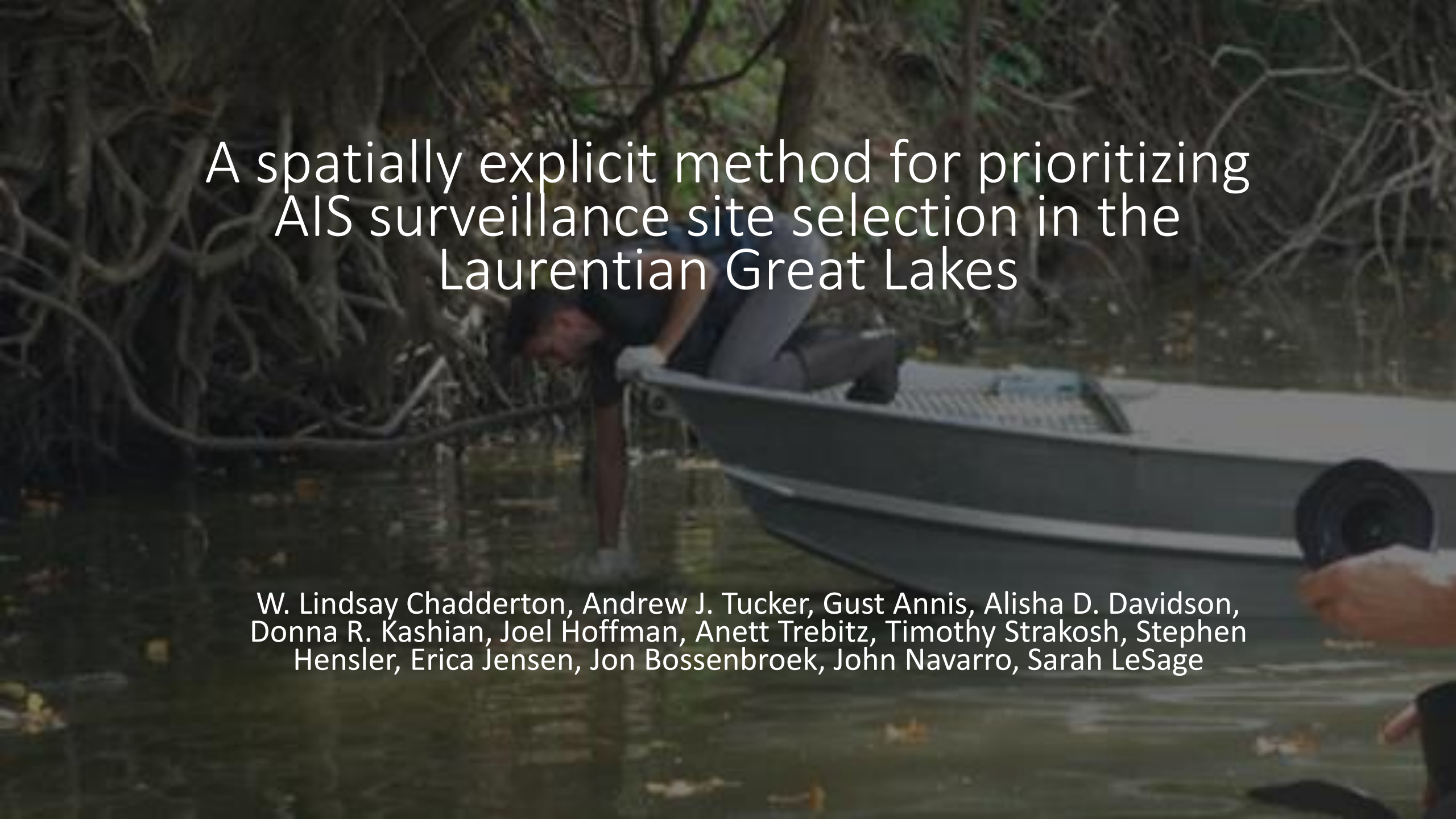

A spatially explicit method for prioritizing AIS surveillance site selection in the Laurentian Great Lakes

W. Lindsay Chadderton, Andrew J. Tucker, Gust Annis, Alisha D. Davidson, Donna R. Kashian, Joel Hoffman, Anett Trebitz, Timothy Strakosh, Stephen Hensler, Erica Jensen, Jon Bossenbroek, John Navarro, Sarah LeSage

Great Lakes Restoration Goals

GLRI Action plan

Establish a comprehensive framework for,

1) detecting and tracking invasive species in the U.S. waters of the Great Lakes, and
2) providing up to date information needed by decision makers for evaluating potential response actions.

Great Lakes Water Quality Agreement (GLWQA 2012) between Canada and the United States

Annex included provisions to develop and implement an early detection and rapid response initiative that:

(a) Develops species watch lists.

(b) Identifies priority locations for surveillance.

(c) Develops monitoring protocols for surveillance.

(d) Establishes protocols for sharing information

State and federal collaboration to develop a plan to guide future surveillance across the region.

- GLRI project – funded by USFWS – led by MDEQ
- Sarah Le Sage, Mike Hoff, Amy McGovern

<u>Science collaborators</u>

Andrew Tucker, Gust Annis, Joel Hoffman, Anette Trebitz, Tim Strakosh, Stephen Hensler, Donna Kashian, Alisha Davidson, Jon Bossenbroek,

Erica Jensen,

<u>Management collaborators</u>

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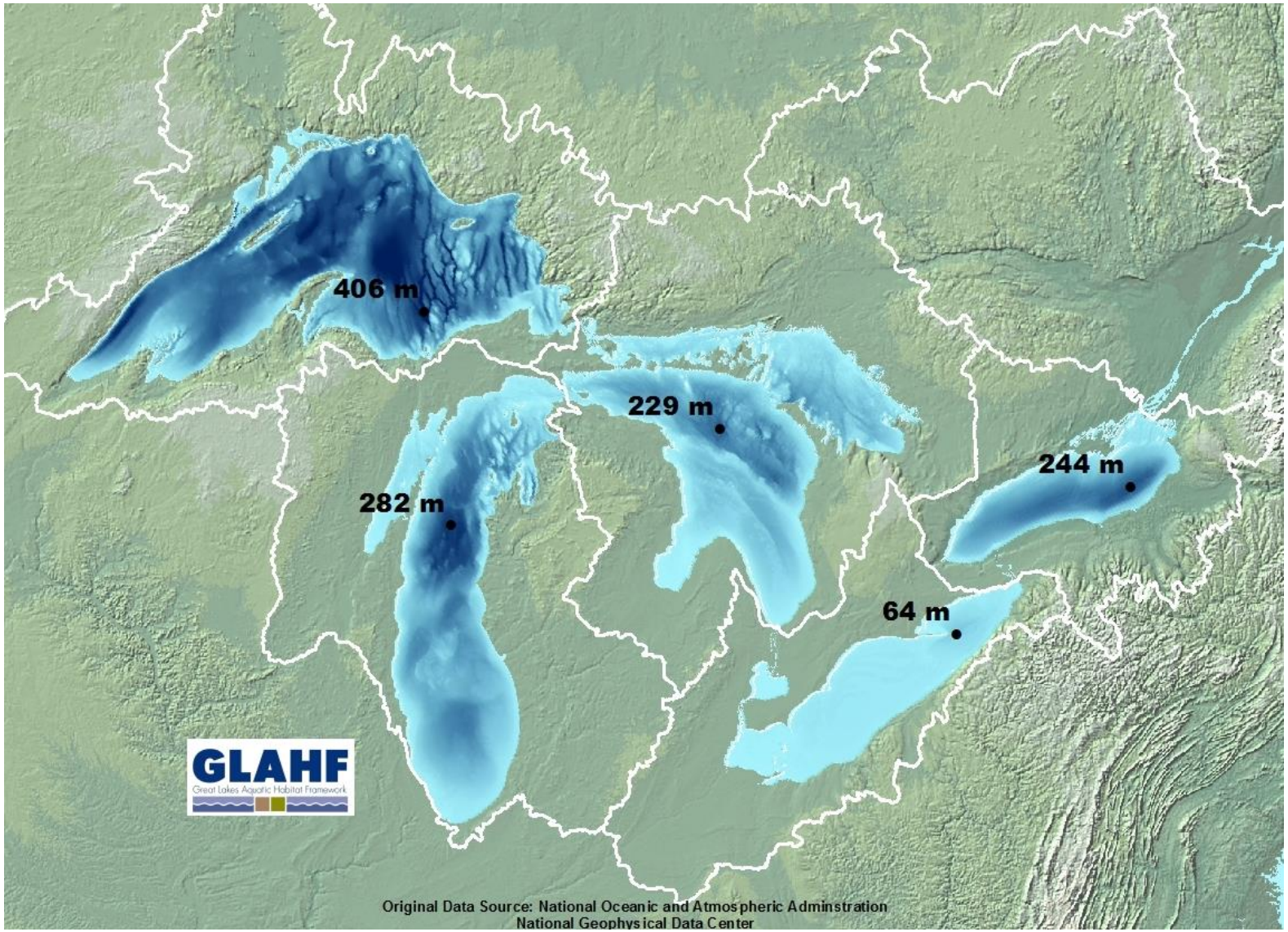
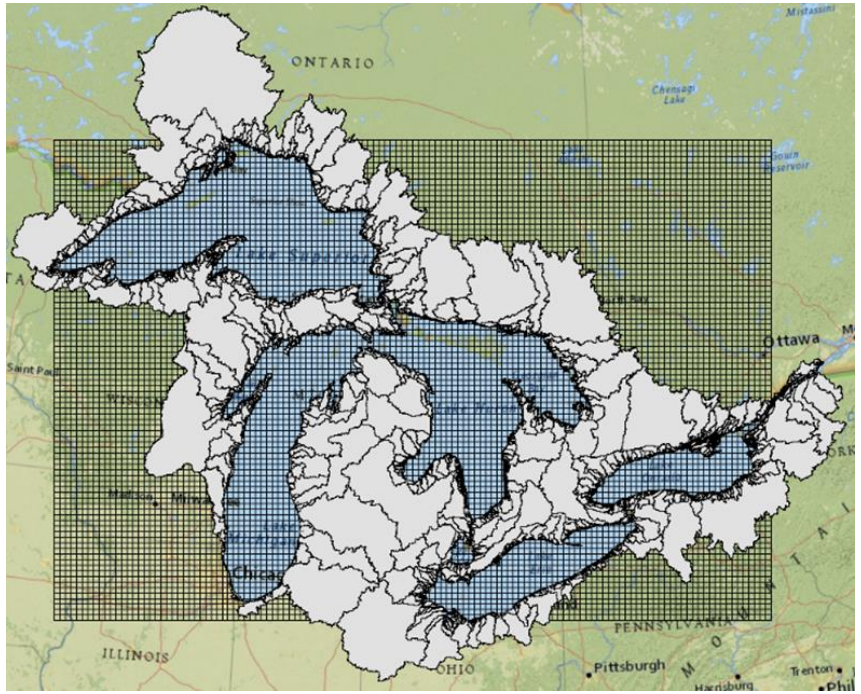
The North American Great Lakes



