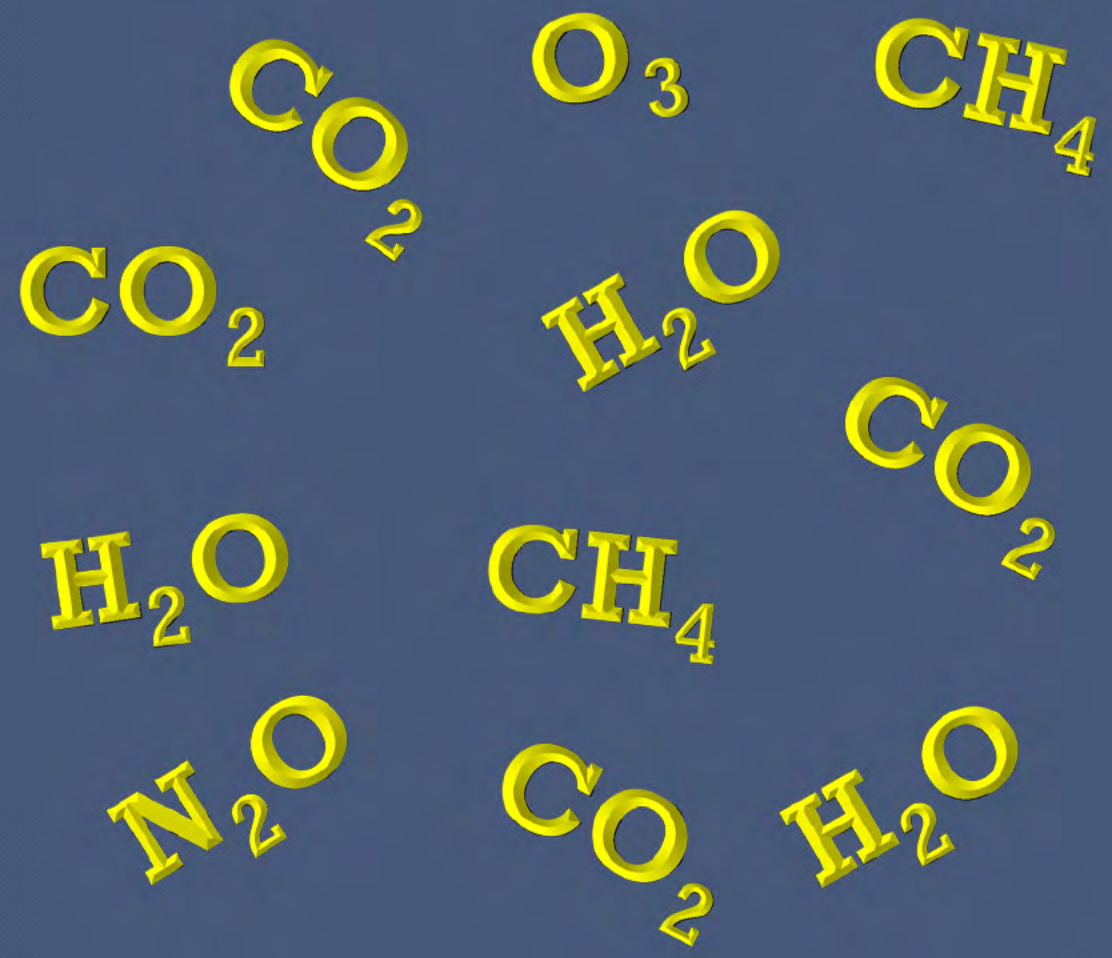
Modeling Select Cold, Cool and Warm Water Fish on Lake Ontario

Barbara J. McKay Archibald
MGIS Student
Pennsylvania State University

Introduction: Climate Change and Species

- climate change
  - carbon dioxide (CO_2) and other green house gasses[1]
  - 0.74° C last 100 years[1]
  - projected 1.1° – 6.5° C by 2100[2]



Species Impact

- species
  - observed: changes in range, frequency, and phenology of species[1]
  - projected: mid-century eastern Amazonia may see replacement of tropical forest with savanna[3]

Species Impact

fish:

- fish are among the impacted species
- trend: warm water fish increase in warm periods, cool and cold water fish increase in cold periods[4]

GAP Process

Land cover and species layers

↓

Model potential habitat distribution and biodiversity

↓

Protected lands

↓

Gaps in protection

Aquatic GAP Process

Multiple habitat and species layers

↓

Model potential habitat distribution and biodiversity

↓

Protected Water

↓

Gaps in protection

Objective

- model impact of climate change on freshwater fish of Lake Ontario
  - use C-GAP techniques[5]
  - expanding the variables[6]
  - model population size and range of three species of fish[7]

Project Details

- fish
  - lake trout – cold water
  - yellow perch – cool water
  - smallmouth bass – warm water[8]

