Analyzing Asian Carp Spawning Location and Timing using Coupled Hydrodynamics and Egg Transport Modeling

Mina Shahed Behrouz, Zhenduo Zhu  
*University at Buffalo, SUNY*

David Soong, *USGS-ILIAWSC*

Tatiana Garcia, *Optimatics*

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Introduction

What is the issue of Asian Carp?!
Background

Diameter increases

Spawning grounds

Eggs drifting

Flow

Swim vertically

Hatching

Gas bladder inflation

Larvae leave the current looking for habitat
Methodology

The FluEgg Model

Biology + Hydrodynamics + Lagrangian particle tracking model

- Development of fluvial egg drift simulator to evaluate the transport and dispersion of Asian carp eggs in rivers, Garcia, T., Jackson, P. R., Murphy, E.A., Valocchi, A.J., Ecological Modeling 263 (2013) 211-222.
FluEgg Graphical User Interface
Research Objectives

Unsteady hydrodynamics
HEC-RAS

Inverse particle tracking

Asian Carp Spawning Grounds Estimated by Egg Transport Analysis and Egg Sampling
Inverse tracking → Sampling → Data Analysis → HEC-RAS

FluEgg

Probability of Spawning Location
Lagrangian Particle Tracking Algorithm

Forward Lagrangian particle tracking:

1. Longitudinal movement:
   \[ X_{t+\Delta t} = X_t + u\Delta t + R\sqrt{2K_H\Delta t} \]

2. Lateral movement:
   \[ Y_{t+\Delta t} = Y_t + v\Delta t + R\sqrt{2K_H\Delta t} \]

3. Vertical movement:
   \[ Z_{t+\Delta t} = Z_t + (w + V_s)\Delta t + K'_V(Z_t)\Delta t + R\sqrt{2K_V(Z_t + \frac{1}{2}K'_V(Z_t)\Delta t)\Delta t} \]

Reverse Lagrangian particle tracking:

1. Longitudinal movement:
   \[ X_{t-\Delta t} = X_t - u\Delta t + R\sqrt{2K_H\Delta t} \]

2. Lateral movement:
   \[ Y_{t-\Delta t} = Y_t - v\Delta t + R\sqrt{2K_H\Delta t} \]

3. Vertical movement:
   \[ Z_{t-\Delta t} = Z_t + (w + V_s)\Delta t + K'_V(Z_t)\Delta t + R\sqrt{2K_V(Z_t + \frac{1}{2}K'_V(Z_t)\Delta t)\Delta t} \]
Calibrated HEC-RAS model of Illinois Waterway

**Length:** 292 mi (470 km)
Illinois Natural History Survey (INHS)

2015 egg sampling data

<table>
<thead>
<tr>
<th>Egg collection location</th>
<th>Egg sampling time</th>
<th>Egg stage</th>
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Bongo net - photo by Holly Embke
University of Toledo

EXPLANATION

- Lock and Dam
- INHS Egg sampling sites
Where are the spawning grounds?
Probability distribution of the “mean” spawning location of each egg
Result of one sampling location

Probability of spawning location of eggs collected at Havana on 6/10 – 6/11

Probability of spawning location of eggs collected at Havana on 6/17 – 6/18
Future Work

Where would they hatch?

Under which hydraulic condition do they spawn?

Can we develop a spawning suitability index?
Thank you