Site Prioritization System

- US waters of Great Lakes, connecting channels and tributaries up to first barrier
- Plants and animals (fish and invertebrates)
- Framework that allows sites across basin to be ranked on basis of invasion risk
- 9x9 km grid squares – using GLAHF framework
- 5,953 management units in the US waters,

GLAHF
Great Lakes Aquatic Habitat Framework



Surrogate variables as proxies for invasion pathways

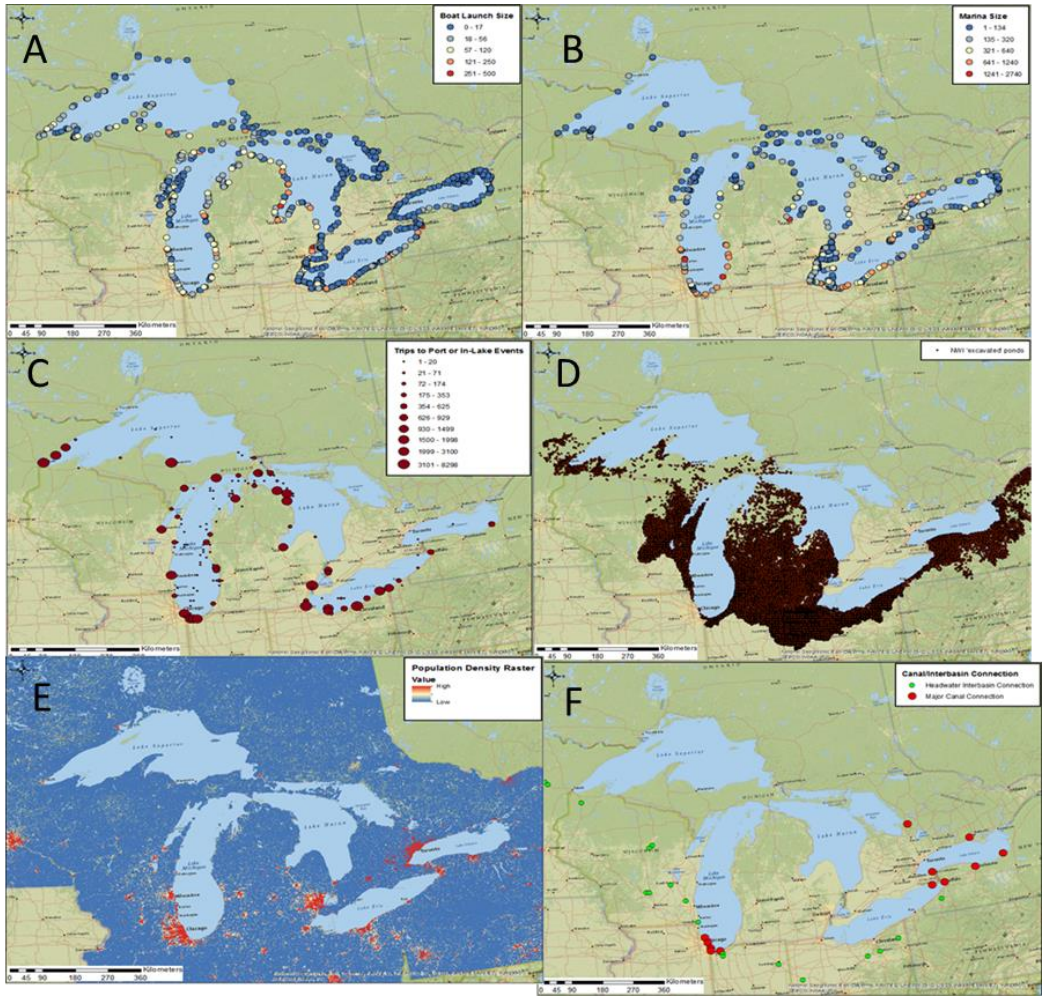
A. Marina size
B. Boat launch size
} ➢ Recreational boating,

C. Ship visits ➢ Ballast water, shipping

D. Excavated ponds ➢ Stocking, water gardens,

E. Population ➢ Live trades (aquarium live food etc)

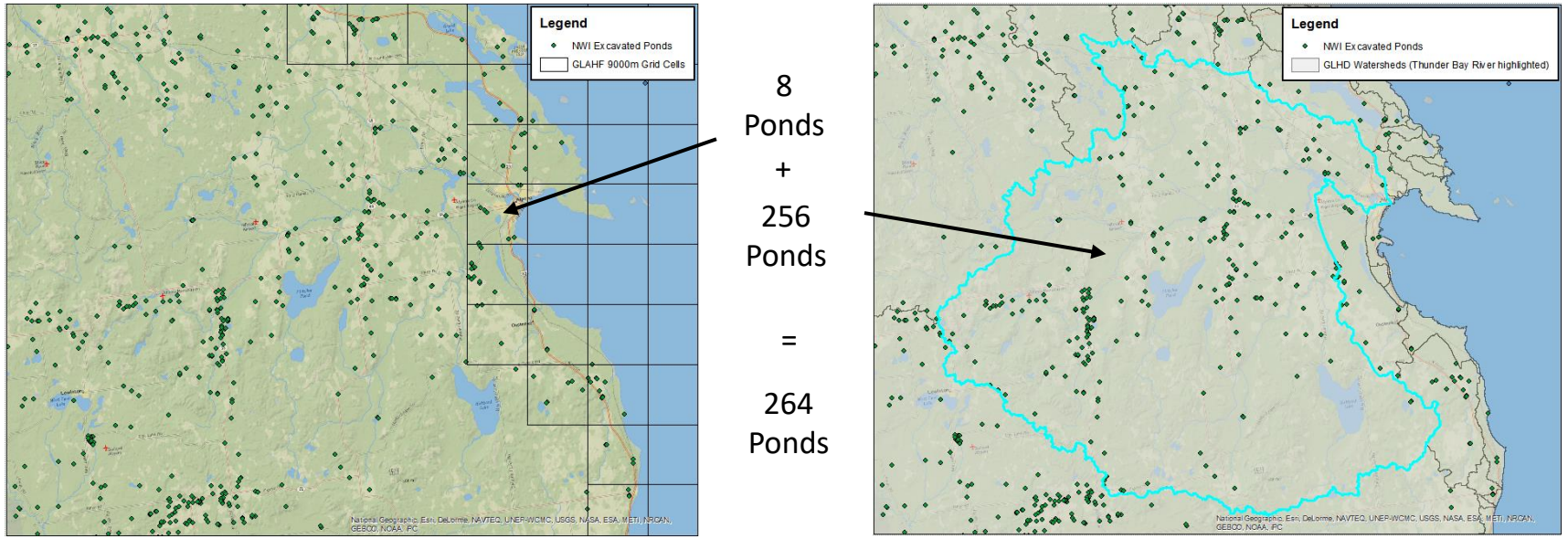
F. Canals ➢ Dispersal through artificial connections