Summary of Fish Models

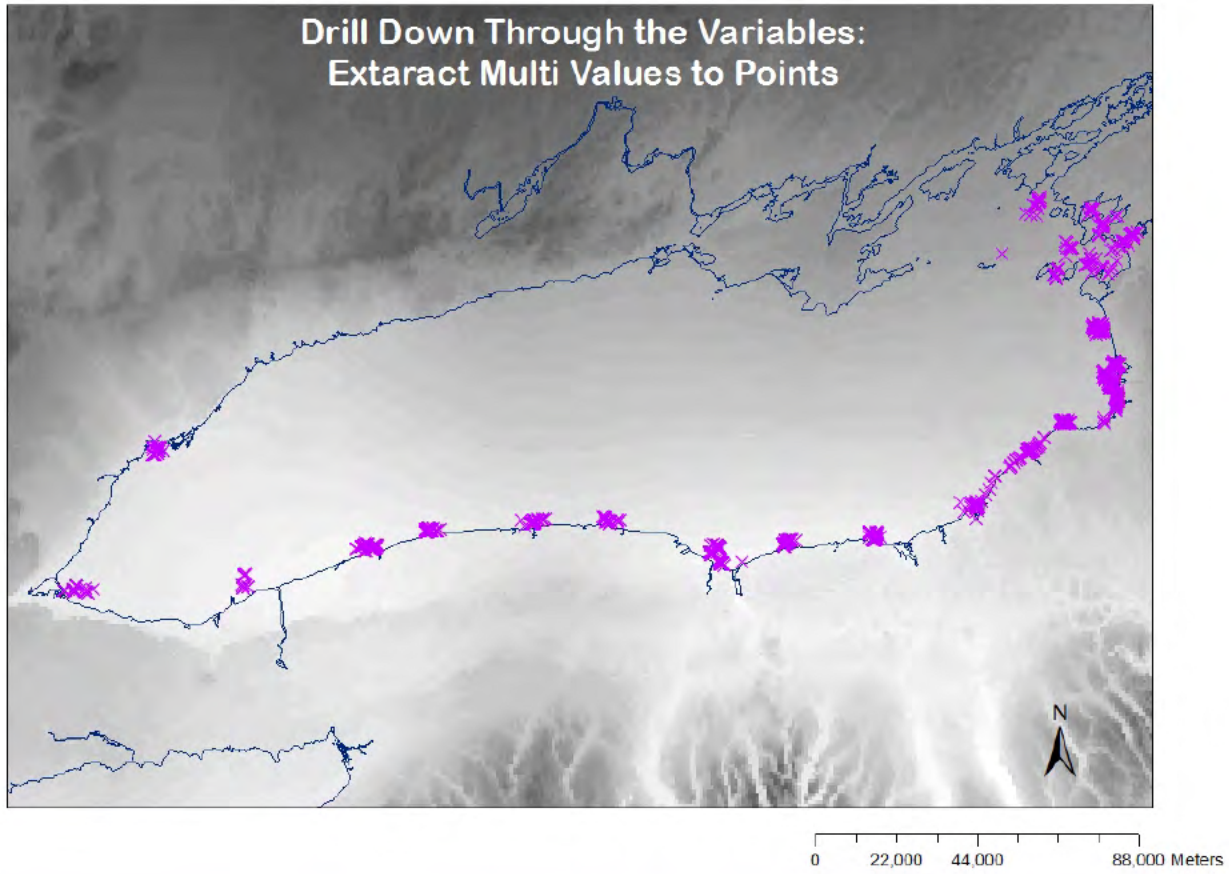
Time	Model	Habitat[9]	Climate	Habitat[9] and Climate
Current		$A_{l, y, s}$	$E_{l, y, s}$	$I_{l, y, s}$
2020		$B_{l, y, s}$	$F_{l, y, s}$	$J_{l, y, s}$
2050		$C_{l, y, s}$	$G_{l, y, s}$	$K_{l, y, s}$
2080		$D_{l, y, s}$	$H_{l, y, s}$	$M_{l, y, s}$

Data and Tools

Data Set	Resolution	Format
Coastal-GAP spatial unit layers	90 m x 90 m	Raster
USGS standardized fish survey data		Excel
USGS and USFWS Habitat variable data set	90 m x 90 m	Raster
Climate variables (Canadian Centre for Climate Modelling and Analysis model CGCM3.1/T63 SRES A1B)	1 km x 1 km	Raster

