STATUS OF GRASS CARP SPAWNING IN LAKE ERIE TRIBUTARIES AND IMPLICATIONS FOR MANAGEMENT

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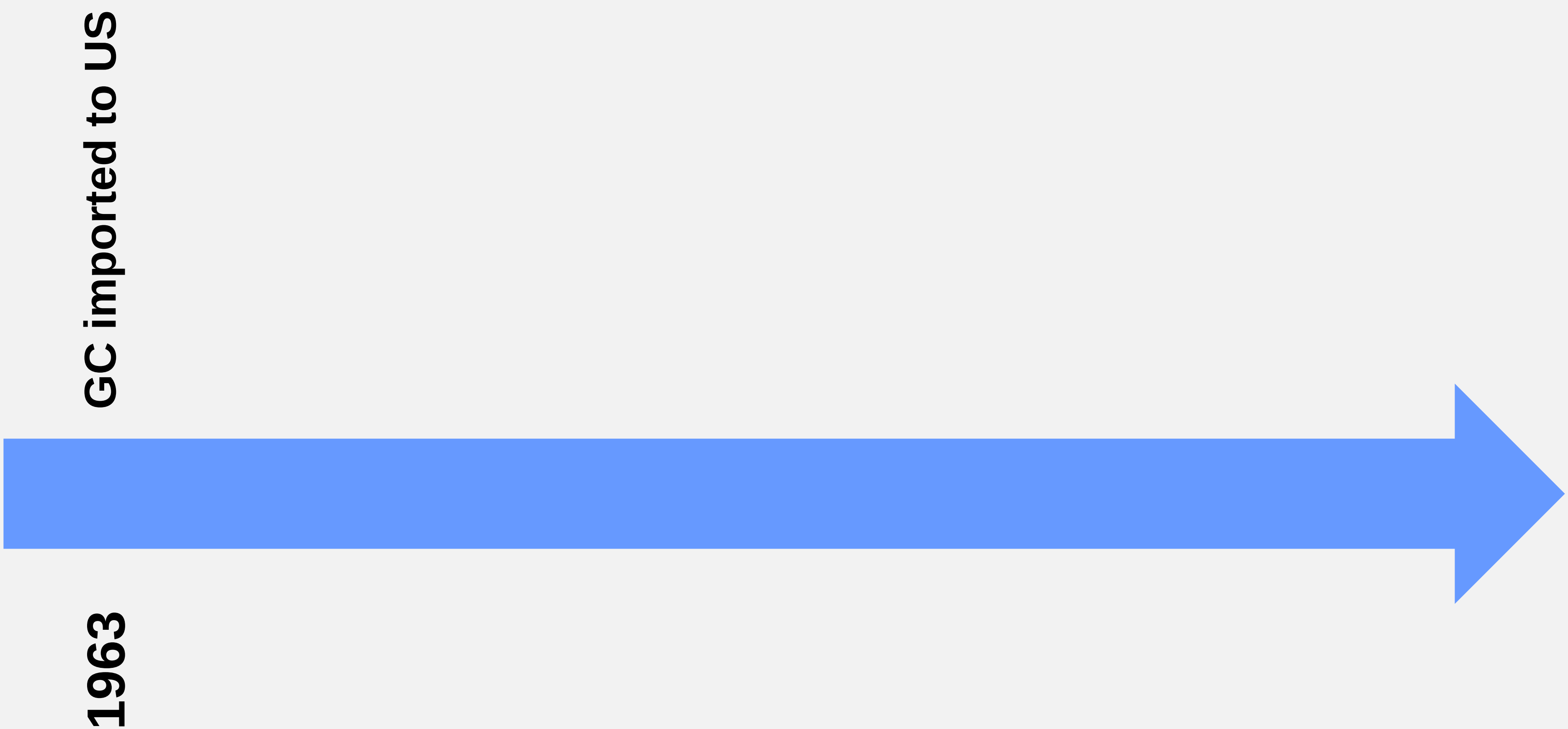
Photo: mdc.mo.gov

IMPACTS OF GRASS CARP

- Consume large amounts of aquatic vegetation
  - 20-100% of body weight per day
- Damage wetland ecosystems
  - Impacts on native fish species, invertebrates, waterfowl
  - May promote algal blooms
- Similar spawning requirements to other 'Asian Carp' species

World record : 92lbs

Timeline of grass carp in Lake Erie



Timeline of grass carp in Lake Erie

GC imported to US

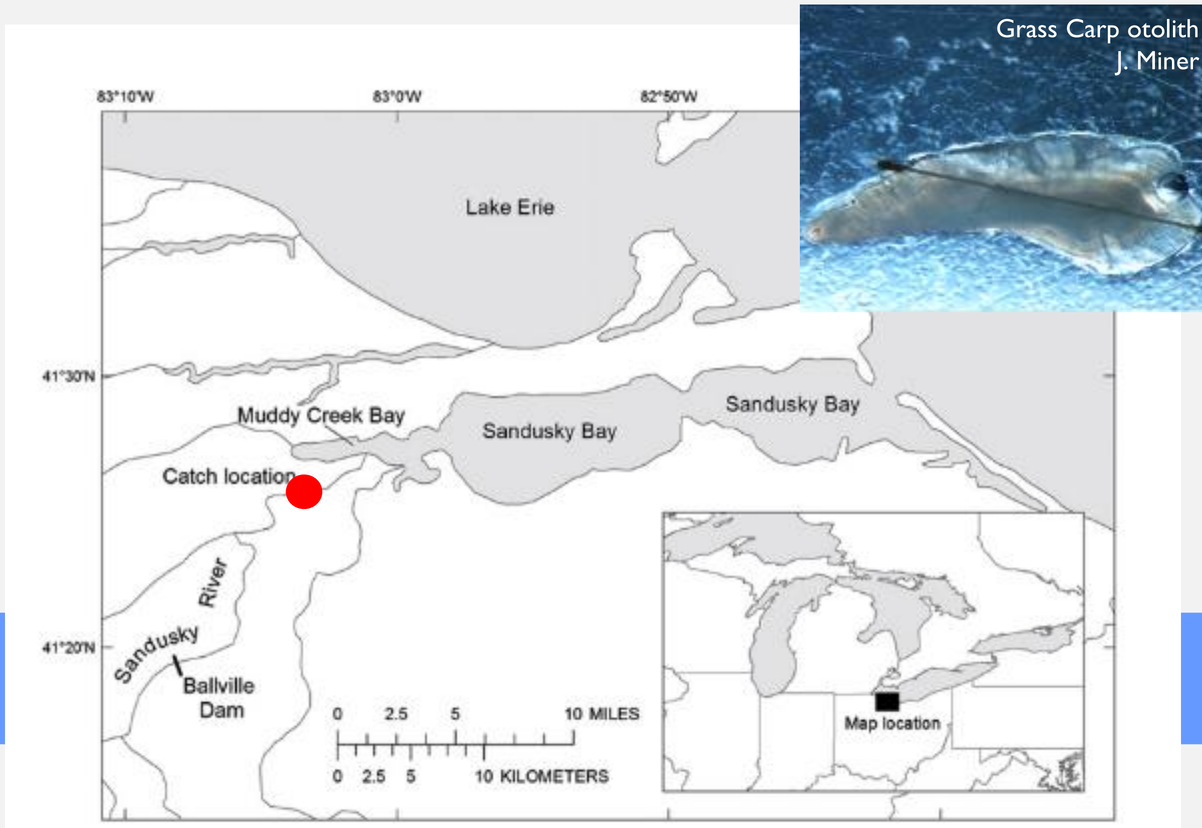
Triploid process

1963

1983

Timeline of grass carp in Lake Erie

Timeline of grass carp in Lake Erie



10 juv GC likely from Sandusky River

196

198

198

2012

Timeline of grass carp in Lake Erie

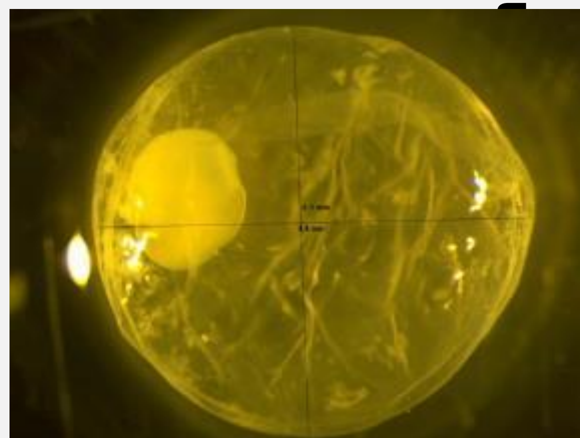
UT STUDENT DISCOVERS FIRST GRASS CARP EGGS IN GREAT LAKES TRIBUTARY

A graduate student at The University of Toledo is the first researcher to find direct proof of grass carp, a type of invasive Asian carp, spawning in a Great Lakes tributary.

Holly Embke collected eight grass carp eggs last summer in the Sandusky River, which flows into Lake Erie. She discovered the eggs between Fremont, Ohio, and Lake Erie's Sandusky Bay after a period of heavy rains.

The fish eggs, which were confirmed through DNA testing, mark the first direct evidence of the invasive species reproducing in the Great Lakes basin. Embke's paper is published in the Journal of Great Lakes Research. Embke also will present her work at the annual conference of the International Association for Great Lakes Research Thursday, June 9, at the University of Guelph in Ontario, Canada.

This research was conducted as a follow-up to U.S. Geological Survey findings in 2013 that indicated four young grass carp taken from the Sandusky River were the result of natural reproduction.



Spawning confirmed
Sandusky River

1963

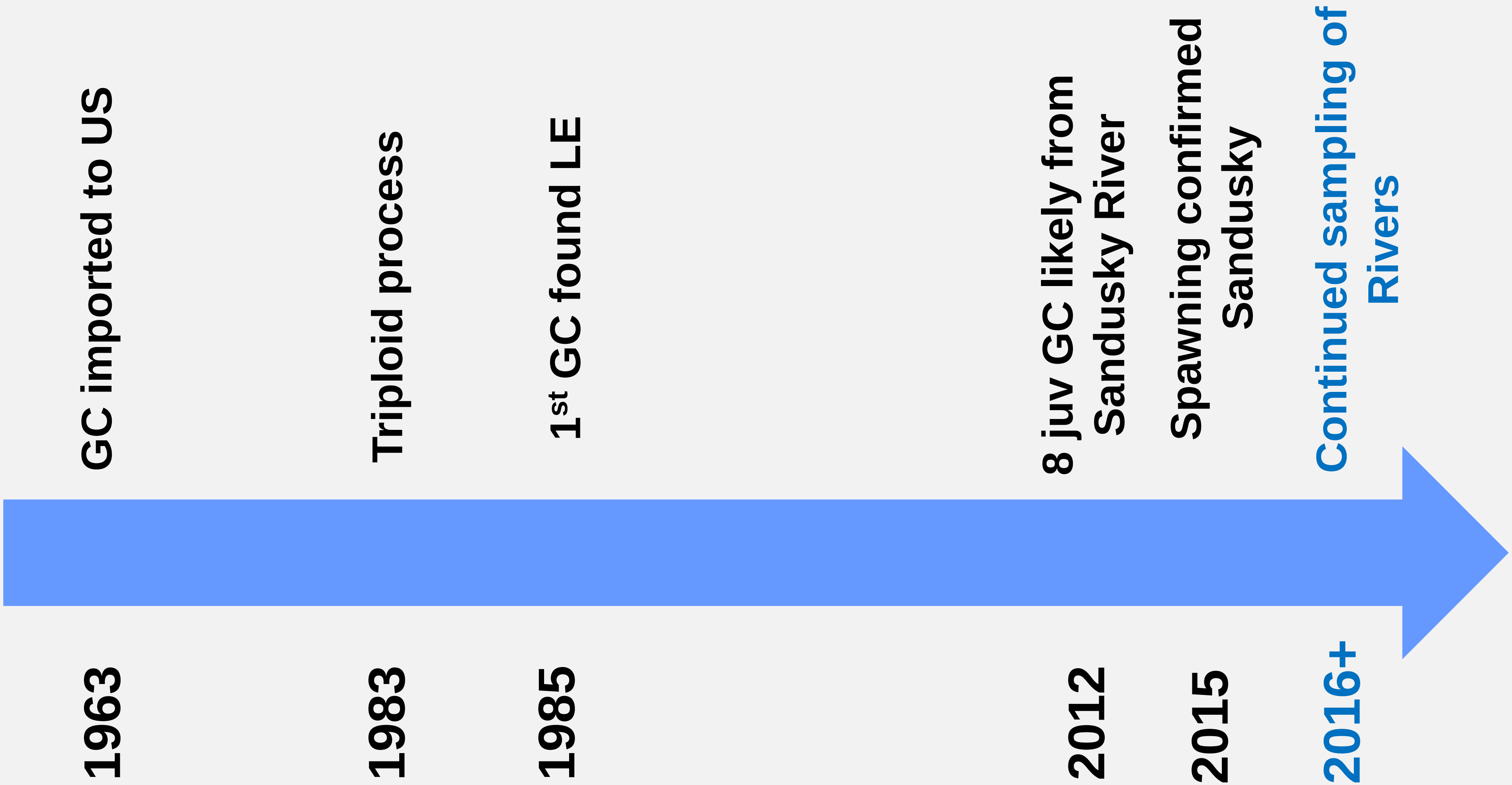
1983

1985

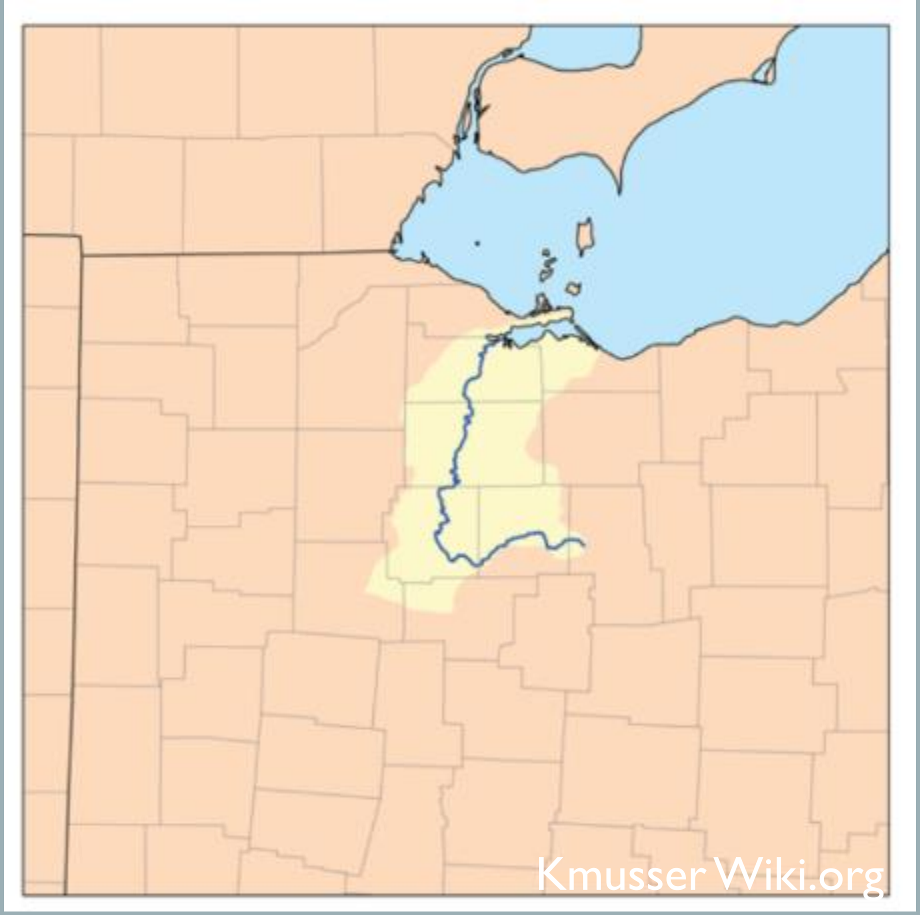
Eight fertilized eggs found and genetically confirmed