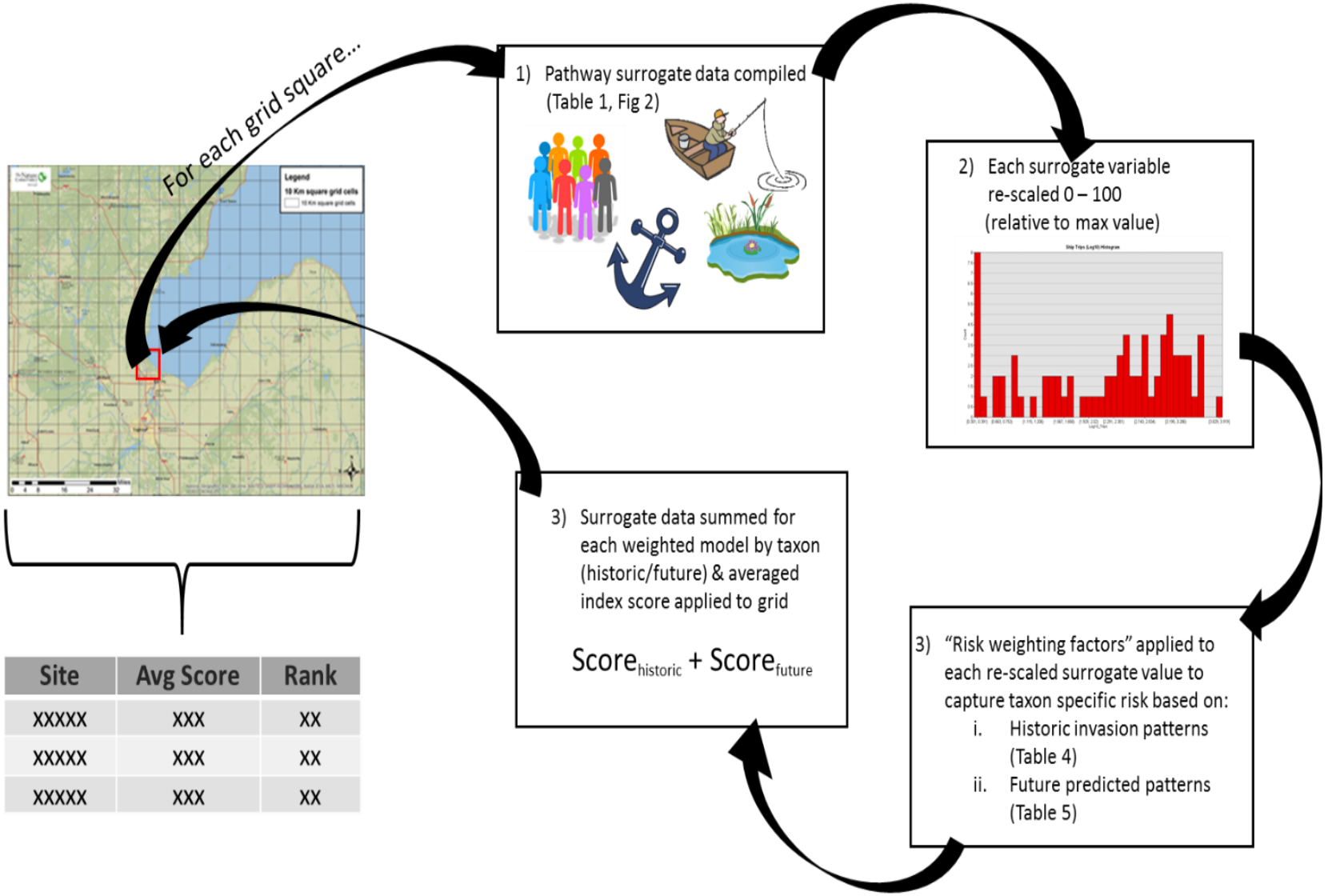
Data available across all US states
Standardized scale (0-100) - proportional to highest value
Attributed to each 9x9km grid square – (contributing catchment and grid square)
About 2,266 grid squares have attributes resulting in index scores greater than zero.

Quantifying Variables to Grid Cells

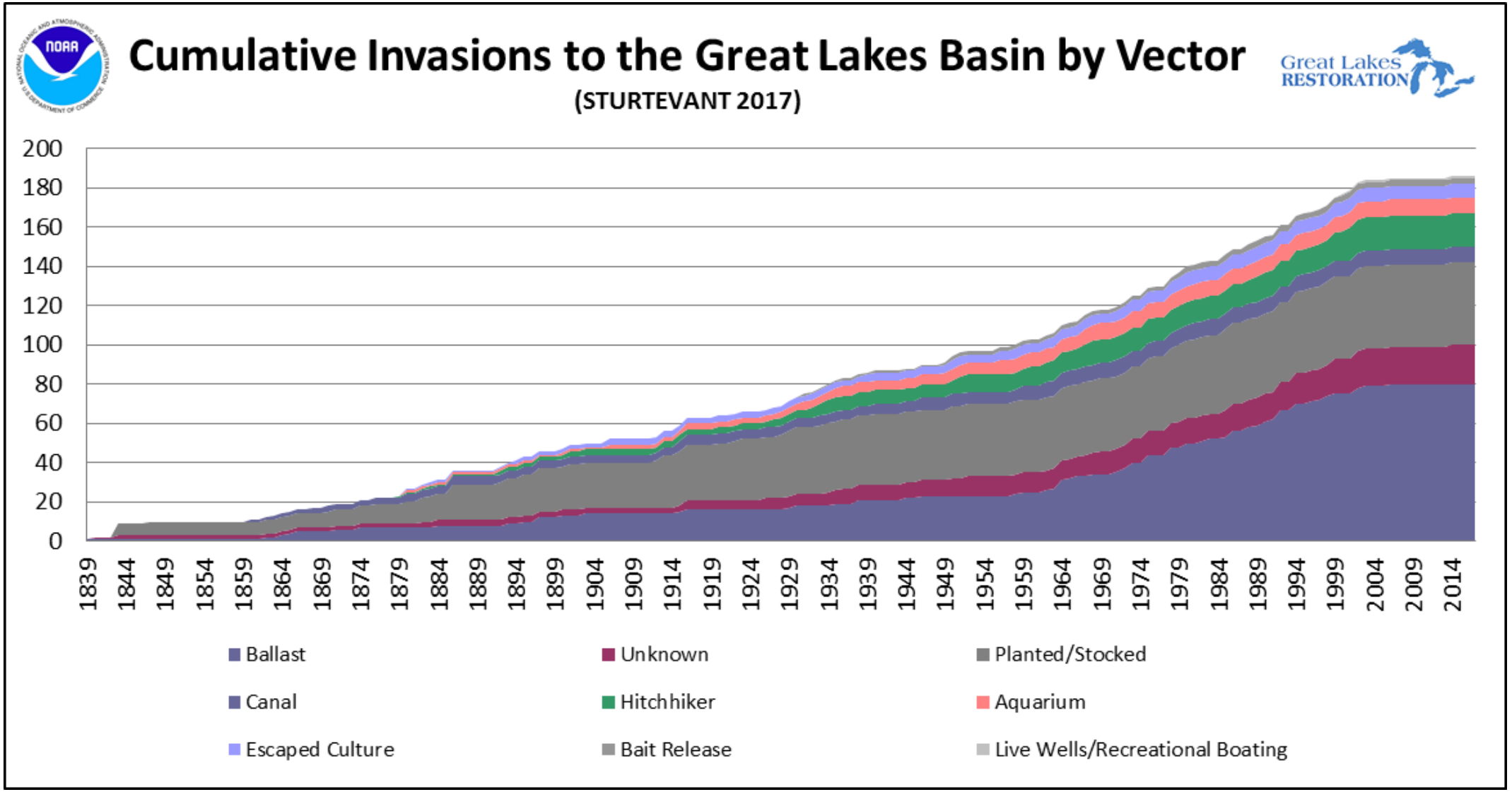
- Most variables quantified as amount in local grid cell
  - Pathway surrogates located along the coastline or in the lakes (not upstream)
- Population and ponds were quantified in the local grid cell and in the upstream drainage area of each tributary outlet



Site prioritization method



Historic patterns of invasion
Relative importance of invasion pathways change through time



Watch list
Predicted future invaders

Compiled data from existing studies

Species assessed met the following conditions:

1) a vector currently exists that could move the species into the Great Lakes,

2) the species is likely to tolerate/survive transport (including in resting stages) in the identified vector,

3) the species has a probability of being introduced multiple times or in large numbers,

4) the species is likely to be able to successfully reproduce in the Great Lakes, and

