Developing virtual learning opportunities to train *community scientists* about lake sturgeon and coupled Great Lakes-tributary ecosystems

Project Investigators – Kim Scribner, Brandon Schroeder, Douglas Larson, Edward Baker
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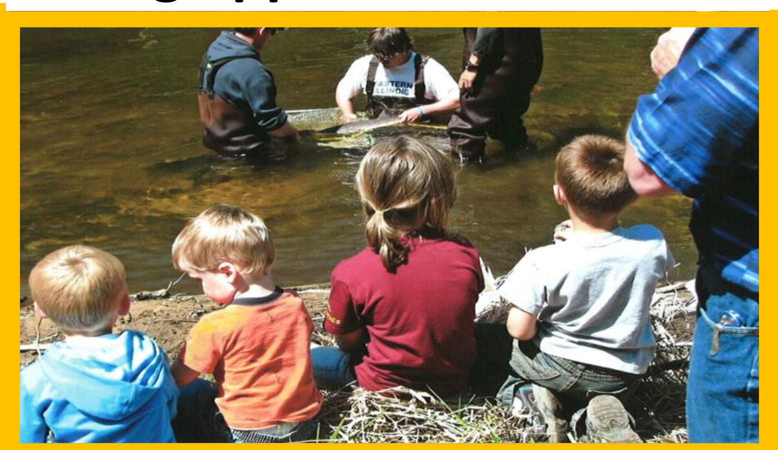
Teacher Consultant – Brooke Groff

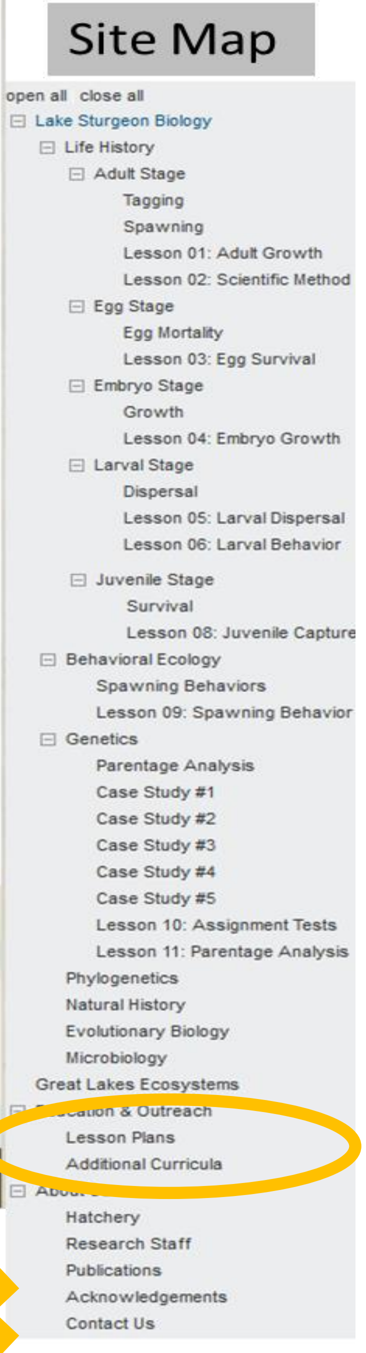
Funding and Logistical Support

Michigan State University Extension
Sea Grant Michigan
Great Lakes Fishery Trust
Michigan State University AgBioResearch
DNR
U.S. Fish & Wildlife Service, Department of the Interior
Department of Fisheries and Wildlife • Michigan State University •

Over 18 years MSU/MiDNR place-based and 'virtual' experiences offer K-12 students and teachers learning opportunities centered around lake sturgeon



For more information on Black Lake sturgeon web site see https://www.glsturgeon.com
Community Science web site see https://sites.google.com/msu.edu/sturgeoncommunityscience

Kim Scribner (scribne3@msu.edu) or Doug Larson (larso147@msu.edu)

Lake Sturgeon Community Science Videograph Program

- We have established an interpretative "***Community-science***" videography system that used underwater cameras to record fish entering the Black River in NE Michigan and the time and date of passage up- and down-stream.
- We have developed a species identification key that allows users to identify fish species.
- We have developed a web site to host the videos and background materials on fish migration, reproductive ecology, and predator-prey relationships.
- We have worked with K-12 STEM educators to develop lesson plans to direct student learning.

Goal: *This e-learning platform will allow students and citizens to make observations, synthesize information, and draw conclusions in a web-hosted environment. Citizen science can help community members learn more about scientific processes, become more engaged in local issues, and better understand policy decisions.*

Communicating science is a two-way street

Sturgeon data providing virtual classroom learning opportunities

Students providing data to scientists

Summary

- **Date**
- **Time**
- **Species #**

Community Science Project Summary

Goal - to provide educational and outreach community science e-learning to inform K-12 students, citizens, and stakeholders about Great Lakes tributary communities, inter-species interactions, and human disturbance that affects the ***sustainability*** of ecosystem processes and ***species viability***.

Methods - hands-on data collection, analysis, and interpretation of videography and fish tracking data that is interpreted using long-term data.

Charismatic lake sturgeon is the ‘hook’ to grab participant’s attention.

Please identify the fish in the above video.

- Smallmouth Bass (Micropterus dolomieu)
- Yellow Perch (Perca flavescens)
- Walleye (Sander vitreus)
- Spotted Gar (Lepisosteus oculatus)
- Largemouth Bass (Micropterus salmoides)
- Rainbow Darter (Etheostoma caeruleum)
- White sucker (Catostomus commersonii)
- Bluegi [illegible] acrochirus)
- Uh, that's not a fish!

Is this fish a predator or prey?

Is high abundance good or bad?

Sturgeon Videography Learning Pathway

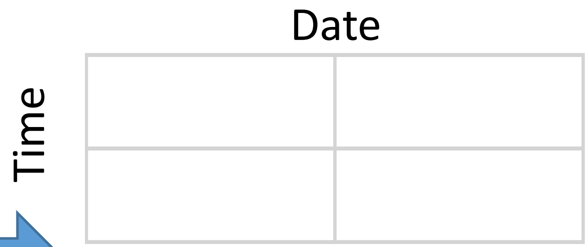
Step 1 – Have students complete tutorials, take fish ID videography test, view videos, and review assignment.

1 ½ to 2 hrs

Step 2 – Using the worksheet provided, assign the videos we have selected to students (a single 1 hour video). Using fish species key, students will tally species numbers, movement direction, and times.

1 1/2 hrs

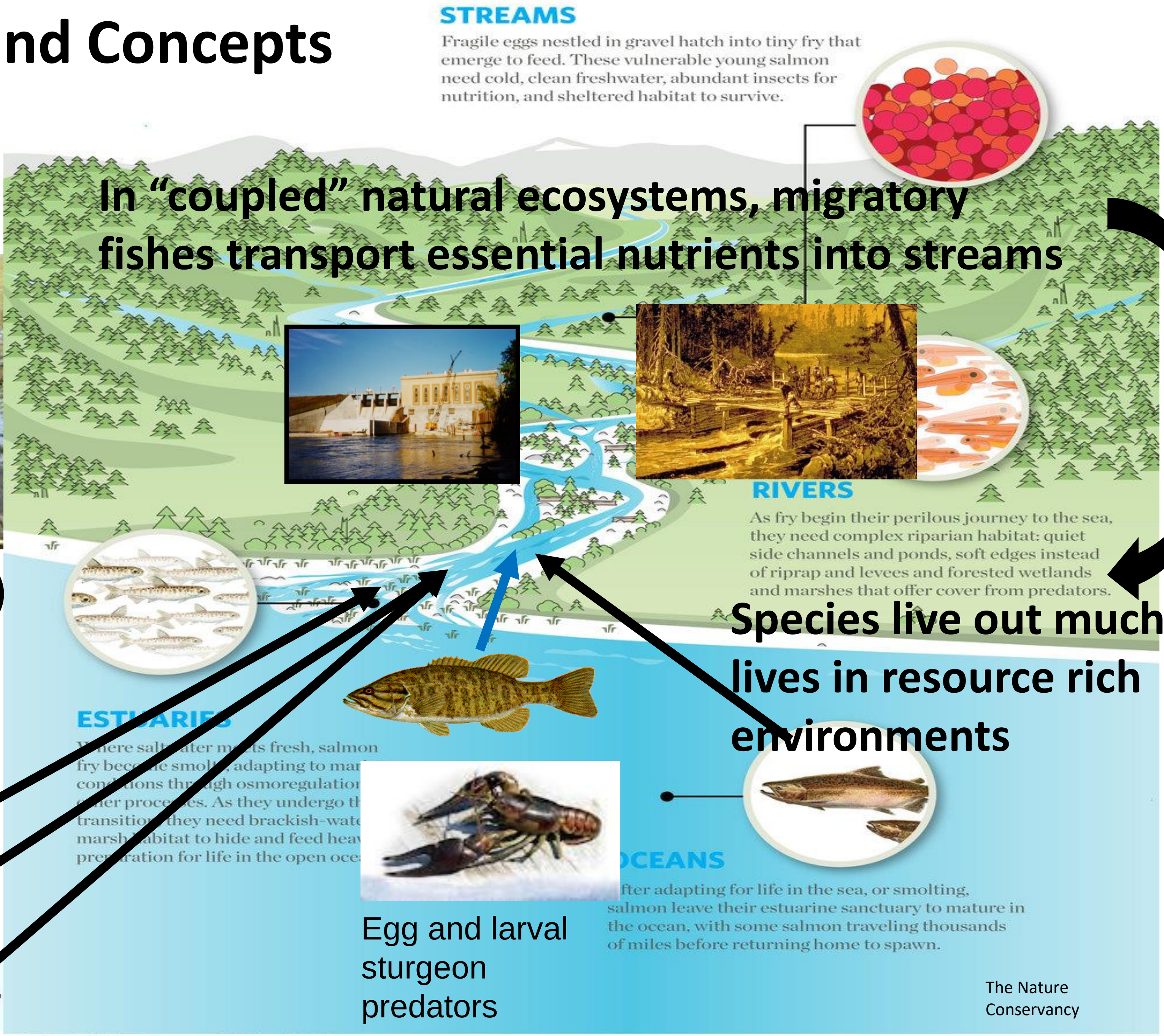
Step 3 – Combine all students' information into a table and diagram. The teacher leads discussion on trends students observe in data. The lesson plan provides concepts and questions that students will likely observe in the data to help the teacher focus the discussion associated with each video presentations and video on data.



