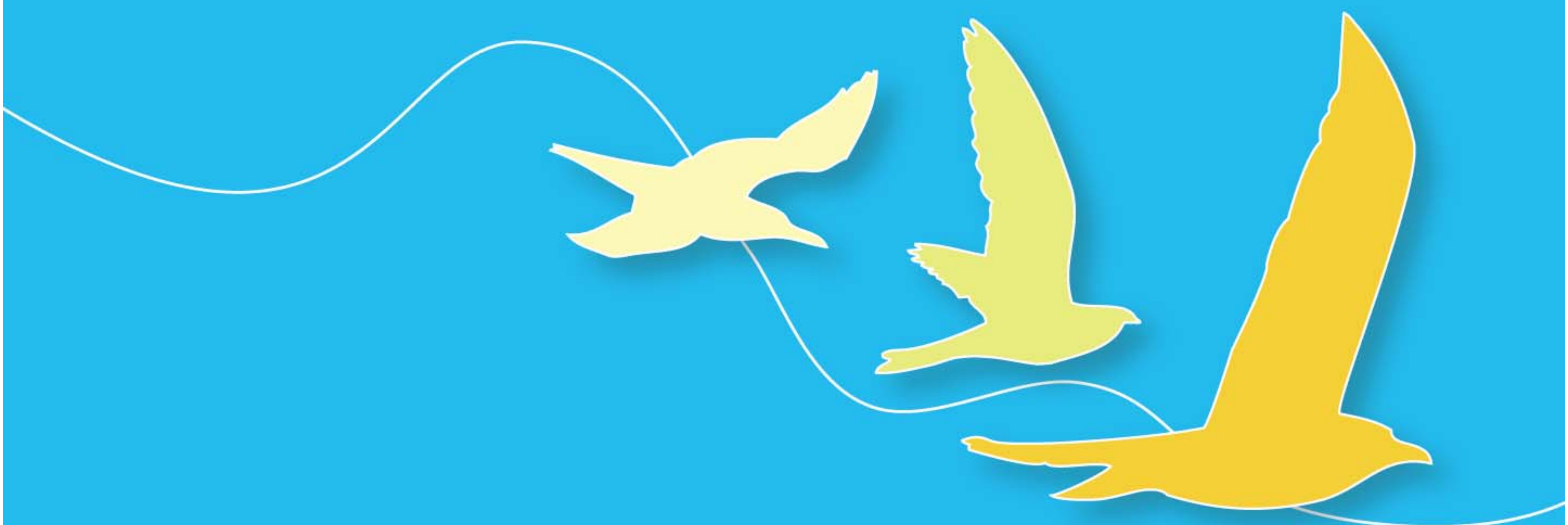
# Mapping and Monitoring Great Lakes Waterbirds to Support Management

*November 15, 2017*



# History and Origins

- Began as a planning assessment for proposed offshore wind development in the Great Lakes
- Interest in Great Lakes wind power declined over the course of the project
- Great Lakes avian research and coastal planning community see significant value in the project
- Workplan and deliverables were slightly updated to reach a broader audience and provide utility for a wider array of researchers and planners unrelated to offshore wind development

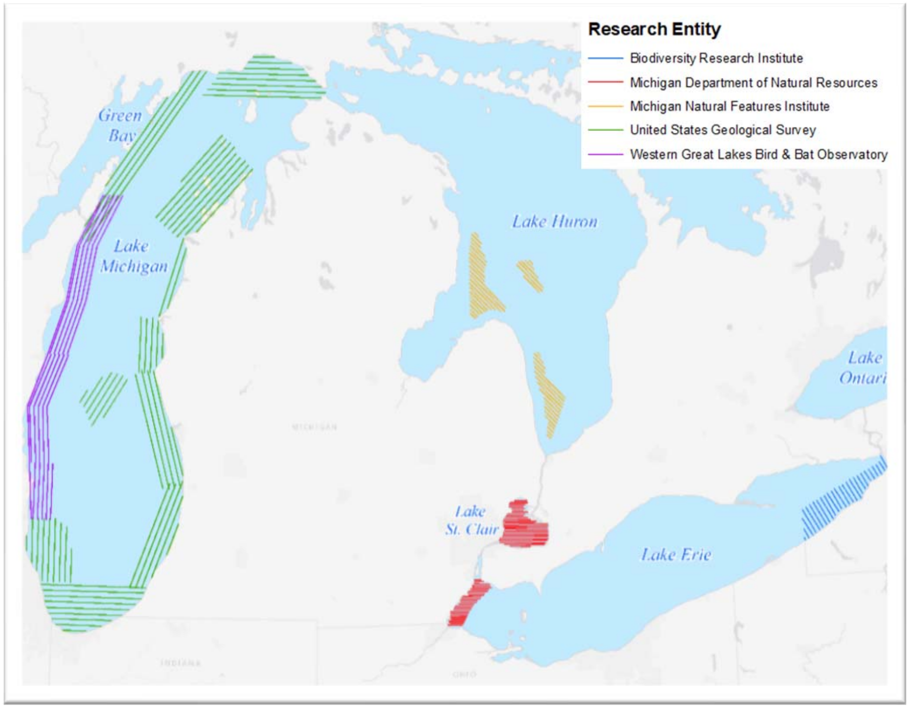
# Multi-Phase Approach

## Phase I

- ➢ Aerial surveys, fall 2012 and spring 2013 migration seasons

## Phase II

- ➢ Aerial surveys, fall 2013 through the spring 2014 migration and overwintering seasons




## Phase III

- ➢ Development of a data management system for over-lake survey data and the development of predictive models

# Phases I and II: Complete

- Over 1.8 million individual birds observed
- More than 53 different species
- Over twice the number of birds per km of transect in Lake St. Clair than other sites
- Fewer individuals in Phase II, maybe due to high level of ice coverage during that winter

| Study Area | Bird Count | % of Total |
|---|---|---|
| Lake St. Clair | 1,401,982 | 76% |
| Lake Erie | 276,392 | 15% |
| Lake Michigan | 141,589 | 8% |
| Lake Huron | 9,545 | 1% |

# Phase III: Project Summary

- **September 2015 – August 2017**
- **Funded by U.S. FWS – Great Lakes Fish and Wildlife Restoration Act**
- **Research questions:**
  - *How do birds use near-shore and offshore areas of the Great Lakes during the non-breeding season?*
  - *How can this information be used to evaluate the potential impact of offshore and coastal development projects, and other resource management decisions?*

# Phase III Objectives

- Build a community of Great Lakes avian researchers.
- Inform Great Lakes conservation and management decisions.
- Develop and promote the use of the Midwest Avian Data Center.
- Develop predictive models of waterbird distributions and densities across the Great Lakes.
- Incorporate data and project results into relevant decision-making and conservation planning tools and documents.

# Phase III: Stakeholders Workshop

## March 22-23, 2016 in Ann Arbor

## Objectives:

- ➢Identify management needs for which data can inform decision-making.
- ➢Work with conservation managers and the regional project team to determine the best ways to apply the project's information to support their management activities.
- ➢Define user interface options for the analysis tools developed by the project that will be integrated into the Midwest Avian Data Center website.
- ➢Gauge the need for continued data collection, monitoring and review of impacts of management actions.

# Phase III: Data Management

Point Blue
Conservation
Science

# Describing and managing Great Lakes aerial survey data in the Midwest Avian Data Center

Leo Salas
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Point Blue
Conservation science
for a healthy planet

Monitoring and Mapping of Avian Resources over the Great Lakes

# About Point Blue

Reducing the impacts of habitat loss, climate change, and other environmental threats while promoting nature-based solutions for wildlife and people.

- Founded in 1965 as Point Reyes Bird Observatory
- 160+ seasonal and full time staff
- Manage >1 billion ecological observations
- Working in all 4 Flyways across Western Hemisphere

# Brief outline

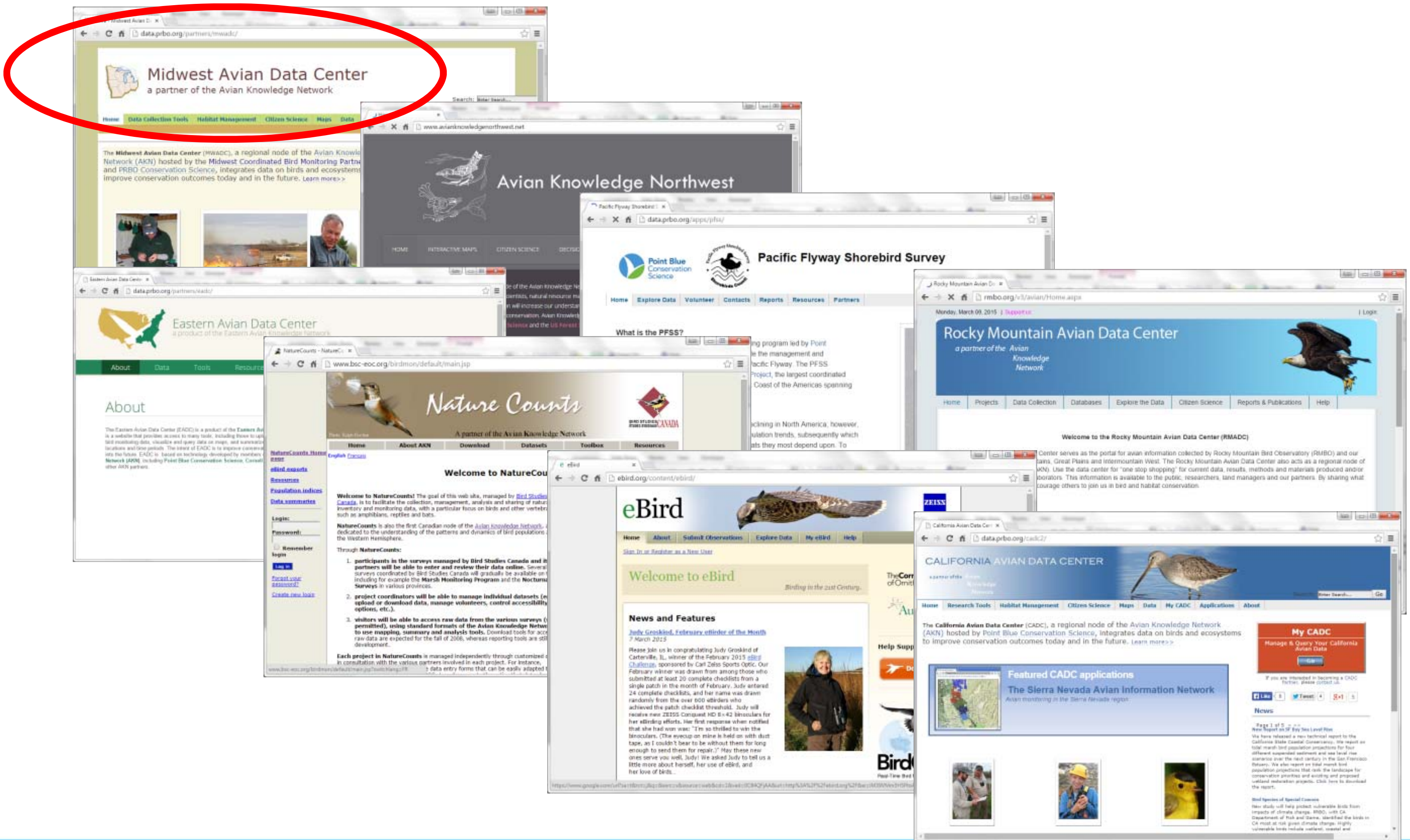
- About the AKN and the Midwest Avian Data Center (MWADC)
- Data life cycle
- Describing, federating, and managing data in MWADC
- Warehousing and simple visuals for the GLC aerial transect surveys

Midwest Avian Data Center
a partner of the Avian Knowledge Network

Avian Knowledge Network

Avian Knowledge Network

A **partnership** supporting the **conservation of birds and their habitats** based on data, adaptive management, and best available science. AKN partners improve awareness, purpose, access to, and use of **data and tools at multiple scales**.