2015

Timeline of grass carp in Lake Erie



SANDUSKY RIVER

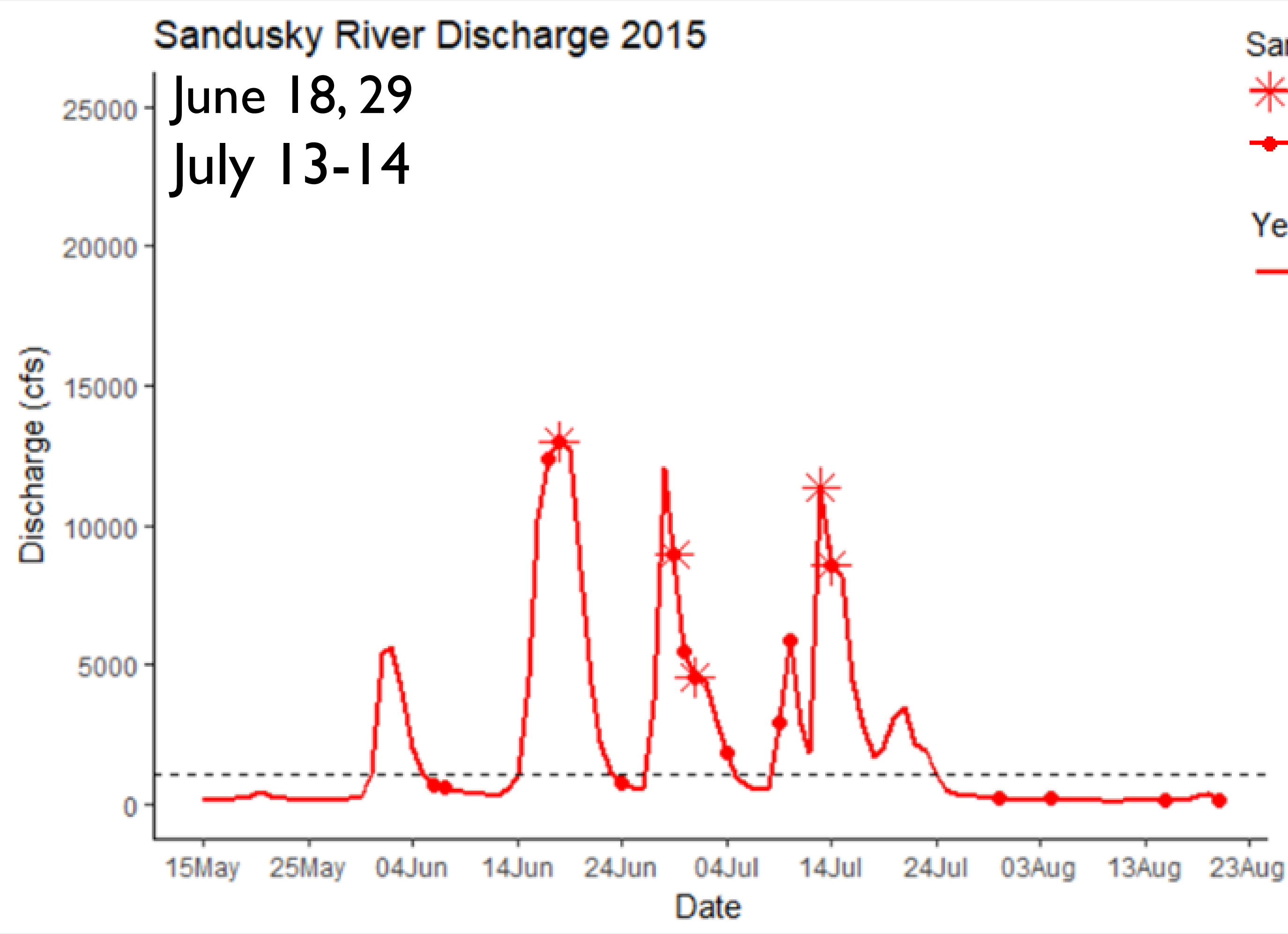


SAMPLING: PAIRED BONGO NETS
'SURFACE' AND 'DEEP'

(50 lbs. dog for scale)