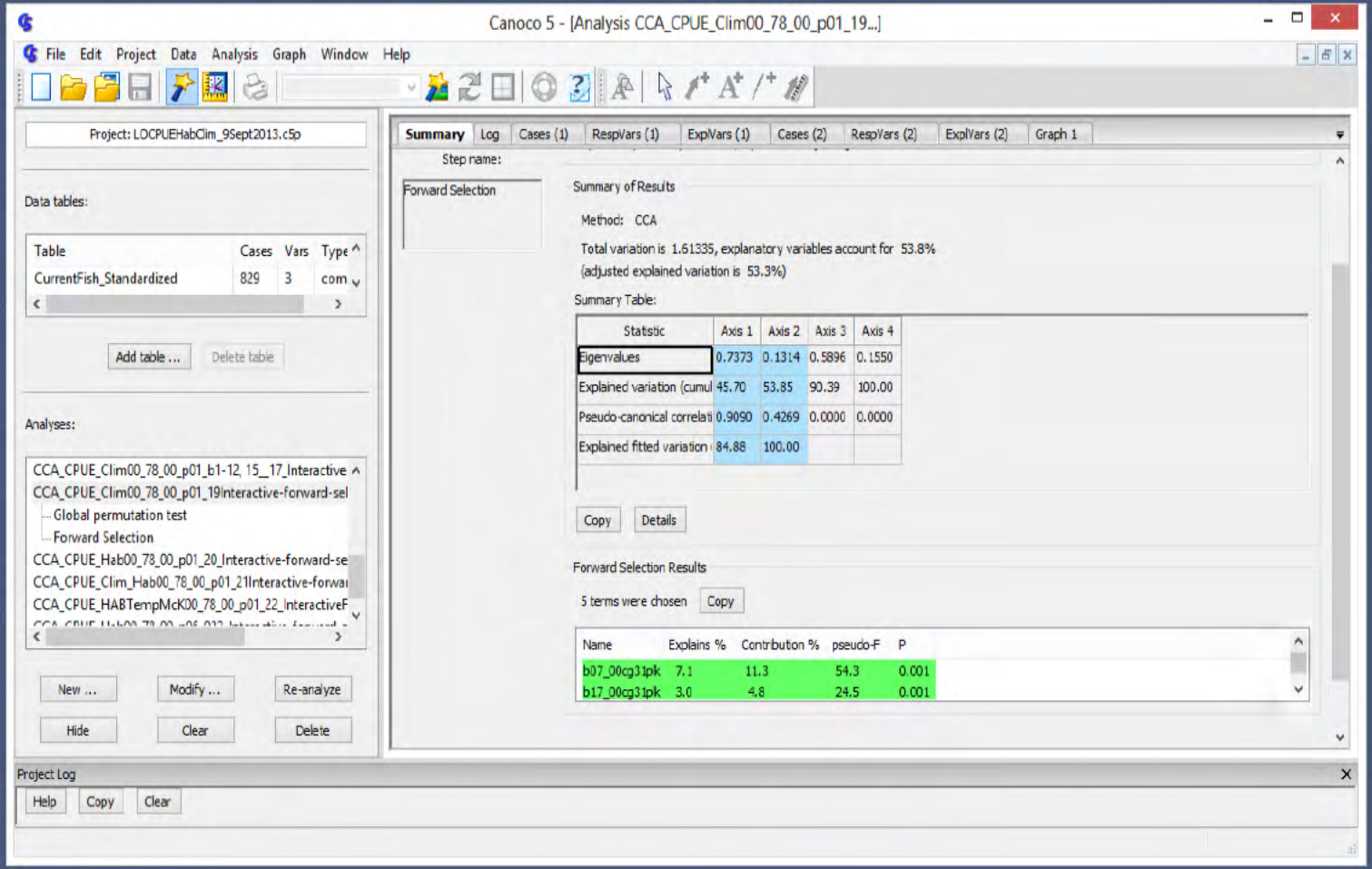
Method

- ArcMap
  - Spatial Analyst… Extract Multi Values to Points



Method

- extract attribute table values to Excel
- perform canonical correspondence analysis (CCA)
  - Identify most influential[10]



Method

- CCA: multivariate statistical method

LakeOntario_HabClimVariableList - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW ADD-INS