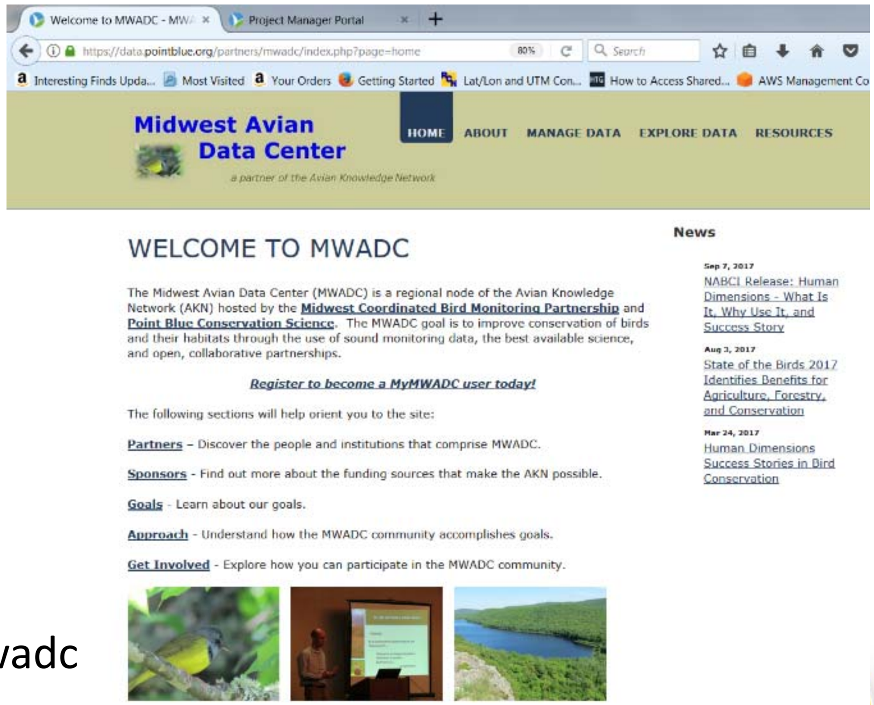



Monitoring and Mapping of Avian Resources over the Great Lakes

# MWADC ("mowadsee")

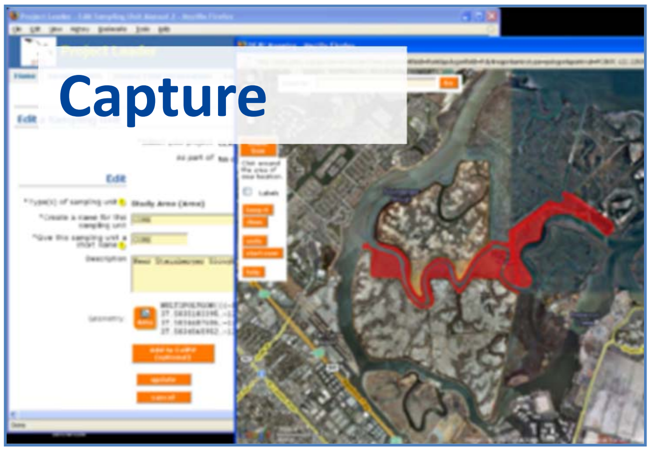
## AKN node hosted by the MCBMP

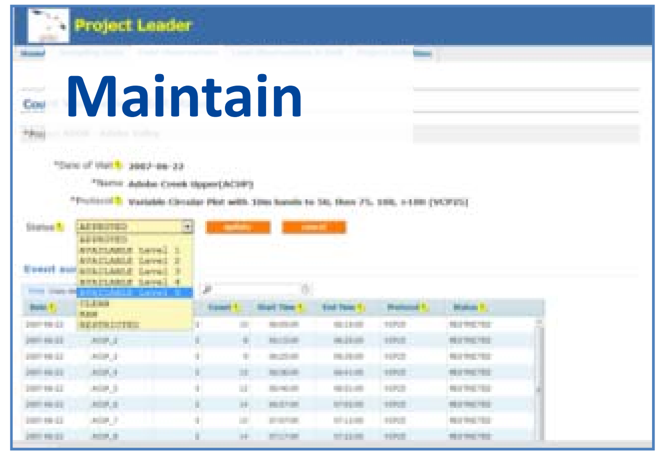
- The MWADC goal is "to improve conservation of birds and their habitats through the use of sound monitoring data, the best available science, and open, collaborative partnerships.
- 128 different projects (federal, state, NGOs)
- 29,000+ locations surveyed

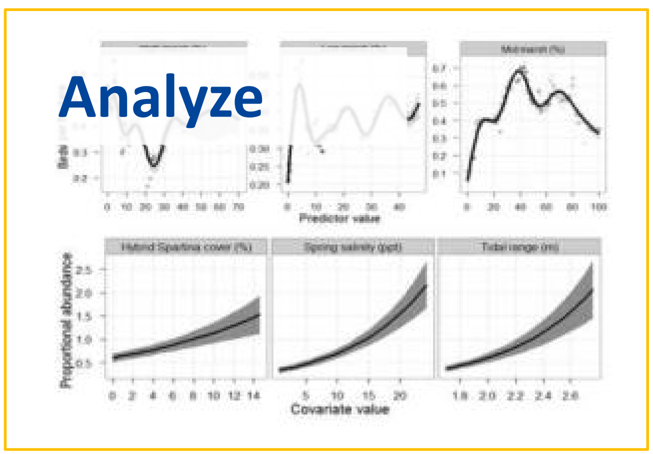



https://data.pointblue.org/partners/mwadc

# AKN Data Life Cycle

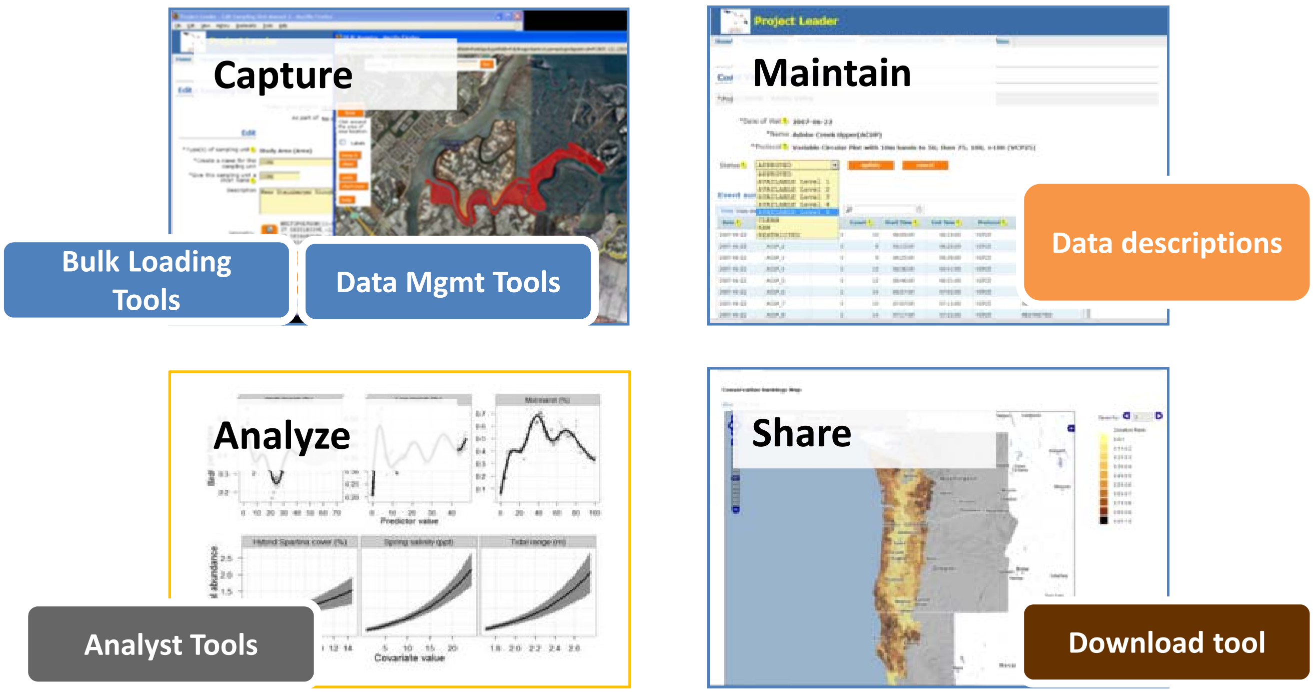



# Our goal for the project

Leverage the infrastructure of MWADC to provide the full data life cycle to the GLC aerial transects datasets



# Incorporating Aerial Survey Data

- Data descriptions:

https://data.pointblue.org/science/biologists/php/protocolsearch.php#FixedTransect

- Importing data: https://data.pointblue.org/apps/bulk-uploader/
- Project management: http://data.prbo.org/apps/projectleaders/
- Data management: https://data.pointblue.org/science/biologists/
- Data visualizations:

http://data.pointblue.org/apps/analyst/home

https://data.pointblue.org/partners/mwadc/index.php?page=map

- Data sharing: https://data.pointblue.org/apps/downloader/

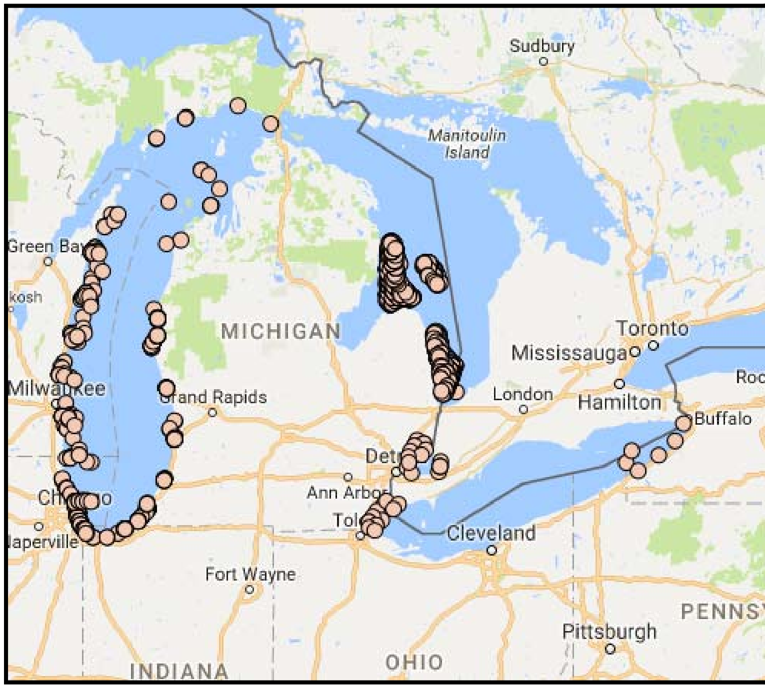
ATTENTION: for all but the last two links you will need an account in MWADC and access permission from the data owners.