2 hrs

Teacher Background Concepts

(a) Salmon decomposition after reproduction



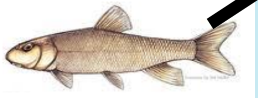
In "coupled" natural ecosystems, migratory fishes transport essential nutrients into streams

Species live out much of their lives in resource rich environments

(b) Freshwater (Great Lakes) migratory species deposit feces, sperm & eggs

Lake Sturgeon

Suckers (several species)



Walleye

Egg and larval sturgeon predators

The Nature Conservancy

Smolt and Adult Salmon Illustrations - U.S. Fish & Wildlife Service

Examples of species utilizing Great Lakes tributaries for spawning and year-round residents

Temporary (migratory) users

Lake sturgeon

Salmon

Suckers

Sea lamprey

Walleye

Mayflies

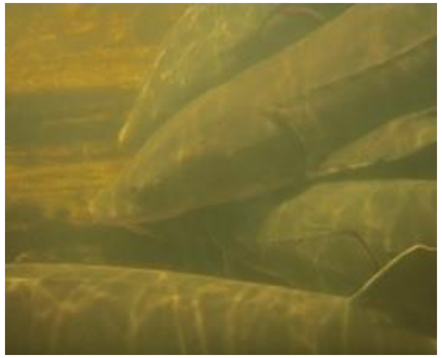
Year – round residents

Smallmouth bass

Crayfish

Darters

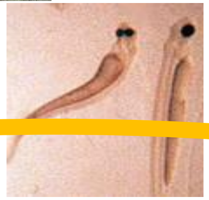
Lake Sturgeon life stages and biological and physical features of Great Lakes tributaries that contribute to high early life mortality



Adult: spawning	Egg: incubation	Free embryo: development in substrate	Larval: emergence and dispersal	Juvenile

beneficial and pathogenic colonists of egg and GI tracts

Egg and larval sturgeon predators



Alternative prey

Stream Physical features

Underwater videography background

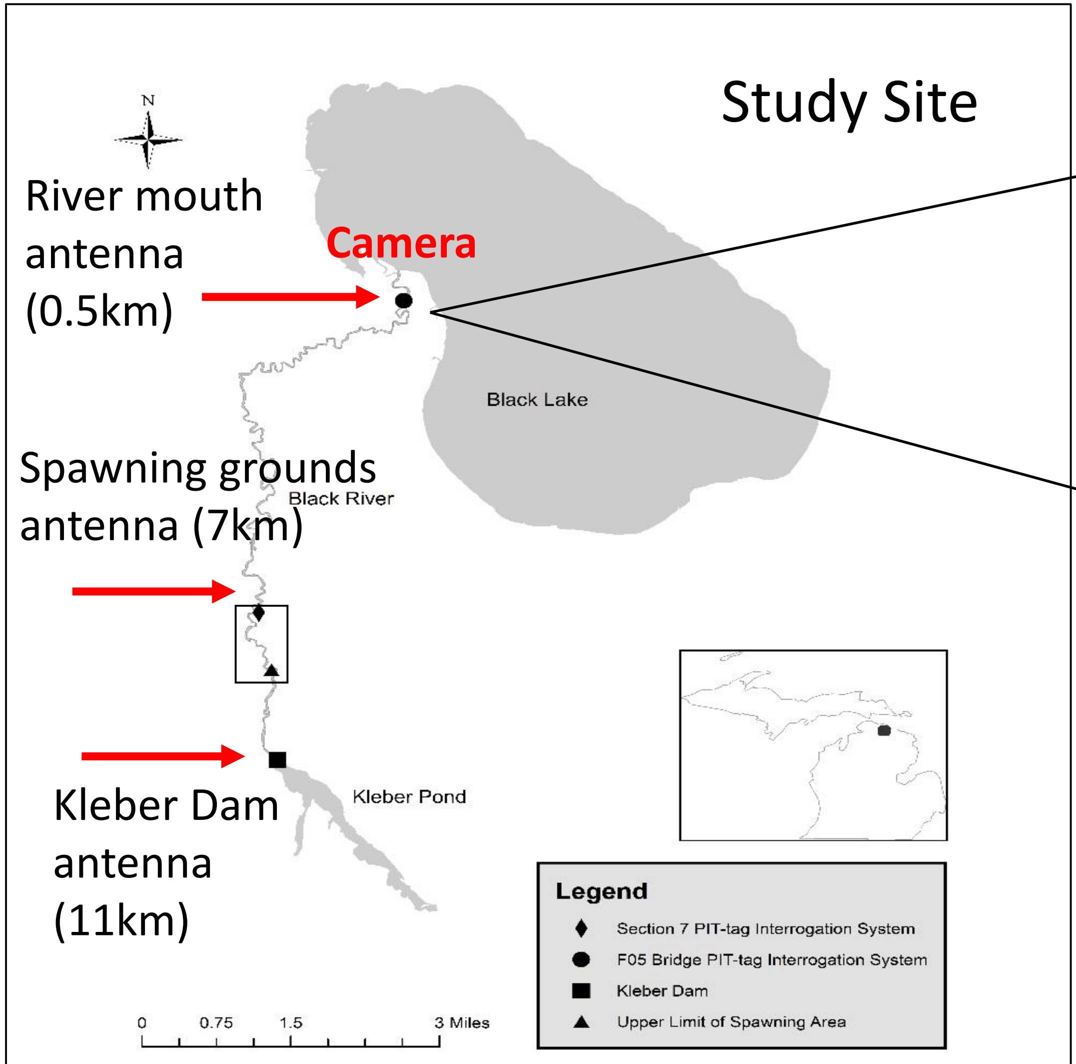


Figure 1: Study site map of the Black River in Michigan showing the locations of PIT-tag interrogation systems, Kleber Dam, and the upper limit of the lake sturgeon spawning area.

Credit: Danielle Blumstein

Youtube sites to use videography

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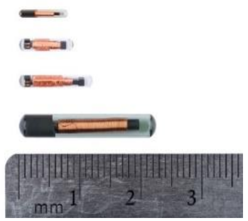
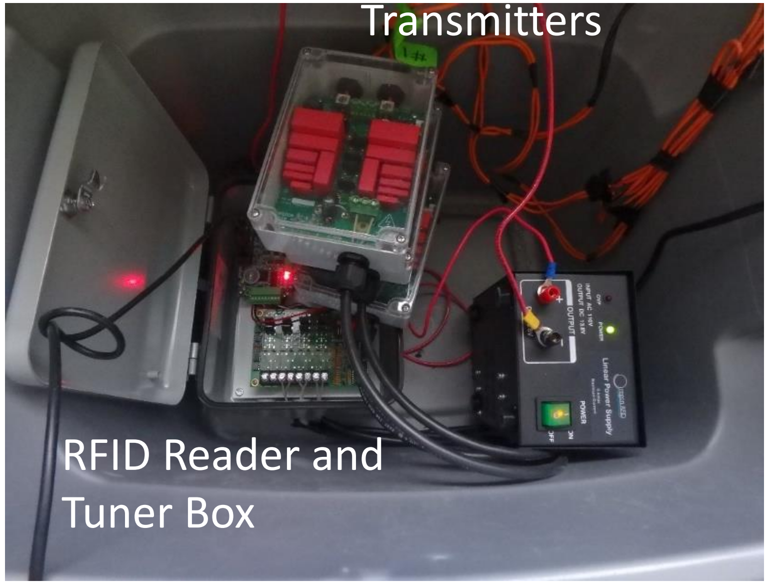
YEP - https://youtu.be/vzjBQVFZ4Q8
SPG - https://youtu.be/FdO1RXmaTnk
BLG - https://youtu.be/8efmp75uSf8
SMB - https://youtu.be/kuyeQxuRgT4

Acoustic telemetry and PIT-tag RFID technology – two ways researchers are able to follow lake sturgeon migrating into the river and into spawning areas upstream.