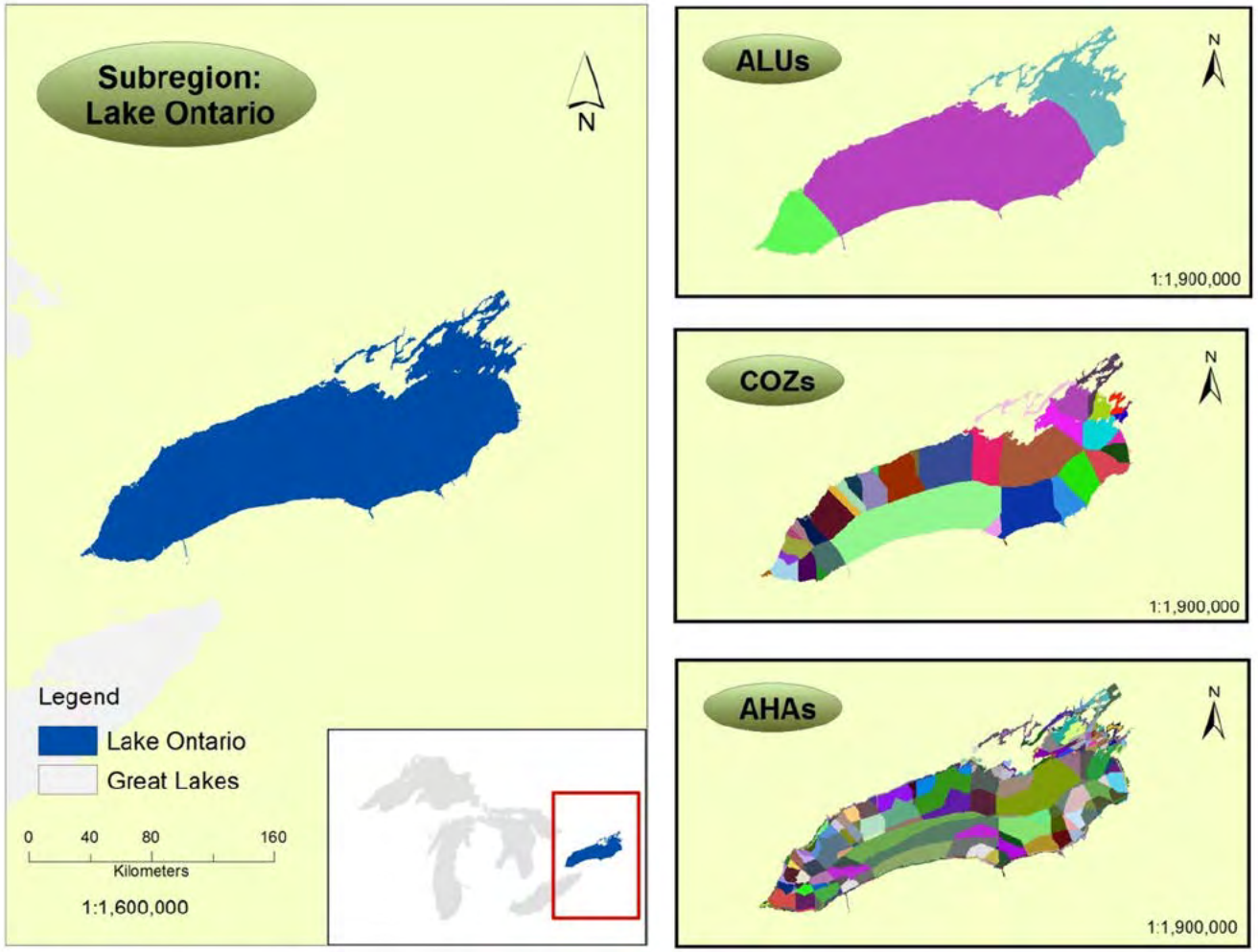
Keith and Barbara A

A1 Run

	A	B	D	E	F	G	H	J	K	L	R	S	T	V	X	AA	AC	AD	AF	AH	AJ
1	Run	Habitat	Climate	Expl Var acct %	Adj. Expl var %	# Var	b19 Ppt Coldest Quarter	b17 ppt Driest Quarter	b16 Ppt Wettest Quarter	b15 Ppt Seasonality (Coeficient of Variation)	b09 Mean T Driest Quarter	b08 Mean T Wettest Quarter	b07 T annual Rng (B5 - b6)	b05 Max T Warmest Month	b03 Isothermality [(B2/b7)100]	Bath	Slope	Fetch	Sinuosity	RivDir	RivDens
2	p=0.01																				
3	CCA_CPUE_HABTempMcK00_78_00_p01_22_InteractiveFS	x		83.6	82.7	[illegible]										x	x	x	x	x	x
4	CCA_CPUE_Hab00_78_00_p01_20_Interactive-forward-selection-2	x		69.3	68.6	10										x	x		x	x	x
5	CCA_CPUE_Clim_Hab00_78_00_p01_14Interactive-forward-selection	x	x	76.1	75.2	16				x	x	x		x	x	x	x	x	x		x
6	CCA_CPUE_Clim00_78_00_p01_19Interactive-forward-selection		x	53.8	53.3	5	x	x	x			x	x								
7																					