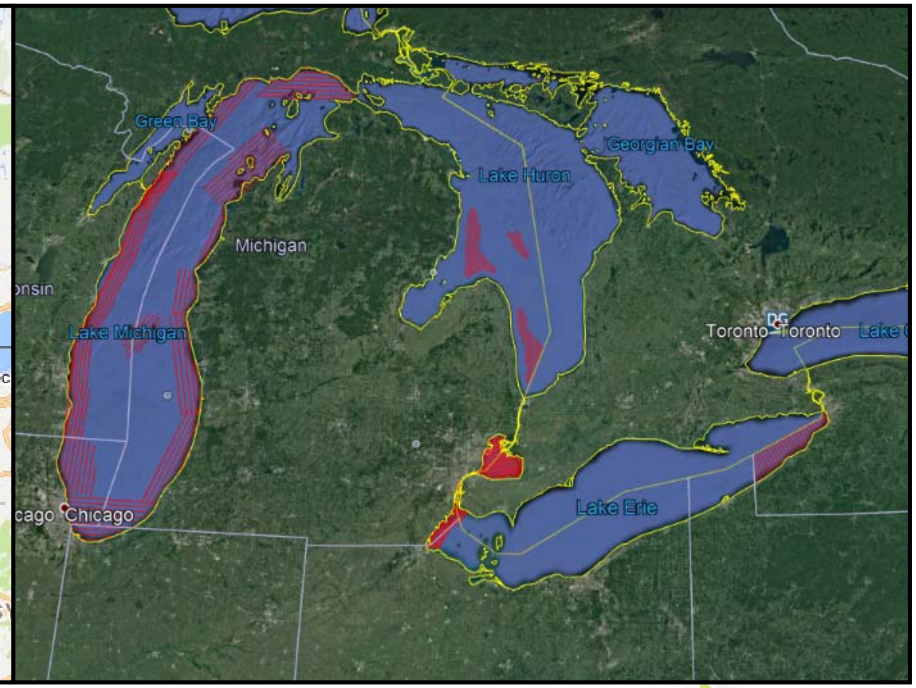
# Summary of data

41,000+ records

269 distinct transects

2,577 survey events



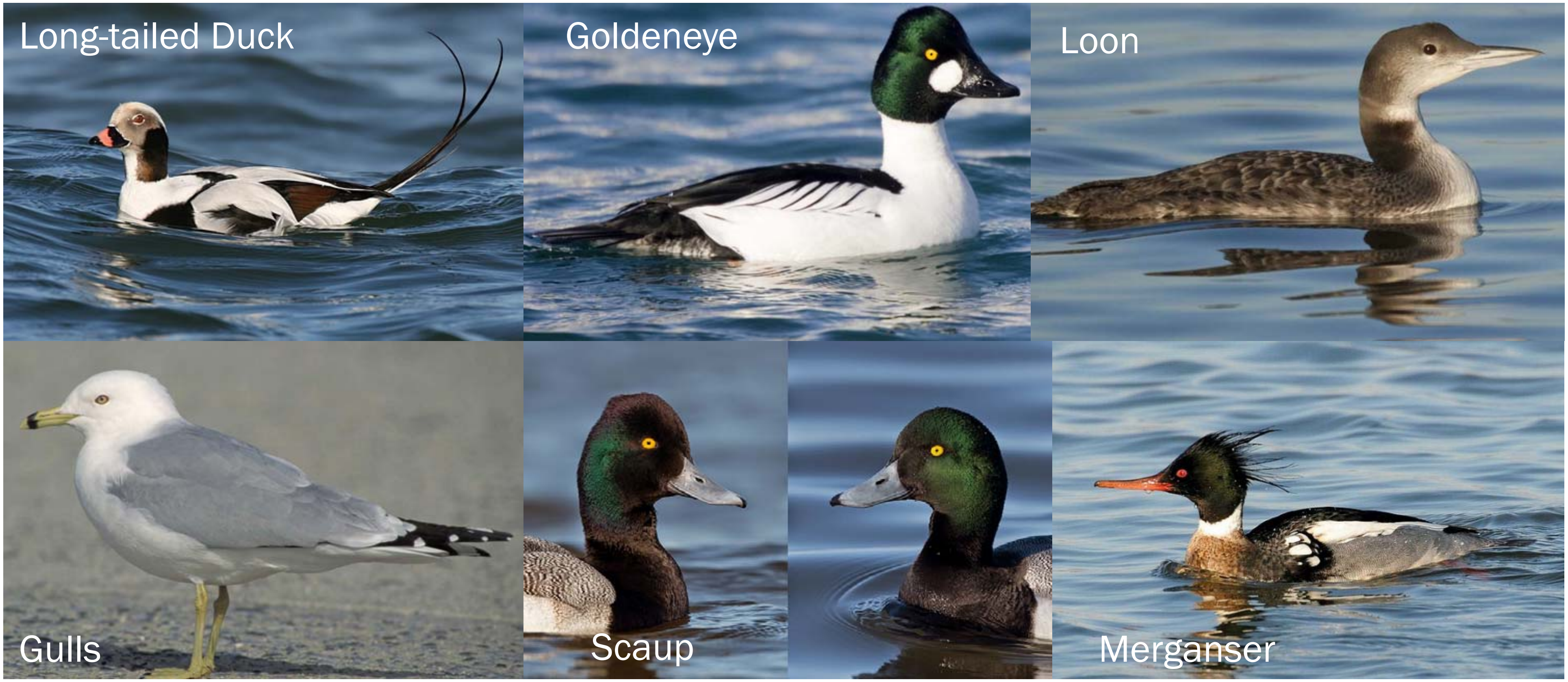
# Phase III: Predictive Modeling

MICHIGAN STATE UNIVERSITY

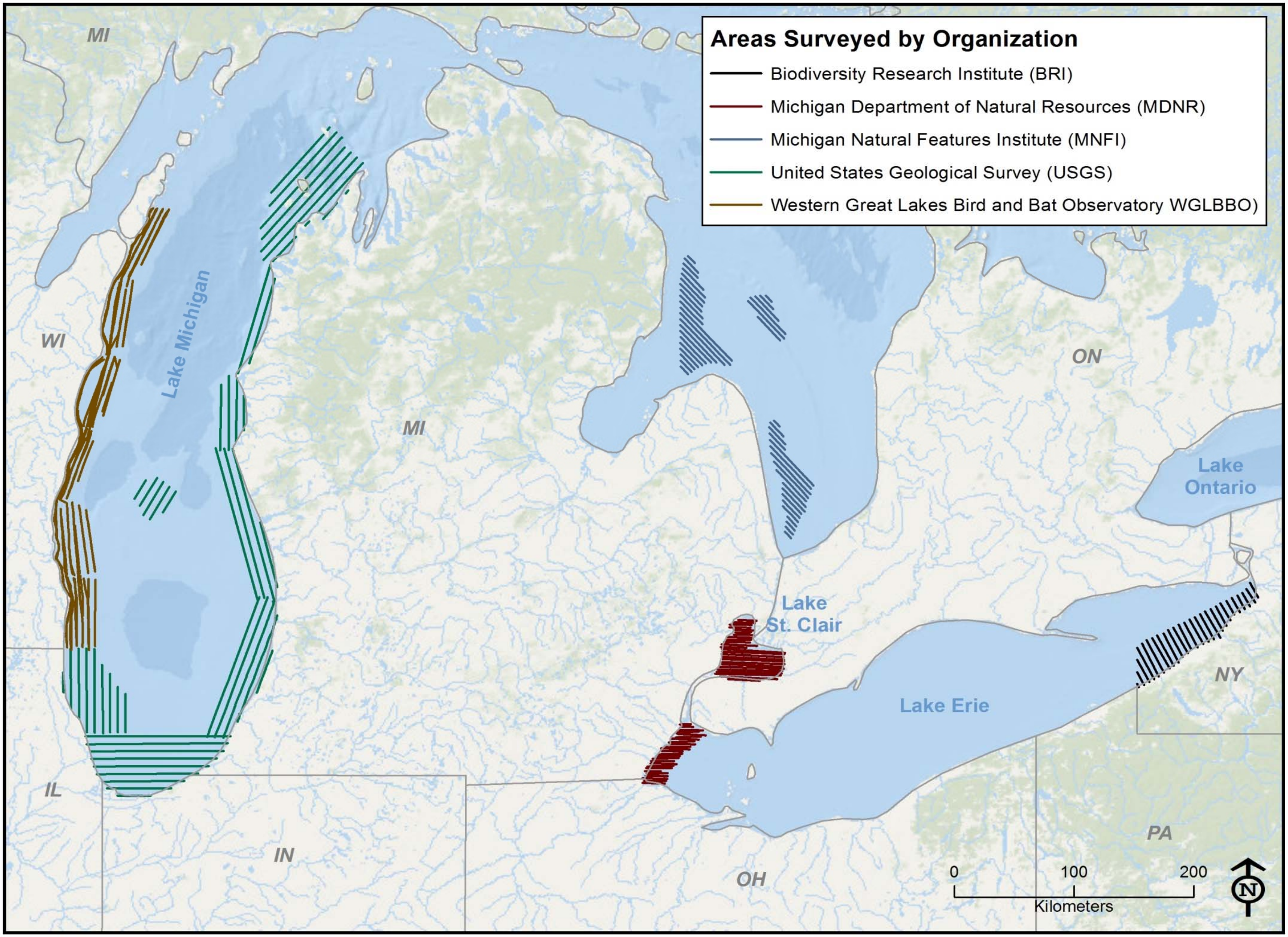
bri
BIODIVERSITY RESEARCH INSTITUTE
innovative wildlife science

W UNIVERSITY of WASHINGTON

# Taxonomic Groups



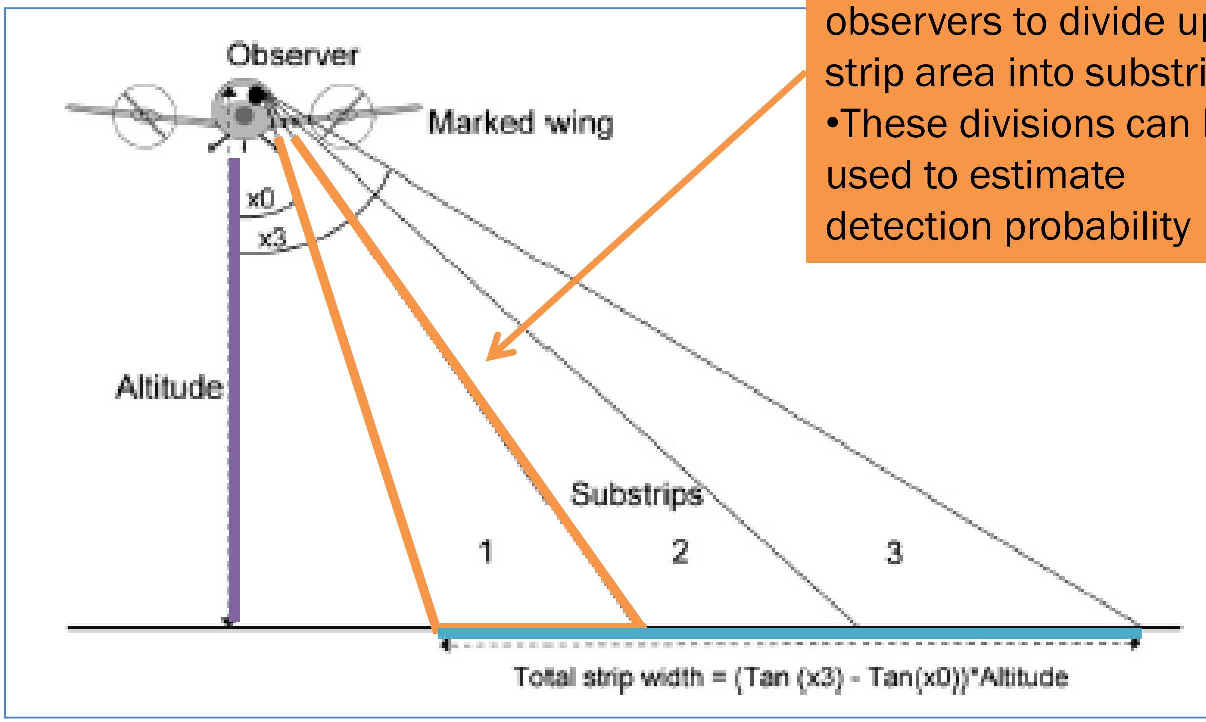

- **Why?**
  - Helps with observations that aren't identified to species
  - Helps reduce the number of zeroes