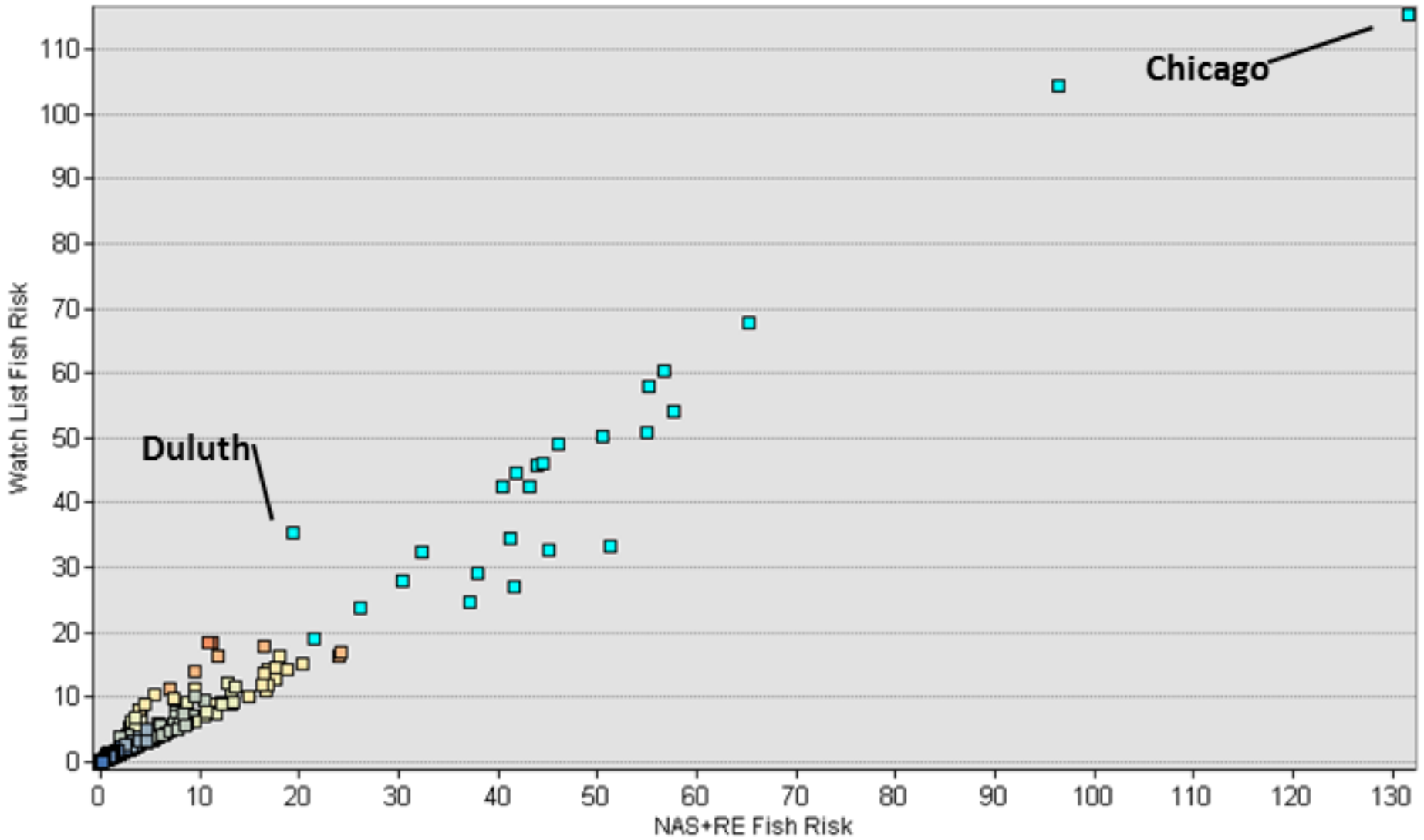
5) the species has been known to invade other areas; or the species was identified in one or more peer-reviewed scientific publications as having high probability for survival, establishment, and/or spread if introduced to the Great Lakes.

138 high to medium risk species identified

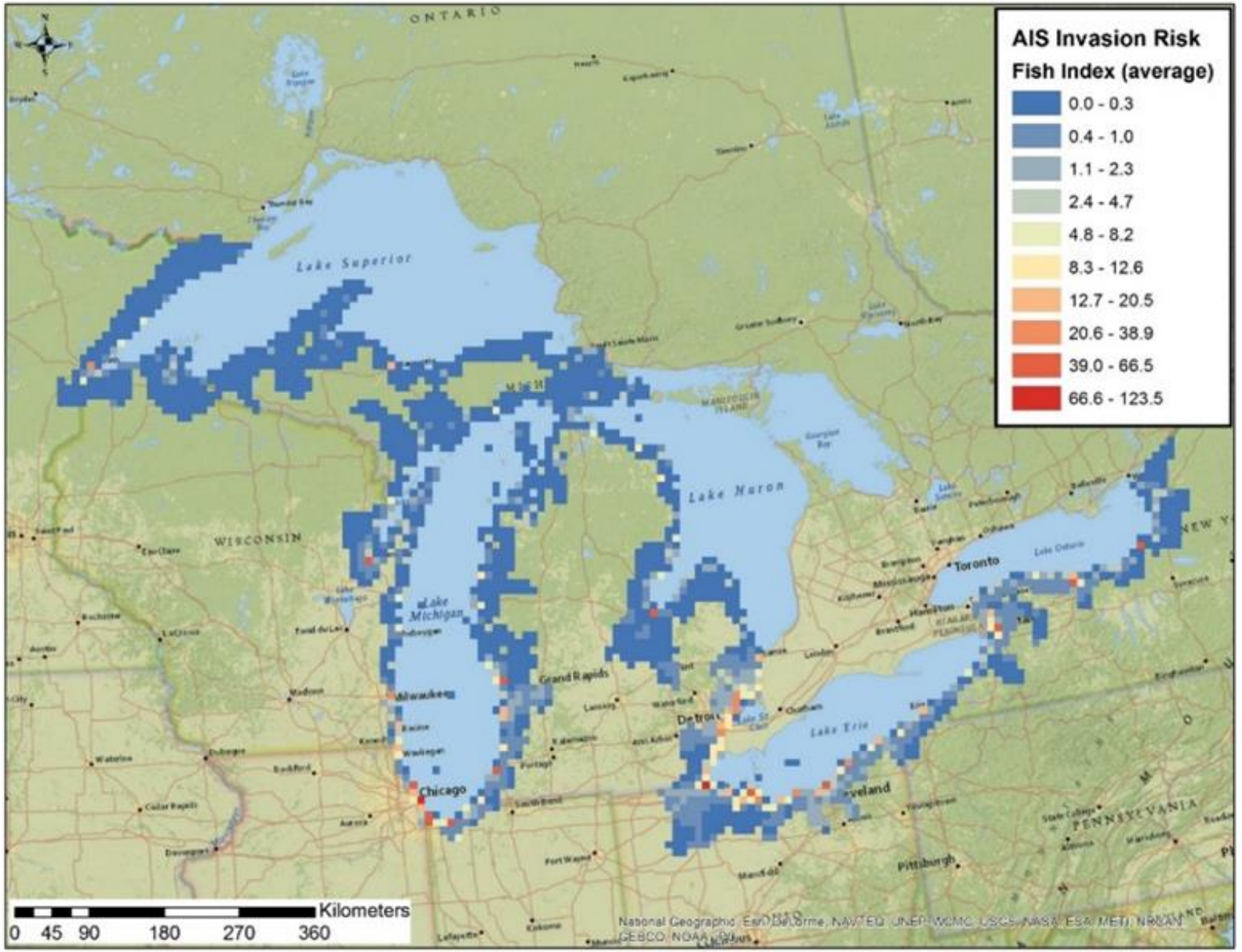
Assessed risk and pathways using GLANSIS method (Davidson et al. 2017).