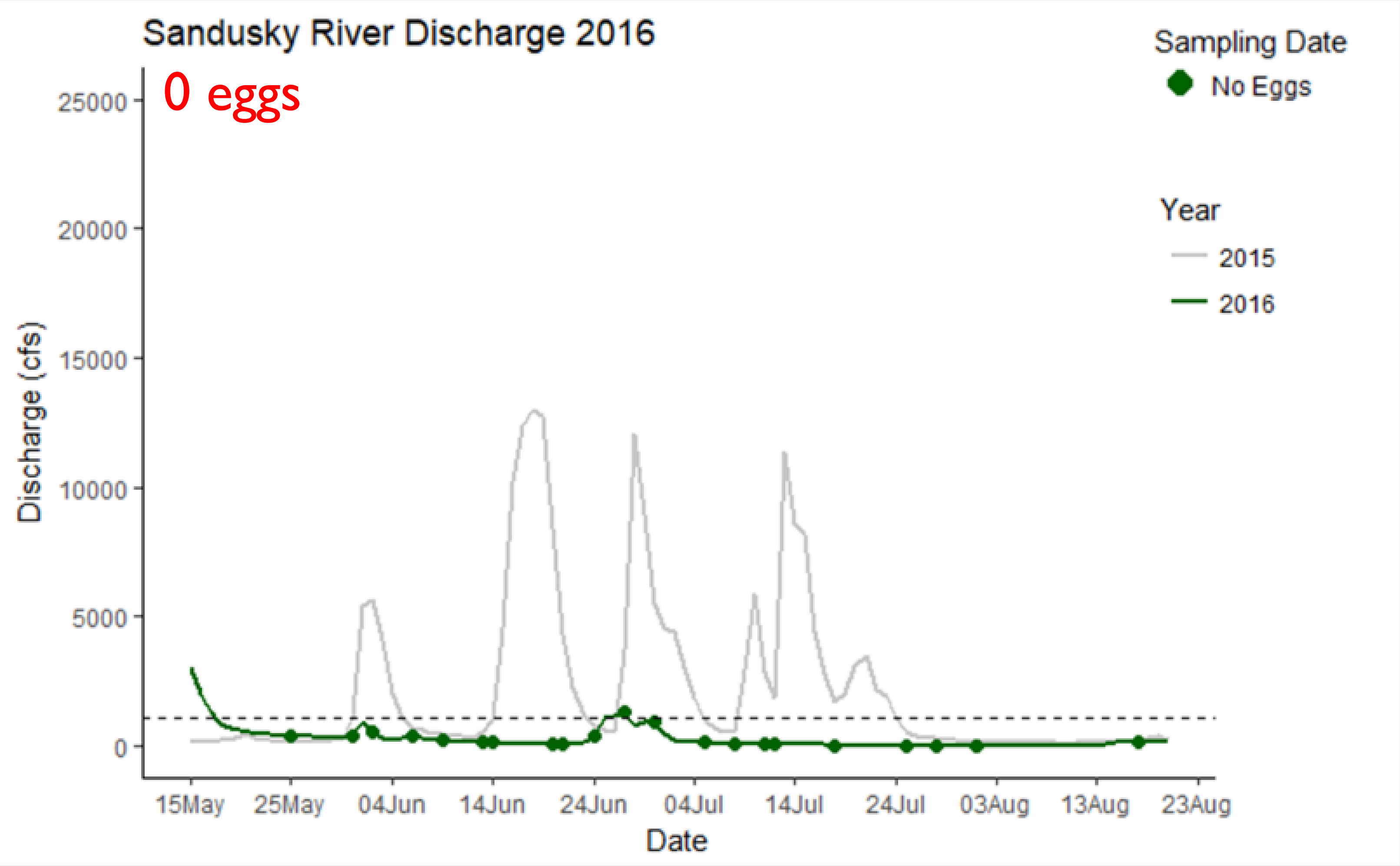
SPAWNING DURING HIGH FLOWS

EGG CAPTURES DURING HIGH FLOWS

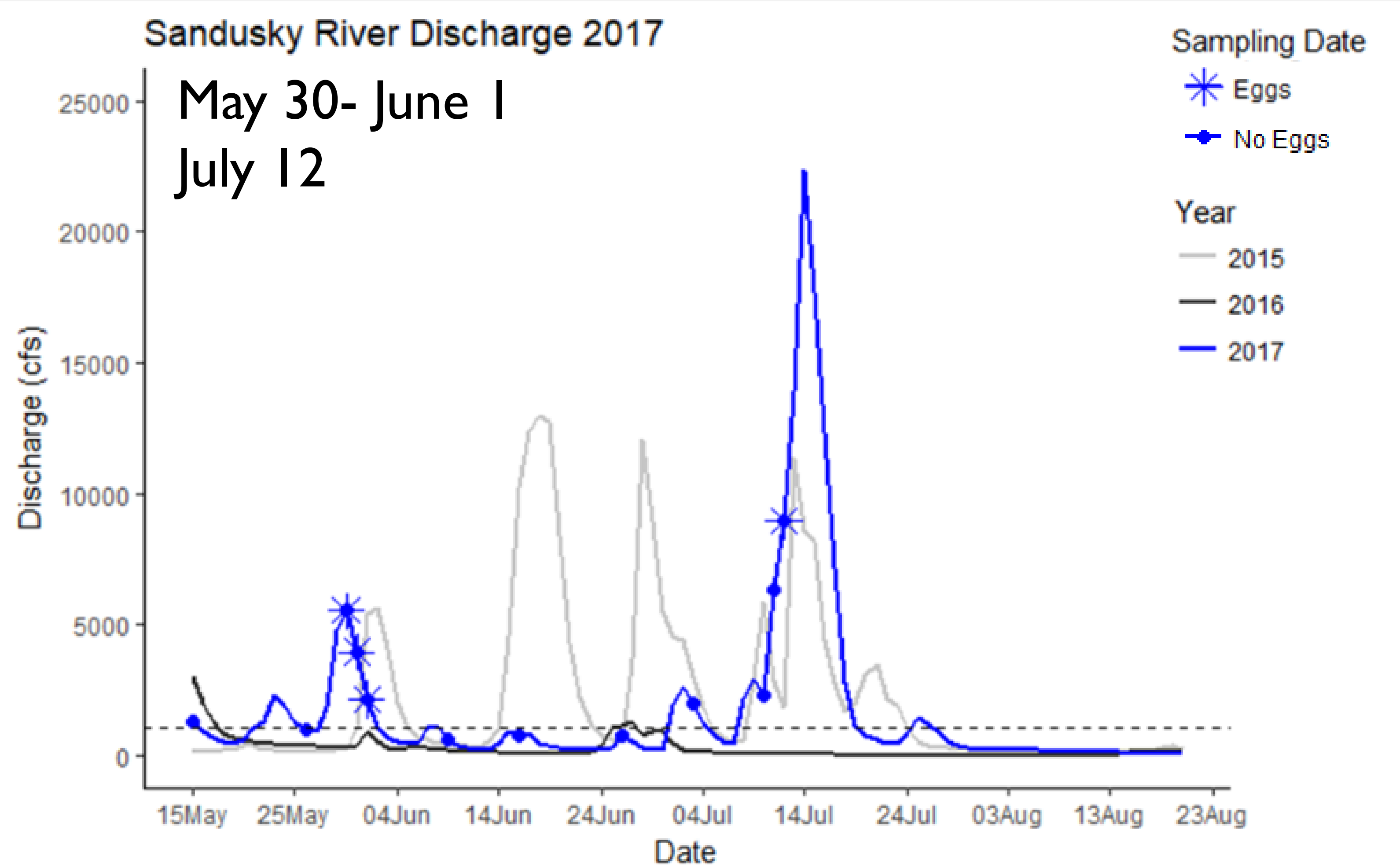


Flow needed to suspend eggs

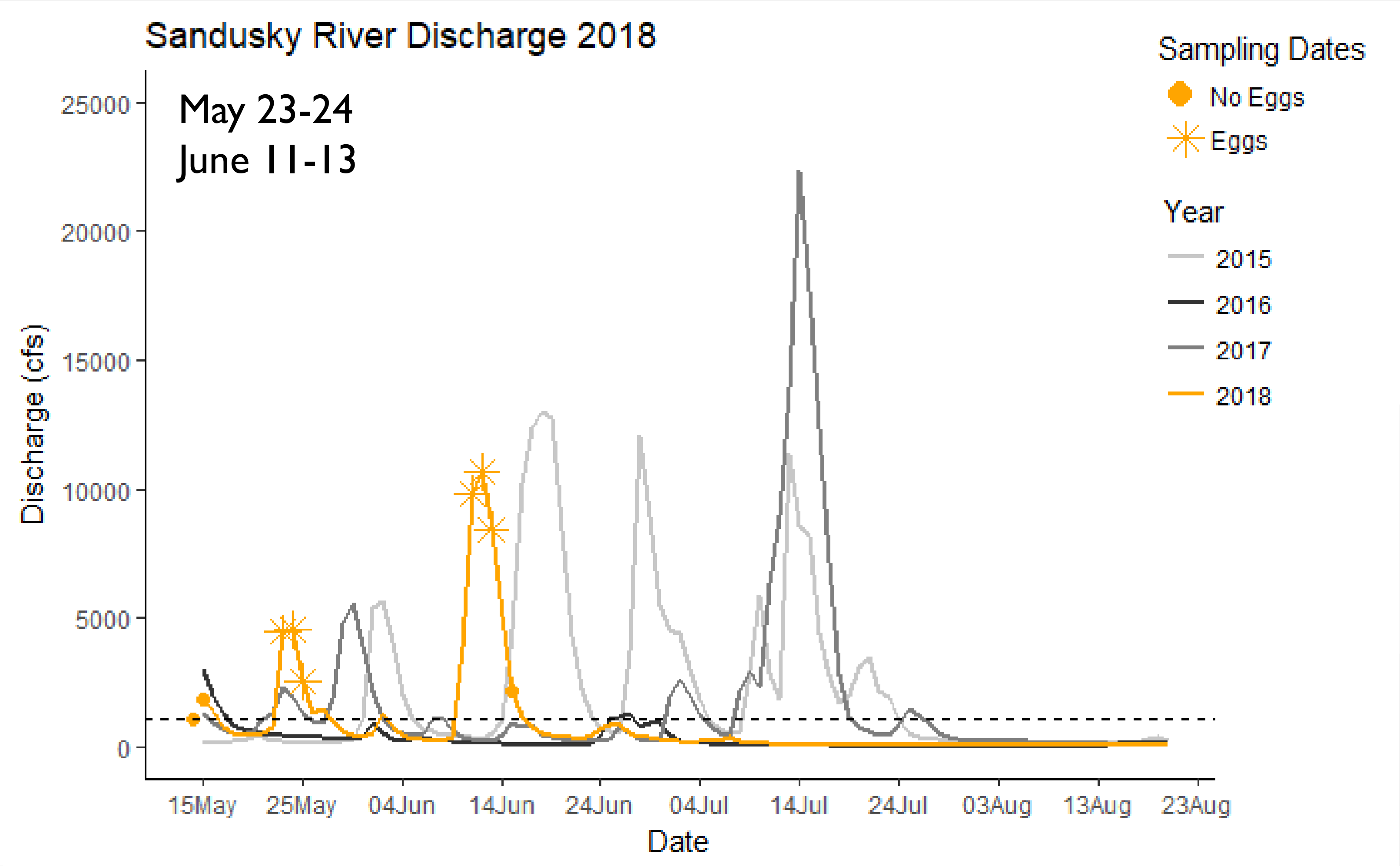
EGG CAPTURES DURING HIGH FLOWS



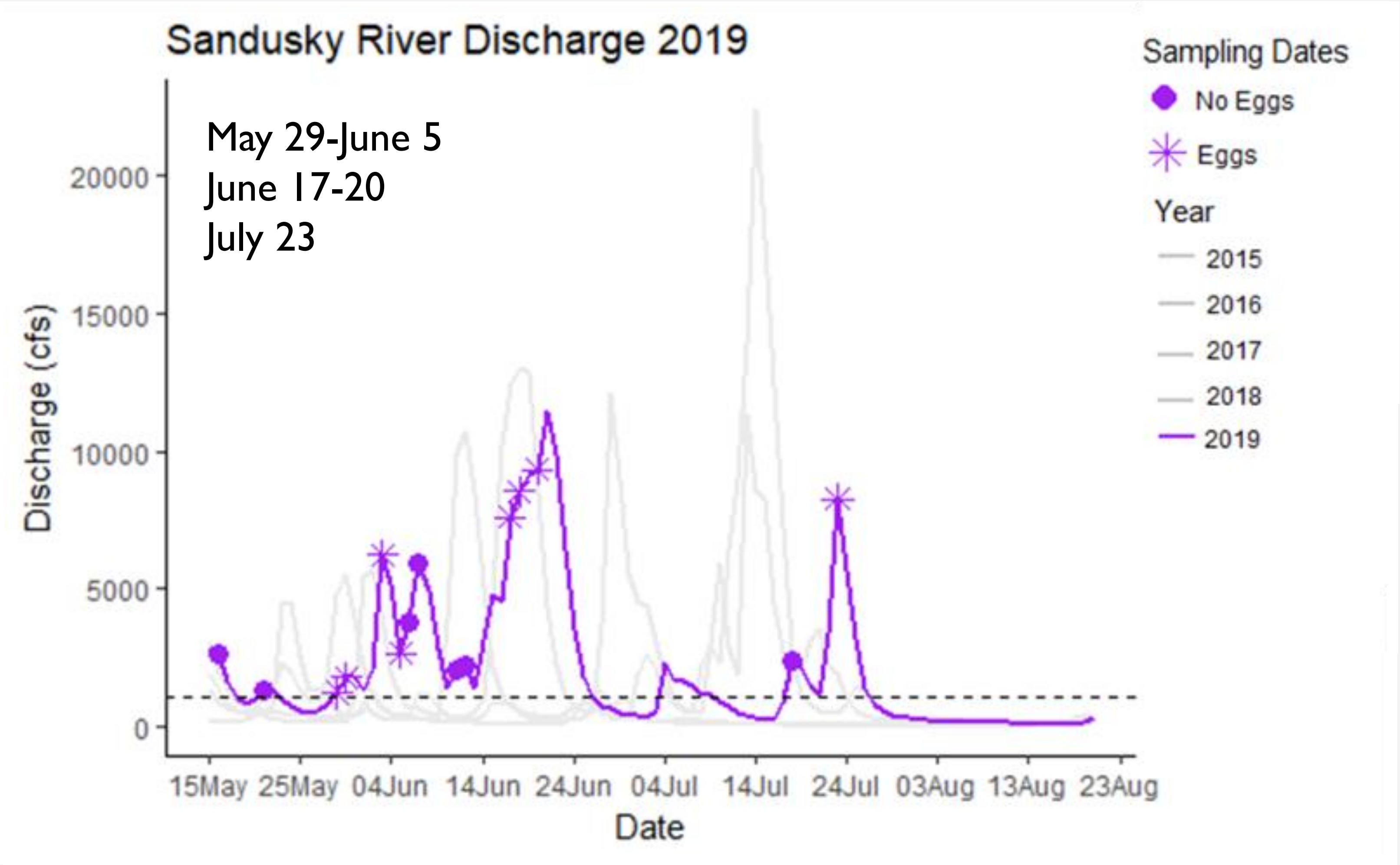