Areas Surveyed by Organization
Biodiversity Research Institute (BRI)
Michigan Department of Natural Resources (MDNR)
Michigan Natural Features Institute (MNFI)
United States Geological Survey (USGS)
Western Great Lakes Bird and Bat Observatory WGLBBO)
MI
WI
Lake Michigan
MI
ON
Lake Ontario
Lake St. Clair
NY
Lake Erie
IL
IN
OH
PA
0
100
200
Kilometers
N

# Aerial Survey Techniques

**Substrips:**
- Marks on the wing allow observers to divide up the strip area into substrips
- These divisions can be used to estimate detection probability

**Flight Height**




**Strip Width:**
- Total area surveyed

from Certain and Bretagnolle (2008)

# Variation in Survey Methods Across Protocols

| | U.S. Geological Survey (USGS) | Western Great Lakes Bird and Bat Observatory (WGLBBO) | Michigan Natural Features Inventory (MNFI) | Michigan Division of Natural Resources (MDNR) | Biodiversity Research Institute (BRI) |
|---|---|---|---|---|---|
| Geographic area | Lake Michigan | Western shoreline of Lake Michigan | Portions of Northern Lake | Lake St. Clair and western Lake Erie | New York's portion of Lake Erie |
| Years surveyed | 2013-2014 | 2013-2014 | 2012-2014 | 2012-2014 | 2013-2014 |
| Transect spacing | 4.8 km | 3.2 km | 5 km | 3.2 km | 5 km |
| Plane type | Partenavia P.68 | | Partenavia P68C | amphibious Cessna | amphibious Cessna |
| Altitude of flights | 61-76 m (200-250 ft) | 100 m | 91 m (300 ft) | 91 m (300 ft) | 61 m (200 ft) |
| Flight speed | 200 km/hr | 148 km/hr | 130-200 km/hr | 145 km/hr | 145-169 km/hr |
| Strip width (when no distance provided) | 200 m | | 412 m | | 200 m |
| Distance bands | 2 | 3 | 4 or 5 | 5 | 3 |
| Species recorded | Waterbirds and waterfowl | Waterbirds and waterfowl | Waterbirds and waterfowl | Waterbirds and waterfowl | Waterbirds and waterfowl |

# Challenges

- To estimate abundance, we need to incorporate variation in detection
- Each surveyor implemented a different sampling protocol that could change between years
- Counts of birds were highly variable and included a large number of zeroes

# Multi-Protocol Distance Sampling

- Combined distance detection protocols for each species along shared parameters of interest
- Three components:
  - Detection function based on distance
    - Half-normal or hazard function
  - Model for observed groups
    - Zero-inflated overdispersed Poisson
  - Group size regression
    - Allows group size to vary with distance to observer (i.e., detection probability)

# Modeling Numbers of Groups

- Zero-inflation model
  - Estimates the probability that a species could be found at the site
- Overdispersed Poisson model
  - Given that the animal can be found at the site, this estimates the number of groups there

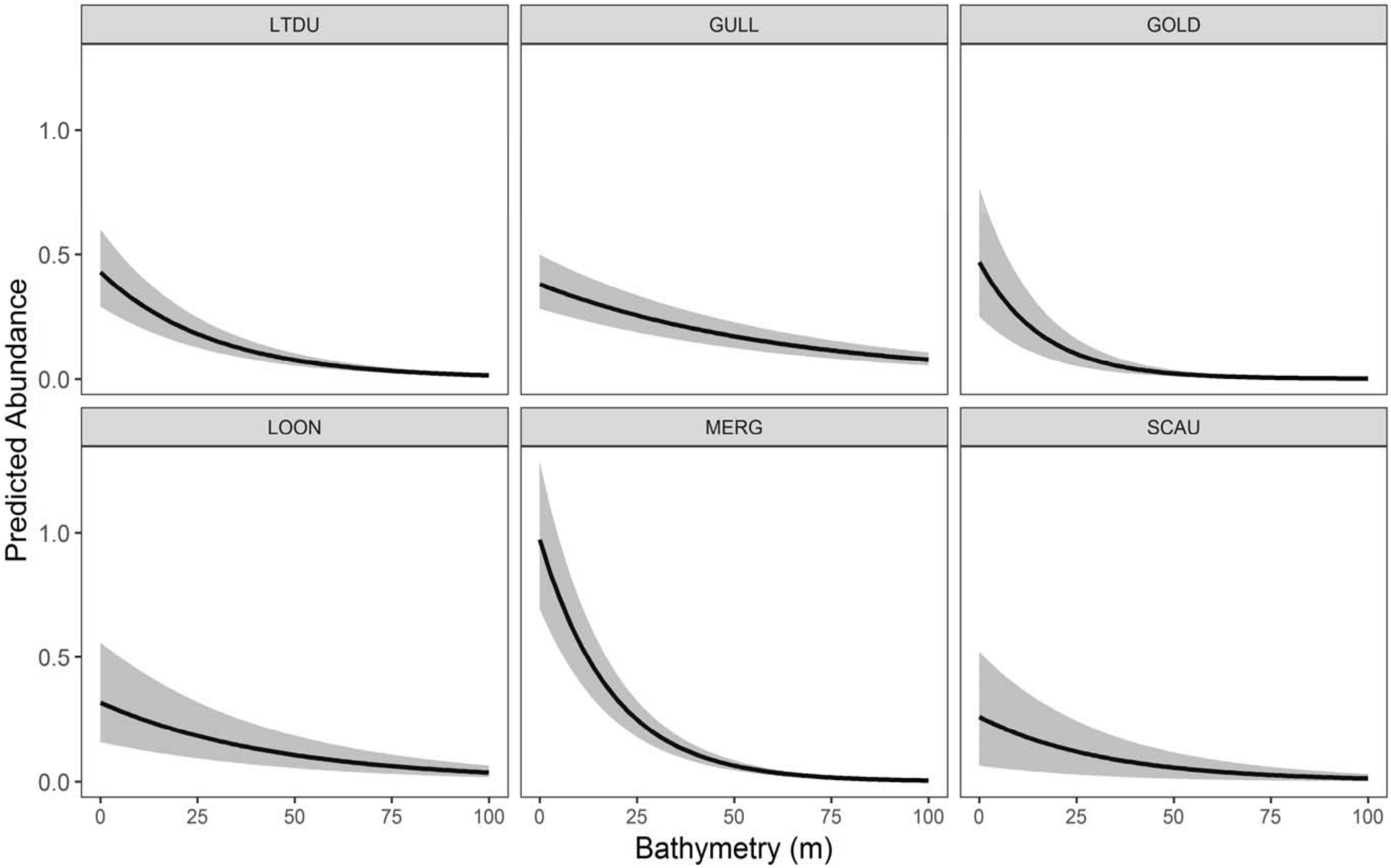
# Environmental Covariates

- Zero-inflation covariates
  - Longitude
  - Time of year (fall, winter, spring)
  - Ice coverage (solid ice or not)
- Abundance covariates
  - Bathymetry (m)
  - Lake bottom substrate (6 categories)
  - Ice coverage (% coverage)
  - Area offset

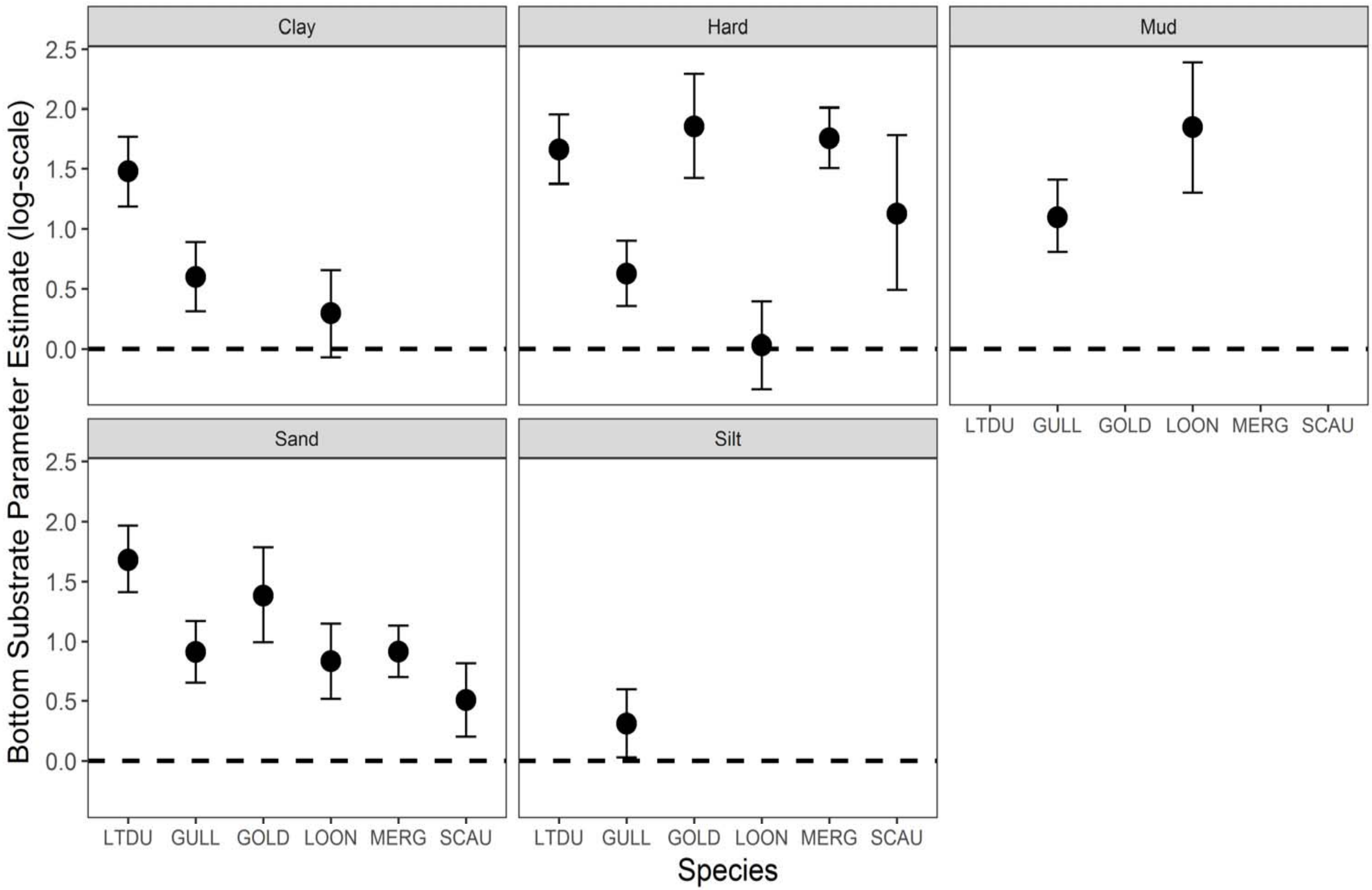
# Model Implementation

- A Bayesian framework using JAGS 4.0
- Convergence assessed visually and the Gelman-Rubin statistic
- A posterior predictive check using a Bayesian *p*-value was used to quantify goodness of fit