The white PVC tubing houses special that transmits an electrical signal that is received by the ‘RFID Reader”. If a lake sturgeon that has a RFID transmitter tag passes over the antenna a signal is transmitted that records the tag number.

Instructional materials focus on:

(i) Ecology – Great Lakes ecosystem processes and inter-relationships (spawning migration, effects of nutrients, substrate, species abundance and composition, and predator-prey relationships)

(ii)Reproductive biology, *physiology*, *anatomy and behavior* - Problem-solving of costs and benefits of sturgeon behaviors that link to outcomes (i.e., successful reproduction) will help students develop cognitive skills while learning biological principles.

(iii) Geology, *physical sciences*, *water quality* - Exercises will be developed quantifying chemical and physical characteristics of streams.

(iv) Sociology - We will focus instructional materials on effects of humans and human cultural and economic ties to aquatic systems.

(v)Evolutionary biology - Changes to aquatic ecosystems result in differential survival and reproduction – process of natural selection on individuals operating on heritable characters.

(vi)Math and statistics - Data covering multiple variables gathered by videography will be manipulated to develop quantitative problem-solving skills.

Example of Lesson Content - Sturgeon Lesson Plan

Lesson Title: ***Understanding Fish Seasonal Migrations and Predator-Prey Relationships Through Underwater Video***

Summary: xxxxx Learning Objectives: yyyyy Duration: portions of 5-6 hours

General life-history traits of large, long-lived Lake Sturgeon

Subjects: Biology or Life Science Grade Level(s): 7-12

Content Standards:

MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Materials/What you Will Need:

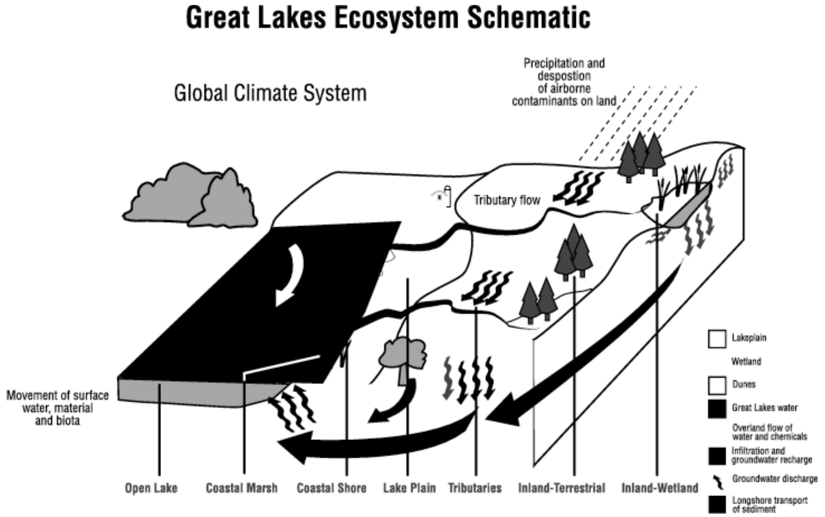
•Computer Lab with Excel 2007 or higher

•Data sets from and lesson for videography.

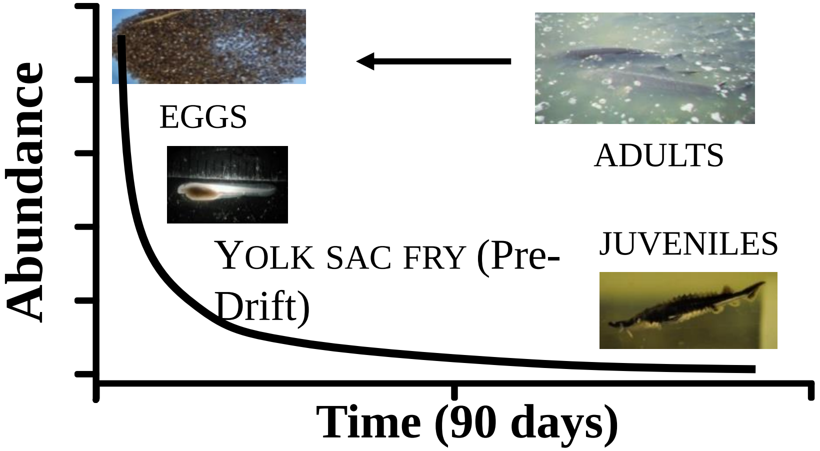
•Background presentations. Larval life stage background from lake sturgeon web site https://www.glsturgeon.com.

Other Background Visual Presentations and Curricula Material

Coupled Great Lakes – Tributary Ecosystems

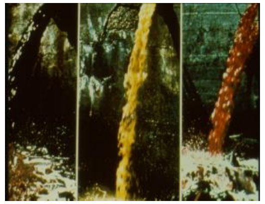


Lake Sturgeon Ecology



Land use & Land Cover Changes

Climate change & variability

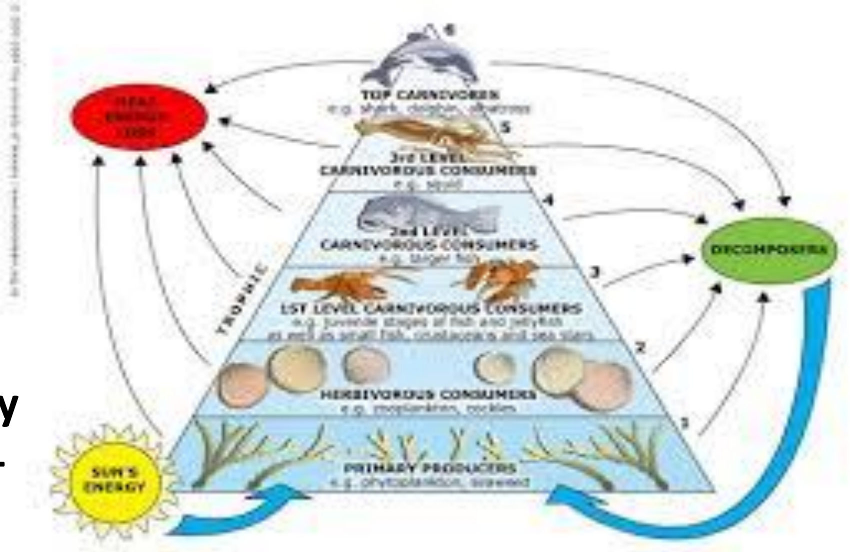


Human Disturbance To Great Lakes-Tributary Ecosystems

Waterway Uses & Pollution

Barriers to Spawning Migration

Over Exploitation



Community Ecology including predator-prey relationships


Help Students Have Fun With Lake Sturgeon!

Enhancing Michigan's virtual and place-based educational opportunities and community stewardship using charismatic Lake Sturgeon in connected Great Lakes - tributary ecosystems