EGG CAPTURES DURING HIGH FLOWS



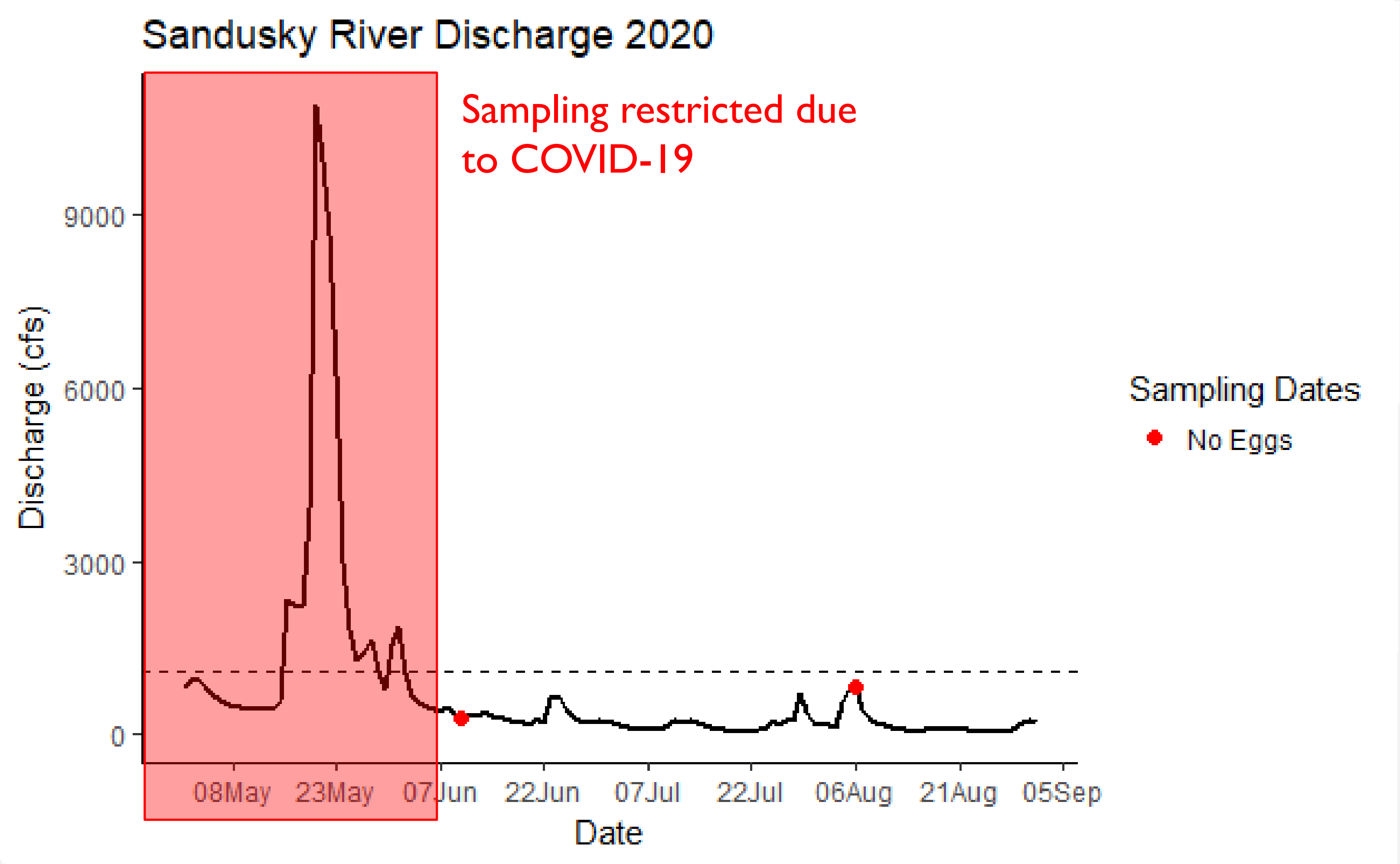
EGG CAPTURES DURING HIGH FLOWS



EGG CAPTURES DURING HIGH FLOWS

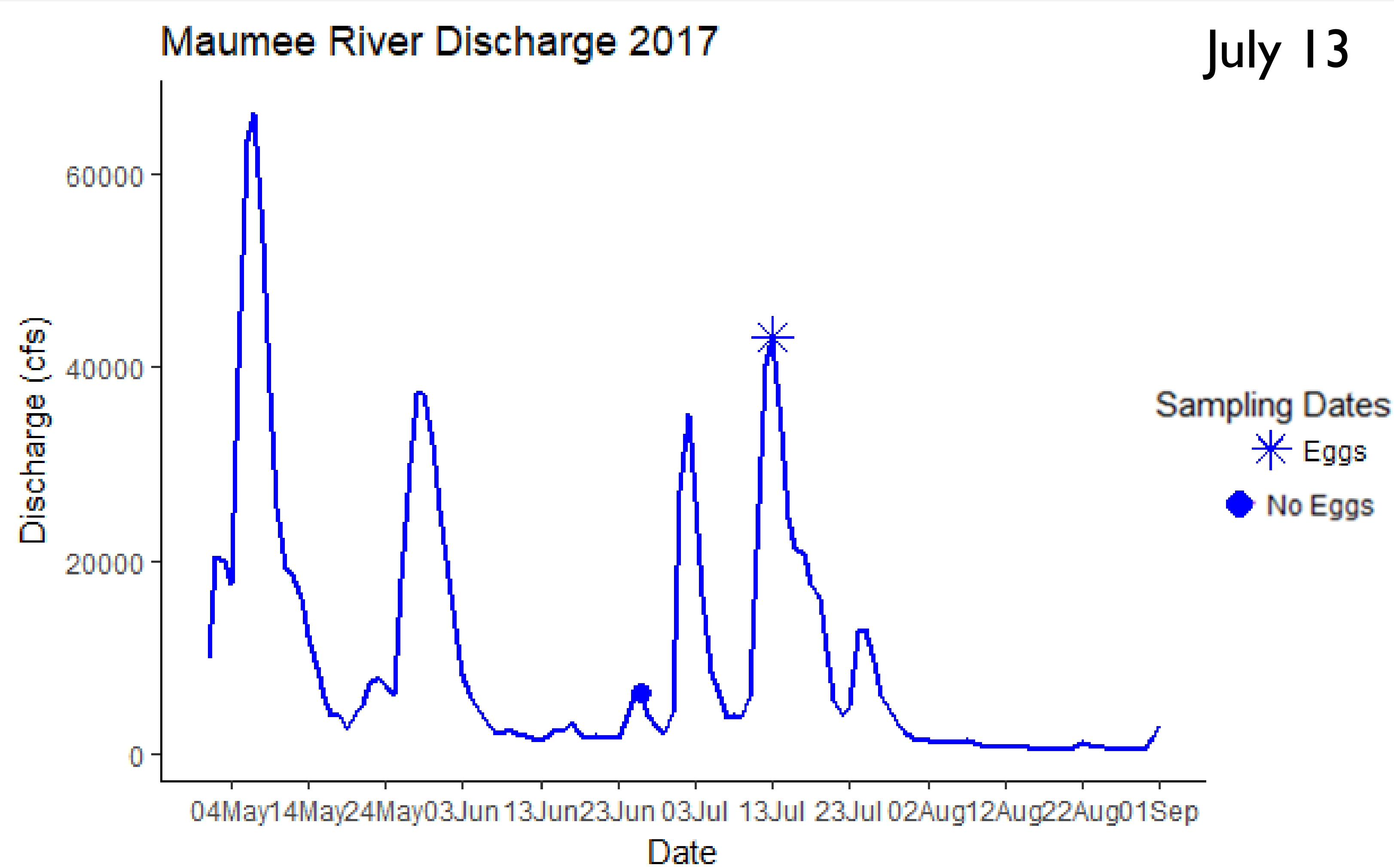


EGG CAPTURES DURING HIGH FLOWS

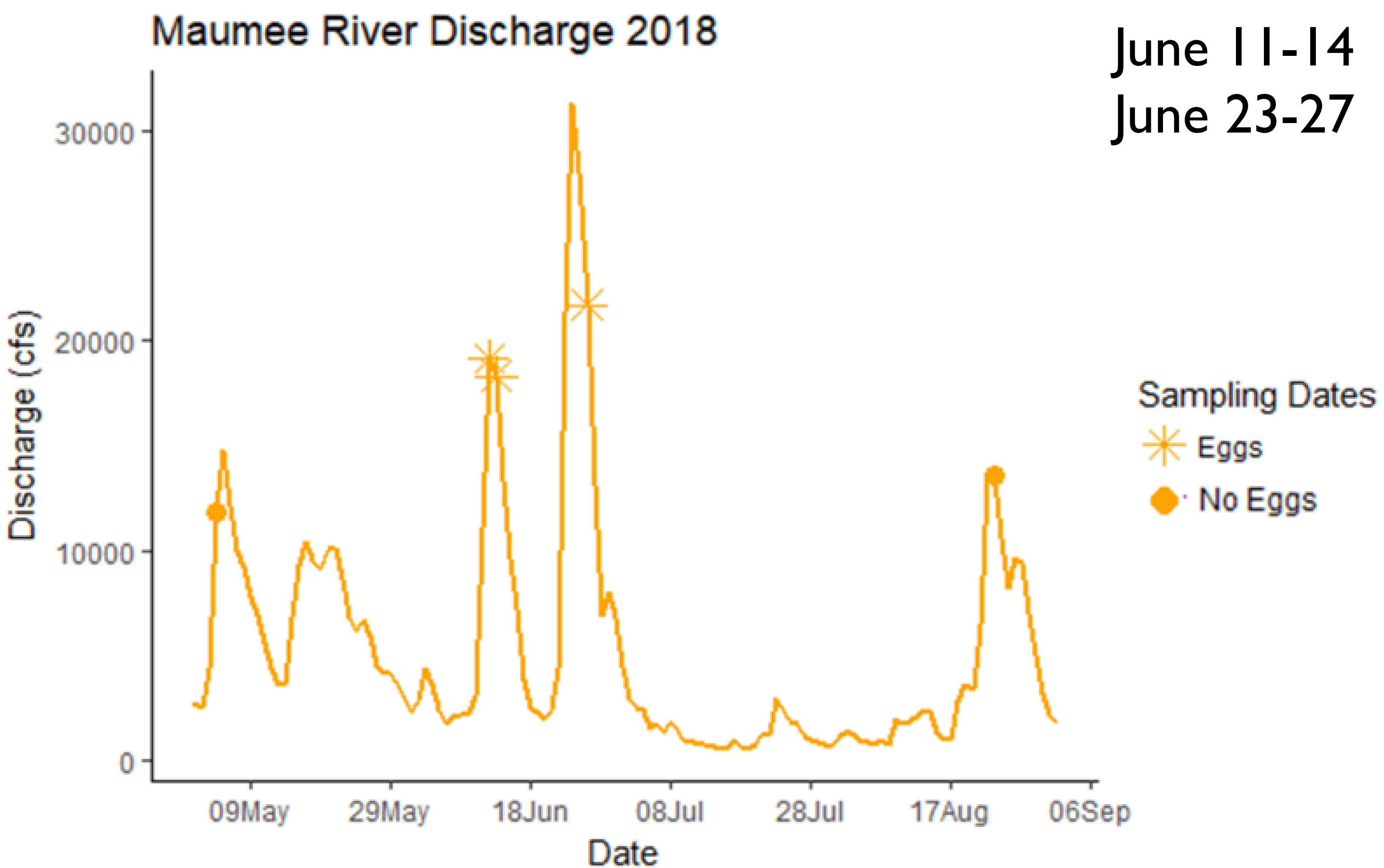


MAUMEE RIVER (OH)