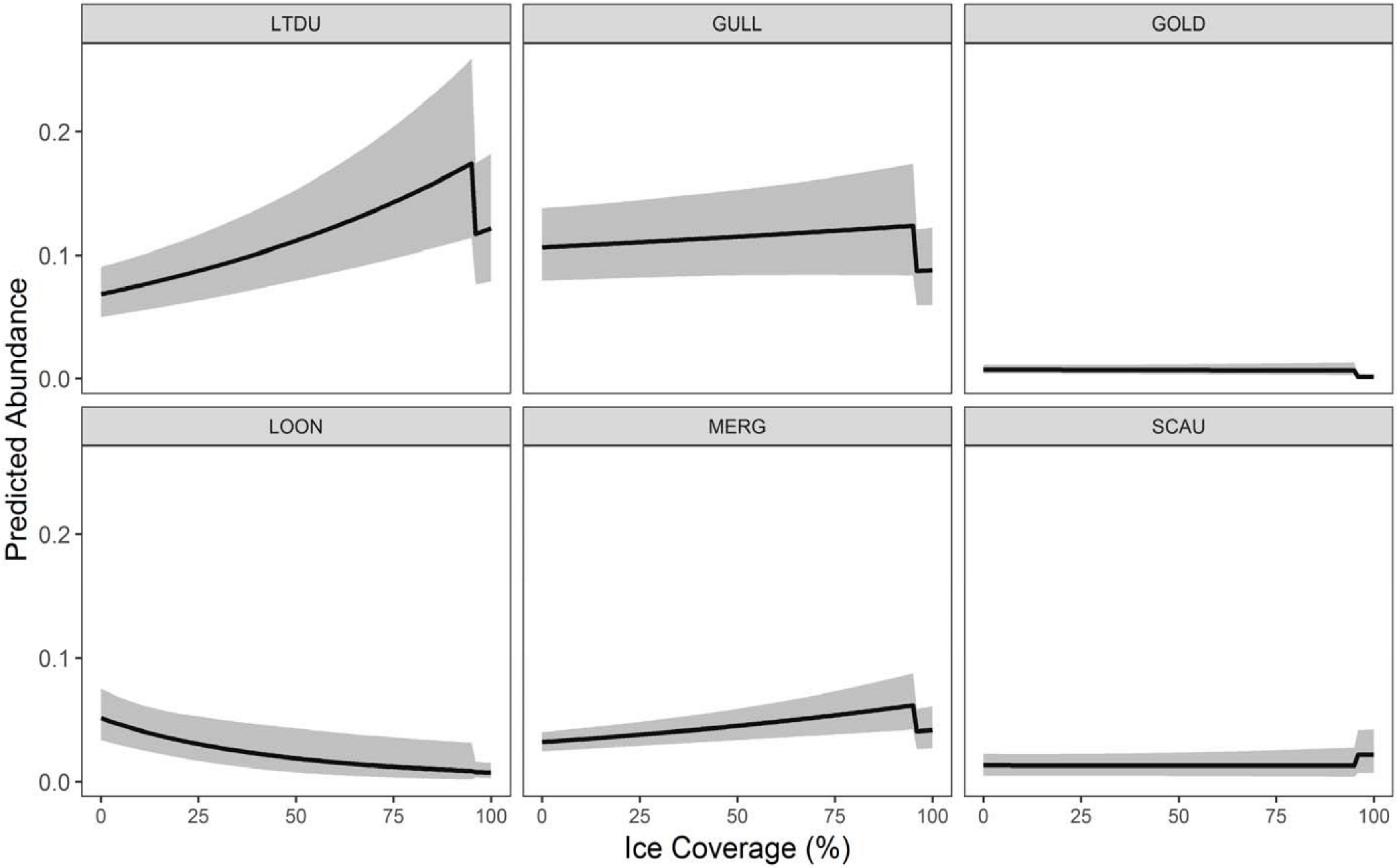
# Bathymetry


LTDU
GULL
GOLD
LOON
MERG
SCAU
Predicted Abundance
1.0
0.5
0.0
0
25
50
75
100
Bathymetry (m)

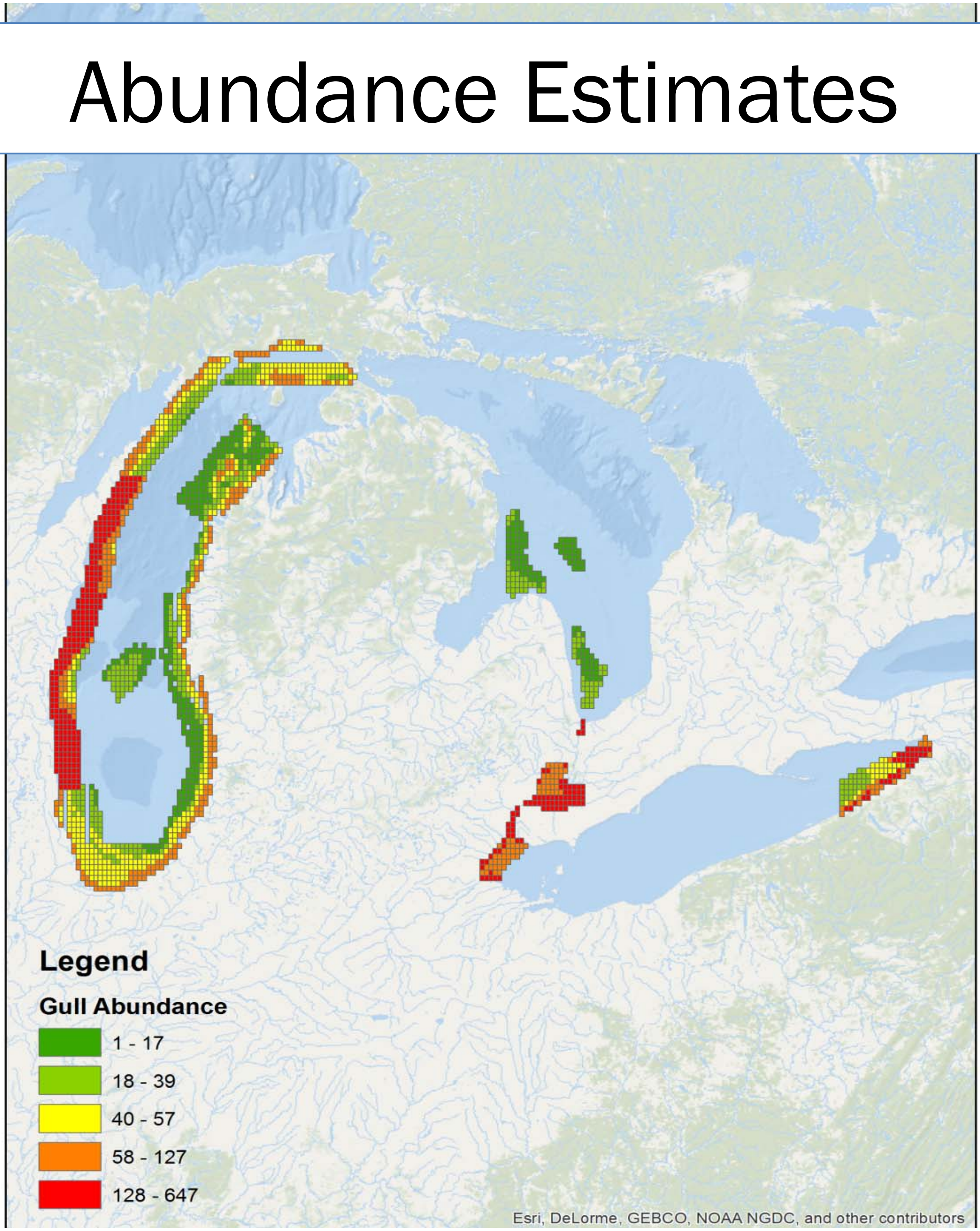
# Lake Substrate



# Ice Cover


LTDU
GULL
GOLD
LOON
MERG
SCAU
Predicted Abundance
0.0
0.1
0.2
0
25
50
75
100
Ice Coverage (%)

# Abundance Estimates



# Summary

- The multi-protocol distance model allowed us to describe patterns of abundance at the scale of four Great Lakes
- All species had higher abundance in shallower waters
  - But the rate of change differed considerably among species
- Most species were less likely to be present at high ice locations
  - Scaup were the opposite and Long-tailed Ducks decreased but were still higher than zero ice
  - These results suggest error in our ice coverage estimates or attraction to icy edges for these species (or both)

# Future Directions

- More aerial surveys to fill in gaps in inference
  - Groups are highly clustered, can make it difficult to predict to unsurveyed areas
  - Particularly a focus on areas of high regulatory or conservation interest
  - High annual variance due to ice coverage, so repeating surveys for multiple years will be key
- To make useful predictions, we would need estimates of ice coverage across the lakes
  - Current forecasting occurs up to 5 days out
    - Great Lakes Coastal Forecasting System
  - Longer time scale forecasting is an area of active research

# Thanks!

# Waterbird hotspots in the Great Lakes

Allison Sussman

and

Elise Zipkin

# Outline

- Background
- Hotspot analyses
- 4 models
- Comparing the models
- Recommendations

# Waterbirds

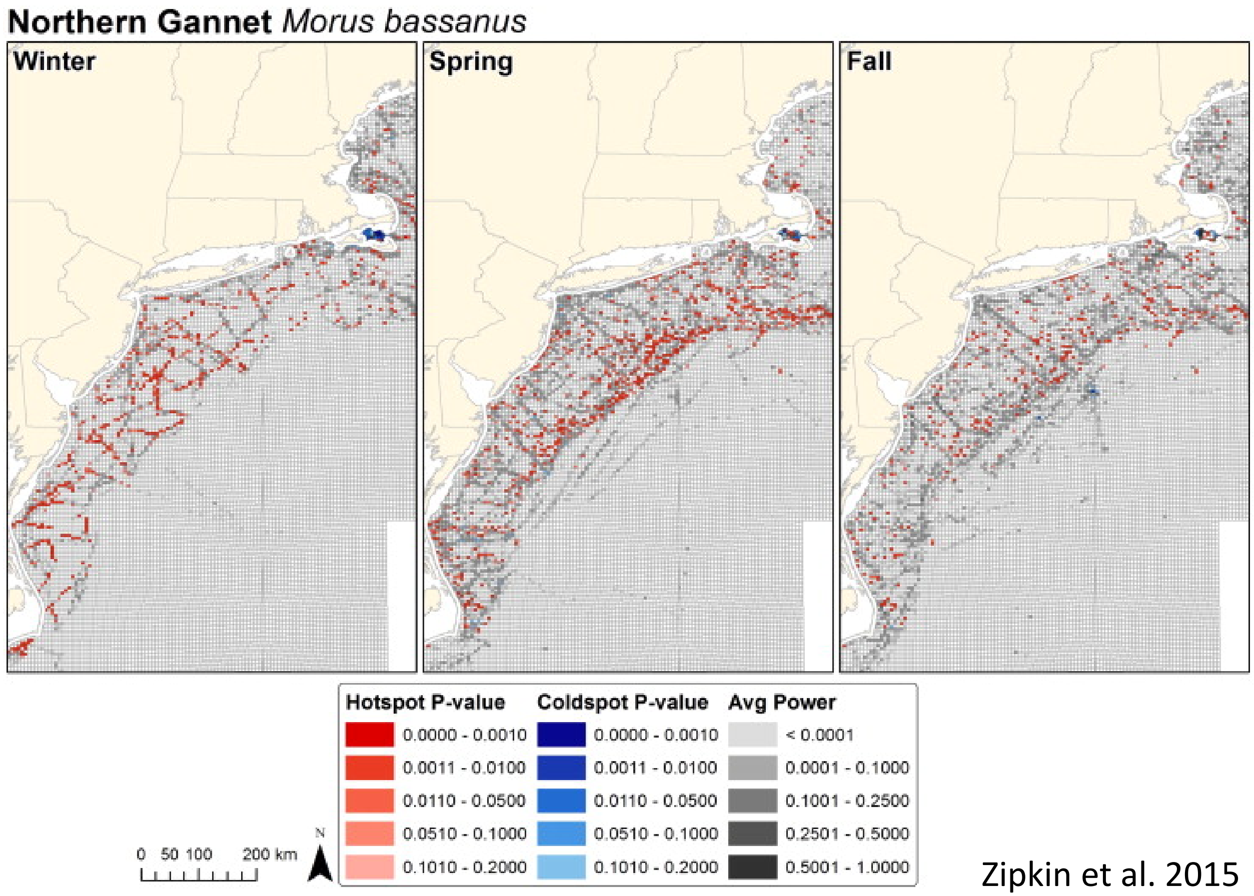
- Difficult to study
- Ecosystem indicators
- Threats