Biodiversity and Connected Great Lakes-Tributary Ecosystems

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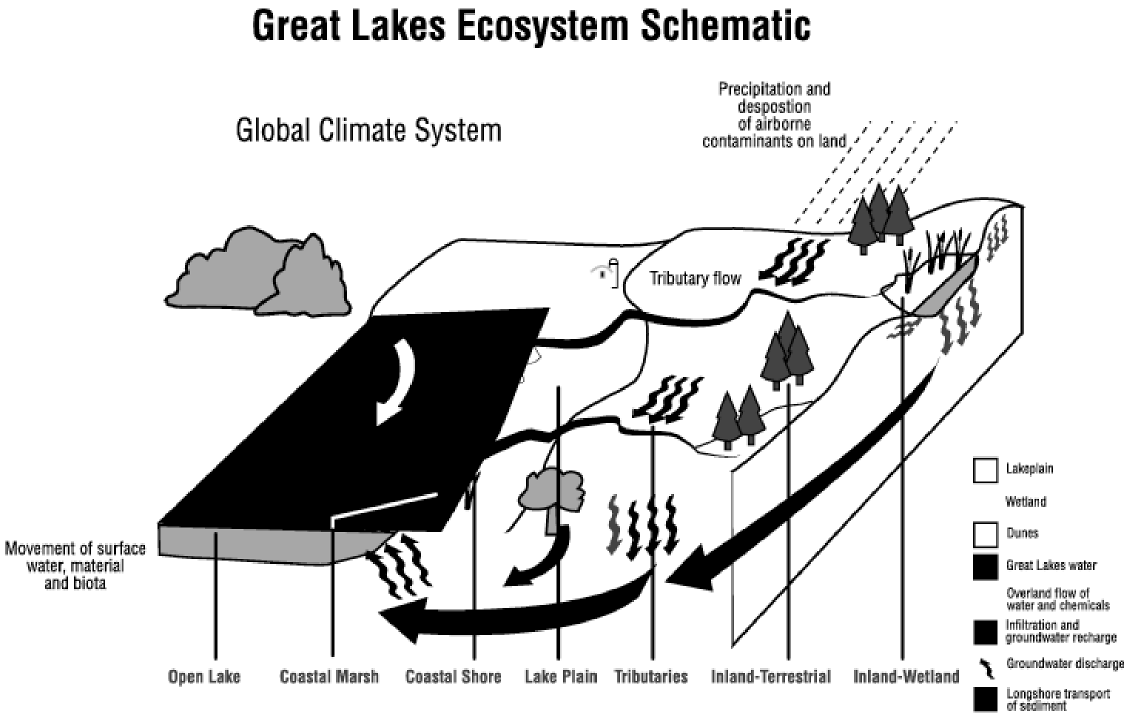
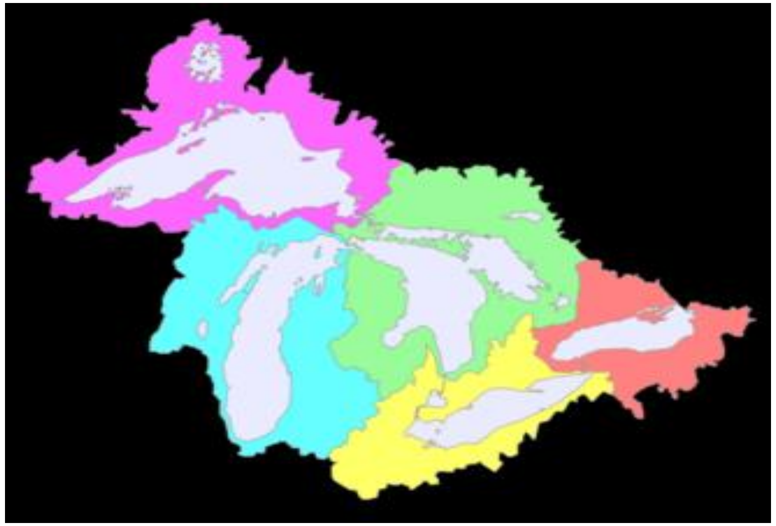
Connected Great Lakes-Tributary Ecosystems





Source-Wikipedia

- 84% of North America's surface fresh water
- ~20% of the world's supply of surface fresh water
- 10,500 miles of coastline
- 295,710 square miles of drainage area (watershed)
- Ecosystems support thousands of species – *a natural treasure**
- Ecosystems support commerce and economies– *ecosystem services*

Ecosystem Services = Nature's Benefits

Ecosystem Services: The benefits that humans receive from the goods and services that are supplied by natural ecosystems.

- **PROVISIONING, such as the production of goods like food and water;**
- **REGULATING, such as the control of climate and disease;**
- **SUPPORTING, such as nutrient cycles and crop pollination;**
- **CULTURAL, such as spiritual and recreational benefits.**

Source: the Millennium Ecosystem Assessment and GLEAM

We receive many benefits from the coupled Great Lakes-Tributary Ecosystems.

Connected Great Lakes-Tributary Systems Enhance and Sustain Biodiversity

Biodiversity = variety (different) of life forms (biological) at a site, ecosystem, or landscape.

Richness = Number of groups of related individuals - usually the number of species.

> or <

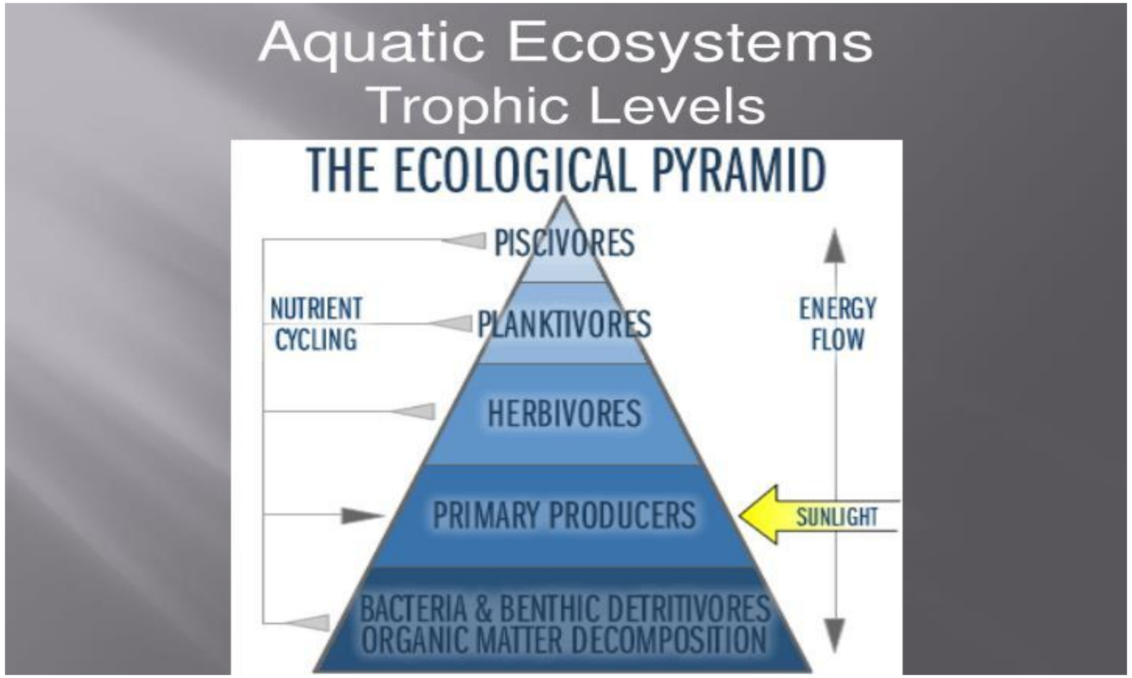
Evenness = Proportions (combinations) of species present on a site. The more equally represented species are in proportion to each other the greater the evenness of the site.

(low evenness means only few and numerically abundant species in a site).

> or <

Source – University of Idaho

Measures of Biodiversity



Numerical abundance

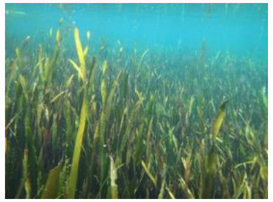
Black River Trophic levels

Are these species migratory ('M' seen in photos) or stream residents ('R')?

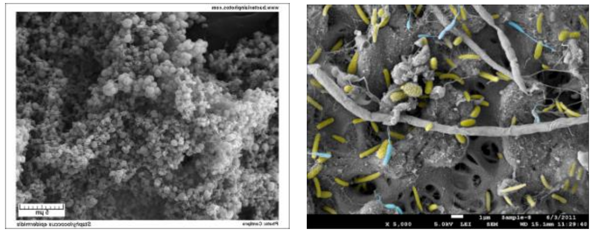
Fish predators

Fish larvae, insects

Plants



Bacteria & fungi



Biodiversity can be measured in three different ways:

Alpha diversity (α) is diversity in a location (e.g., an area, community or ecosystem) = number of species

Beta diversity (β) is species diversity between locations = comparison of the number of species unique (or different) in each location

Gamma diversity (γ) measures overall diversity for different locations in a region (α + β)

Diversity measures are typically estimated at individual trophic levels.

Question

Does the connection of Great Lakes and tributaries increase or decrease the region's diversity?

Why measure biodiversity?