EGG CAPTURES DURING HIGH FLOWS

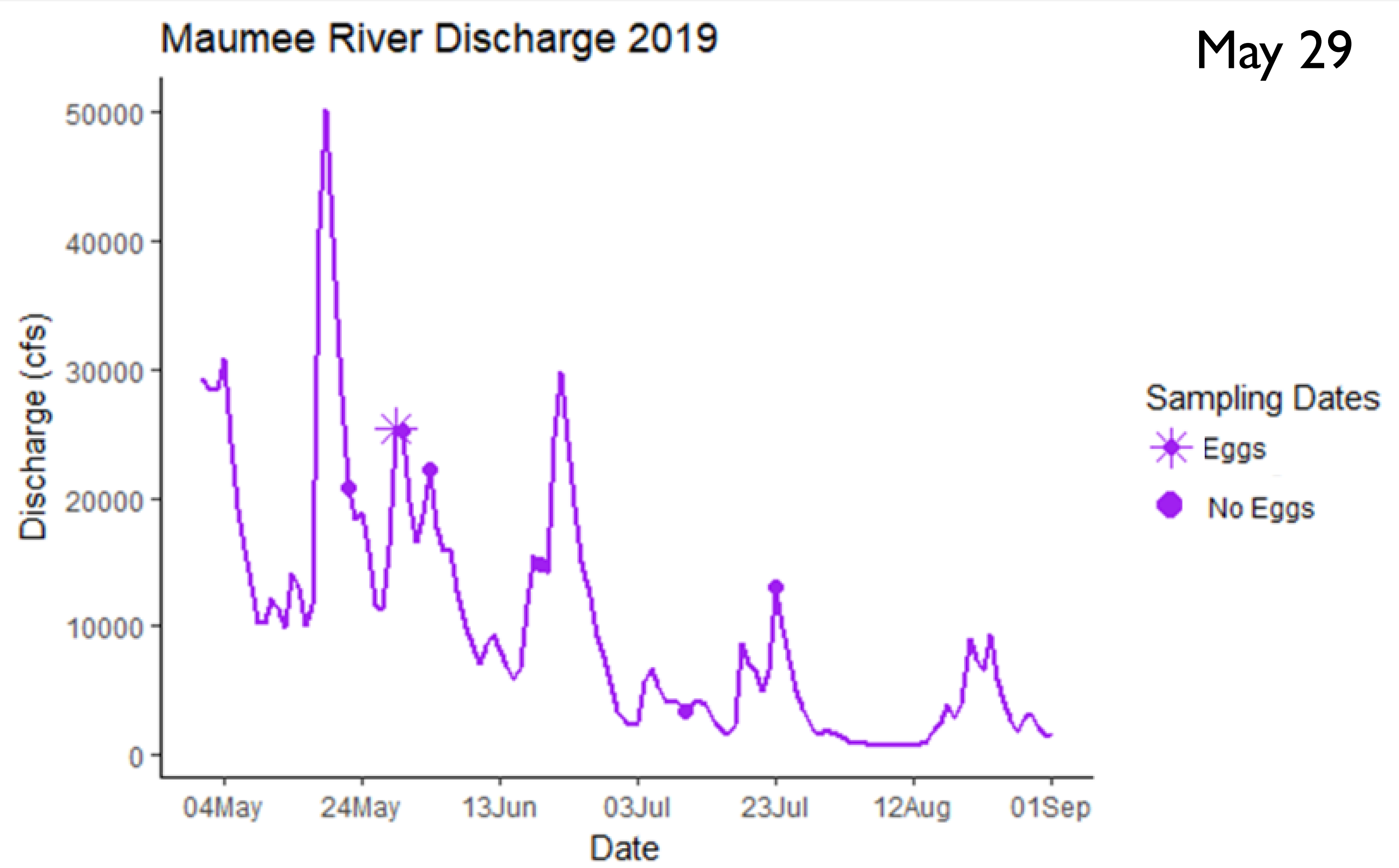


EGG CAPTURES DURING HIGH FLOWS



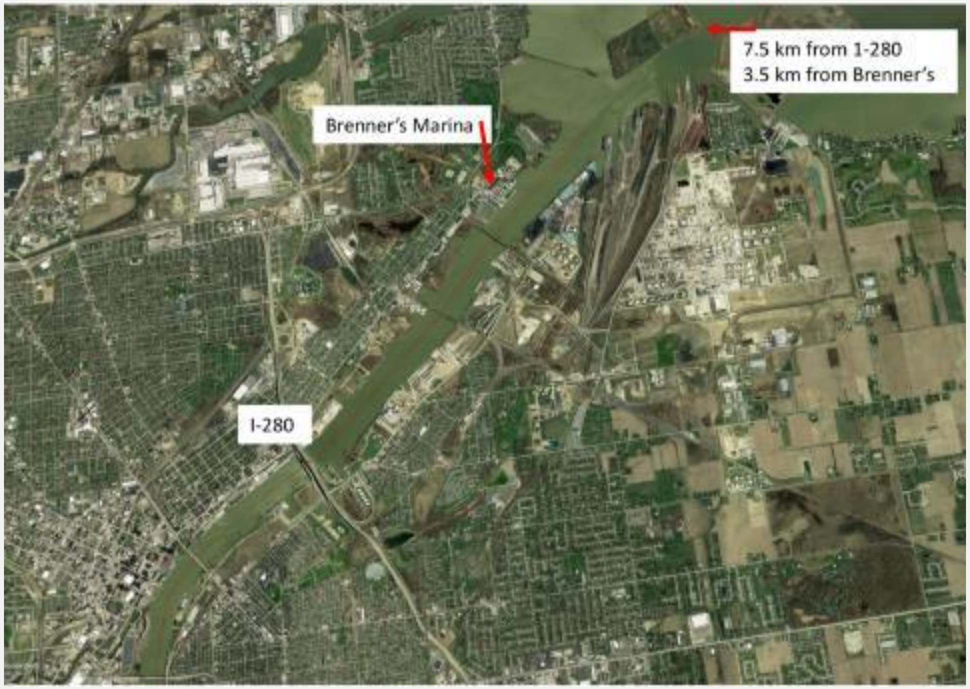
June 11-14
June 23-27

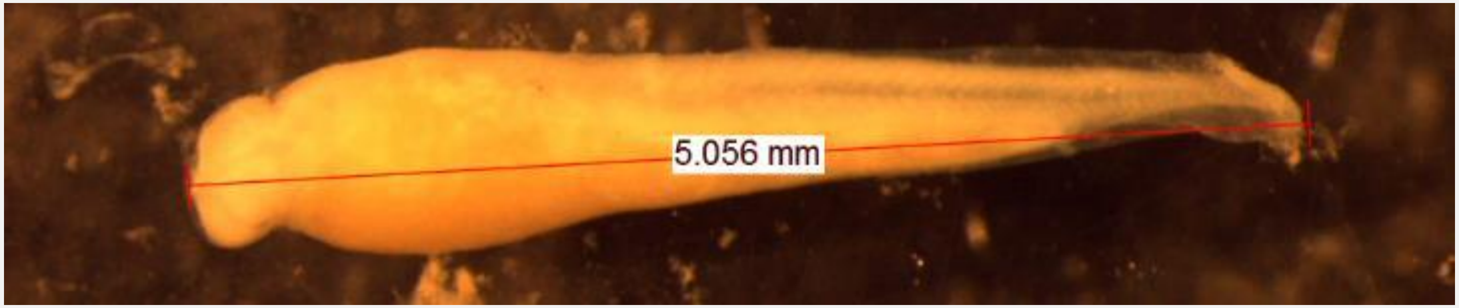
EGG CAPTURES DURING HIGH FLOWS



2018: EGGS CAN HATCH IN RIVER

- 6 larvae collected just upstream of river mouth, 2 events



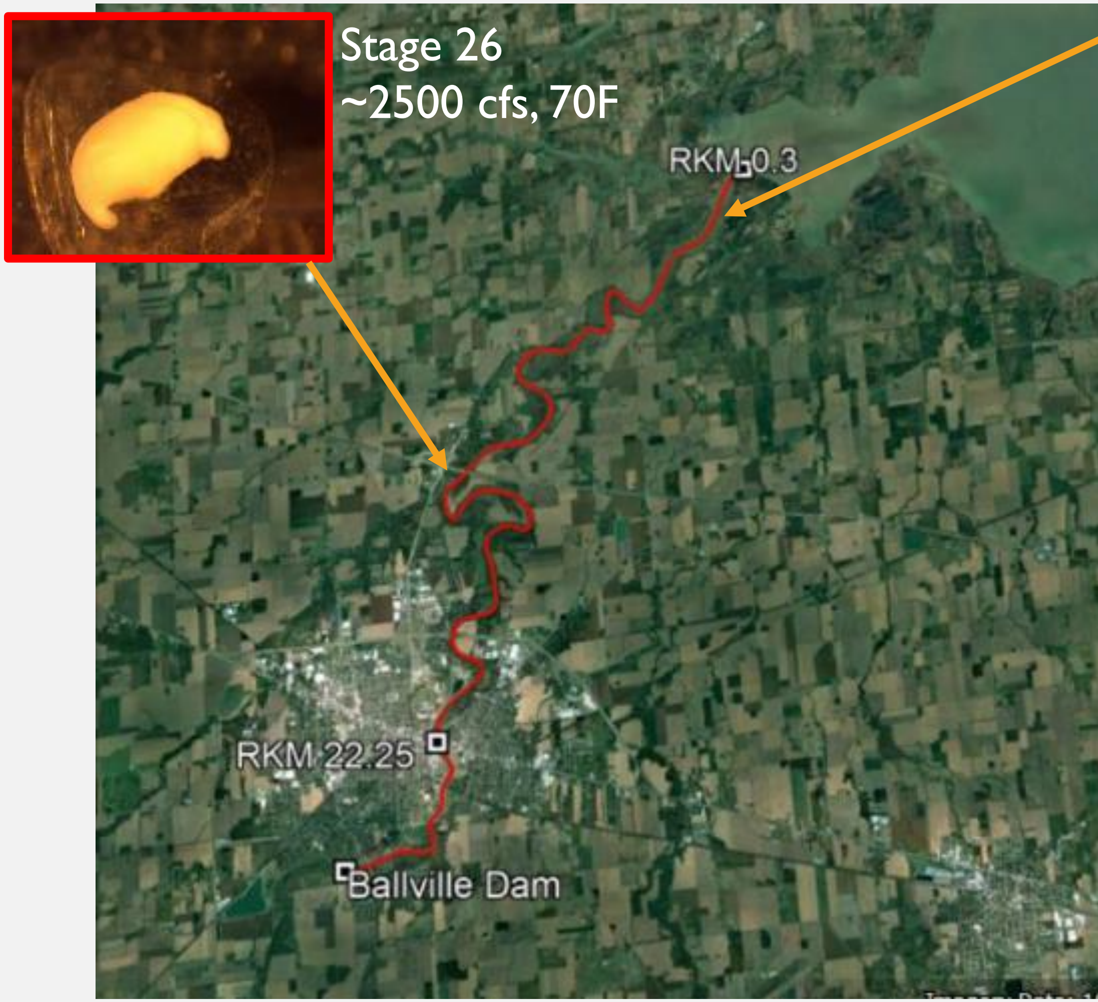


SPAWNING LOCATION

& implications for management

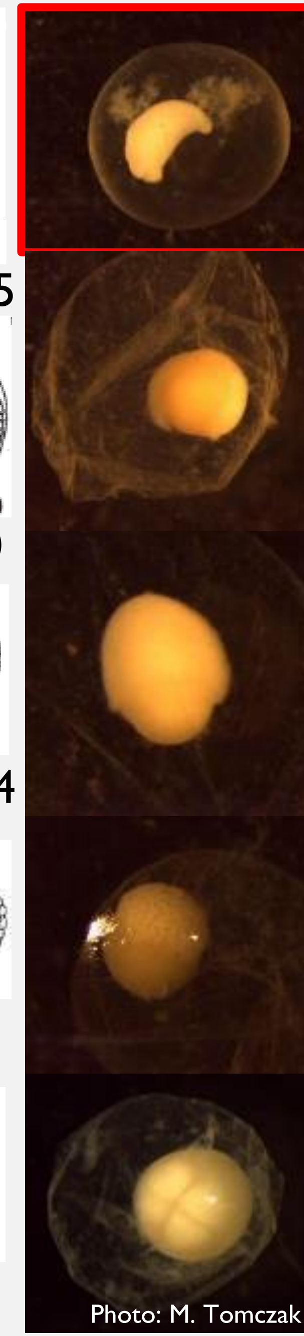
Where are the spawning grounds?

EGG STAGES, TEMPERATURE & FLOW

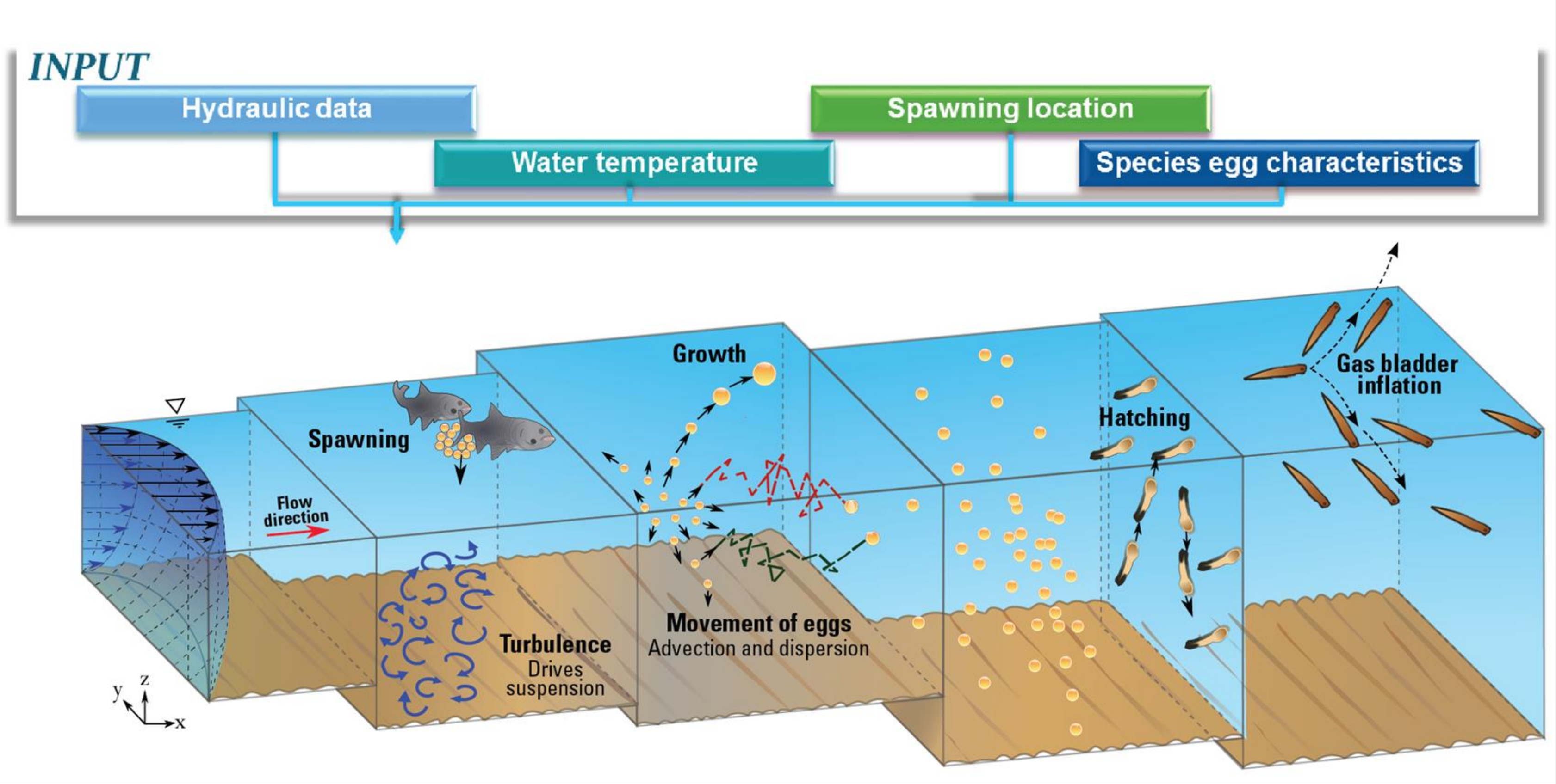


From Yi et al. 2006

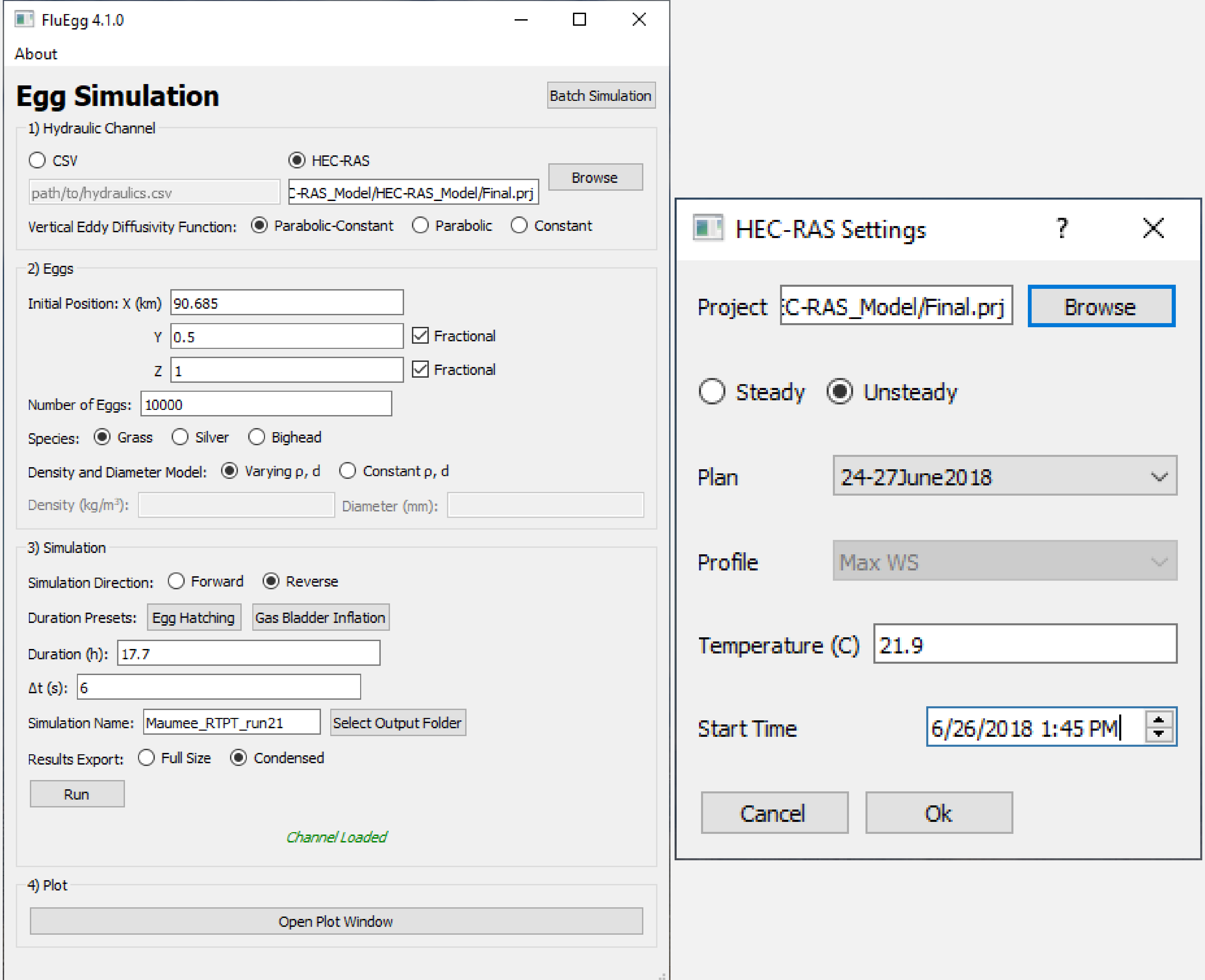
~9000 cfs, 70F



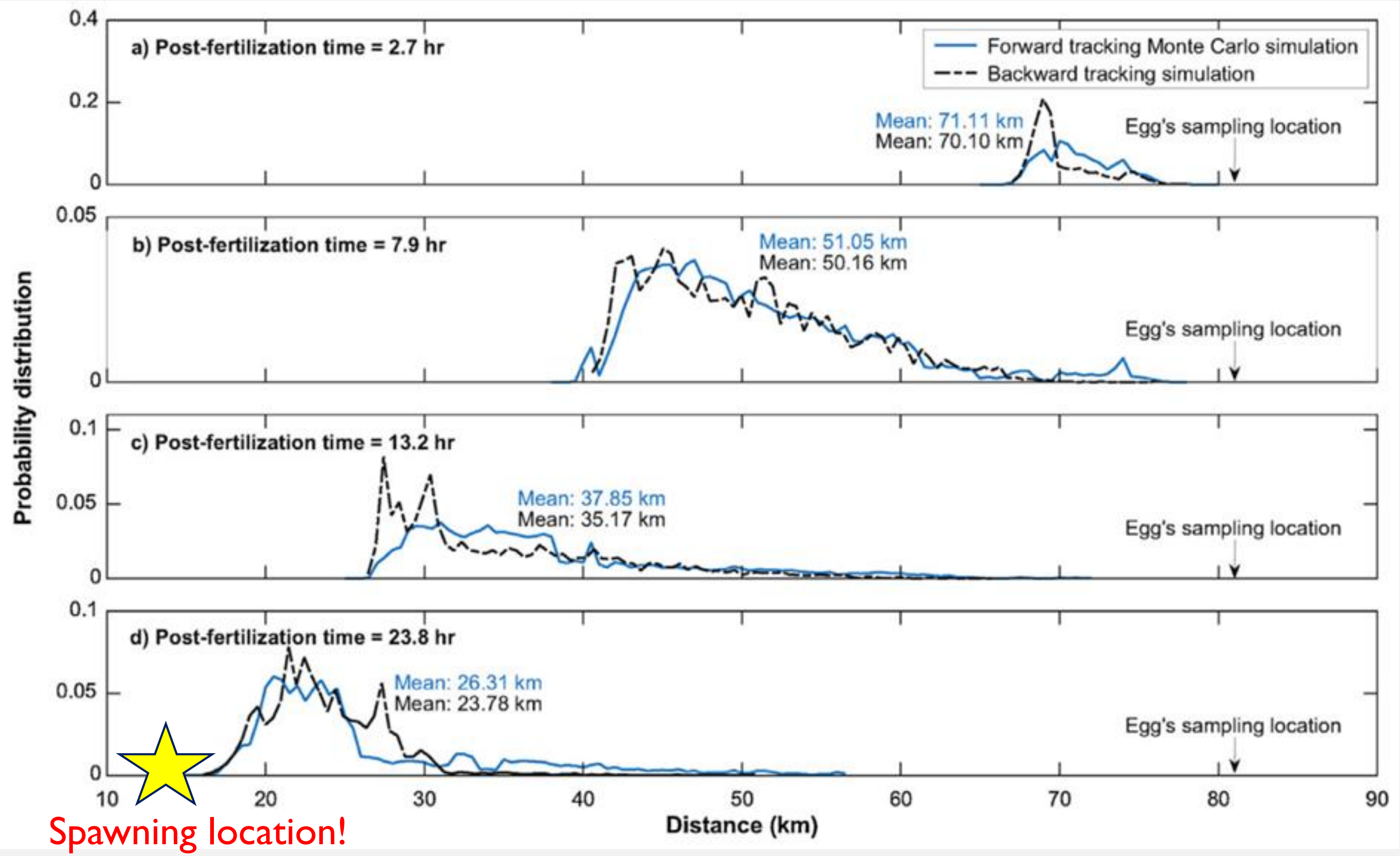
FLUEGG



INPUT
Hydraulic data
Water temperature
Spawning location
Species egg characteristics
Spawning
Flow direction
Growth
Turbulence
Drives suspension
Movement of eggs
Advection and dispersion
Hatching
Gas bladder inflation
y
z
x