# Hotspots

- Useful for waterbirds
- Since introduction, no scientific consensus
- Inconsistent results

# Types of hotspot analyses

- Qualitative
- Spatial models
- Parametric models




Zipkin et al. 2015

# Four hotspot models

- Two spatial models
  - Kernel density estimation
  - Getis-Ord Gi*

- Two parametric models (non-spatial)
  - Hotspot persistence
  - Hotspots conditional on presence

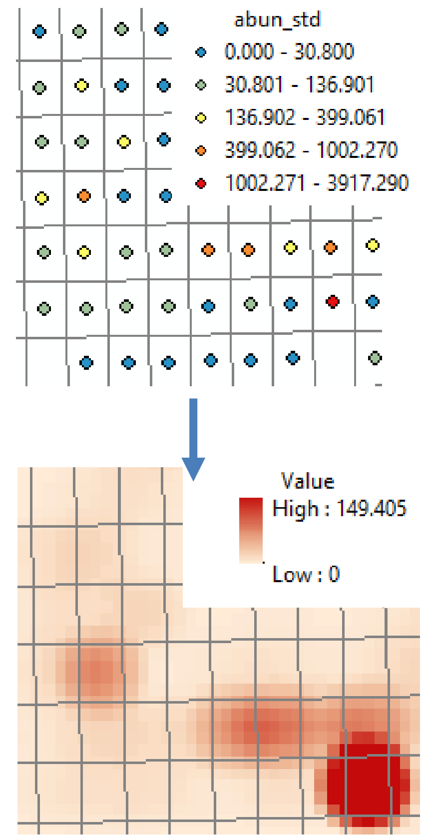
# Kernel density estimation

- Identifies areas of high density based on known areas

- Subjective: bandwidth, cell size

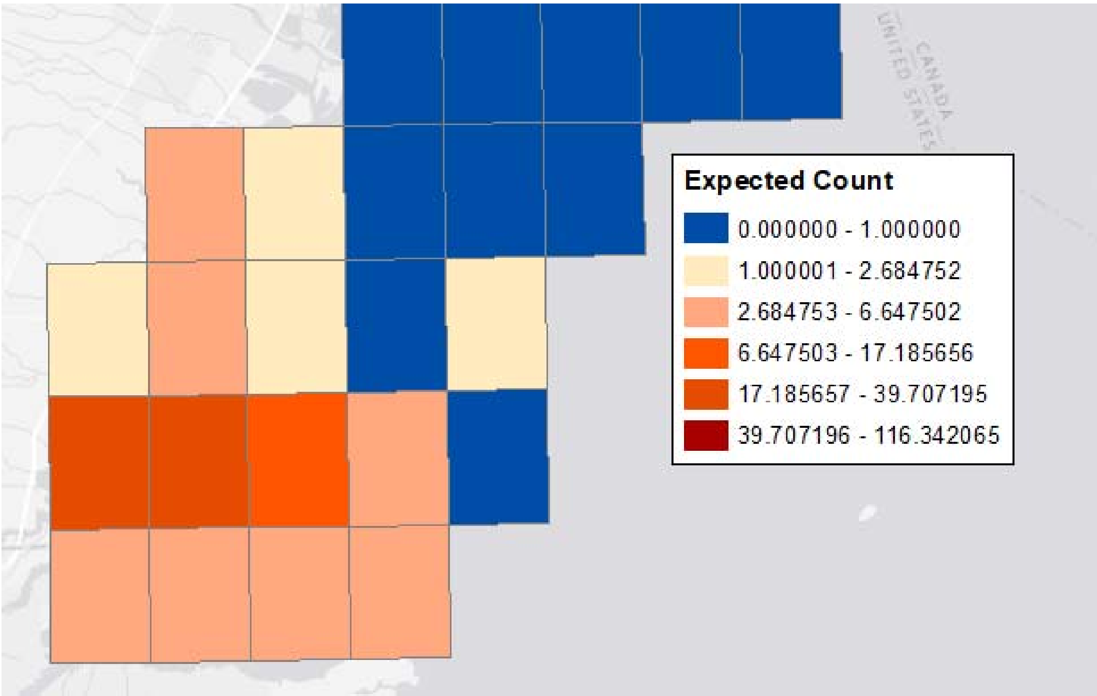
- Hotspot

  High density




Wilson et al. 2009 Suryan et al. 2012
O'Brien et al. 2012 Wong et al. 2014

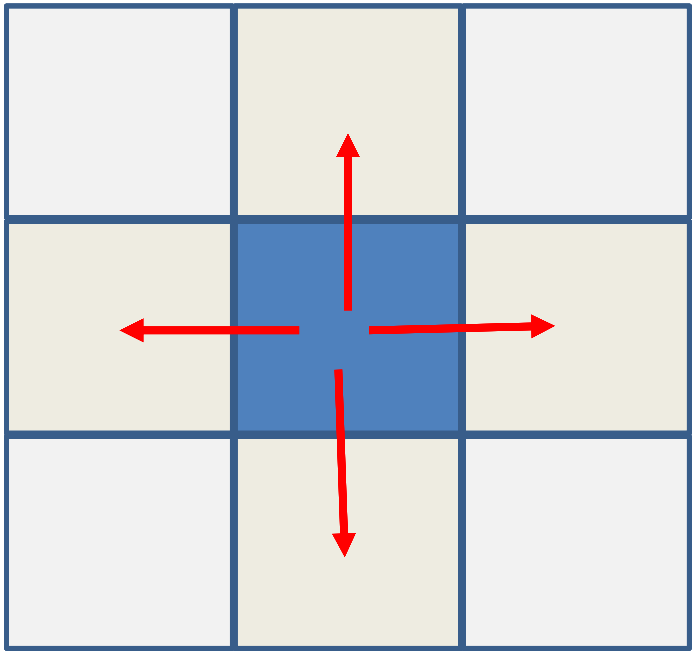
# Kernel density estimation



# Getis-Ord Gi*

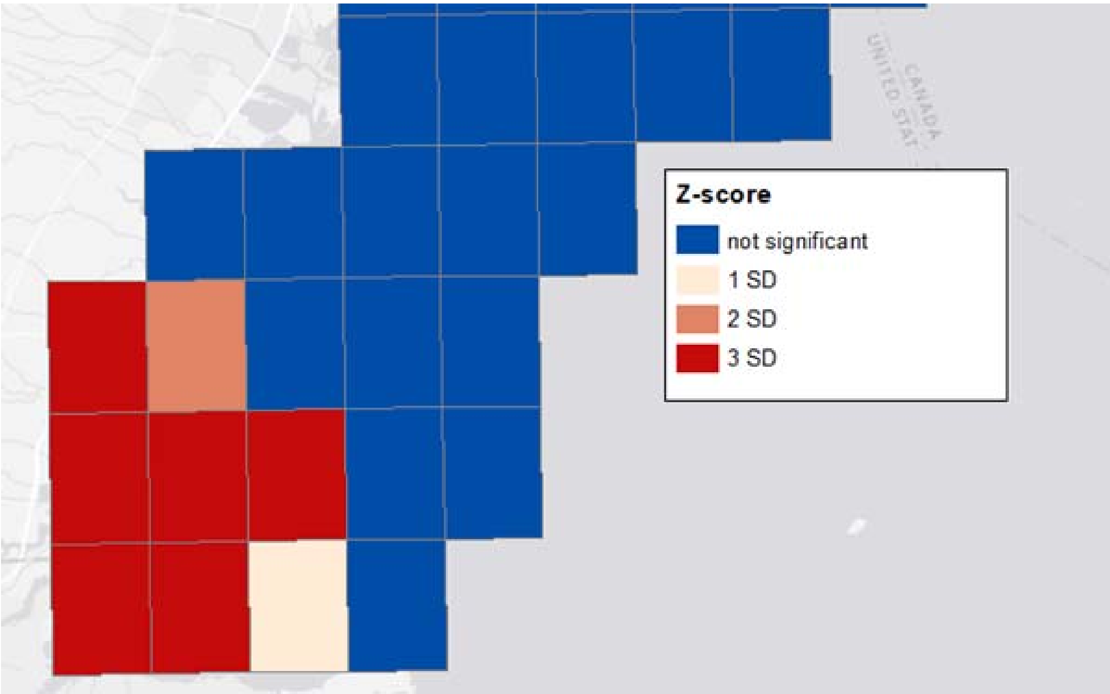
- Clusters of grid cells within context of neighbors
- Calculate neighbors
- Hotspot