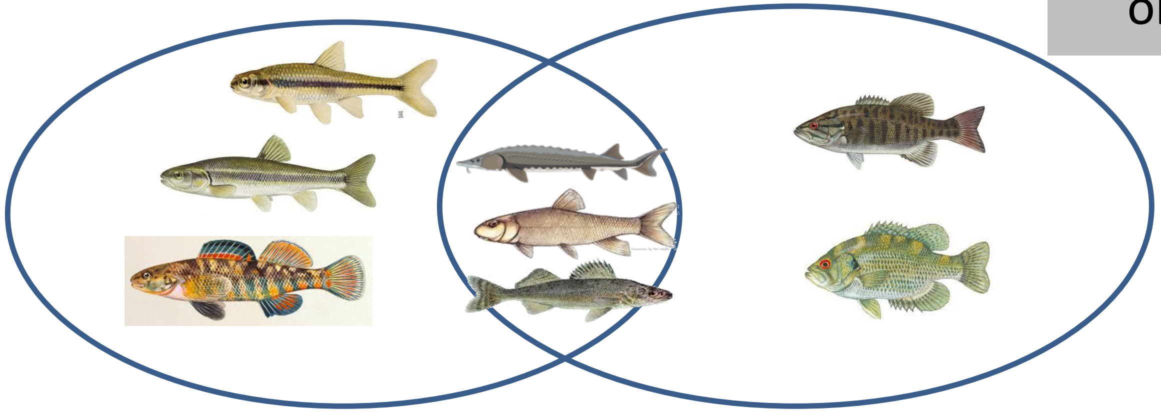
High biodiversity = Indicator of high ecosystem health.

Diverse communities are typically **more stable** and **productive** & **resilient to change or disturbances** (can experience change and quickly bounce back).

Example - Rivers with diverse habitats and different plant species help to:

- Provide food for insects and fish
- Protect and enhance recovery from extreme events like floods or droughts

Great Lakes



Tributary (River)

Biodiversity is enhanced through <u>connectivity</u>…

Or the movements of animals between different areas

Rivers often have HIGHER diversity and productivity because of connection to the Great Lakes.

Diversity describes variation in several ways:

- Genetic (species, populations, individuals, genes)
- Life form (fish, insects, plants, bacteria and fungi)
- Functional group (predators, filterers, scrappers)

Diversity of aquatic insects play many different, important roles in the food web based on HOW AND WHAT they eat!

Examples of insect functional feeding groups

filterer

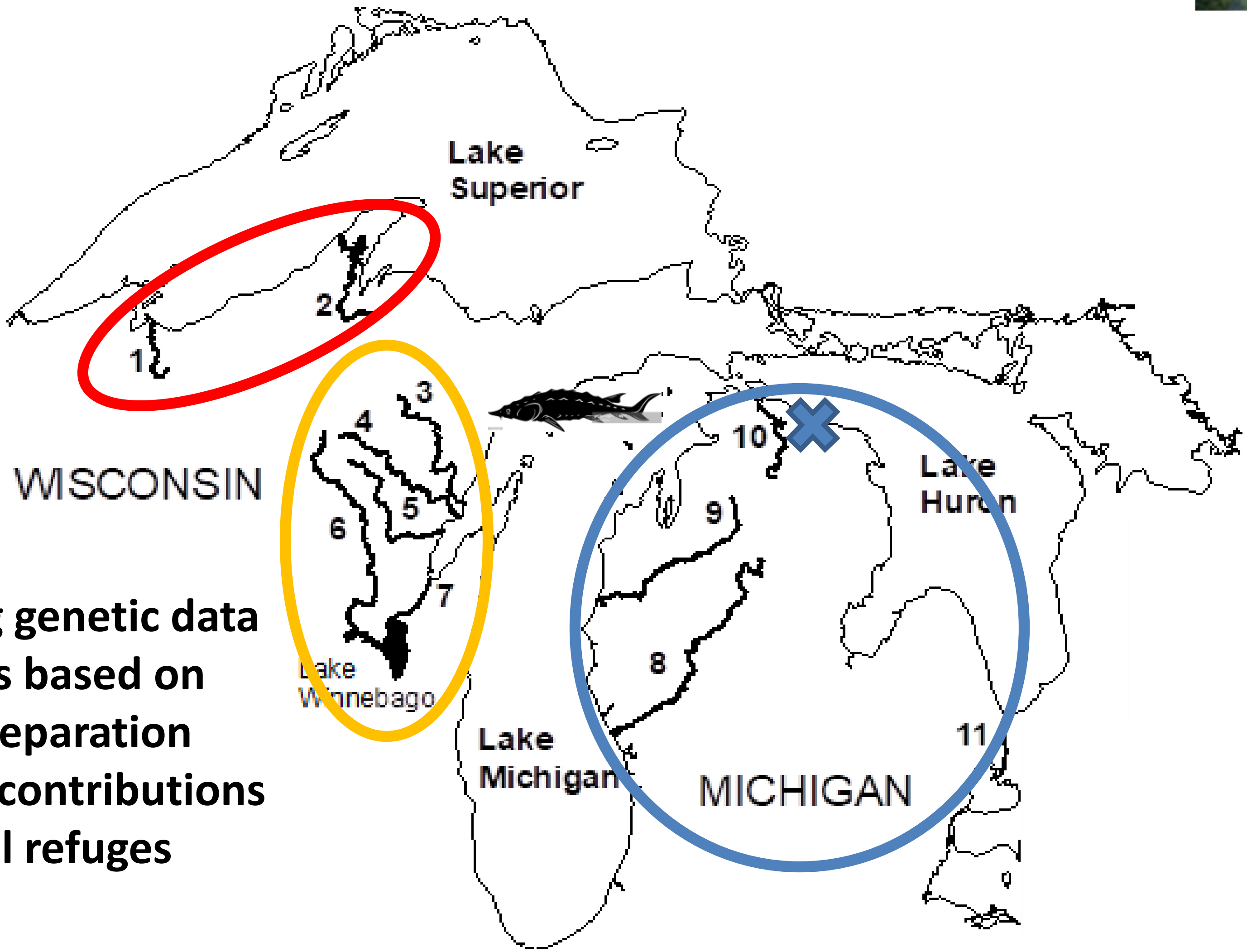
scrapper

predator

mayflys

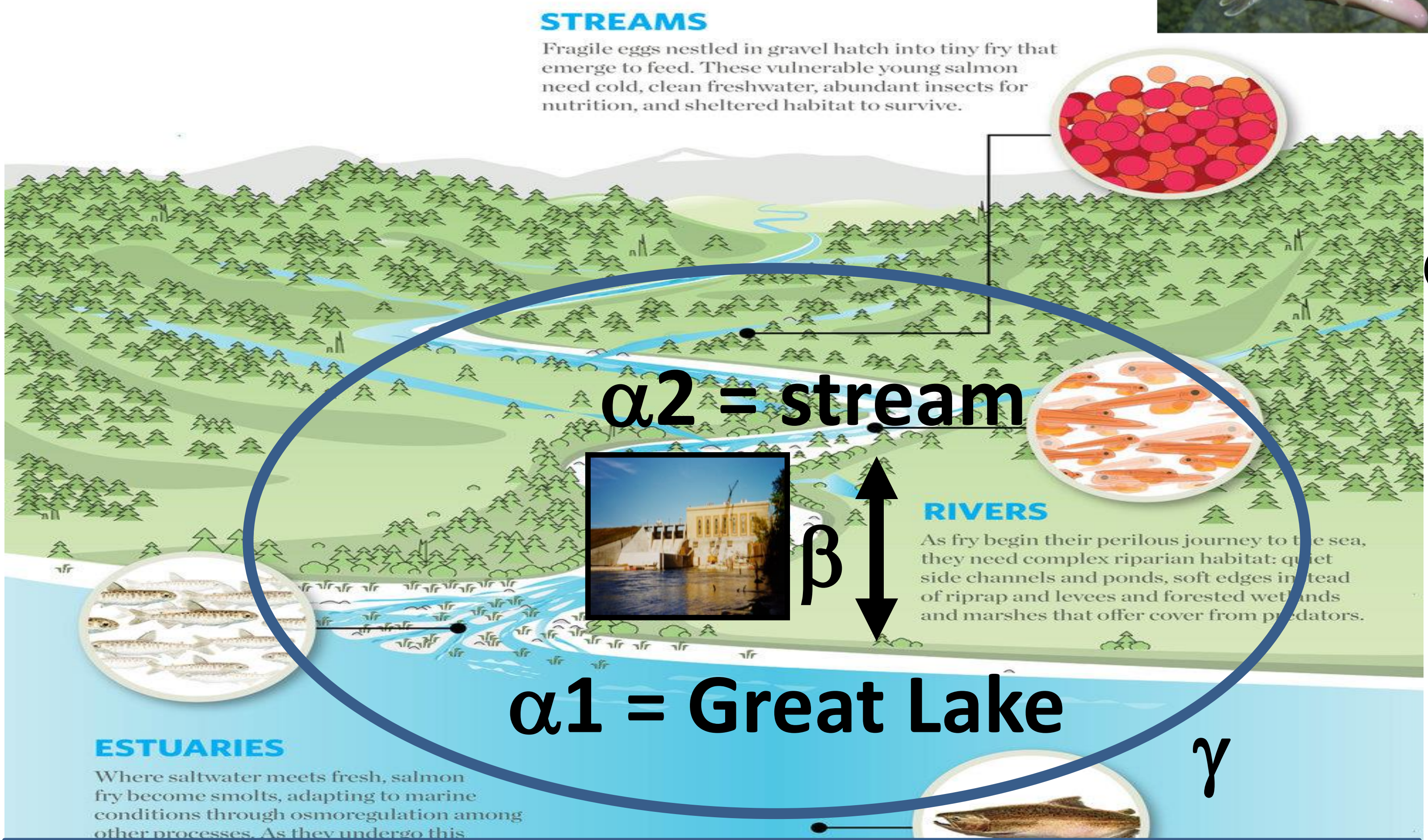
stonefly

Levels of Biological Diversity: Great Lakes MI Populations of Lake Sturgeon



- Groups resolved using genetic data
- Population differences based on times of geological separation (glacial history) and contributions from different glacial refuges

Biodiversity in Coupled (connected) Great Lakes-Tributary Ecosystems.