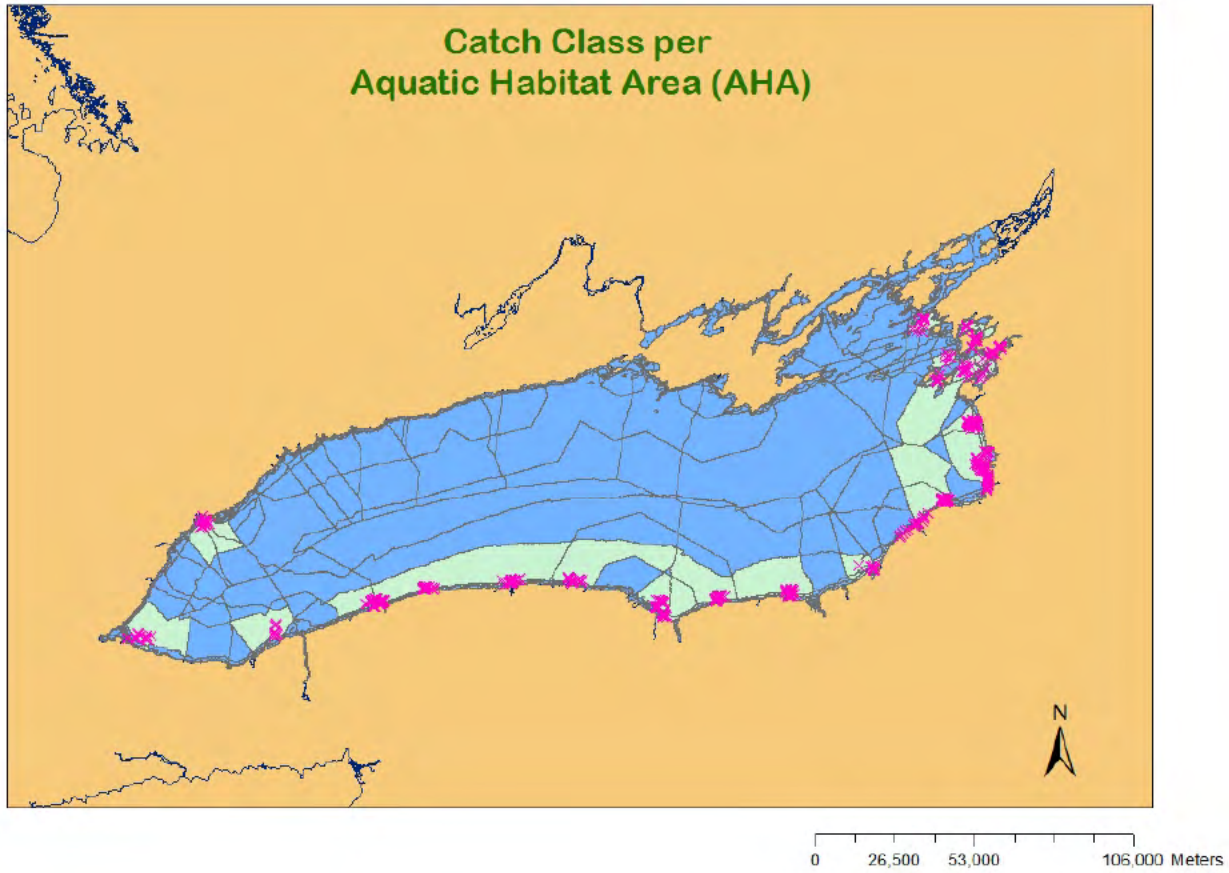
Method

- ArcMap
  - spatial join catch data to Aquatic Habitat Area (smallest unit of the C-GAP Framework)[11]



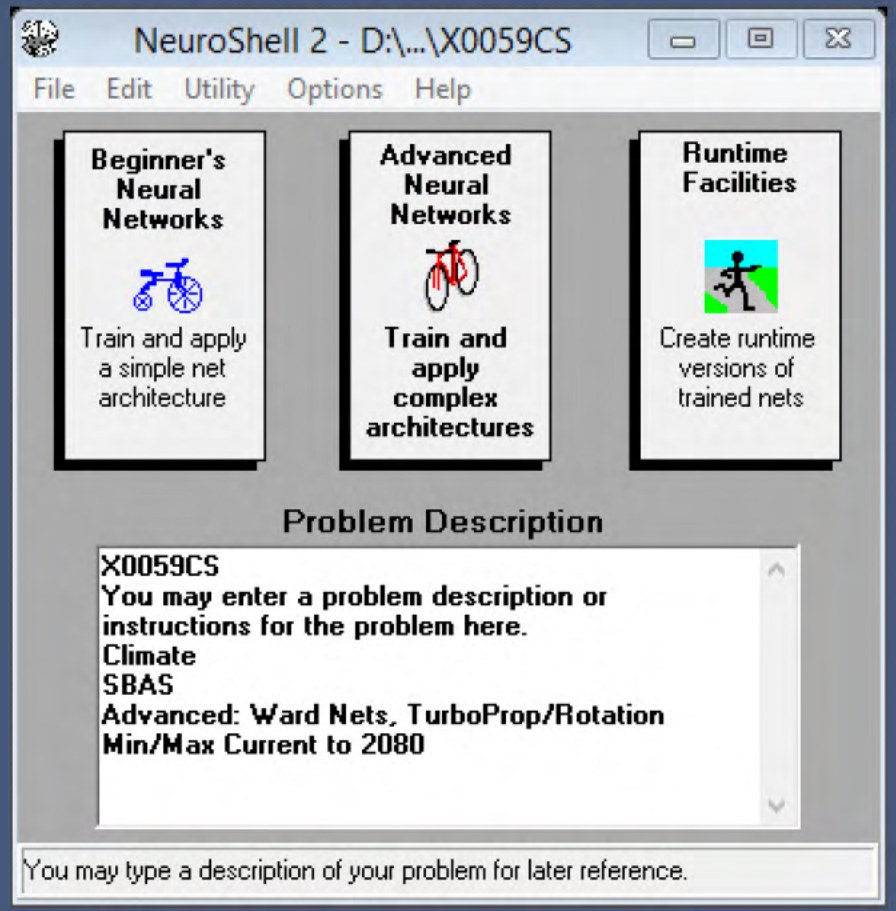
Method

- ArcMap
  - calculate average catch per AHA
  - classify on log Scale (0,1,10, 100,…)



