

Assessing the Risk of Asian Carp Presence in the Chicago Area Waterway System (CAWS)

A Probabilistic Interpretation of eDNA Monitoring Results

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International Conference on Aquatic Invasive Species (ICAIS)

Winnipeg, Manitoba

April 10-14, 2015



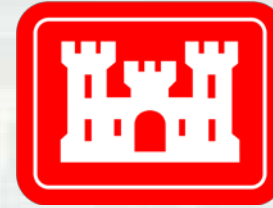
US Army Corps of Engineers®

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Acknowledgements



Environmental DNA Calibration Study

- Interagency collaboration: USACE, USGS, USFWS
- US EPA Great Lakes Restoration Initiative (GLRI)
- Asian Carp Regional Coordinating Committee (ACRCC)
- US Army Corps of Engineers (USACE) Chicago District.

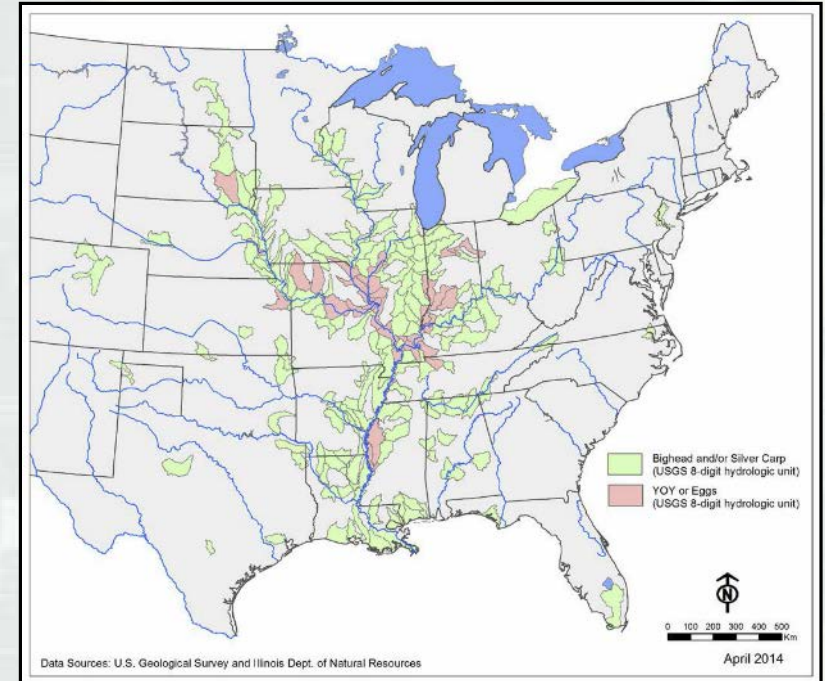
Final report available on the ACRCC website:

- ▶ http://www.asiancarp.us/documents/FINAL_REPORT-ALL_ACRCC_Framework_Item_2.6.3.Probabilistic_Model_120314.pdf.



Asian Carp

- Bighead carp
 - *Hypophthalmichthys nobilis*
- Silver carp
 - *Hypophthalmichthys molitrix*
- Invasive species
- Established in Mississippi & Missouri River Basins.
- Out-compete native fish
 - Efficient filter feeders, plankton
 - Undermine food webs