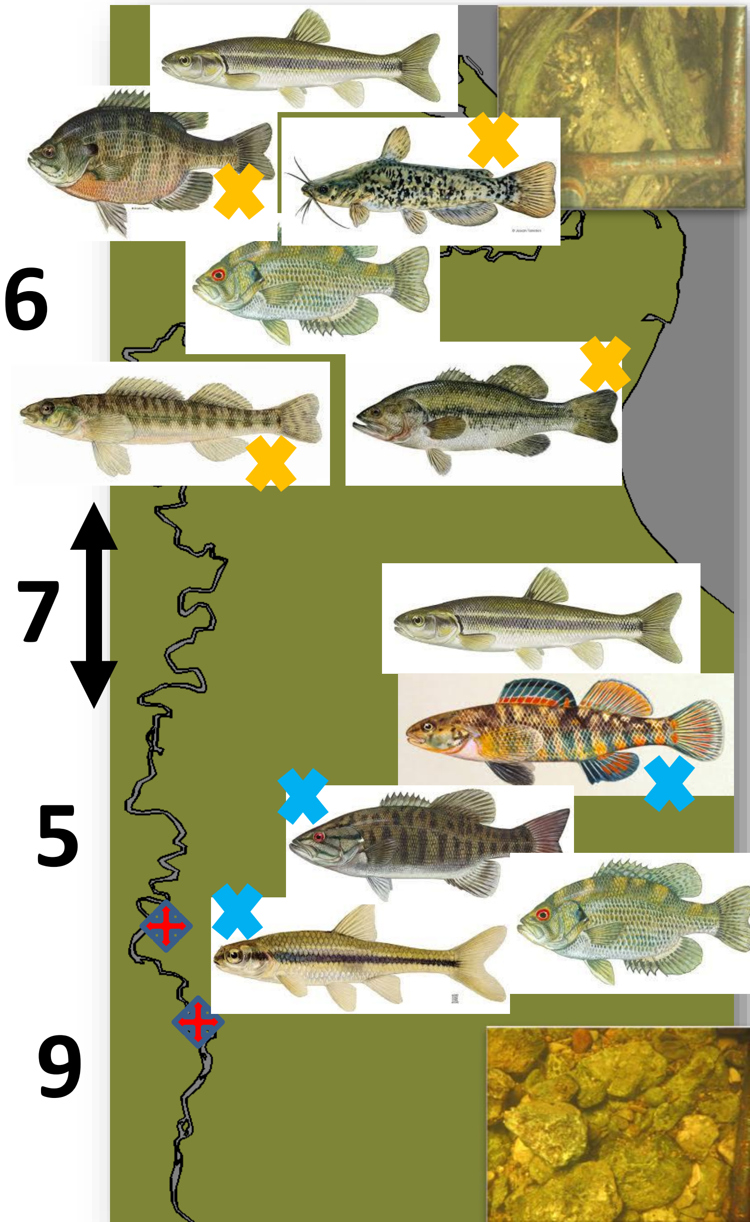
Diversity in the Black River and Black Lake

α1 = 6

β = 7

α2 = 5

γ = 9



- Do you think α1 or α2 in the picture above is greater? Why?
- Will fish migrating into the river increase or decrease α1 and α2? Why?
- Will fish migrating into the river increase or decrease β? Why?
- What would happen to β and γ if a dam were constructed in the river?

Fish Move Nutrients in a Watershed

1. Salmon die in rivers after spawning – and decompose (nutrients!)

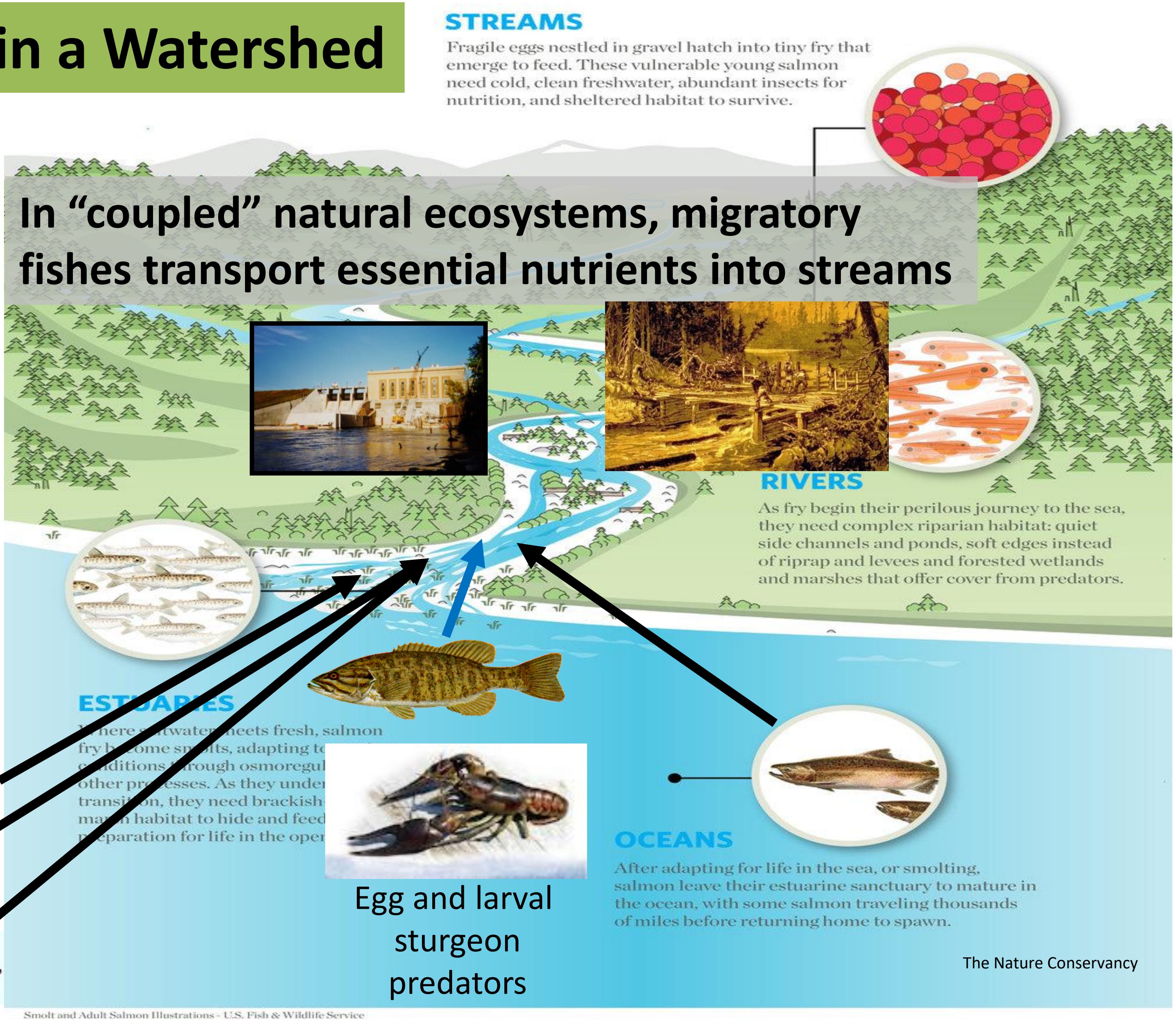
2. Other migratory species don't die *but* deposit feces, sperm & eggs

Lake Sturgeon

Suckers

Walleye

In "coupled" natural ecosystems, migratory fishes transport essential nutrients into streams



Egg and larval sturgeon predators

The Nature Conservancy

Examples of Species Using Great Lakes Tributaries

Temporary visitors – migrate from the Great Lakes into rivers to reproduce or find food (eggs and juveniles produced from spawning fish).