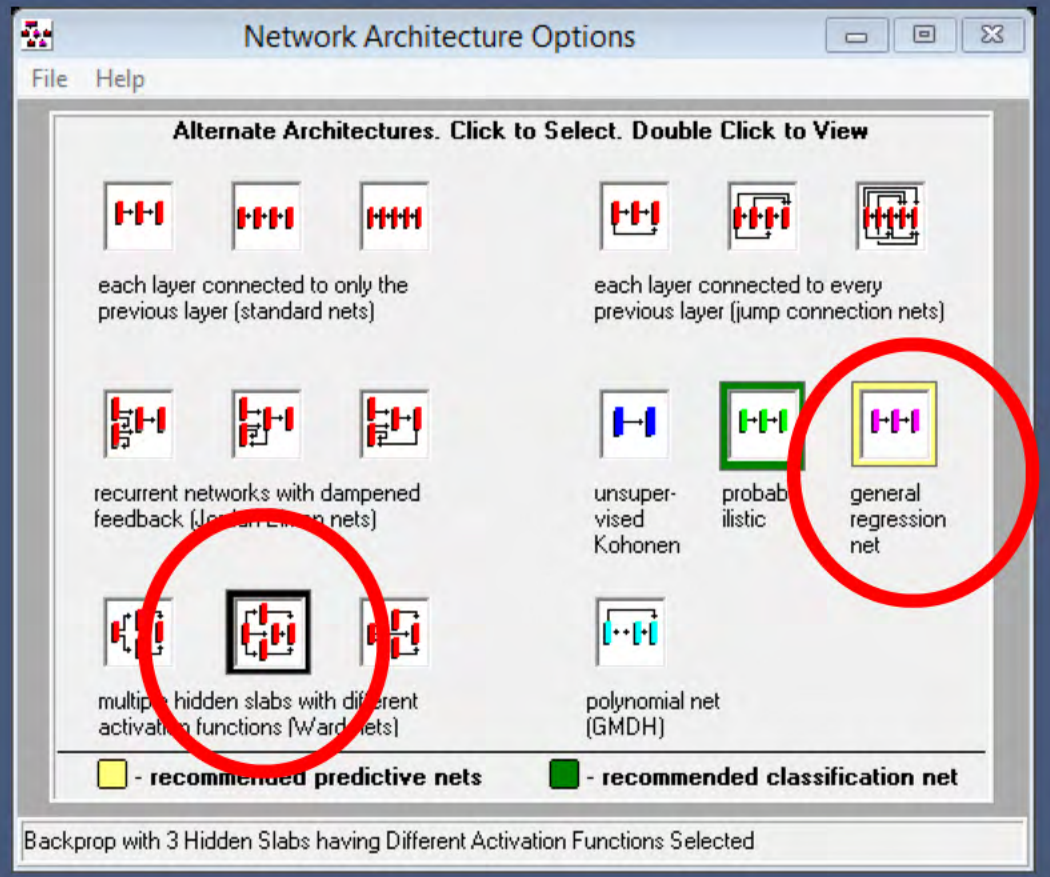
Method

- create Excel table of classified fish counts, habitat and climate values
- perform neural network analysis (NNA) create models



Method

- NNA
  - combination of simpler statistical elements to describe the relationship between multiple layers[12]
- three variation
  - 2 Ward Nets
  - 1 General Regression Net (GRNN)[13]



Method

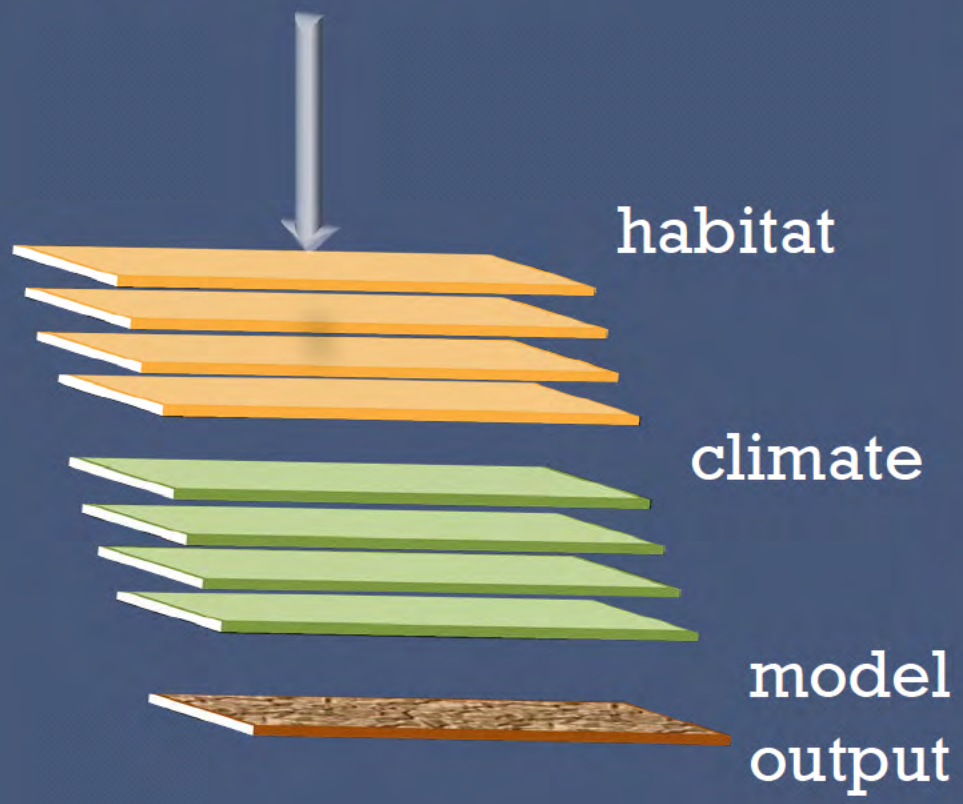
- evaluate NNA
  - R-square
  - whole catch dataset
  - subset omitted from the NNA[14]
  - pick the "best" model