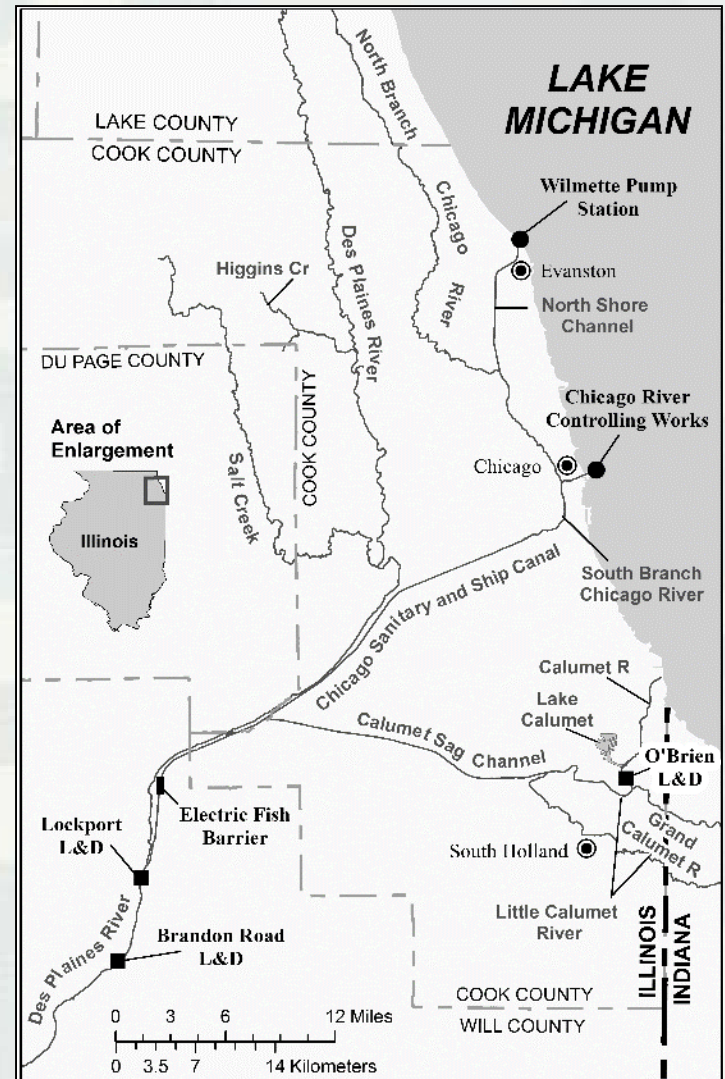
Baerwaldt, K., A. Benson, and K. Irons. 2013. Asian Carp Distribution in North America. Report to the Asian Carp Regional Coordinating Committee, April 2013. (updated April 2014)

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Asian Carp & the CAWS

- Illinois River Basin
 - Highest population density in world.
 - Adult population front at Brandon Road Lock & Dam.
 - Potential access to Lake Michigan *via* the CAWS.
- Electric fish barrier
 - Blocks access to Lake Michigan.
 - Operated by USACE.
 - ~ 35 miles from Lake Michigan.



There are two forms of Asian carp surveillance.

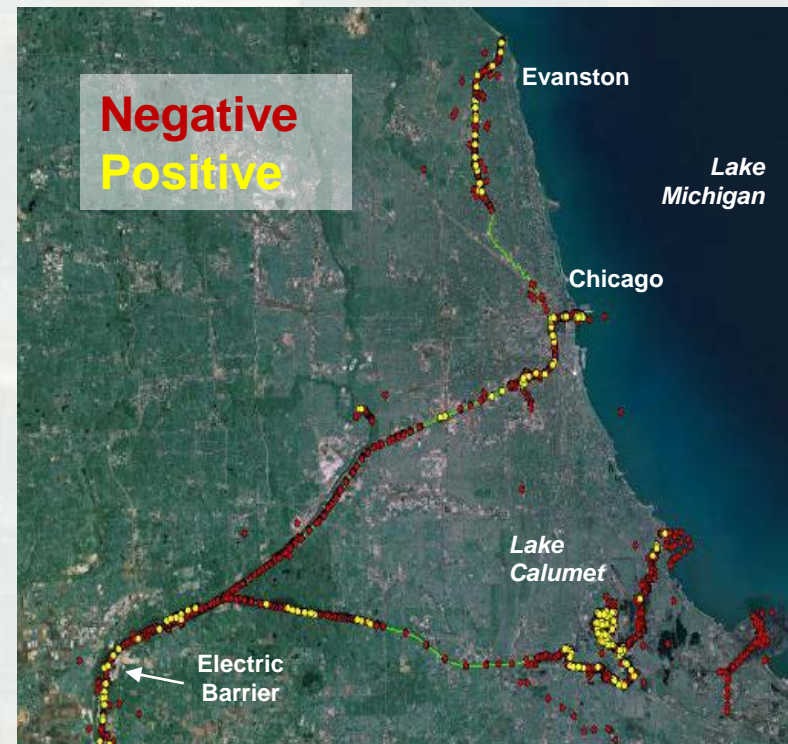
- Conventional fish sampling
 - Effort (2010-14): 19,388 man hours
 - Electrofishing: 769.4 hours
 - Gill/trammel net: 524 km
 - Catch: 1 bighead (6/2010), 0 silver carp
- Environmental DNA (eDNA)
 - DNA found in environmental samples.
 - 5,500 two-liter water samples (2009-12).