FluEgg 4.1.0
About
Egg Simulation
Batch Simulation
1) Hydraulic Channel
CSV
HEC-RAS
path/to/hydraulics.csv
C-RAS_Model/HEC-RAS_Model/Final.prj
Browse
Vertical Eddy Diffusivity Function:
Parabolic-Constant
Parabolic
Constant
2) Eggs
Initial Position: X (km)
90.685
Y
0.5
Fractional
Z
1
Fractional
Number of Eggs:
10000
Species:
Grass
Silver
Bighead
Density and Diameter Model:
Varying ρ, d
Constant ρ, d
Density (kg/m³):
Diameter (mm):
3) Simulation
Simulation Direction:
Forward
Reverse
Duration Presets:
Egg Hatching
Gas Bladder Inflation
Duration (h):
17.7
Δt (s):
6
Simulation Name:
Maumee_RTPT_run21
Select Output Folder
Results Export:
Full Size
Condensed
Run
Channel Loaded
4) Plot
Open Plot Window
HEC-RAS Settings
?
Project
C-RAS_Model/Final.prj
Browse
Steady
Unsteady
Plan
24-27June2018
Profile
Max WS
Temperature (C)
21.9
Start Time
6/26/2018 1:45 PM
Cancel
Ok

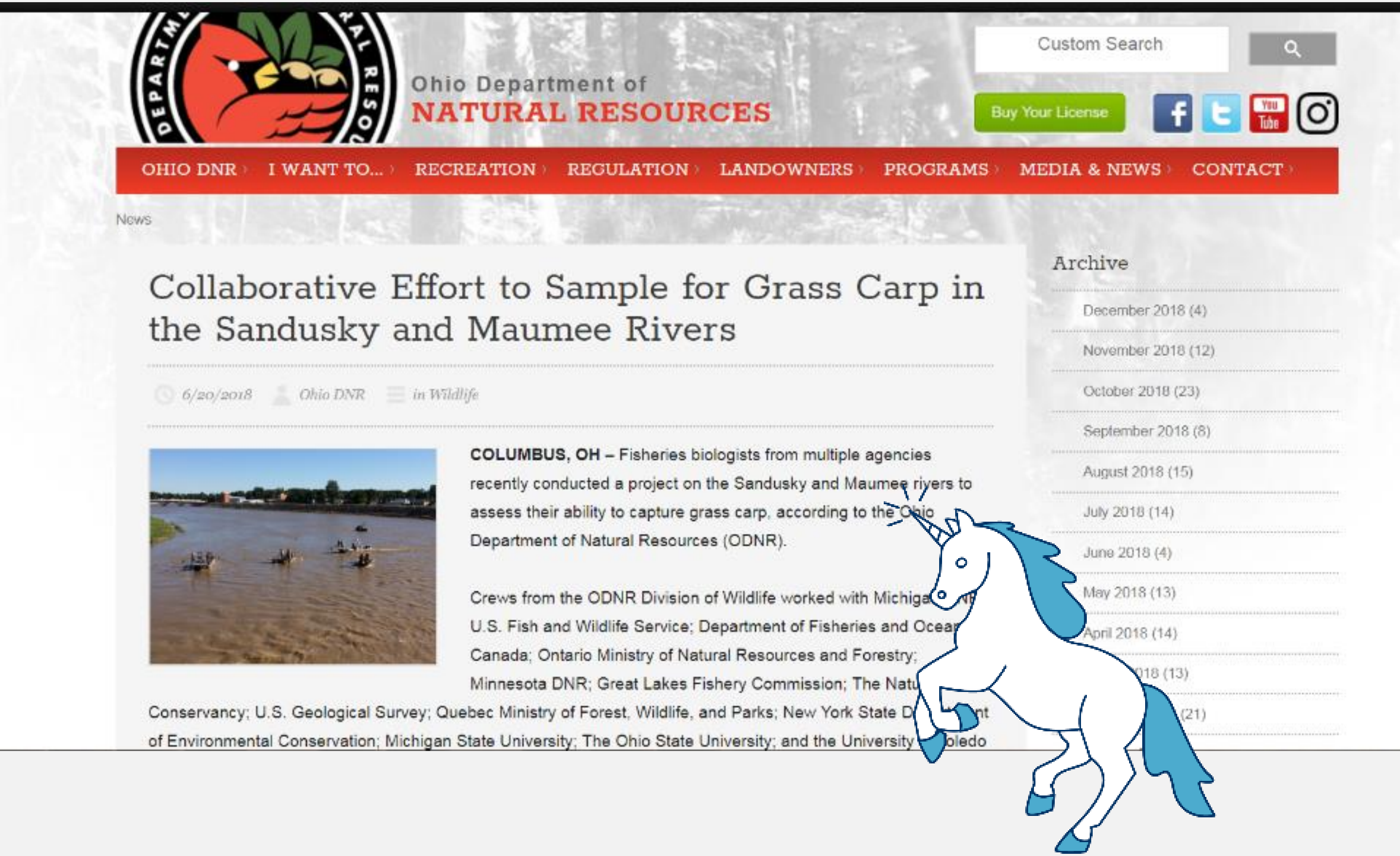
WHERE ARE THE SPAWNING GROUNDS?



FLUEGG ESTIMATED SPAWNING GROUNDS: SANDUSKY RIVER

Credible Interval

2018 Multi-agency effort to sample grass carp



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News

Collaborative Effort to Sample for Grass Carp in the Sandusky and Maumee Rivers

6/20/2018 Ohio DNR in Wildlife

COLUMBUS, OH – Fisheries biologists from multiple agencies recently conducted a project on the Sandusky and Maumee rivers to assess their ability to capture grass carp, according to the Ohio Department of Natural Resources (ODNR).

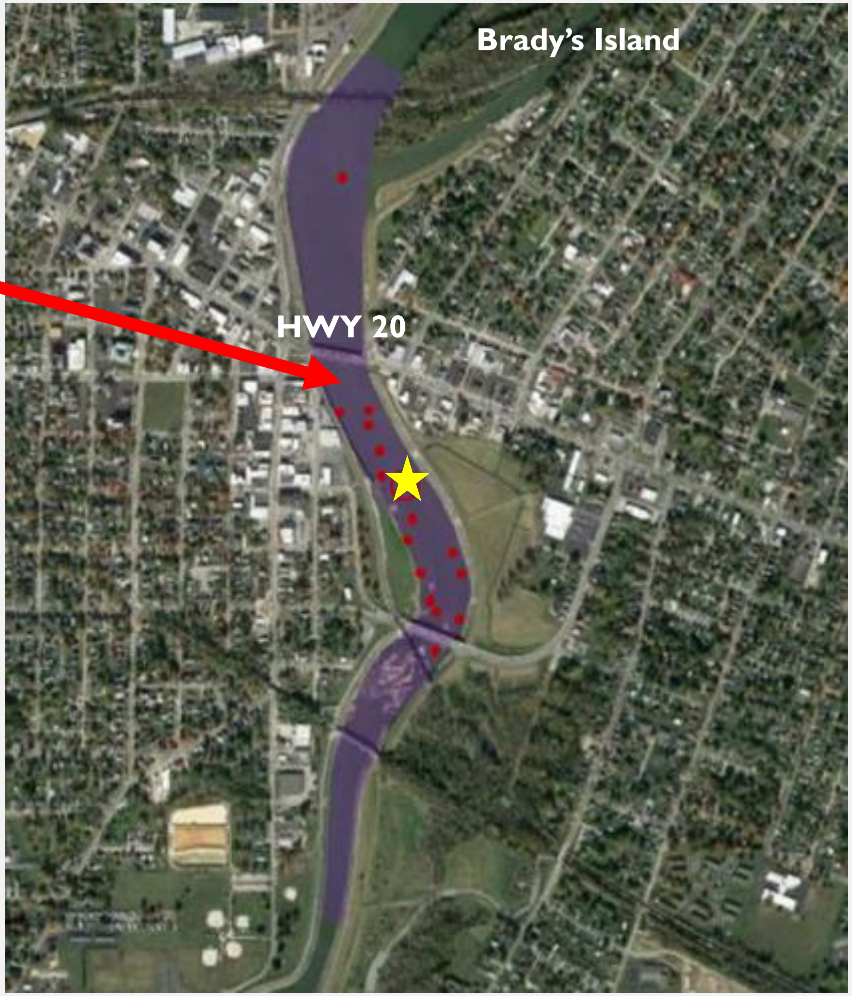
Crews from the ODNR Division of Wildlife worked with Michiga[n] ... U.S. Fish and Wildlife Service; Department of Fisheries and Ocea[ns] Canada; Ontario Ministry of Natural Resources and Forestry; Minnesota DNR; Great Lakes Fishery Commission; The Natu[re] Conservancy; U.S. Geological Survey; Quebec Ministry of Forest, Wildlife, and Parks; New York State D... of Environmental Conservation; Michigan State University; The Ohio State University; and the University ... oledo

Archive

- December 2018 (4)
- November 2018 (12)
- October 2018 (23)
- September 2018 (8)
- August 2018 (15)
- July 2018 (14)
- June 2018 (4)
- May 2018 (13)
- April 2018 (14)
- ...018 (13)
- ... (21)

SPAWNING LOCATION VERIFIED

Stage I eggs just upstream of HWY 20



June 2018 event coincided w/ODNR Planned Action

Journal of Great Lakes Research xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Great Lakes Research

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ELSEVIER

IAGLR

Validation of the model-predicted spawning area of grass carp *Ctenopharyngodon idella* in the Sandusky River

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[b] *University of Toledo, 2801 W. Bancroft St., Toledo, OH 43606, USA*
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ARTICLE INFO

Article history:
Received 26 November 2019
Accepted 12 June 2020
Available online xxxx
Communicated by Kelly Robinson

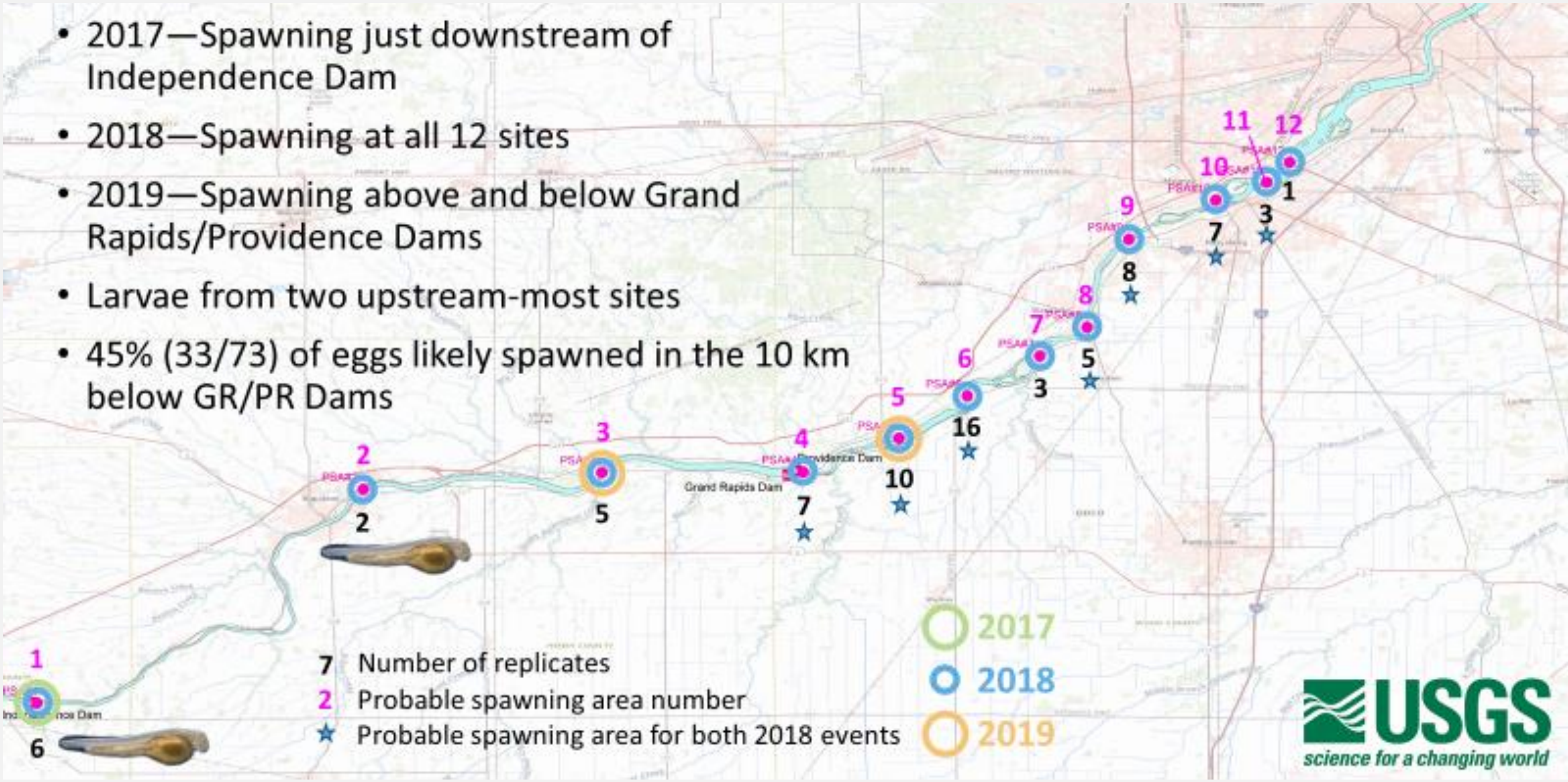
Keywords:
Particle tracking
Invasive species
Native species
Recovery
Restoration

ABSTRACT

Spawning of grass carp, *Ctenopharyngodon idella*, in the Great Lakes basin was verified when eight fertilized eggs were collected in the Sandusky River, a tributary to Lake Erie, in 2015. Using a fluvial drift model (FluEgg) and simulation modeling, researchers predicted the fertilization location for those eggs was 3.8 ± 1 km (95% credible interval, CI) downstream of Ballville Dam. In June 2018, simultaneous collection of fertilized eggs and adults within the model-predicted spawning area provided the opportunity to verify the fertilization location. We used estimated developmental time (Dt) of eggs calculated from developmental stages, water temperature, and an equation that predicts Dt from cumulative thermal units experienced by developing eggs, in two analyses. First, we regressed Dt versus location of capture and solved that equation for developmental time of 0 hrs (Dt_0) to estimate fertilization location. Second, we used Dt in the Fluvial Drift Simulator (FluEgg) to simulate 23 scenarios representative of drift conditions throughout the spawning event using the model-predicted spawning area and the site of Ballville Dam as potential spawning locations. Regression analysis placed the mean fertilization location 3.36 km (95% CI 2.27, 4.24) downstream of the site of Ballville Dam, within the model-predicted spawning area. Drift models demonstrated the model-predicted spawning area was best supported. Histograms of fertilization times overlapped with capture times by boat electrofishing of diploid adult grass carp in the model-predicted spawning area. This suite of analyses confirms the model-predicted spawning area and validates the methodology used to locate it.