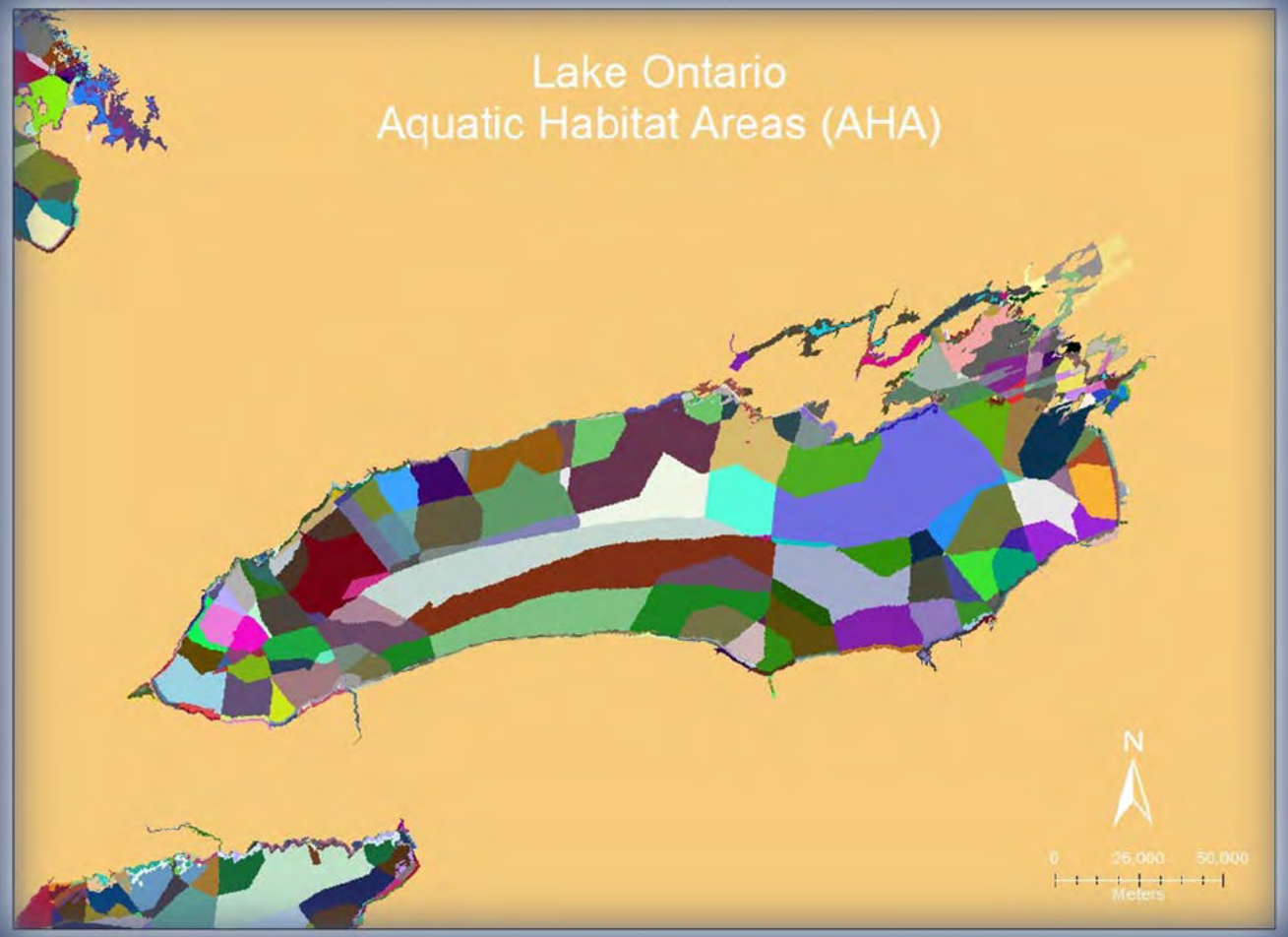
.pat		Climate			
		3 Spp.	LTRT	PRCH	SBAS
Ward'sNet					
TurboProp/		X0050C3	X0053CL	X0056CP	X0059CS
Rotation	L	0.7393	0.7659		
	P	0.398		0.7142	
	S	0.8613			0.9296
Moment		X0051C3	X0054CL	X0057CP	X0060CS
um	L	0.8183	0.7508		
/Random	P	0.8231		0.777	
	S	0.9631			0.9657
GRNN					
Vanilla/		X0052C3	X0055CL	X0058CP	X0061CS
Genetic/	L	0.8711	0.8598		
ErCond	P	0.8559		0.8418	
	S	0.9631			0.9002