eDNA is detected in water samples using polymerase chain reaction (PCR).

- PCR is positive or negative.
 - No concentrations
- Detection rates (2009 – 2012)
 - Bighead carp: 43 / 5,522 (< 1%).
 - Silver carp: 236 / 5,503 (4.3%).
- Positive water samples
 - Detections widely distributed over space and time.

Silver carp eDNA samples

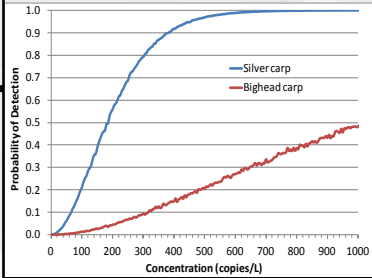


Three factors confound interpretation and these are the focus of this study.

1. Quantity of eDNA is unknown.
 - Quantify the amount of eDNA in the system.
2. Sources of eDNA other than live fish identified.
 - Birds, boats and barges, CSOs, fishing nets, sediment and inflows from Lake Michigan.
 - Characterize primary & secondary sources of eDNA in CAWS.
3. Results of Asian carp surveillance are in conflict.
 - Develop a Bayesian network for probabilistic inference.



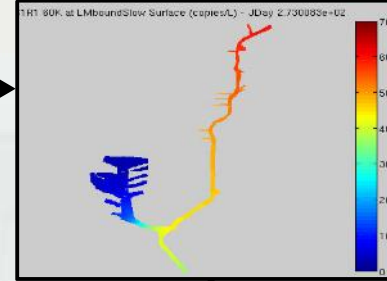
Probability of eDNA detection using PCR



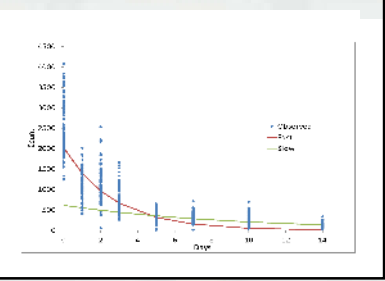
Secondary Sources



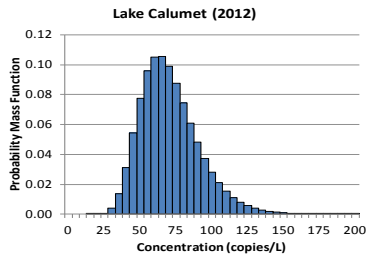
Fate & Transport Model for CAWS



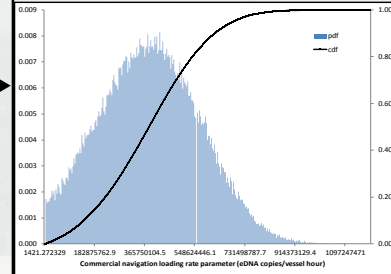
eDNA Kinetics & Shedding Rates



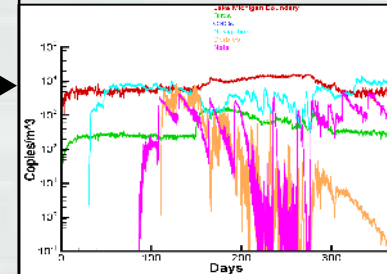
Infer eDNA Concentration



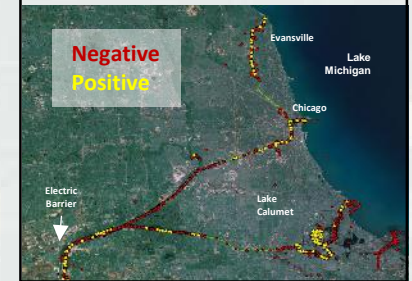
Estimate Loading Rates



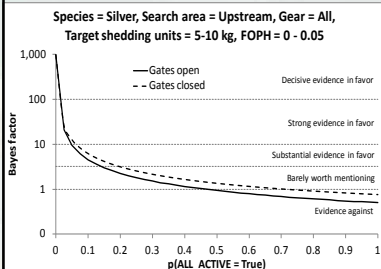
F&T Model Production Days Runs



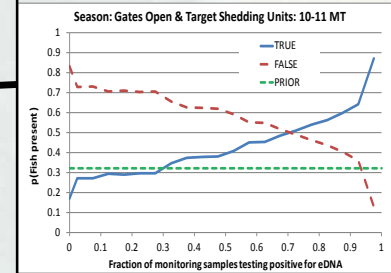
eDNA Monitoring & Fishing Effort



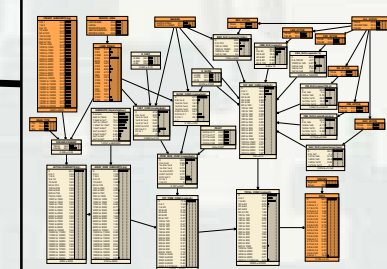
Sensitivity Analysis



Statistical Inference



Bayesian Network Model



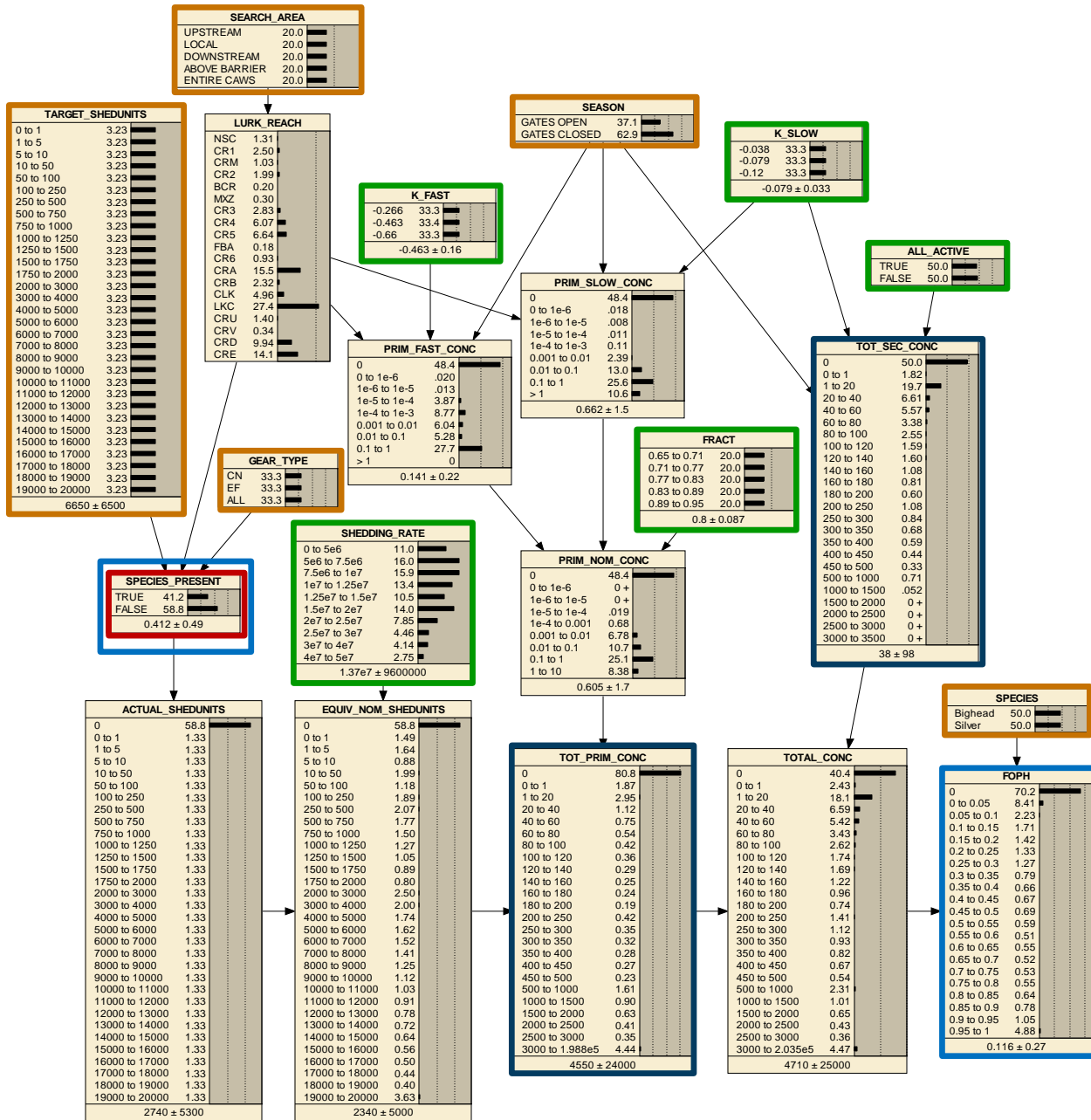
Ambiguity about eDNA source is resolved probabilistically.