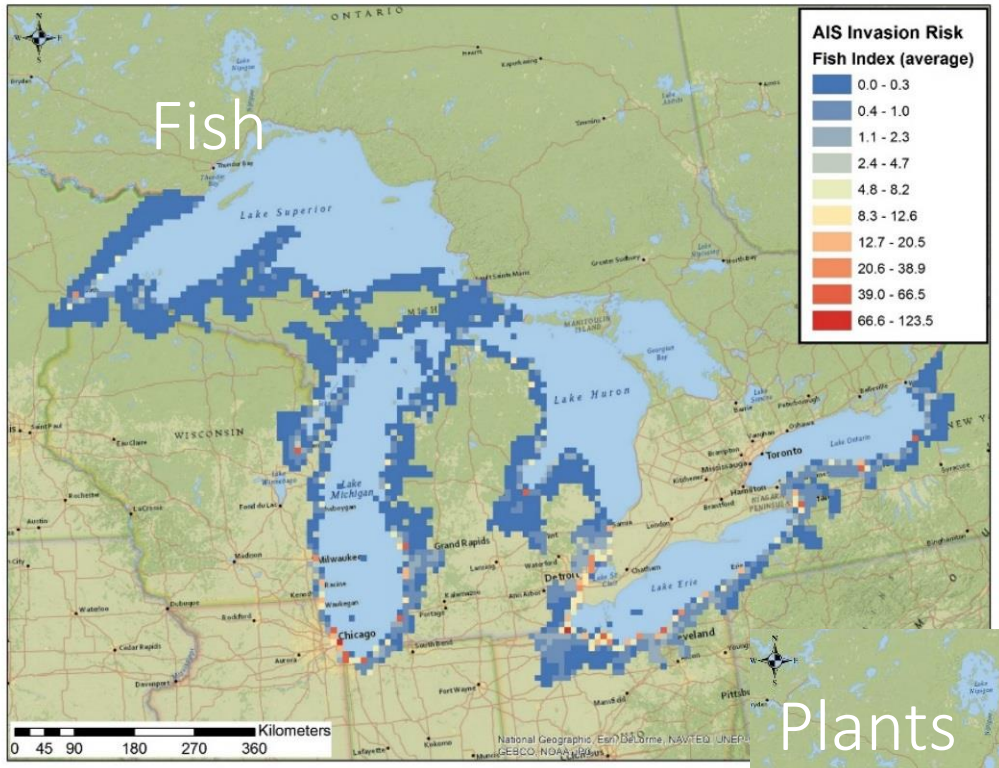
But see See Tucker et al – Thursday morning

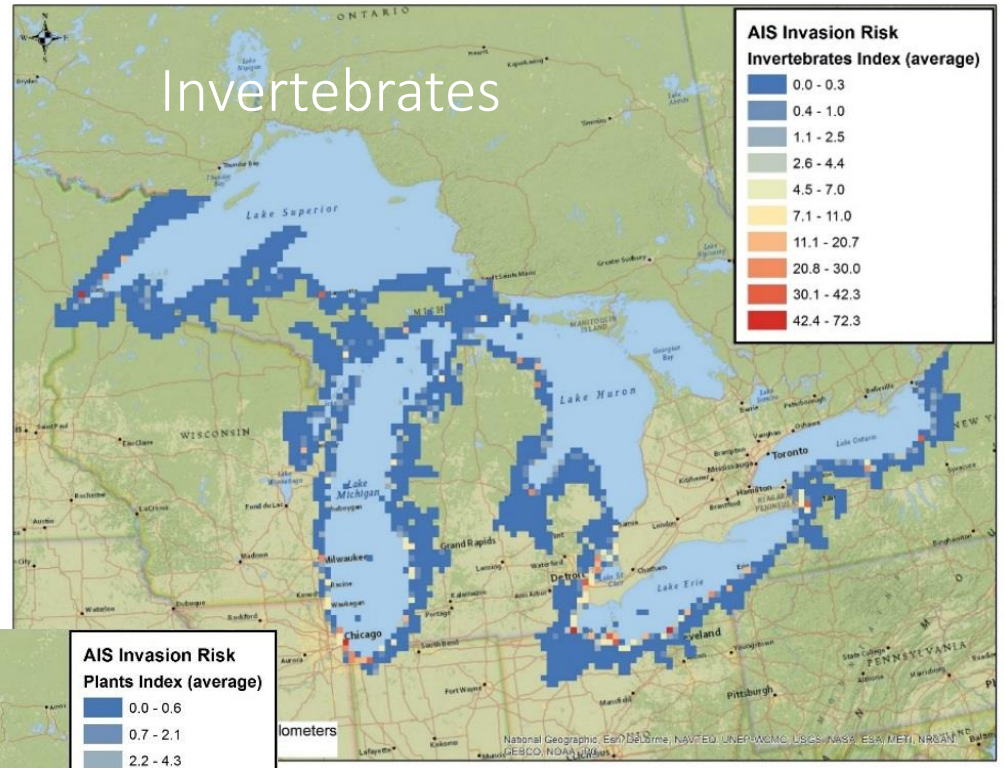
Comparison of Historic and Future invader models



