LIVING LARGE IN MOUNTAIN LAKES: WHAT WE KNOW ABOUT LAKE TROUT IN THE LAKE TAHOE WATERSHED

Dr. Sudeep Chandra, Brant Allen, and Dr. Jenni McDermid



Aquatic Ecosystems Analysis Laboratory **University of Nevada, Reno**





Special thanks to

Almo Cordine CDFG Retired

Brian Shuter Ontario Ministry of Natural Resources

Tahoe Baikal Institute participants 1998, 2005

Dr. Zeb Hogan and Jason Barnes University of Nevada, Reno AEAL

Today's discussion

Lake trout historical range distribution, traits and introduction into the Tahoe basin

Examination of life history traits from lakes within the Tahoe area

Catch comparison and trout reliance on pelagic production







Lake trout distribution and traits

- Cold water fish species (8-12°C)
- Slow growing, large bodied (~70cm)
- Late maturing (4-14 years, mean 8)
- Long lived (20-70 years)
- Recreational and commercial fishing



Native distribution of lake trout



Scott and Crossman 1973

Introduction into the Tahoe region

- Lake Tahoe
 - 1885 egg shipments (2nd one) arrive in good condition from Lakes Huron and Michigan
 - Spring 1896- 59,000 fry deposited in the tributaries of Carson, Walker Humboldt Rivers, and the tributaries of Lake Tahoe
 - 1888- Lakes Huron and Michigan eggs reared in Nevada
 - Spring 1889- fry placed in and around Tahoe
 - 1894- eggs collected from Lakes Michigan, Huron, and Superior, most came from 1st two lakes
 - May 1895- 65,000 fry planted in Lake Tahoe (35,000 Tahoe City, and 30,000 at Tallac)
 - 1896- 50,000 eyed Lake Superior trout received in Nevada and 48,000 fry planted in Lake Tahoe
 - 1907, 1908- Lakes Huron, Michigan, and Superior mixture of 3,500 and 8,745 fry planted into Tahoe from eggs shipped in 1906 and 1907

(Raveneal 1896, 1898, Mills 1897, Shelby 1917, Cordone 2011)

Introduction into the Tahoe region

- Other lakes of the Truckee Basin
 - Precise details lacking
 - 152,500 lake trout were likley responsible for the establishment of lake trout populations in the Stony Ridge, Donner, and Fallen Leaf Lakes
 - 6lb mackinaw caught in 1920 from Stony Ridge Lake by a Homewood homeowner
- Naturalized in 5 lakes
 - Stony Ridge, Gilmore, Fallen Leaf, Tahoe, and Donner
- In general major stockings ceased after the 1908 Nevada plantings into Lake Tahoe, a few plants by CDFG into Donner and Fallen Leaf Lakes, some into Tahoe in 1980 and 1986.

(Raveneal 1896, 1898, Mills 1897, Shelby 1917, Cordone 2011)



Lake trout exhibit a high level of life history variation across their native range.



Considerable variation occurs within smaller regions

- There is also considerable variation within a region.
- Small bodied and large bodied ecotypes.
- Genetically-based variation in developmental rate, growth, age and size at maturity.
- Phenotypic plasticity in maximum size.





Life history traits



Life history traits



Life history traits

 Egg number (mean =5065 <u>+</u> 1780 eggs/kg) did not differ between populations (p=0.08).





- Procrustes superimpositioning
- MANOVA
- Canonical discriminant analysis (CDA)
- Multivariate regression

MANOVA results:

<u>Variable</u>	<u>Pilla</u>	ai's trace	<u>e</u> <u>df</u>	<u> </u>		
Population	0.8	96	46,224	3.952	<0.0001	
Sex	0.191	23,1	11 1.	141 0.3	31	
Maturity	-	-				
Population*	sex	0.609	69,339	9 1.2	250 0.10	
Population*	maturity	0.327	46,224	4 0.9	952 0.57	
Sex*maturit	У	0.168	23,111	0.9	977 0.50	





Multivariate regression of landmarks on centroid size revealed that shape variation was not related to fish size ($r^2=0.005$, p=0.34).



- Included digital images of Lake Superior lake trout as an outgroup.
- Three recognized morphs of lake trout in Lake Superior: leans, humpers, and siscowets (Moore and Bronte 2001).





Compiled historical catch information from the various lakes using similar gillnetting techniques EXCEPT from Stony ridge and Gilmore lakes where smaller nets were utilized



Lake trout mean size (in) varies by ecosystem but not by ecosystem size





Comparison of lake trout data by lake

Lake	Year	No. gill net sets	Depth range of sets (m)	Months set	Range of hours	Lake Trout CPUE (No/hr)	Mean Lake Trout Total Length (cm)	SE, Sample size
Emerald Bay	2011	121	5 to 60	May-Oct	2 to 42	0.06	23.78	0.6, 66
Donner	2004	8	5 to 32	May, July	12	0.46	15.51	0.2, 31
Fallen Leaf Stony Ridge	2004	15	3 to 100	May-Sept	11 to 20	0.56	15.3	0.1, 194
Lake	2004 1988-	2	2 to 35	July	7 to 11.5	0.93	11.17	.4, 53
Lake Tahoe	1992	?	40 to 120	Jan-Dec	12 to 15	1.1	20.8	0.8
Gilmore Lake	2004	2	5 to 40	July	8 to 12	2.58	13.3	1.3, 50

Reliance on pelagic derived resources is mixed even in lakes with mysid shrimp



Future directions

- Compile other characteristics from lake trout populations in their native range and compare them to the plasticity of life history characteristics to the Western US populations
- Are the upper elevation lakes (Stony Ridge and Gilmore) good source populations for recovery in the Laurentian Great Lakes?
- Relate food web structure and diversity of the lakes to lake trout populations structure and energy flow
- Initiate a tagging program in Emerald Bay to determine the amount of movement and migration, compare this with the smaller watersheds in the basin

Genetics

Methods

- Mitochodrial DNA (mtDNA) haplotypes identified using *Bam* HI restriction enzyme.
 - Confirm ancestry and source
- Microsatellite DNA for 11 loci
 - Neutral divergence among populations
 - » Allelic richness
 - » Heterozygosity
 - » F_{ST}
 - Relationships among populations





Genetics - mtDNA

Results

- mtDNA haplotype distribution
- Mixture of haplotypes A, B, and C which is consistent with a Great Lakes source.
- The frequencies point to Lake Michigan as the most likely source (Grewe and Hebert 1988).
- Frequencies from Fallen Leaf are more consistent with a Lake Superior source (Grewe and Hebert 1988).
 - Founder effect??



Genetics – microsatellite

Results

Neutral divergence among populations

V. B. La

<u>Pop' n</u>	<u>Allelic Richness</u>	<u>Heterozygosity</u>
Tahoe	4.55 <u>+</u> 3.27	0.459 <u>+</u> 0.022
Fallen Leaf	4.18 <u>+</u> 3.54	0.435 <u>+</u> 0.026
Stony Ridge	3.64 <u>+</u> 2.77	0.381 <u>+</u> 0.021
Gilmore	4.36 <u>+</u> 3.61	0.409 <u>+</u> 0.022

Genetics – microsatellite

Results

Neutral divergence among populations



Results

Genetics – microsatellite

- Relationships among populations
 - Neighbor-joining tree
 - Nei's standard genetic distance
 - 1000 bootstraps