- Bayesian inference: Prior probability is updated to a posterior probability after evidence is observed.

$$p(\theta | e) = \frac{p(e | \theta)p(\theta)}{\sum_{\Theta} p(e | \theta)p(\theta)}$$

- Hypothesis, θ : Target species is present.
- Evidence, e :
 - Conventional sampling effort
 - Fraction of water samples testing positive for eDNA



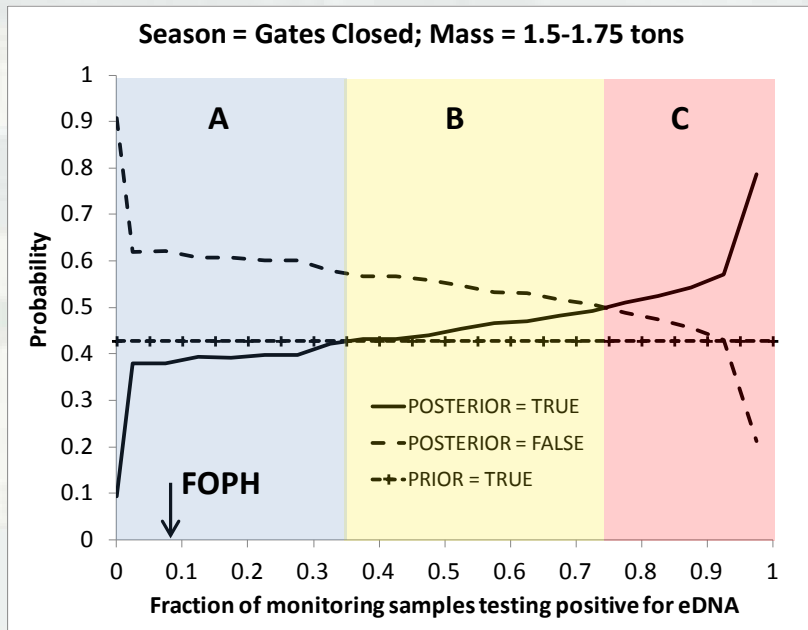


- **Hypothesis**
 - Species present
- **Evidence**
 - Fishing effort
 - eDNA positive rate
- **Conditionals**
 - Target species
 - Hydrologic season
 - Search area
 - Shedding units
 - Gear type
- **Variables**
 - Shedding rate
 - Degradation rate
 - Fraction fast
 - All active
- **Hydrodynamic simulation**



Inference is accomplished using a two-stage updating process.

1. Uniform prior probability on target species presence.
2. Apply conventional fishing effort.
3. Apply fraction of positive water samples.