  ≥ 1 SD from mean



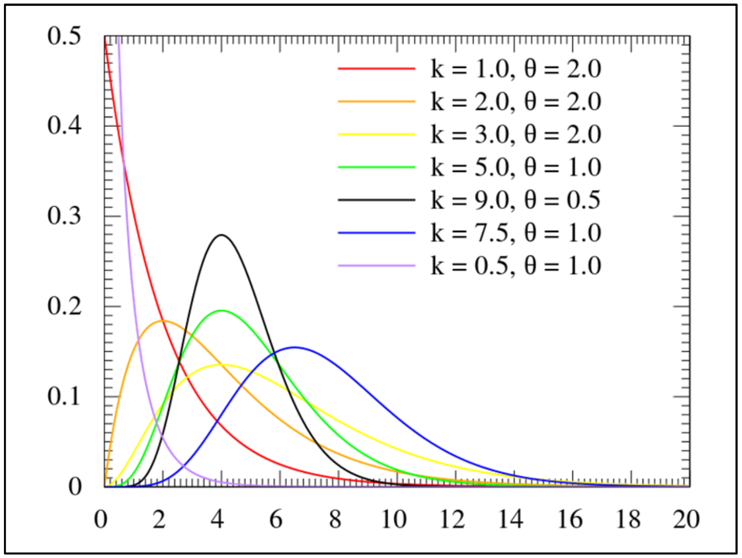
Santora et al. 2010
Kuletz et al. 2015

# Getis-Ord Gi*



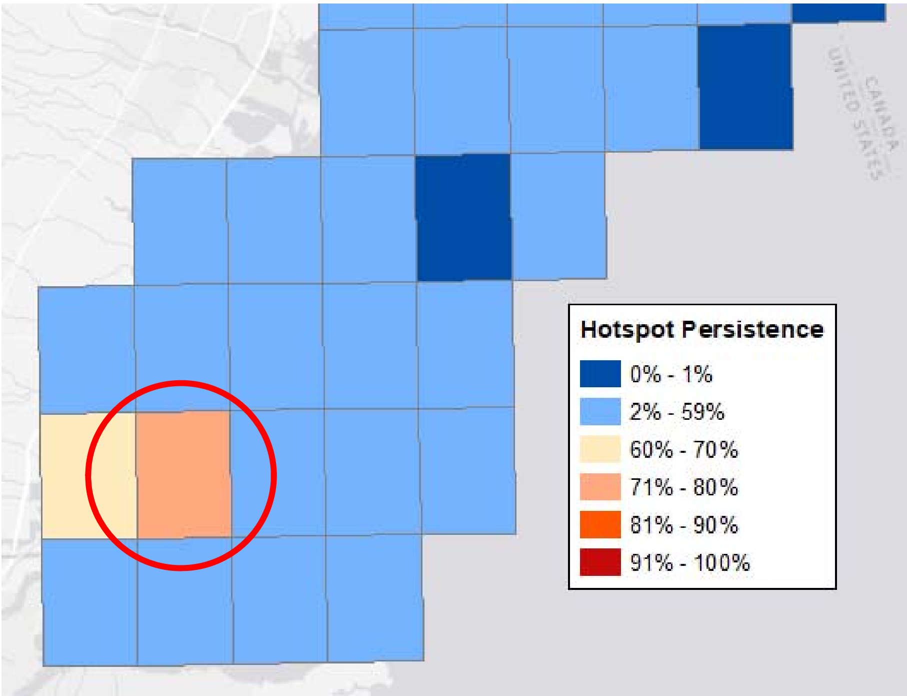
# Hotspot persistence

- Temporal component
- Fit gamma distribution
- Assign probability
- Hotspot
  $\geq 75^{th}$ percentile



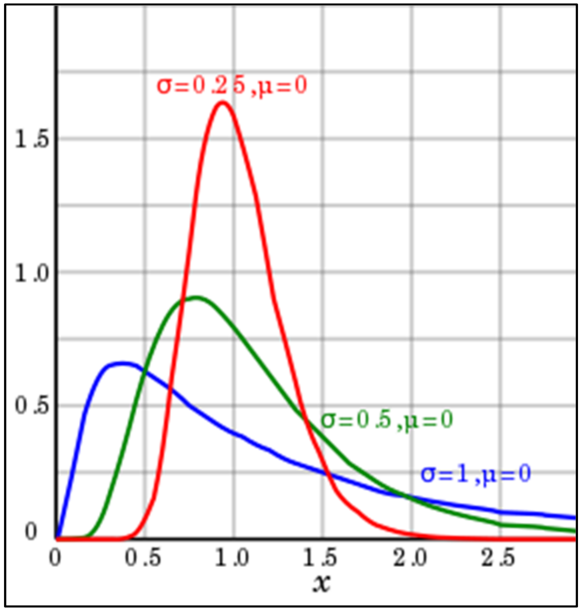

Suryan et al. (2012)
Santora and Veit (2013)
Johnson et al. (2015)

# Hotspot persistence



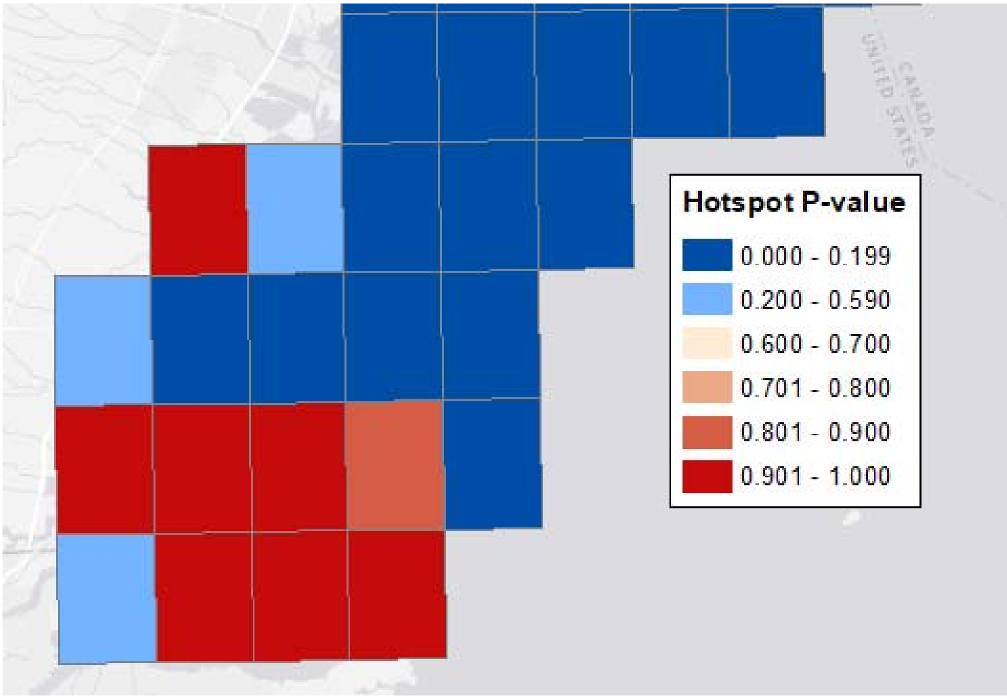
# Hotspots conditional on presence

- Sample mean and mean of reference region
- Fit lognormal distribution
- Monte Carlo method
- Hotspot
  long-term average abundance ≥ 3x mean reference region




Kinlan et al. 2012
Zipkin et al. 2015

# Hotspots conditional on presence



# Objectives

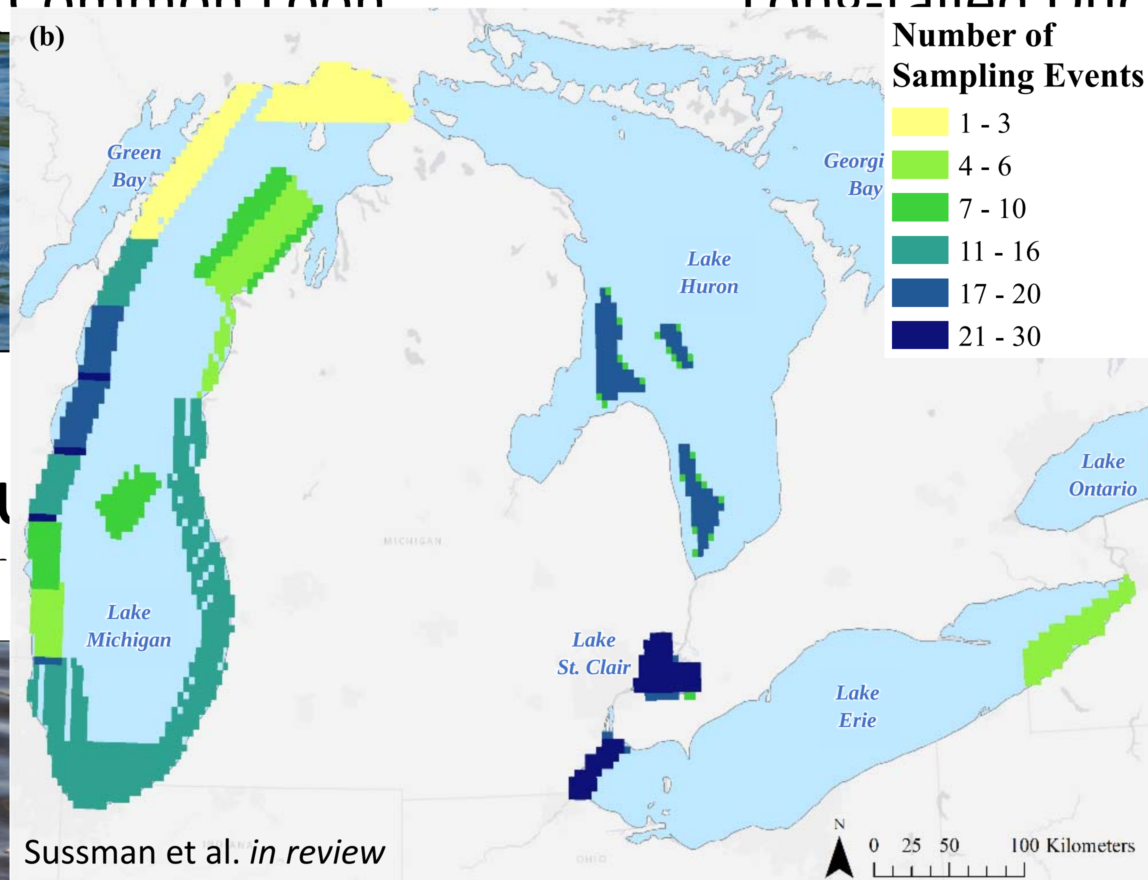
- Explore waterbird hotspots using common methods
- Compare consistency across different methods