Fish invasion risk model





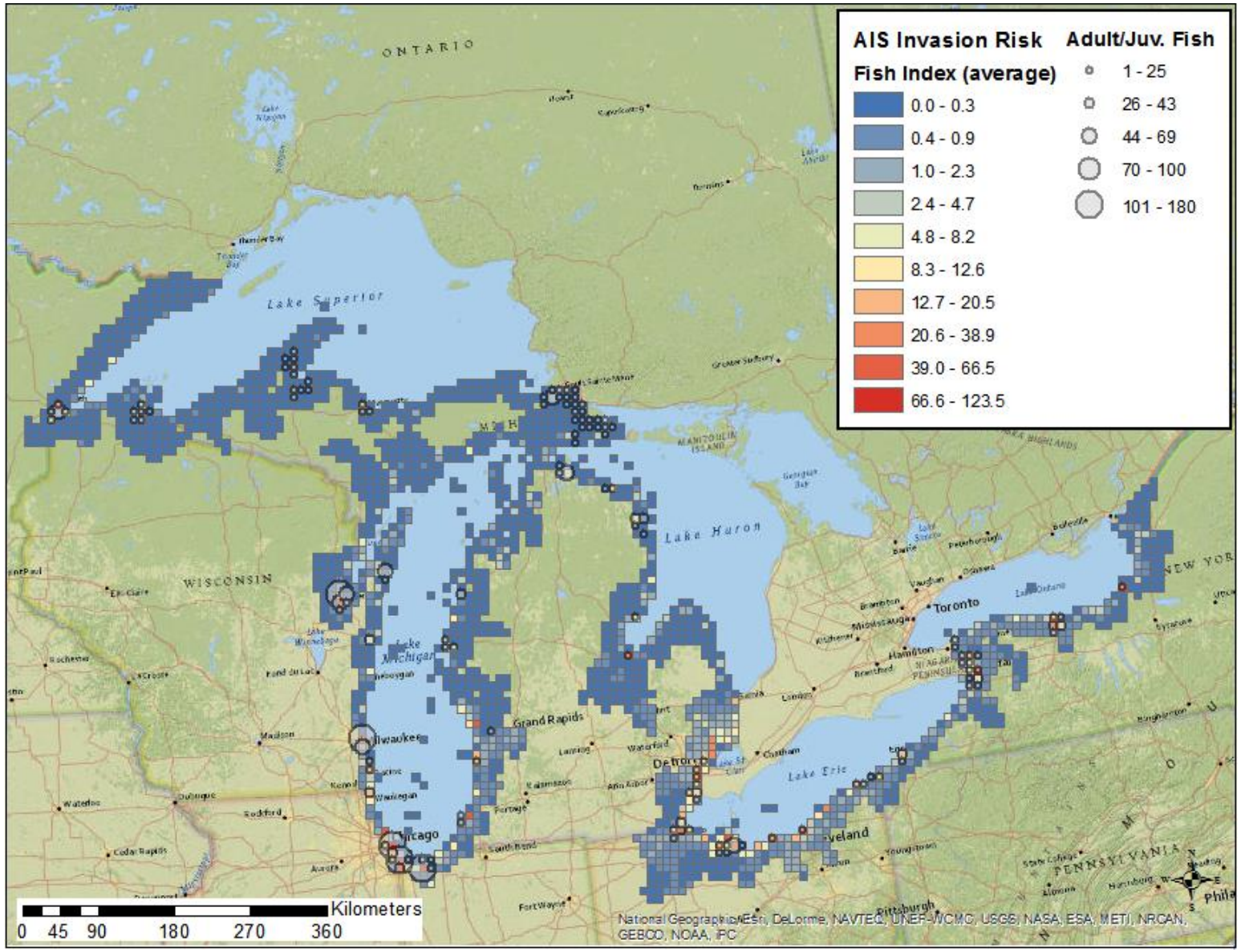


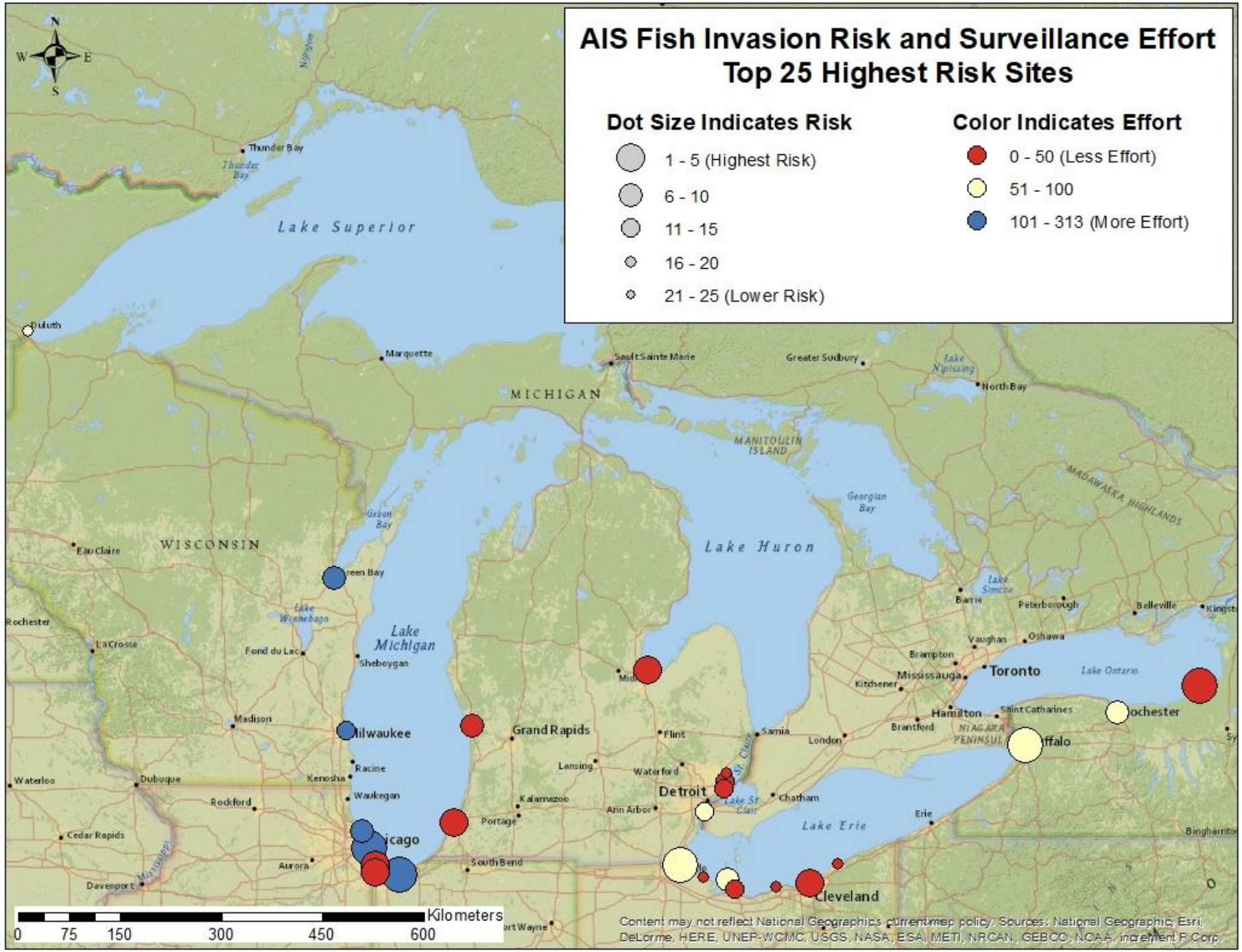
Separate models for major taxonomic groups recognizing different pathways and survey methods

Top ranked sites consistent across all three models

Lake Basin	Location Name	State	Ranks			
			Fish	Inverts	Plants	Average
Michigan	Chicago/Chicago River Mouth	IL	1	3	1	1.7
Erie	Toledo/Maumee River Mouth	OH	2	2	2	2.0
Ontario	Oswego/Oswego River Mouth	NY	3	9	8	6.7
Michigan	Portage/Portage-Burns Waterway	IN	4	5	12	7.0
Erie	Buffalo/Niagara River	NY	5	11	14	10.0
Huron	Saginaw Bay/Saginaw River Mouth	MI	6	15	4	8.3
Michigan	Benton Harbor/Saint Joseph River	MI	7	31	5	14.3
Michigan	Calumet River Mouth/Lake Michigan	IN	8	12	17	12.3
Erie	Cleveland/Cuyahoga River Mouth	OH	9	4	9	7.3
Michigan	East Chicago/Indiana Harbor Canal	IN	10	17	20	15.7

USFWS survey effort (Fish: 2015-16)



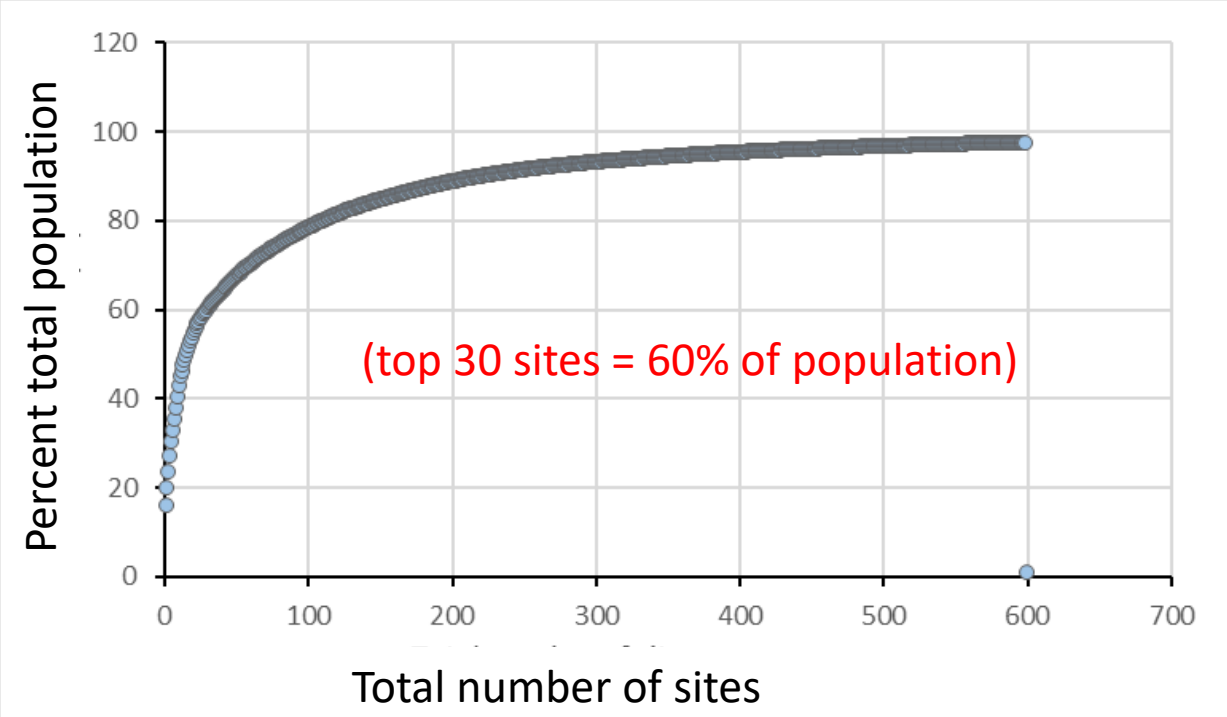

AIS Fish Invasion Risk and Surveillance Effort
Top 25 Highest Risk Sites
Dot Size Indicates Risk
1 - 5 (Highest Risk)
6 - 10
11 - 15
16 - 20
21 - 25 (Lower Risk)
Color Indicates Effort
0 - 50 (Less Effort)
51 - 100
101 - 313 (More Effort)
N
W
E
S
Lake Superior
Thunder Bay
Duluth
Marquette
Sault Sainte Marie
Greater Sudbury
North Bay
MICHIGAN
MANITOULIN ISLAND
Georgian Bay
MADAWASKA HIGHLANDS
WISCONSIN
Green Bay
Eau Claire
Lake Huron
Lake Michigan
Lake Winnebago
Fond du Lac
Sheboygan
Madison
Milwaukee
Grand Rapids
Flint
Lansing
Waterford
Detroit
Lake St Clair
Chatham
Ann Arbor
Kalamazoo
Portage
Racine
Kenosha
Waukegan
Rockford
Dubuque
Waterloo
Cedar Rapids
Aurora
South Bend
Davenport
Lake Erie
Erie
Cleveland
Samia
London
Brantford
Hamilton
Toronto
Mississauga
Brampton
Vaughan
Oshawa
Barrie
Peterborough
Belleville
Lake Simcoe
Lake Ontario
St. Catharines
NIAGARA PENINSULA
Rochester
Binghamton
Kilometers
0 75 150 300 450 600
Content may not reflect National Geographics current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Aquatic plants