Fulltime residents – can be predators or prey representing different 'trophic levels' including fish and aquatic insects

Lake sturgeon

Salmon

Suckers

Sea Lamprey

Walleye

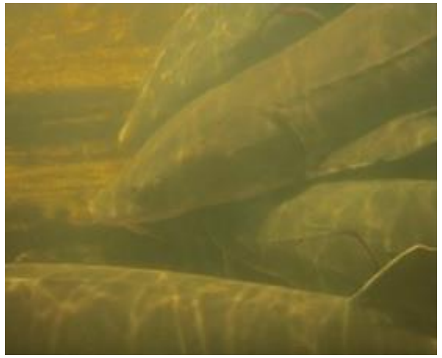
Large mouth bass

Crayfish

Mayflies

Minnows

Lake Sturgeon life stages and biological and physical features of Great Lakes tributaries that contribute to high early life mortality (death)





Adult: spawning	Egg: incubation	Free embryo: development in substrate	Larval: emergence and dispersal	Juvenile

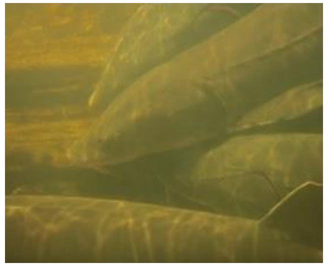
beneficial and pathogenic colonists of egg and GI tracts

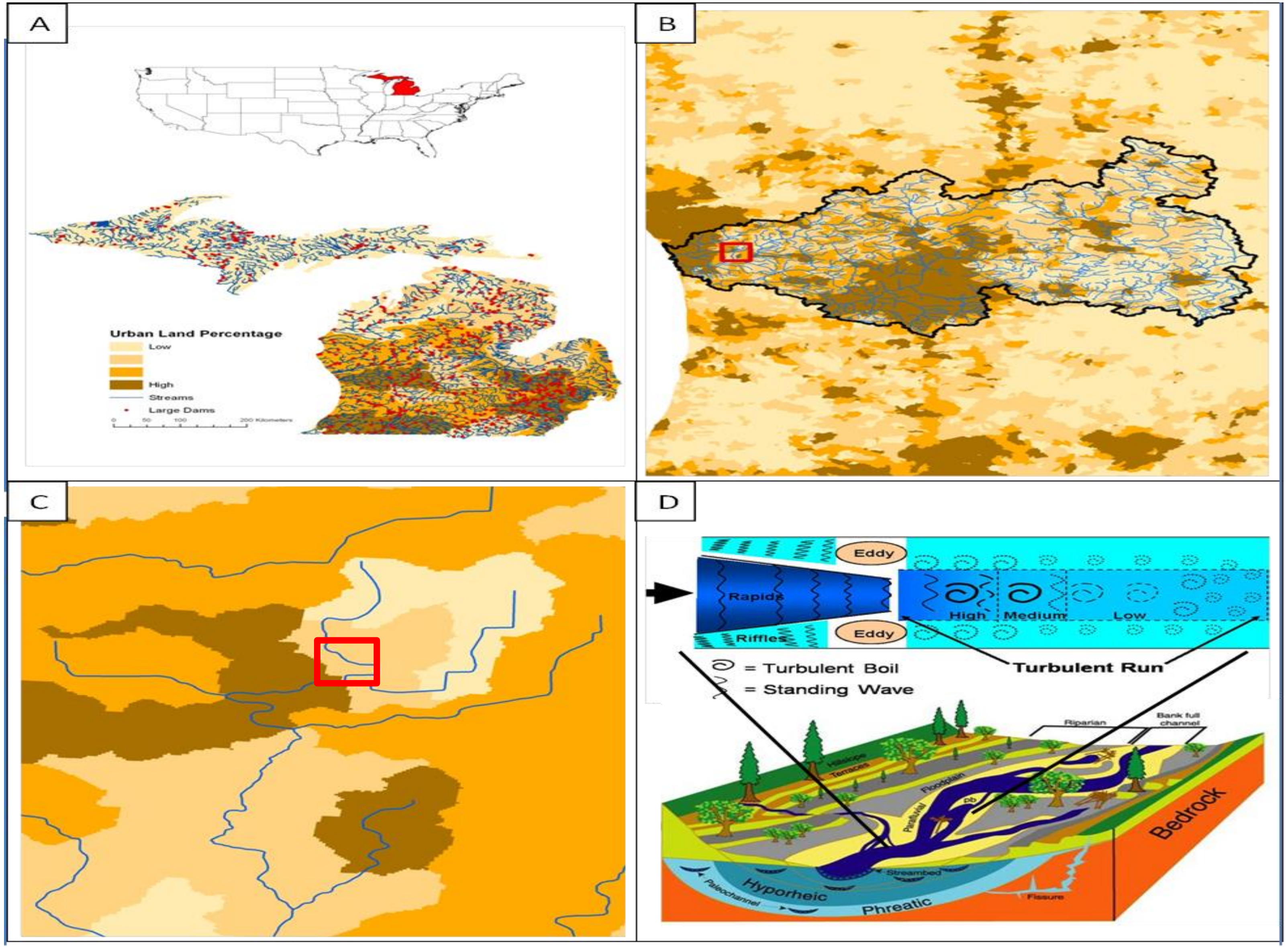
Egg and larval sturgeon predators

Alternative prey

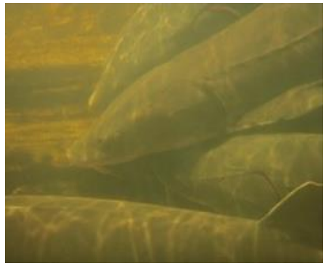
Stream Physical features

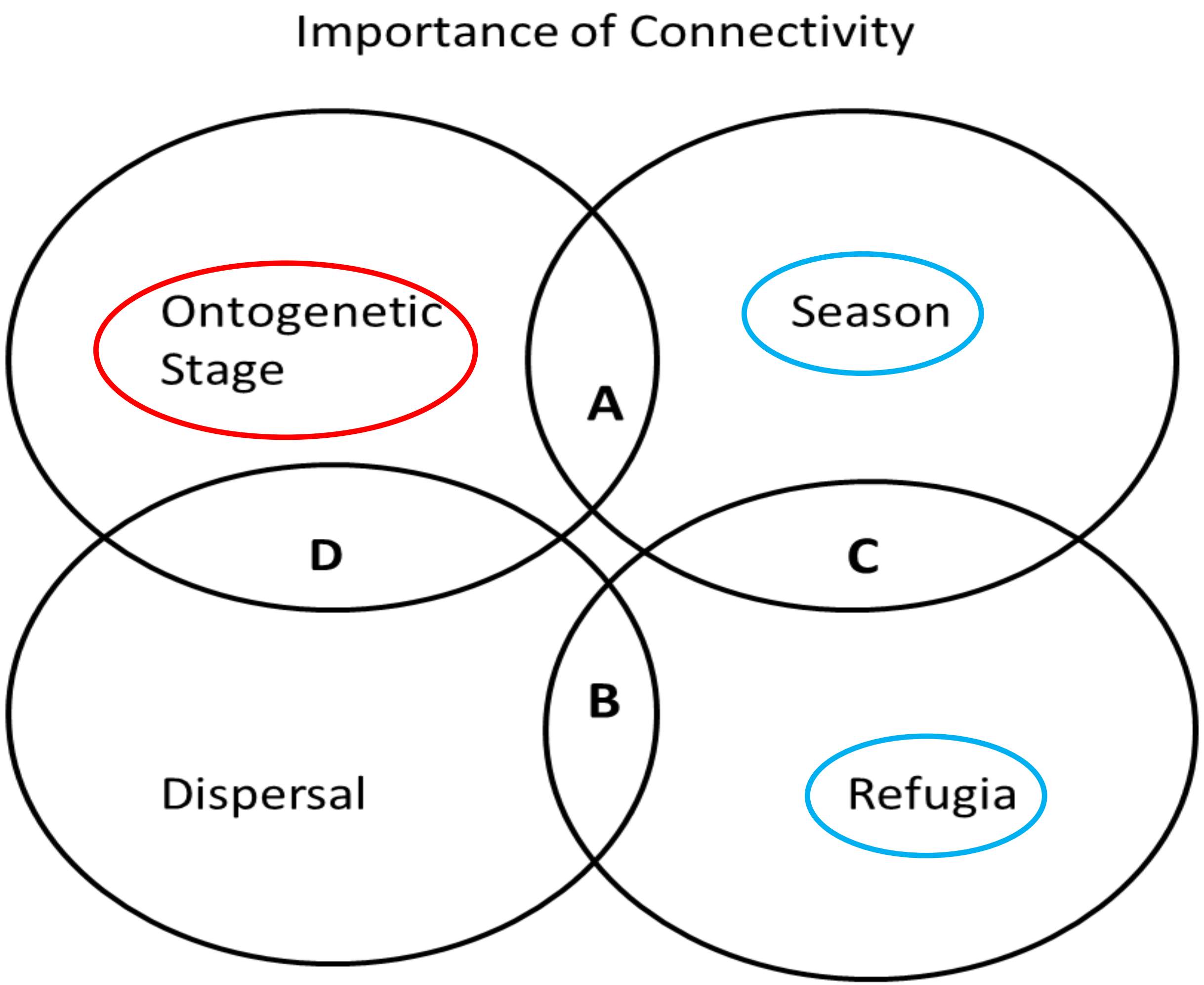
Mapping watersheds can help understand habitats fish encounter in rivers