Influence of eDNA Evidence

A: Reduces probability.

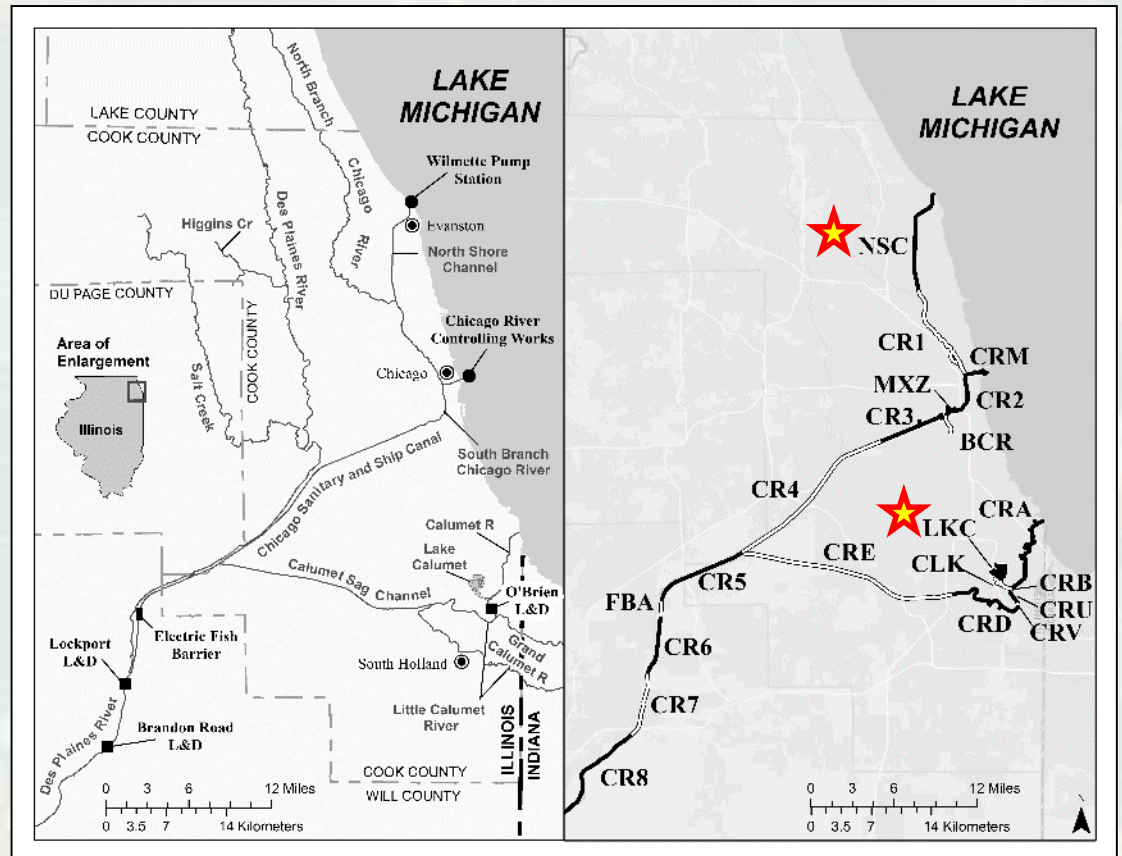
B: Increases probability, species less likely to be present.

C: Increases probability, species more likely to be present.