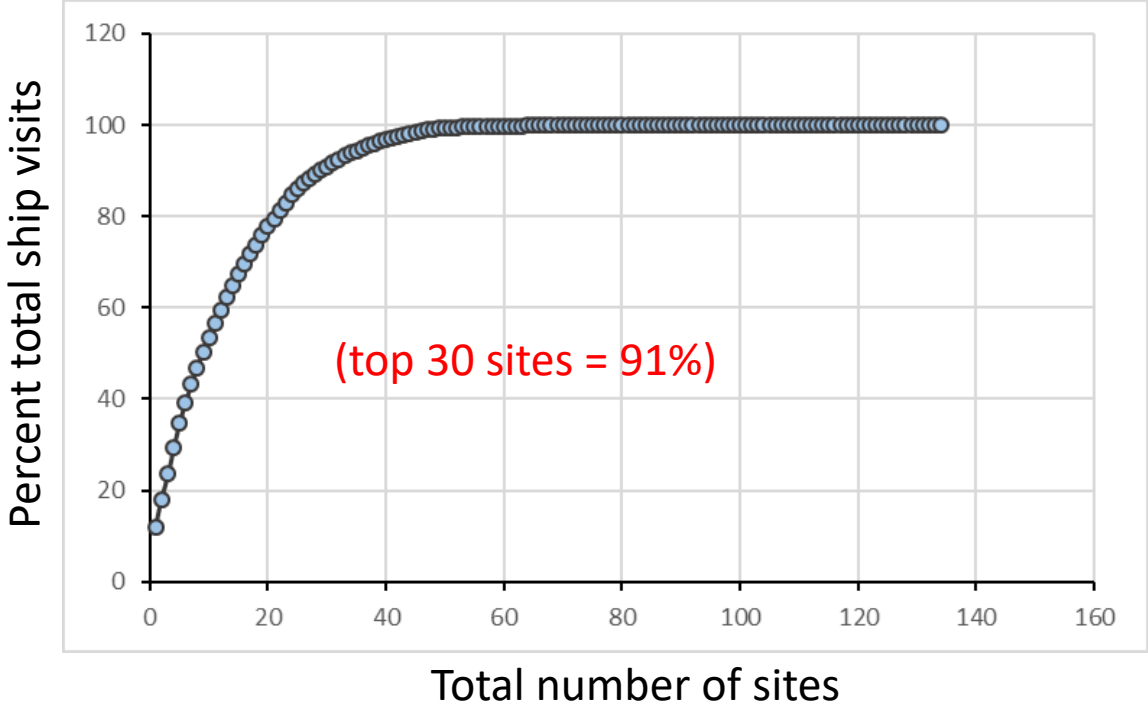
- Major gap in surveillance effort
- Six high risk sites selected from model
- Three sites surveyed this year
- Use to develop and refine survey protocols

How many sites?
What is an acceptable level of risk or optimal sampling effort?

Population – (live trades)



Ship visits



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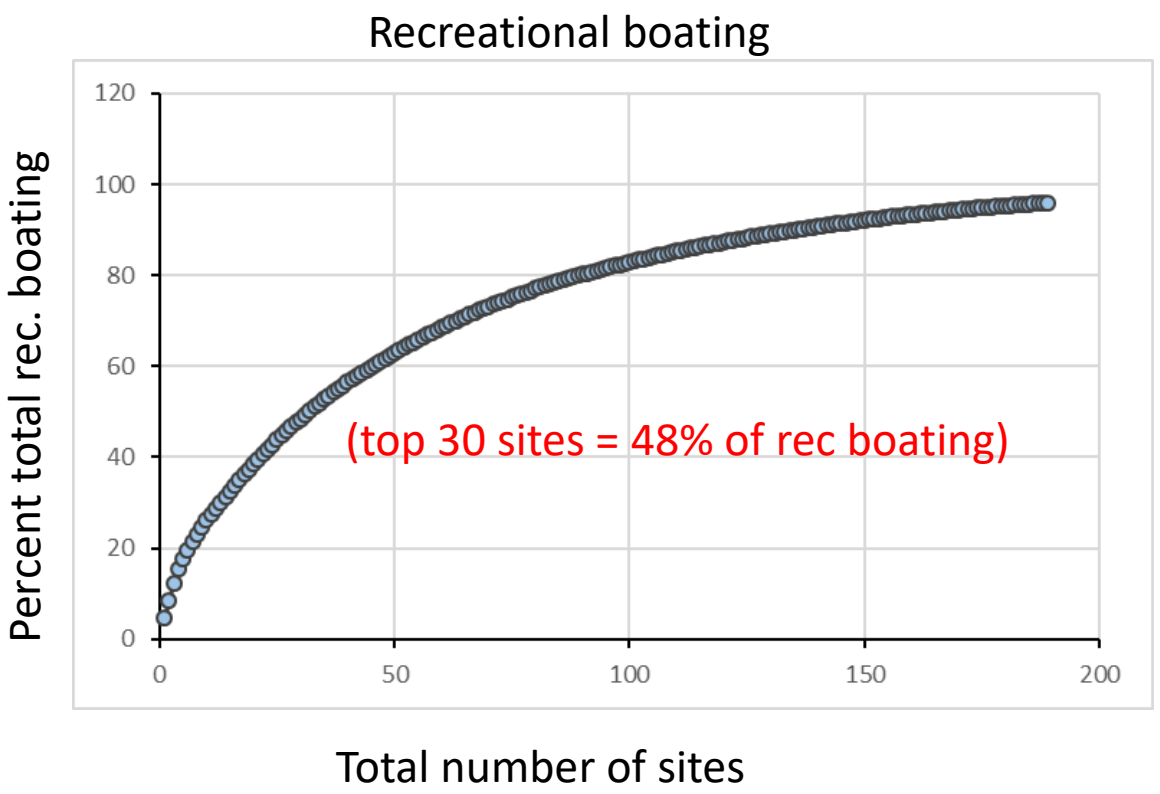
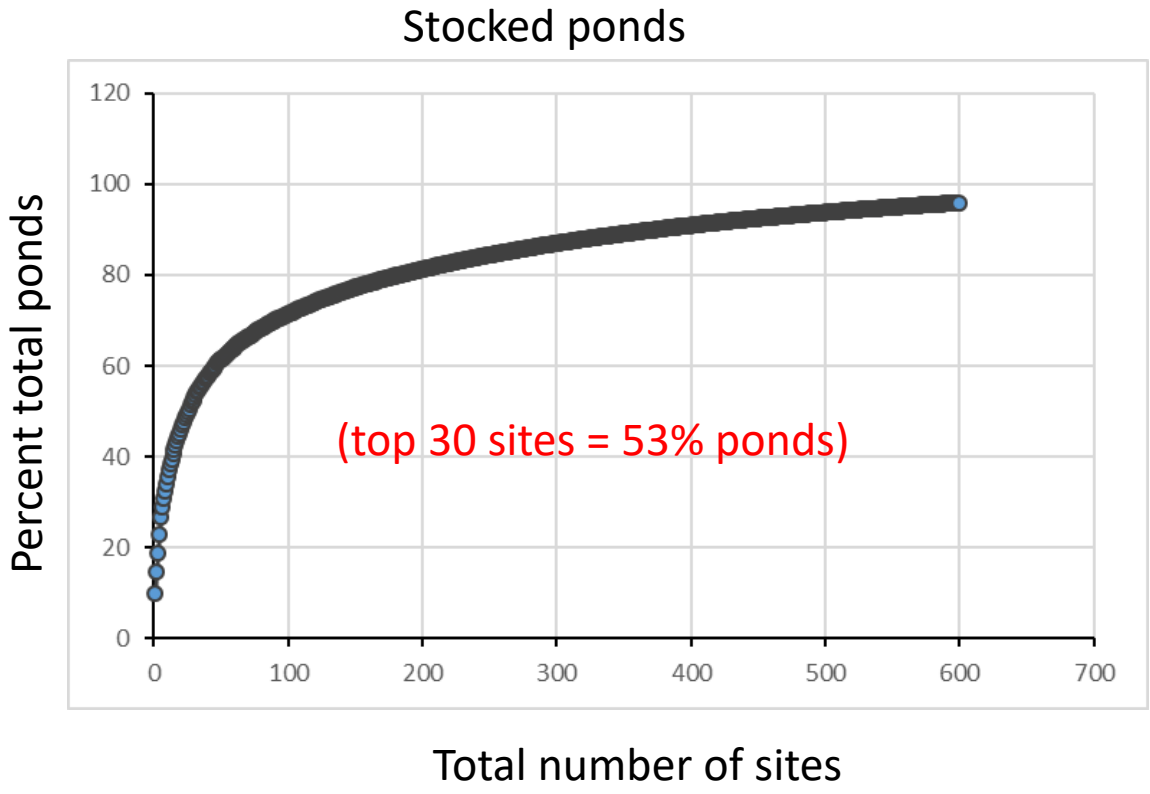
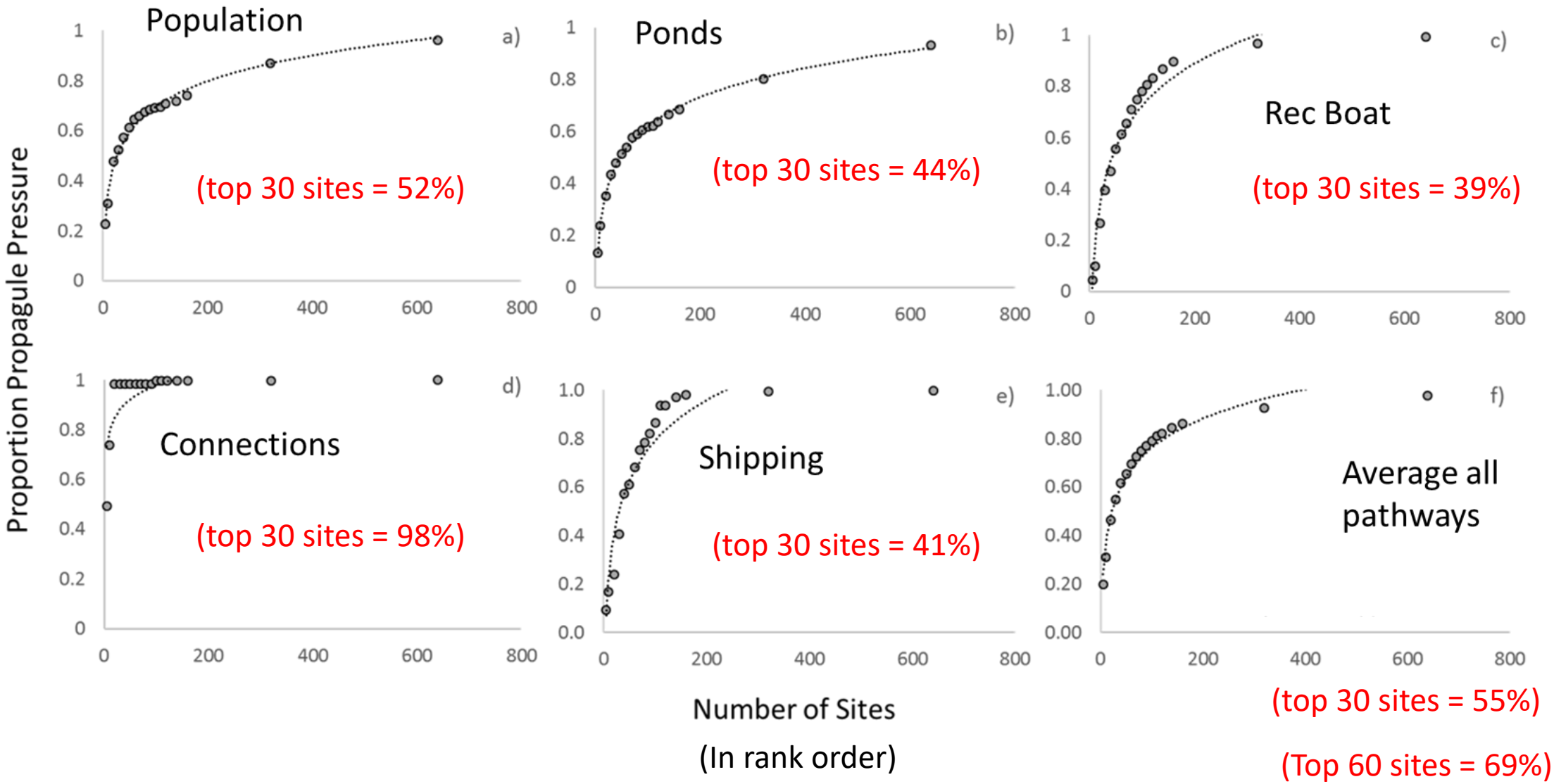
What is an acceptable level of risk or optimal sampling effort?