FLUEGG ESTIMATED SPAWNING GROUNDS: MAUMEE RIVER (12 SITES!!)

- 2017—Spawning just downstream of Independence Dam
- 2018—Spawning at all 12 sites
- 2019—Spawning above and below Grand Rapids/Providence Dams
- Larvae from two upstream-most sites
- 45% (33/73) of eggs likely spawned in the 10 km below GR/PR Dams



Slide: Ryan Jackson

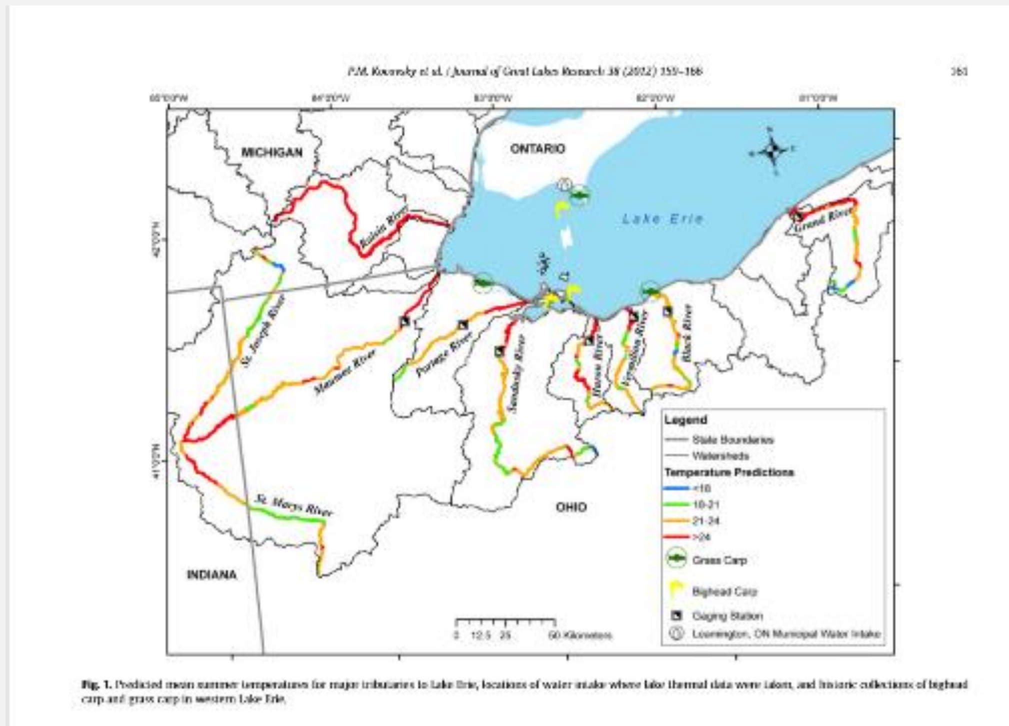
WHAT'S NEXT?

SPAWNING IN OTHER TRIBUTARIES?

✓ Spawning confirmed in Sandusky and Maumee

- Sampling previously conducted in
  - River Raisin (MI)
  - Portage (OH)
  - Huron (OH)
  - Cuyahoga (OH) **

○ Possible tributaries:
  - Vermillion (OH)
  - Black (OH)
  - Grand (OH)
  - Detroit (MI)



REMOVAL EFFORTS

Multi-agency 'Strike Teams'

4 UT/ODNR Teams in 2020, +1 for 2021!

~90+ Grass Carp removed by ST's in 2020!

WHAT DOES THIS MEAN FOR ERIE?

- Eggs/Larvae ≠ recruitment
  - Evidence suggests some recruitment
- Population unknown

  (we're working on it)
- Management ongoing

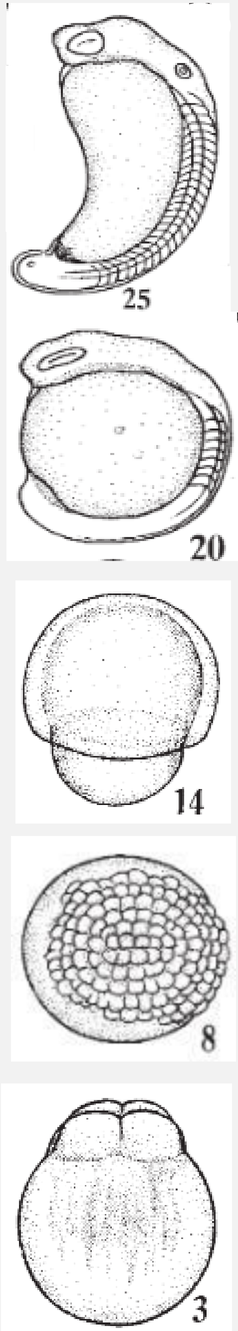
THANK YOU & QUESTIONS?

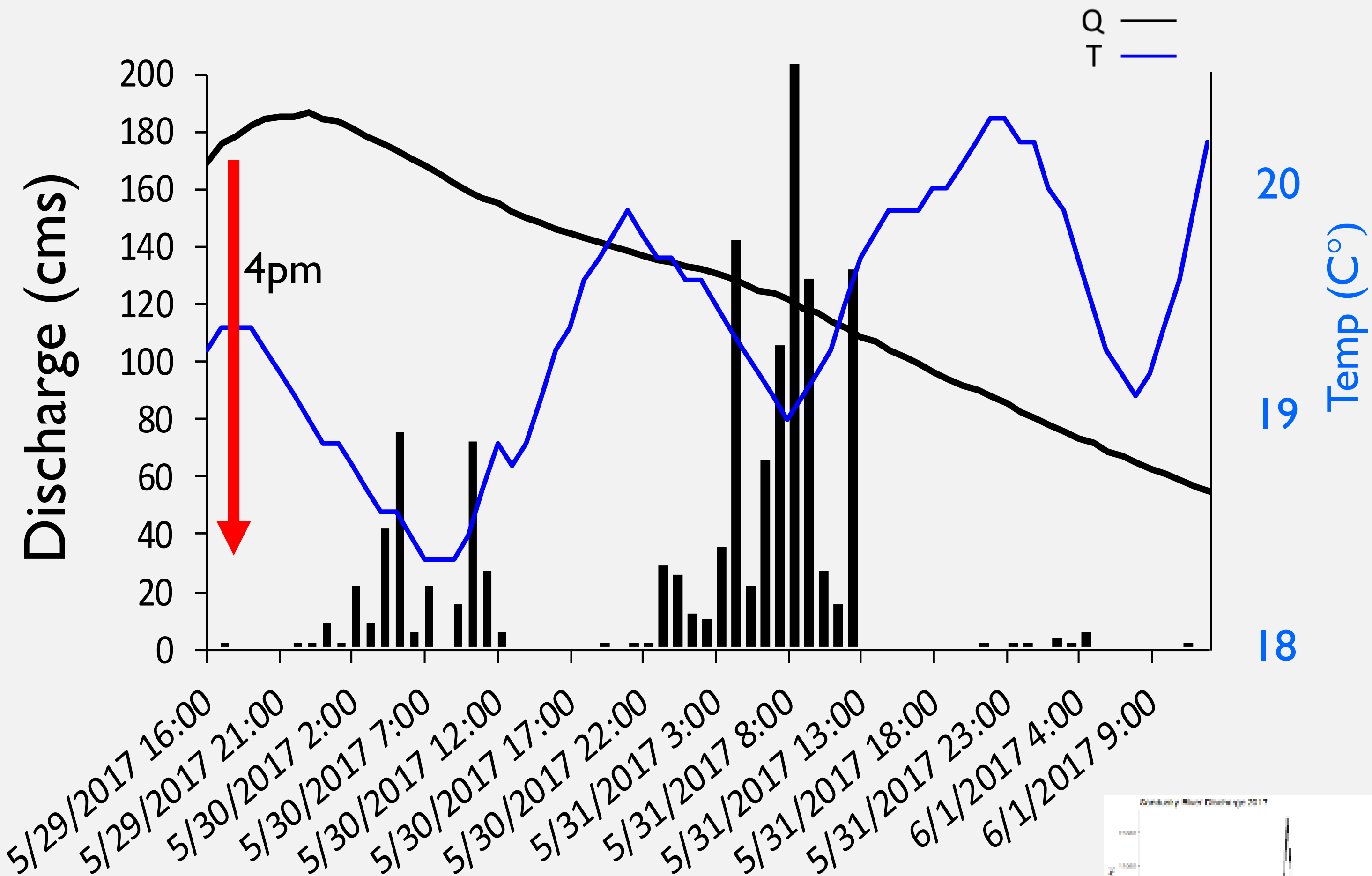
Thank you ODNR & USGS & GLFC!

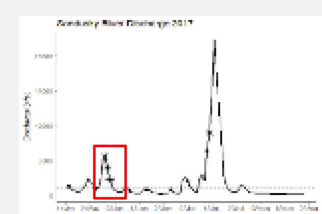
Nicole R. King

Nicole.King2@UToledo.edu

SPAWNING BEGINS AROUND HYDROGRAPH PEAK





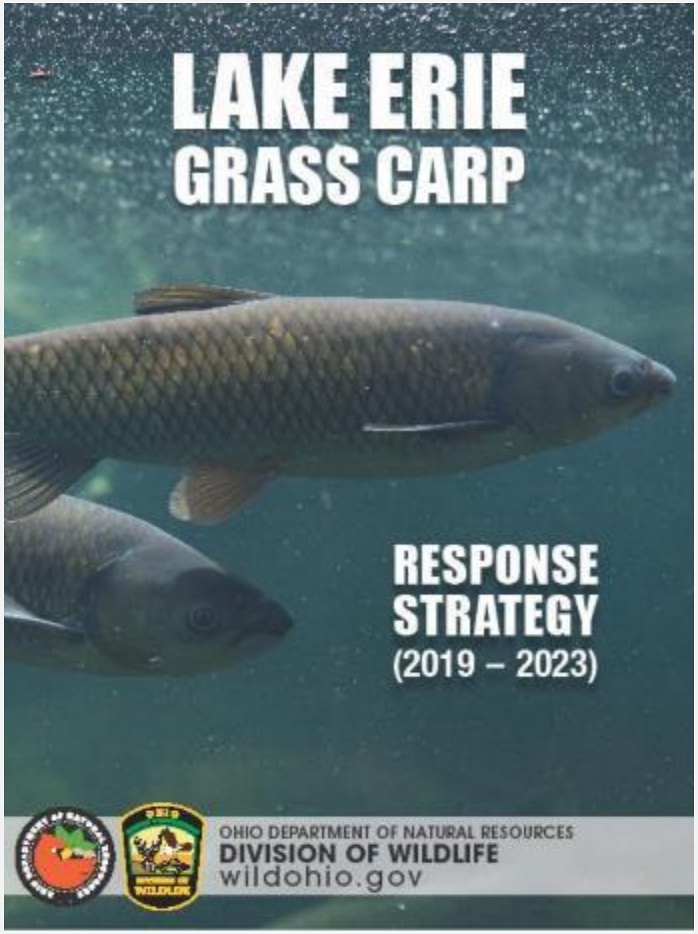


REMOVAL AND RESEARCH EFFORTS

- ODNR Lake Erie Grass Carp Response Strategy

<u>Objectives</u>

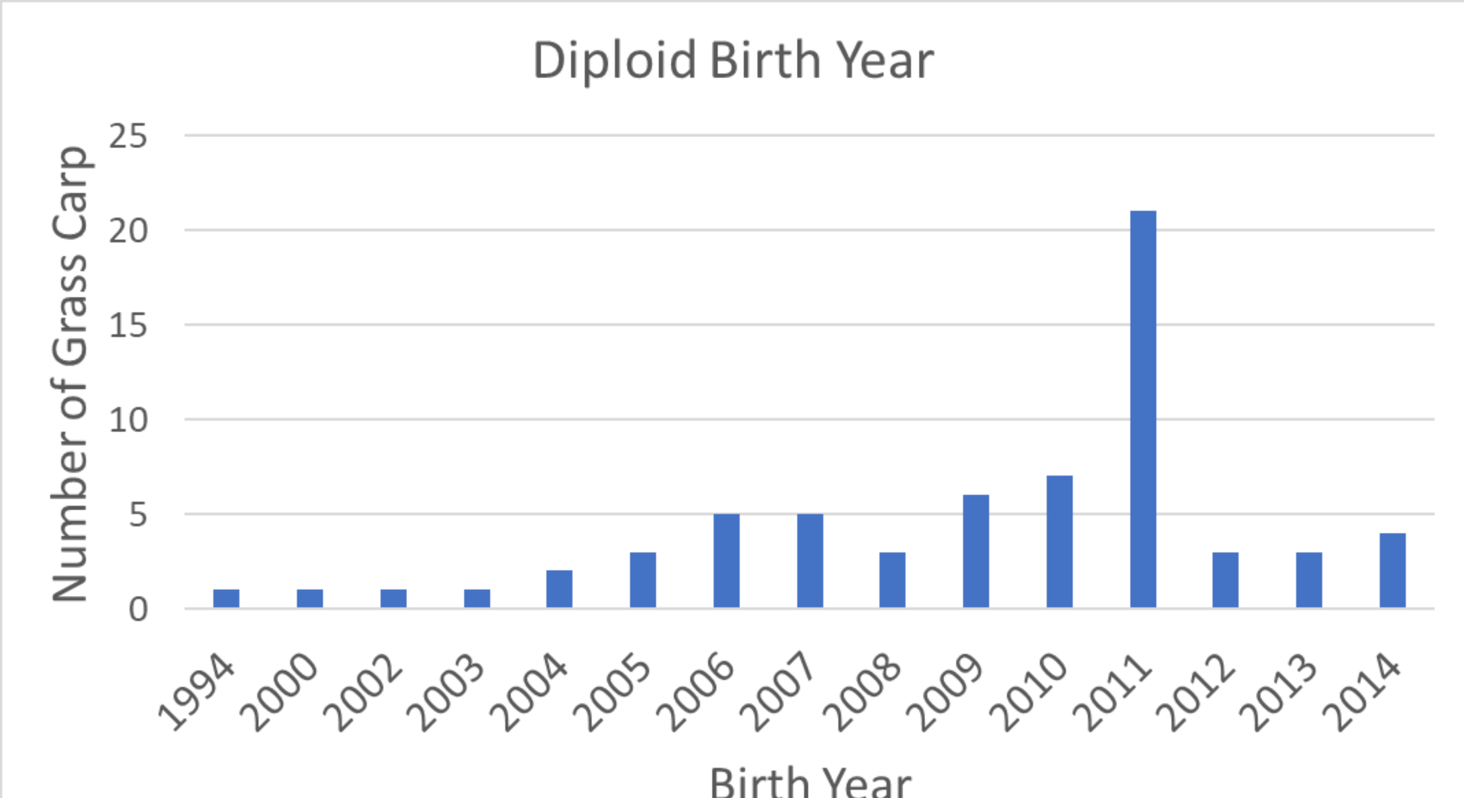
- Secure aquaculture supply chain & bait
- Further research: life history, monitoring, minimize expansion, reduce populations
- Removal efforts (partners & commercial fishermen)
- Evaluate potential barriers