.pro		Climate			
Ward'sNet					
		3 Spp.	LTRT	PRCH	SBAS
TurboProp/		X0050C3	X0053CL	X0056CP	X0059CS
Rotation	L	0.6927	0.7821		
	P	0.3798		0.6273	
	S	0.8715			0.8797
Moment		X0051C3	X0054CL	X0057CP	X0060CS
um	L	0.7727	0.8152		
/Random	P	0.7747		0.7996	
	S	-0.3777			-0.8546
GRNN					
Vanilla/		X0052C3	X0055CL	X0058CL	X0061CS
Genetic/	L	0.9193	0.7844		
ErCond	P	0.7592		0.771	
	S	0.9992			0.7102

Method

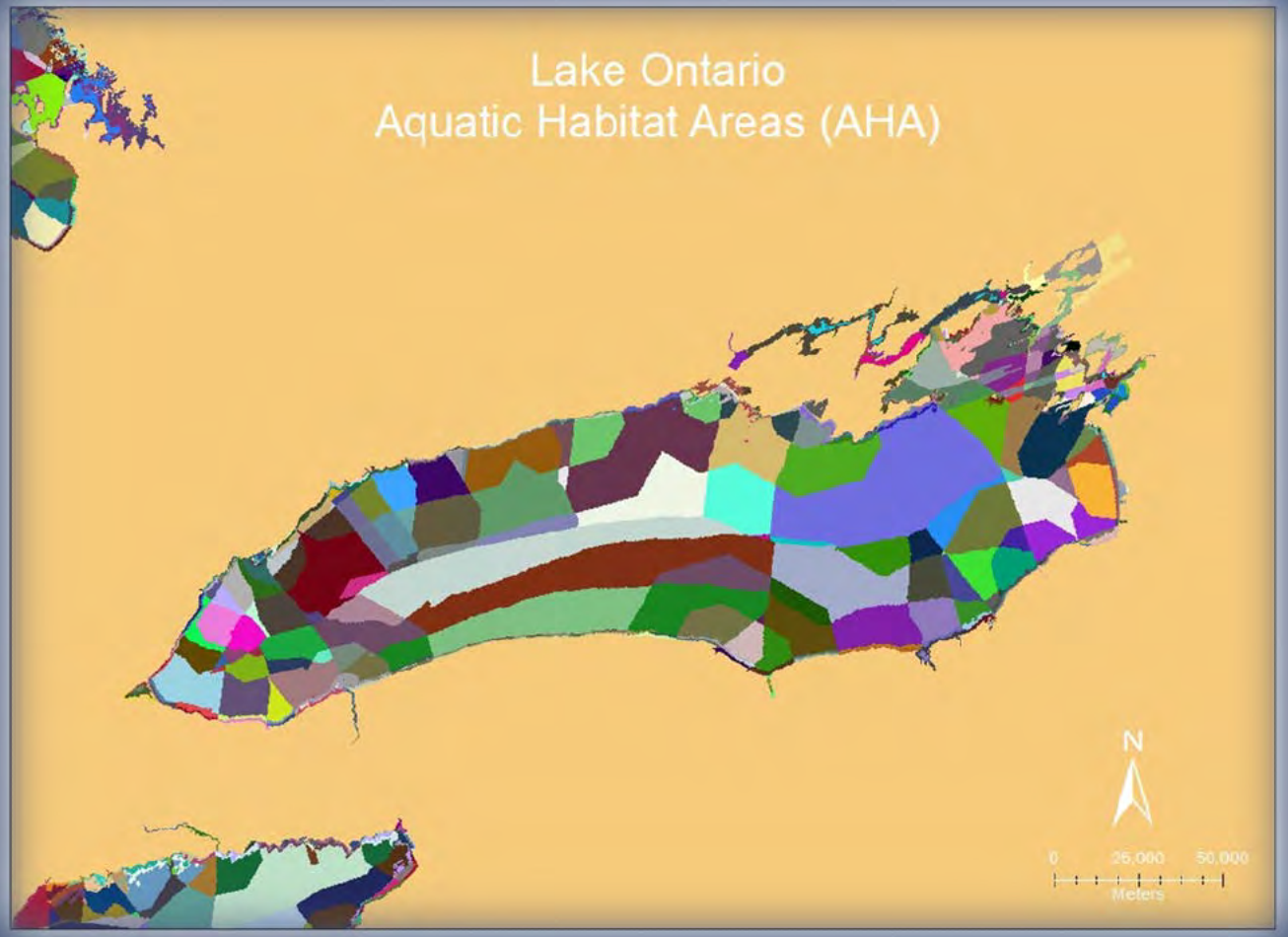
- apply models





Method

- reclassify on spatial cell level
  - log scale
- build Fisheries Conservation and Management Unit



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