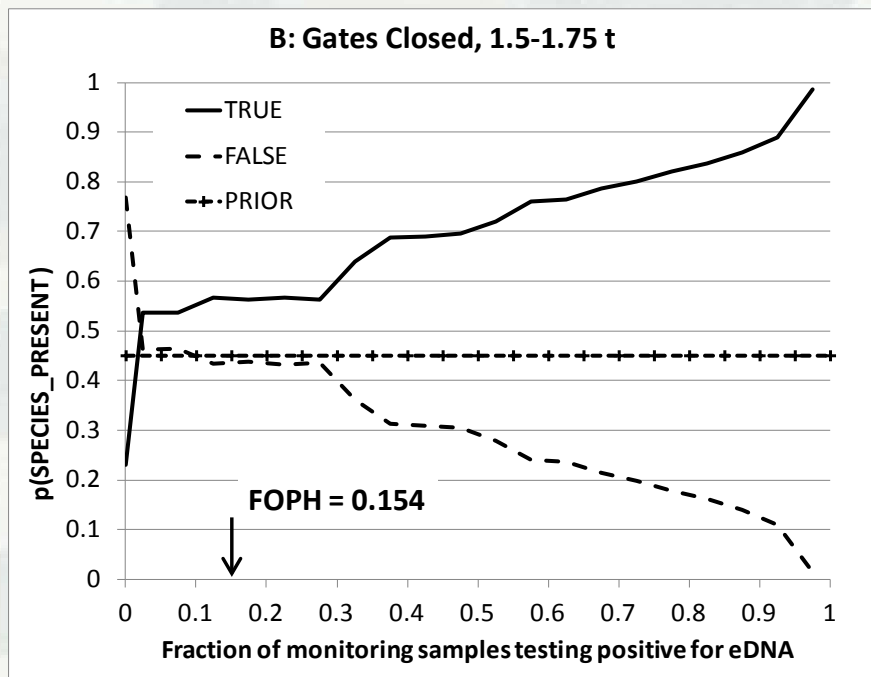
Results: Lake Calumet (LKC) & North Shore Channel (NSC)

Silver carp

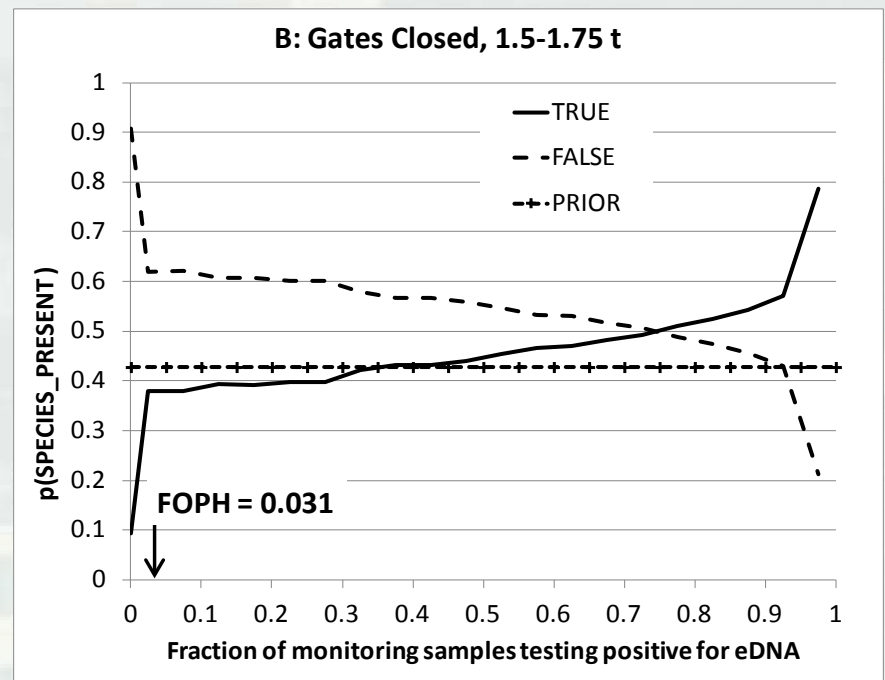


Silver Carp, 1.5-1.75 tons Gates Closed (Oct. 15 – June 1)

Lake Calumet (LKC)



North Shore Channel (NSC)



Conclusions



- Detection of eDNA by itself is not enough - consider hydrology, hydrodynamics, season, secondary sources, fishing effort, target mass.
- eDNA monitoring can be more useful in some places than others.
- Detection of eDNA can increase or decrease the probability of target species presence.
- If live fish were the only explanation for eDNA, there would be 4 - 6 tons of silver carp distributed throughout the CAWS.
- Aim has been to improve quality of interpretation & expand the types of information available from eDNA monitoring results.