REMOVAL AND RESEARCH EFFORTS

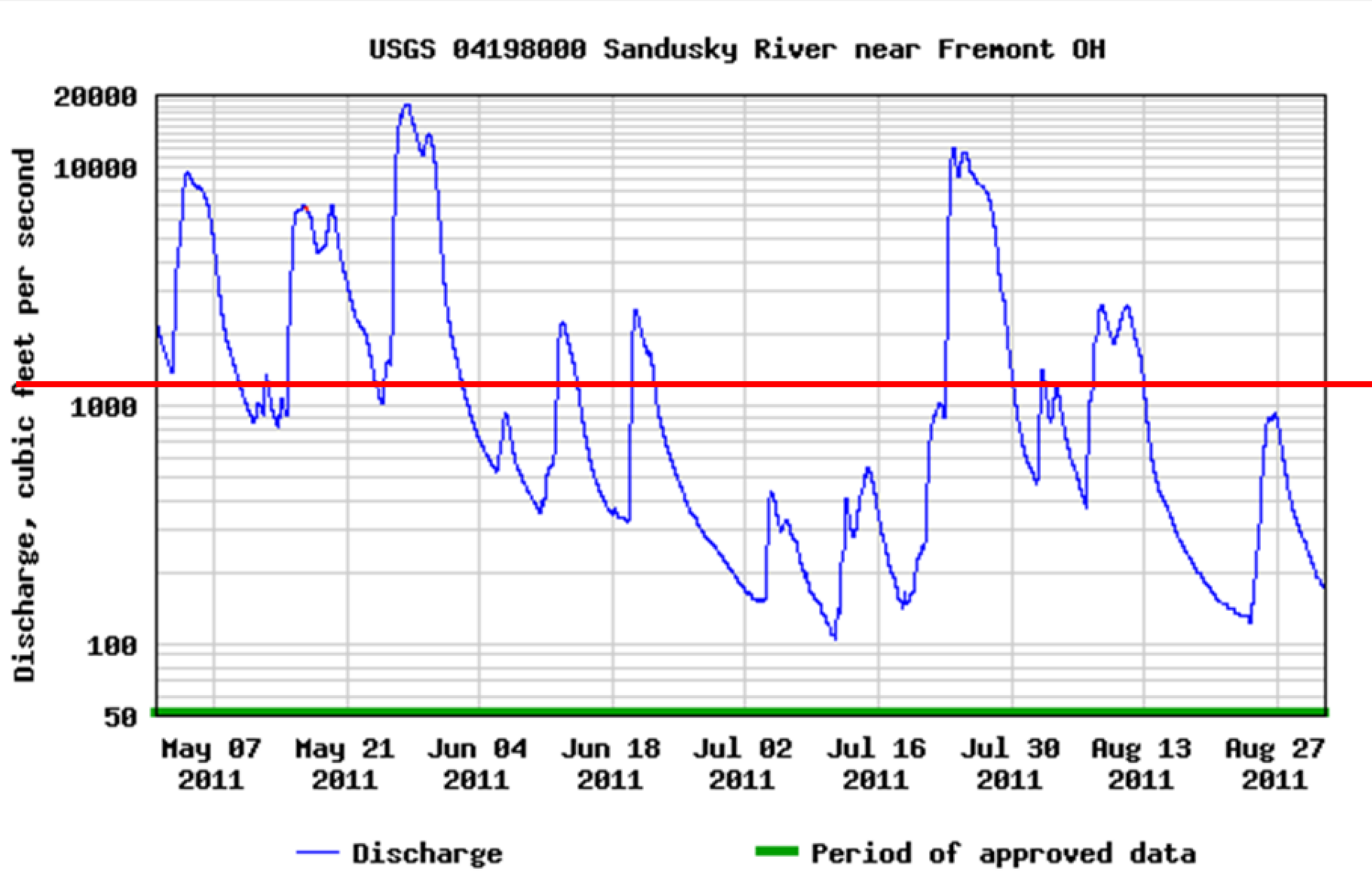
- Early detection
  - eDNA & sampling
- Identify spawning locations
- Capture probability
  - Nets, electrofishing, combos
- Baits & attractants
- Seasonal barriers
- Telemetry

BACK CALCULATING BIRTH YEARS



Data: USGS, ODNR, MDNR

Figure: Sabrina Jaffe, University of Toledo



Waterwatch.usgs.gov

Table 1
Site locations of bongo net and light trap sampling where grass carp eggs were captured with corresponding distance from Ballville Dam and Muddy Creek Bay, number of eggs collected and their developmental stages according to Yi et al. (2006), corresponding mean daily discharge, and river water temperature measurements for the day of egg collection.

			Distance (km) from						
Site	Location	Method	Ballville Dam	Muddy Creek Bay	Dates collected	N eggs	Developmental stage(s)	Mean daily discharge (m^3/s)	Water temperature (°C)
B1	N 41.3566, W 83.1045	Bongo Net	5	20	7/13/2015	1	2	323	19.8
B3	N 41.3864, W 83.0908	Bongo Net	10	15	6/18/2015	1	8	368	22.8
B4	N 41.3972, W 83.1026	Bongo Net	14	11	6/29/2015	1	10	254	19.5
					7/14/2015	4	9, 10, 10, 12	244	21.1
LT2	N 41.4267, W 83.0503	Light Trap	21	4	7/1/2015	1	13	129	20.3

Results

There were two high-flow events that occurred in 2014 when mean daily discharge exceeded 31 m^3/s: June 6–12 and June 19–30 (Fig. 2). The peak flow of the first event in 2014 was ~98 m^3/s while the peak flow of the second event was ~166 m^3/s. During the summer of 2015, there were three high-flow events when mean daily discharge exceeded 31 m^3/s: June 15–23, June 27–July 4, and July 9–23 (Fig. 2). The first event of 2015 (June 15–23) peaked at ~370 m^3/s. The second event (June 27–July 4) had a peak flow of ~340 m^3/s. The third event was the longest and persisted for 15 days (July 9–23), with the peak flow of ~320 m^3/s. All three events achieved peak flow within five days of exceeding 31 m^3/s. The thermal threshold for maturation of 633 ADD15 was reached on June 22, 2014 and June 17, 2015.

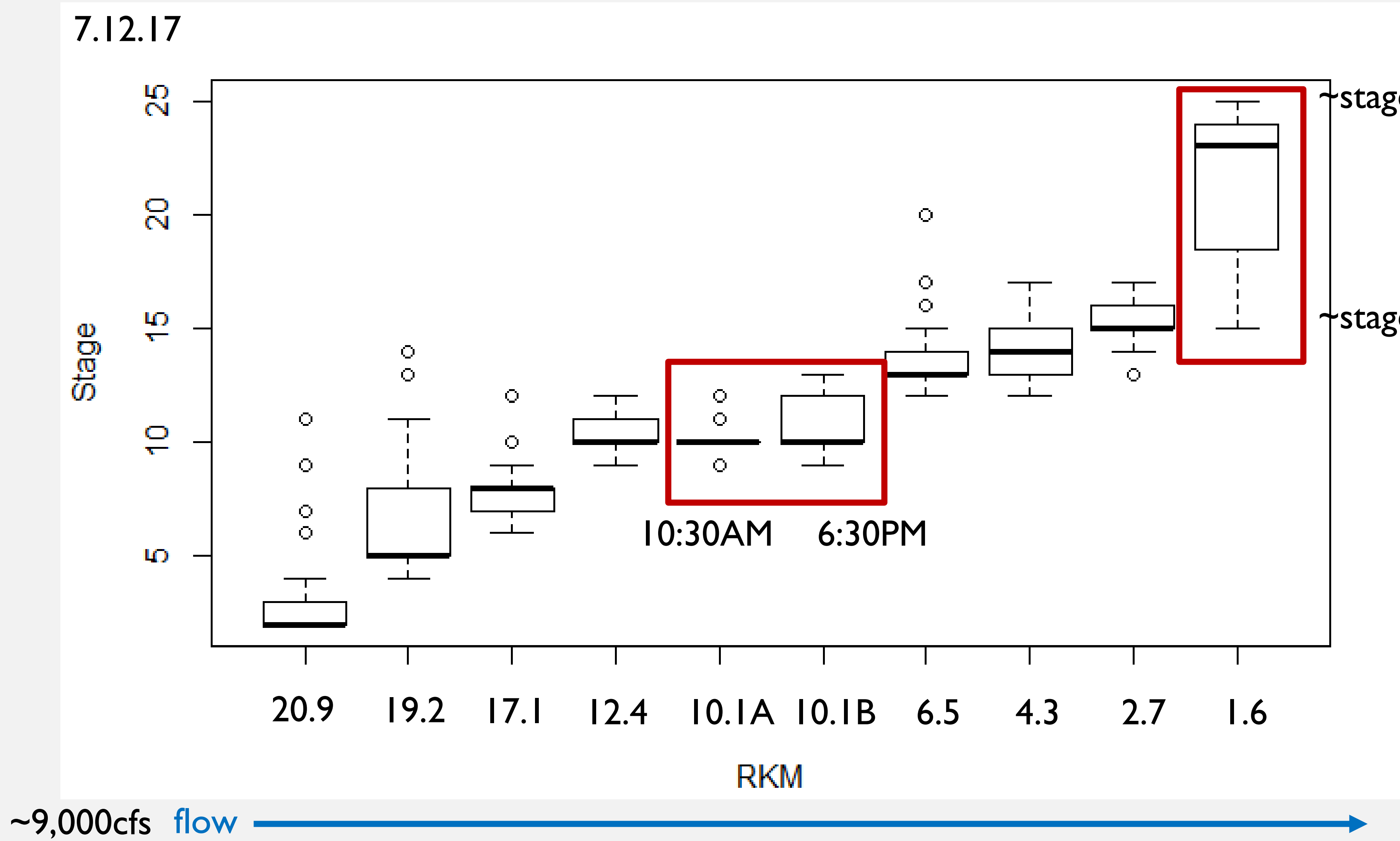
Success of egg capture varied between years. In 2014 there were no eggs collected that were morphologically consistent with grass carp. In 2015 we identified and staged eight potential grass carp eggs on five

All eggs were collected during high-flow events, either on the day of peak flow or 1–2 days following peak flow. This finding supports an earlier suggestion (Chapman et al., 2013) that high-flow conditions favor grass carp spawning. This pattern is consistent with Lin (1935), who reported that high magnitude increases in flow were required to trigger grass carp spawning in Chinese rivers. Although high flows were associated with spawning evidence collected in 2015, others have demonstrated that non-native populations of Asian carps have successfully spawned despite only low-magnitude changes in flow (Aliyev, 1976; Coulter et al., 2013). In the Kara-Kum Canal in Turkmenistan, several species of Asian carp, including grass carp, spawn without discernable flow changes (Aliyev, 1976). Additionally, in the Wabash River, bighead carp and silver carp, which have very similar spawning requirements as grass carp, have spawned regardless of flow increases (Coulter et al., 2013, Deters et al., 2013). Although our sampling was more intense during high-flow events, we did sample during low flows. Collectively, the weight of the evidence suggests high magnitude increases in flow are

Sandusky River rkm 20.93 stage 3, rkm 1.57 stage 25 (~1rkm upstream stage 17 highest)

Site Name	RKM
Ballville Dam	RKM 26.4
Groceries Bridge	RKM 22.25
Upstream Bradys	RKM 21.84
s1	RKM 20.93
s2	RKM 19.22
s3	RKM 17.11
s4	RM 12.35
s5	RKM 10.05
RIverfront Marina	RKM 8.07
Memory	RKM 6.46
LT	RKM 5.38
Swarts chan	RKM 4.3
Fisher	RKM 2.7
Jon	RKM 1.57
Mouth	RKM 0.3

PROLONGED SPAWNING EVENTS EGG STAGES VARIABLE DOWNSTREAM



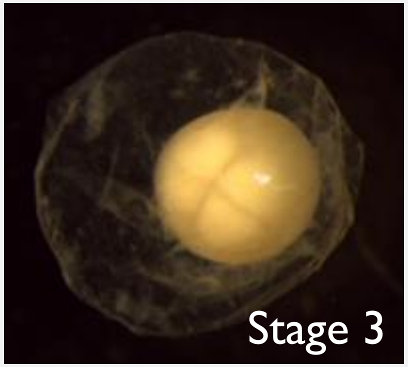
CUMULATIVE THERMAL UNITS

$$CTU = t(T_c - T_{min})$$

t = time in hours

T_c = treatment temperature in degrees Celsius

T_{min} = thermal minimum in degrees Celsius



CTU=9.915

CTU=184.279

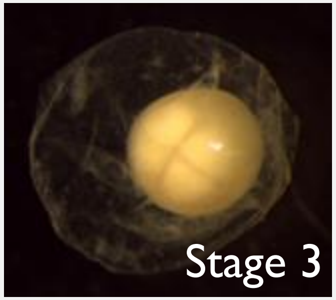
Citation: George AE, Chapman DC (2015) Embryonic and Larval Development and Early Behavior in Grass Carp, Ctenopharyngodon idella: Implications for Recruitment in Rivers. PLoS ONE 10 (3): e0119023. doi:10.1371/journal.pone.0119023

CALCULATING FERTILIZATION TIME

Development based on temperature

- CTU from George & Chapman 2015
- Temp of river (USGS gauge 04198000)

Hours post fertilization = CTU/(T - 13.5) ← Thermal min



CTU=9.915 Water temp=20.48°C

Fertilization time = Capture time - HPF

11:27am 12:53pm 1.42