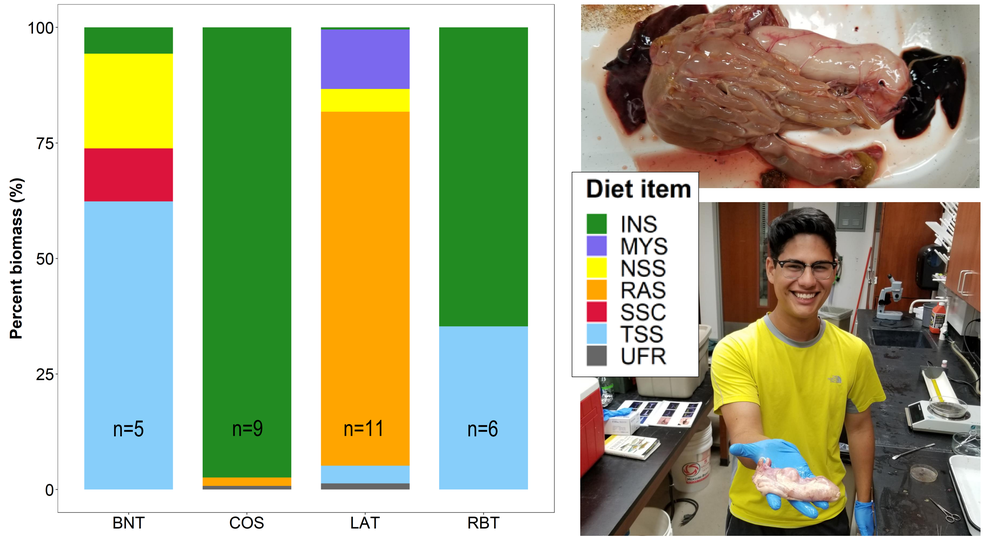
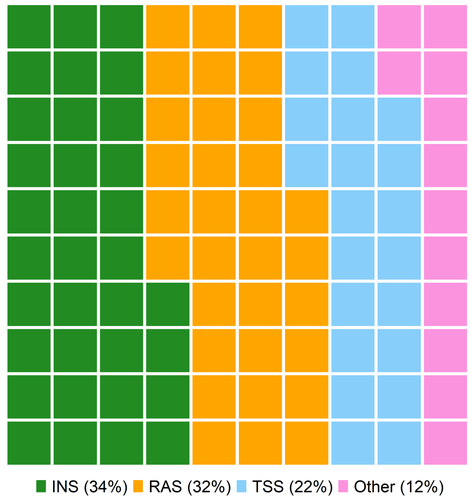


Figure 1. Stacked frequency plot depicting percent dietary biomass of prey items between Salmonines in Lake Superior. Introduced Salmonines integrated more terrestrial insects (INS) and TSS in their diets than LAT, which represents a greater amount of time spent in the epilimnion. CHS and SPL are excluded from this graph due to respective low sample size.



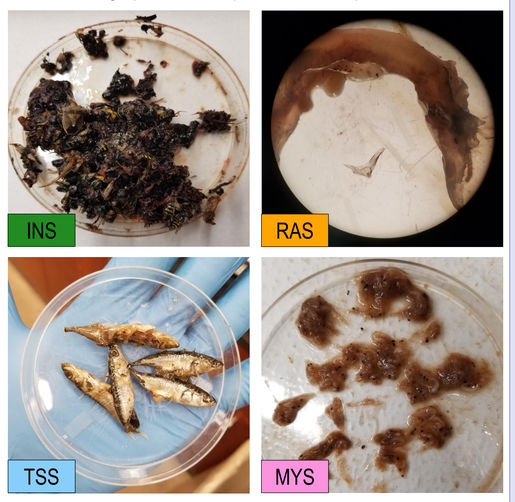


Figure 2. Waffle plot of common diet items in percent biomass for all sampled Salmonines (n=31). Both INS and TSS comprised a majority of introduced Salmonine diet. TSS are an invasive species infrequently found in LAT diets in Lake Superior; however, Salmonines present in the nearshore zone may utilize this resource to a greater extent than previously documented.

Discussion

- Preliminary results support strong reliance on the nearshore zone and epilimnion for introduced Salmonines through high biomass of terrestrial insect and Threespine Stickleback consumption.
- The integration of Threespine Stickleback as a major diet item in Lake Superior has yet to be documented in literature.
- The lack of Splake collected reflects poor catch rates in Munising, however collections for this fish will occur with the Michigan DNR.
- Continuing in the fall, this study will aim to collect more Salmonines as they return in greater abundance to nearshore areas.
- With dietary data, stable isotopes will provide initial data on Brown Trout and Splake niche overlap with Lake Superior Salmonines.

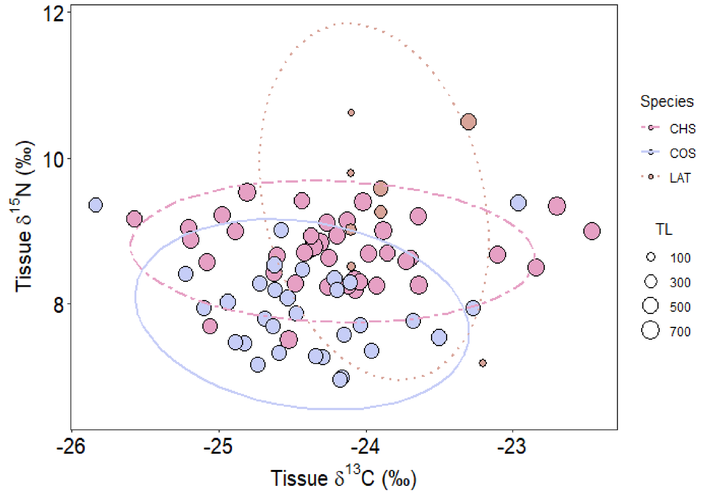


Figure 3. Ellipse plot depicting niche overlap of CHS, COS and LAT in Lake Superior. Data point size represents individual total length (mm). LAT exhibit a variable $\delta^{15}N$ signature, reflecting different feeding ecology throughout ontogeny. CHS and COS have broad but similar $\delta^{13}C$ signatures reflecting similar resource use in Lake Superior. We expect RBT, BNT and SPL to exhibit different $\delta^{13}C$ and $\delta^{15}N$ than the Salmonines depicted above. Data above from the Michigan DNR and USGS samples taken near Marquette, MI.

Future Directions

- Evaluate the integration of nonnative Threespine Stickleback in Salmonine diets through isotopic mixed modeling.
- Contrast isotopes of introduced Salmonines with that of adfluvial Brook Trout (*S. fontinalis*) to determine the extent of niche overlap.

Implications

- This research addresses environmental stewardship of the Great Lakes by informing management practices related to introduced and native Salmonines present in Lake Superior.

Acknowledgements

- Michigan Sea Grant for providing me the opportunity to work on this project.
- S. Sitar, T. Zorn and D. Traynor who consistently lent me their time and knowledge.
- Special thanks to J. Stutesman and R. Papke of the Michigan DNR Creel Survey; without their support, this type of project would not be possible.