Cumulative propagule pressure (Fish model)



Conclusions and next steps

- Objective systematic site prioritization system – helping to identify priority sampling locations
- Strong agreement between priorities and USFWS past surveillance efforts
- Provide ability to objectively quantify optimal resource needs

Next steps

- Optimizing sampling effort – how much is enough
- How often is enough
- Refine models – as data on distribution of NAS improve
- Incorporate site vulnerability and suitability
- Replicate in Canadian waters

Acknowledgements

- GLRI project – funded by USFWS – led by MDEQ
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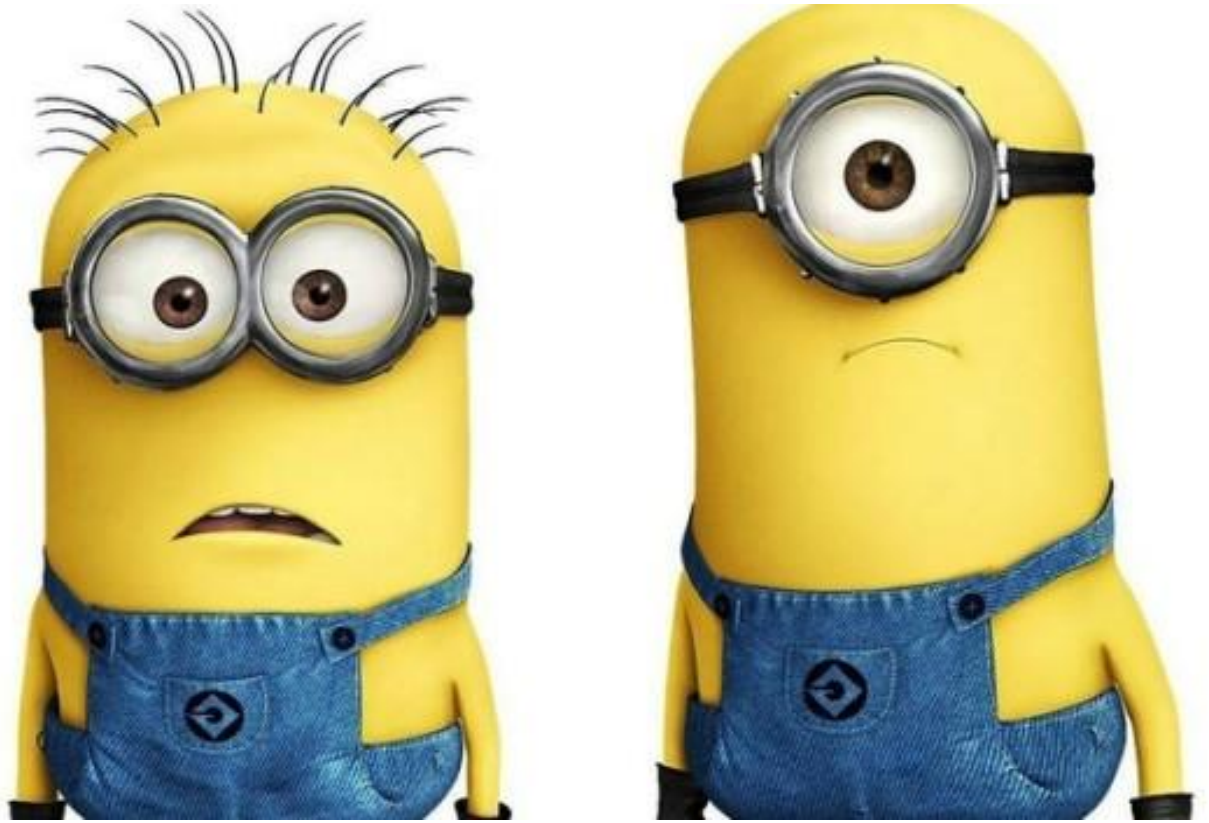
The end



Questions?

Average of two models

Historic patterns of invasion (NAS) and predicted future patterns of invasion (watchlist)

Spatial surrogates		**Fish**	
	Pathways	**NAS**	**Watchlist**
U.S. Population (2013)	Aquarium release	**0.68**	**0.57**
	Pet release		
	Stocked		
	Planted		
Shipping vessel trips to port (2004–2013)	Shipping	0.16	0.33
Marina size (# of boat slips)	Recreational boats	0.51	0.33
Boat launch size (# of parking spaces)	Bait release		
Ponds	Aquaculture	**0.61**	**0.67**
	Planted		
	Stocked		
Canals	Canals	0.4	0.43

How much is enough – optimal sampling effort (site number)

top	popn	ponds	rec boat	connections	ships	AVG	
5	0.30152007	0.26591323	0.17511457	0.61500615	0.34853017	0.34	0.29
10	0.42755902	0.3564542	0.2610727	0.99753998	0.53467468	0.52	0.43
20	0.54517405	0.46077665	0.3853136	1	0.77817408	0.63	0.59
30	0.60269736	0.53096947	0.48498	1	0.90976816	0.71	0.64
40	0.64044576	0.57875201	0.56452527	1	0.96801473	0.75	0.67
50	0.67449521	0.61417783	0.63044323	1	0.99361445	0.78	0.70
60	0.70251507	0.6419068	0.68503344	1	0.99818788	0.81	
70	0.72657637	0.66392608	0.73163188	1	0.99897889	0.82	
80	0.74753541	0.6419068	0.68503344	1	0.99818788	0.81	
90	0.76648771	0.70002142	0.80242425	1	0.9993672	0.85	
100	0.7837363	0.71425281	0.82899062	1	0.99951102	0.87	
110	0.79928381	0.72786288	0.85315218	1	0.99965484	0.88	
120	0.81353407	0.74059454	0.87358909	1	0.99979865	0.89	
140	0.83657984	0.76293519	0.90773429	1	1	0.90	
160	0.85566851	0.7816015	0.93378245	1	1	0.91	
320	0.93615303	0.8786181	0.99923888	1	1	0.96	
640	0.97790577	0.96530798	1	1	1	0.99	

USFWS Surveillance Locations (2015-2016)

Adult/Juv. Fish,