# Data

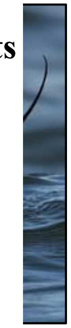
Loons
Common Loon

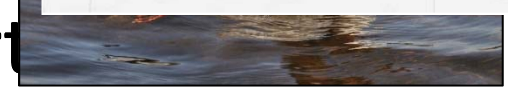
Diving and Sea Ducks
Long-tailed Duck

- 7 spe
- 5km$^2$
- Unequ samp
- Stand effort



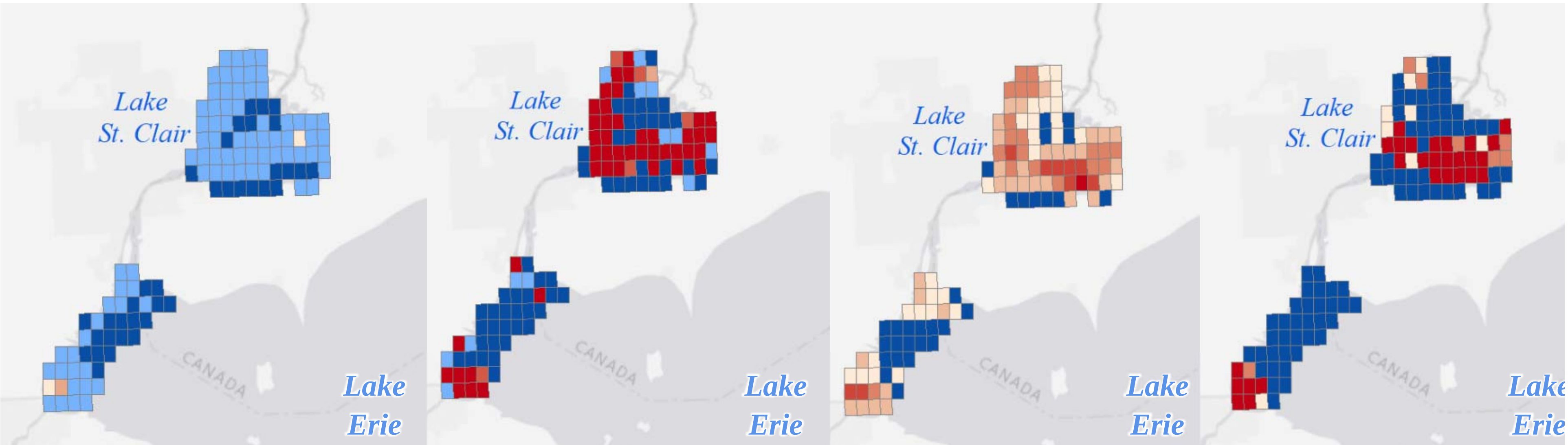

Sussman et al. *in review*





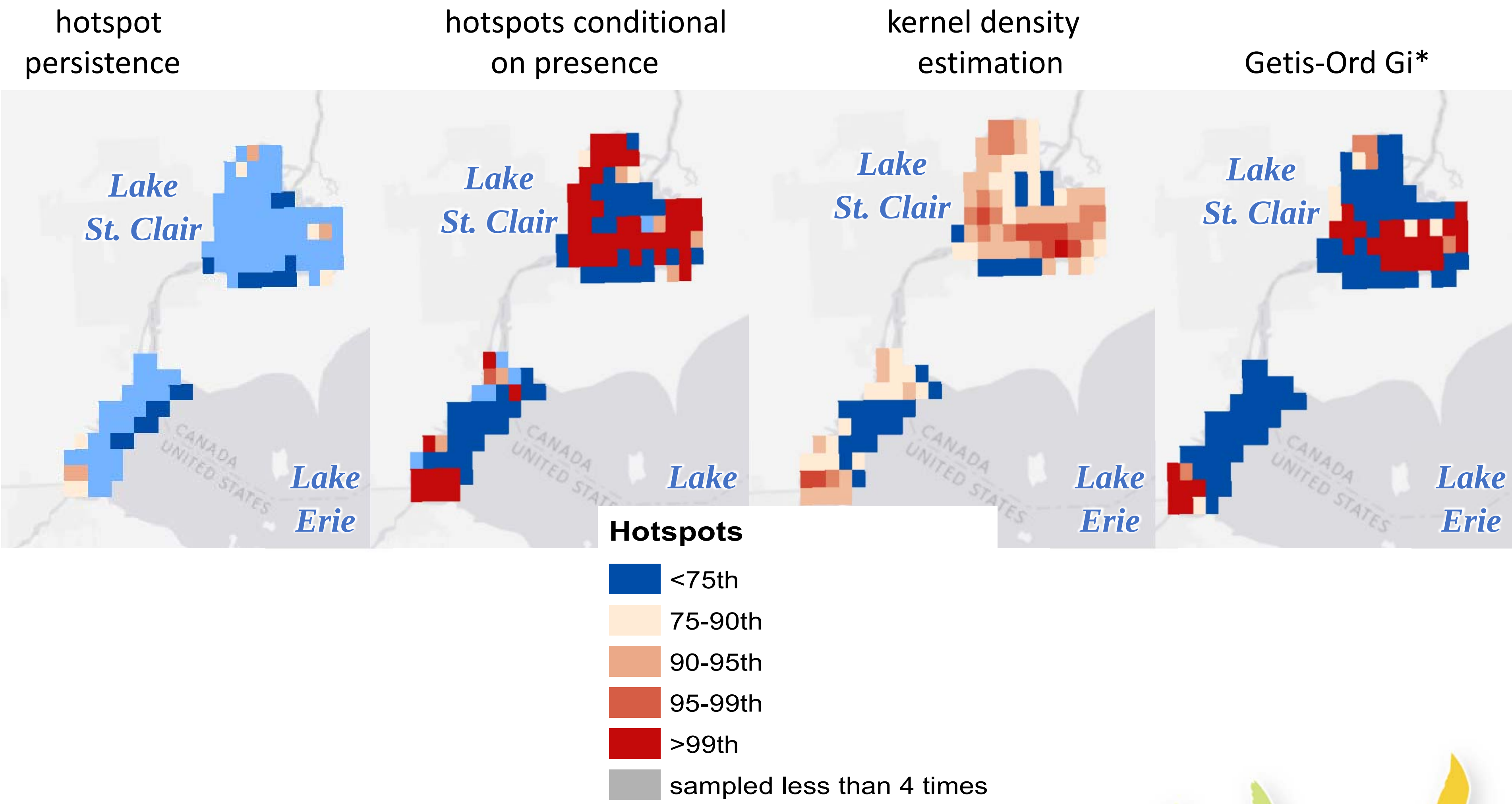
# Comparing the methods visually

hotspot persistence | hotspots conditional on presence | kernel density estimation | Getis-Ord Gi*




Sussman et al. *in review*

# Comparing the methods visually



# Comparing the methods quantitatively

| | Kernel density estimation | Getis-Ord Gi* | Hotspot persistence |
|---|---|---|---|
| **Scaup** | | | |
| **Kernel density estimation** | - | - | - |
| **Getis-Ord Gi*** | 0.878 | - | - |
| **Hotspot persistence** | 0.562 | 0.586 | - |
| **Hotspots conditional on presence** | 0.661 | 0.623 | 0.686 |

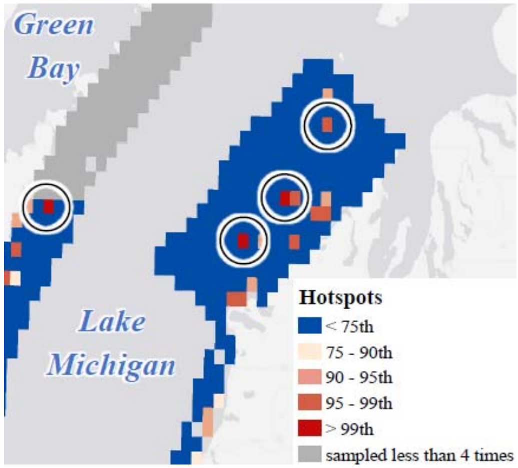
# Comparing the methods quantitatively

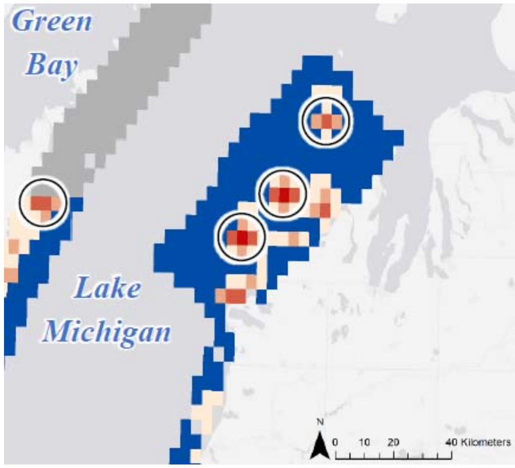
| | Kernel density estimation | Getis-Ord Gi* | Hotspot persistence |
|---|---|---|---|
| **Loons** | | | |
| **Kernel density estimation** | - | - | - |
| **Getis-Ord Gi*** | 0.800 | - | - |
| **Hotspot persistence** | 0.027 | 0.032 | - |
| **Hotspots conditional on presence** | 0.049 | 0.075 | 0.606 |

# Conclusions

- Methods differ
  - Spatial most similar
  - Hotspot persistence

- Dependent upon
  - Data availability
  - Conservation concerns
  - Spatial scale




Sussman et al. *in review*

# Recommendations

- Collect more data
- Environmental data
- Integrated approach combining multiple methods
  - $G_i^*$ and hotspots conditional on presence

# Combining the methods

| Species | Lake Huron | Lake Michigan | Eastern Lake Erie | Western Lake Erie | Lake St. Clair |
|---|---|---|---|---|---|
| Percent of all cells | 8.83% | 79.12% | 5.43% | 2.38% | 4.24% |
| **All-species-combined** | 4.30% | 65.38% | 5.20% | **8.14%** | **16.97%** |
| **Diving/Sea Ducks** | 6.79% | 64.25% | 3.62% | **8.37%** | **16.97%** |
| **Gulls** | 1.58% | 69.91% | **13.57%** | **7.24%** | **7.69%** |
| **Long-tailed Duck** | **18.33%** | **81.67%** | 0.00% | 0.00% | 0.00% |
| **Mergansers** | 1.13% | 62.67% | **13.57%** | **7.69%** | **14.93%** |
| **Scaup** | 7.22% | 66.30% | 4.81% | **7.78%** | **13.89%** |
| **Loons** | 4.73% | 79.05% | **15.99%** | 0.23% | 0.00% |
| **Common Loon** | 3.39% | 78.51% | **17.87%** | 0.23% | 0.00% |

# Recommendations

- Collect more data
- Environmental data
- Integrated approach combining multiple methods
  - $G_i$* and hotspots conditional on presence
- Split species groups

# Thank you!

Project Coordination & Data Management

- Michele Leduc-Lapierre
- Leo Salas
- Victoria Pebbles
- Katie Koch

Modeling Collaborators

- Beth Gardner
- Evan Adams

Surveyors

- Kevin Kenow
- Dave Luukenon
- Mike Monfils
- Bill Mueller
- Kate Williams
- Other flight crew & observers

Photo credit: wikimedia commons unless otherwise credited

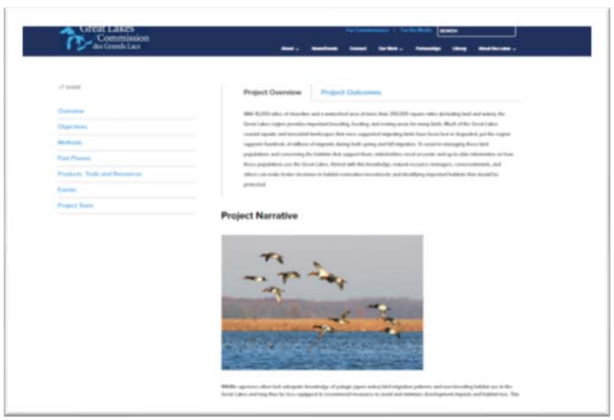
# Phase III: Outreach

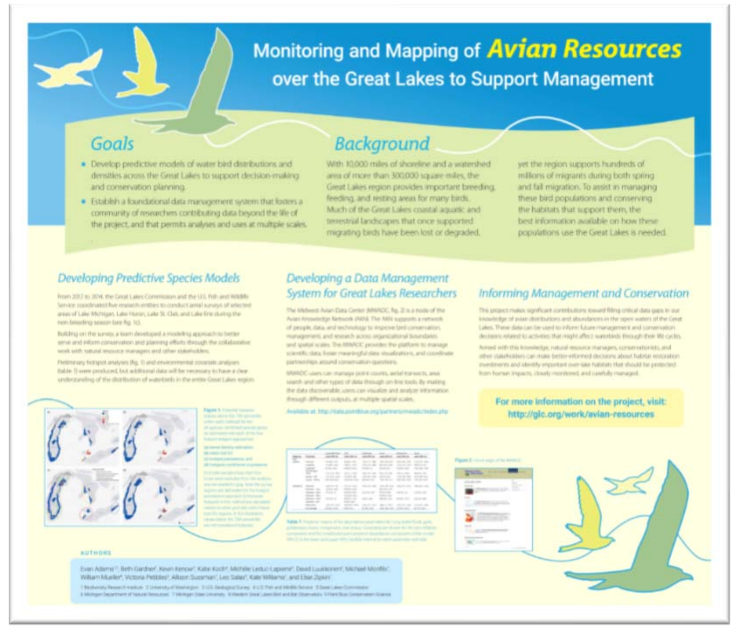
## Outreach products

- Websites

  GLC: www.glc.org/work/avian-resources

  MWADC: http://data.pointblue.org/partners/mwadc/index.php?page=home
- Factsheet
- Posters
- Workshop summary



# THANK YOU!


***Michèle Leduc-Lapierre | michelel@glc.org***

Great Lakes Commission des Grands Lacs