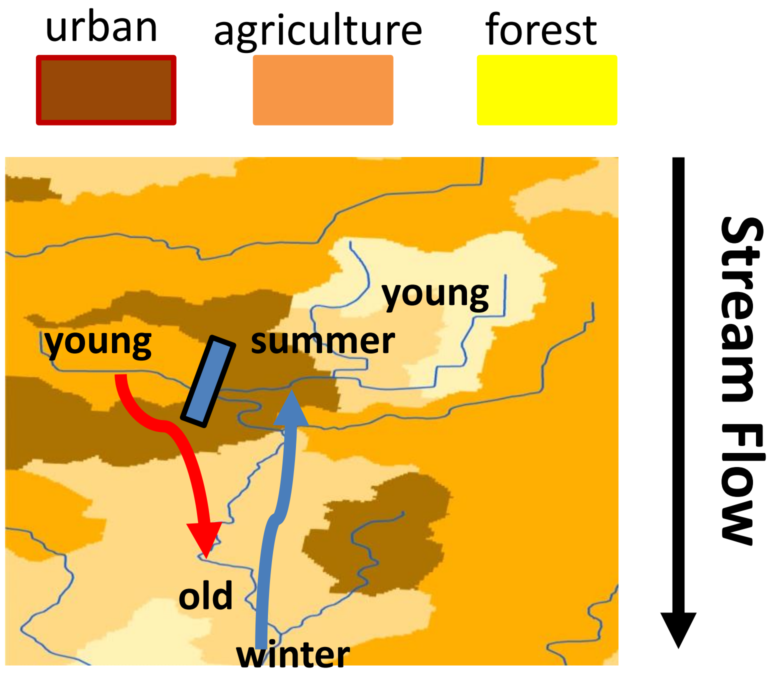




Connectivity is critical for individuals to access food and key habitat at different life stages.







Example of stream locations Important to different ages (young vs old) and during different seasons (summer vs winter)

Adapted from Dan Letcher AFS Slide

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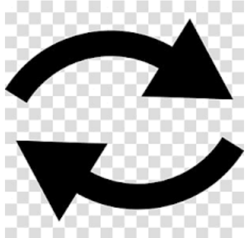
Main Hatchery Black River

When larvae are feeding well, they are taken to other sections of the hatchery where they are maintained in larger tanks or raceways. Juveniles will be kept in these tanks until they are released in late summer. Some experiments have been conducted where individual larvae were housed in small cups.

Other place-based Black River educational activities

Communicating science is a two-way street

Sturgeon data providing virtual classroom learning opportunities



Students providing data to scientists

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Underwater videography background

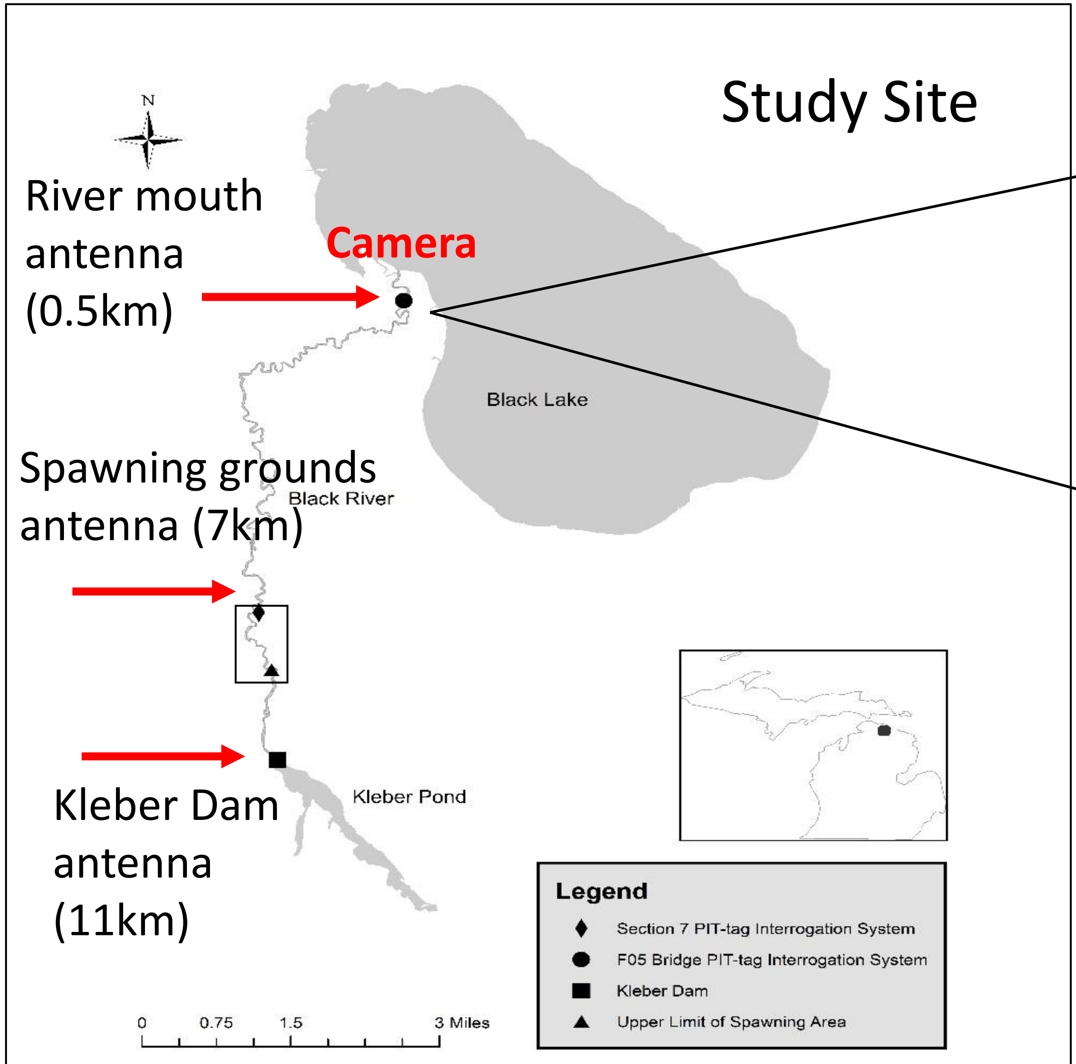

Figure 1: Study site map of the Black River in Michigan showing the locations of PIT-tag interrogation systems, Kleber Dam, and the upper limit of the lake sturgeon spawning area.

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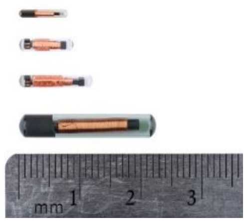
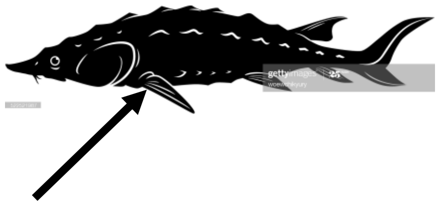
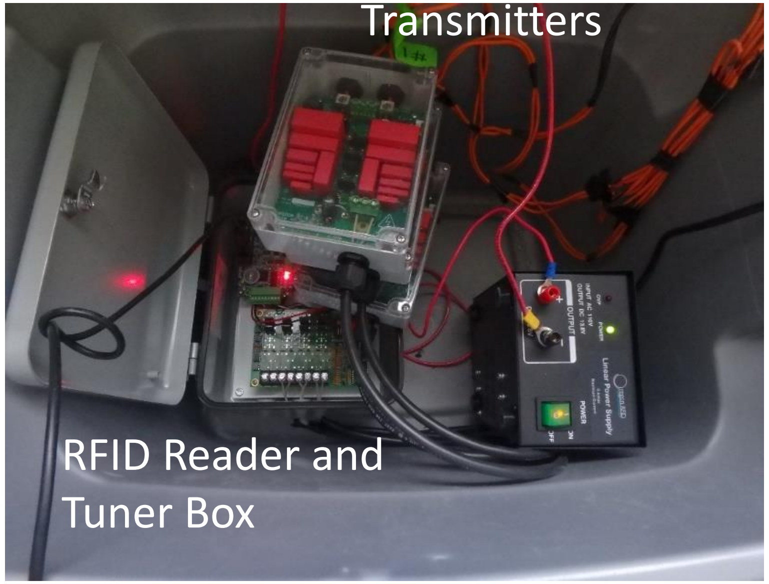




RFID tags



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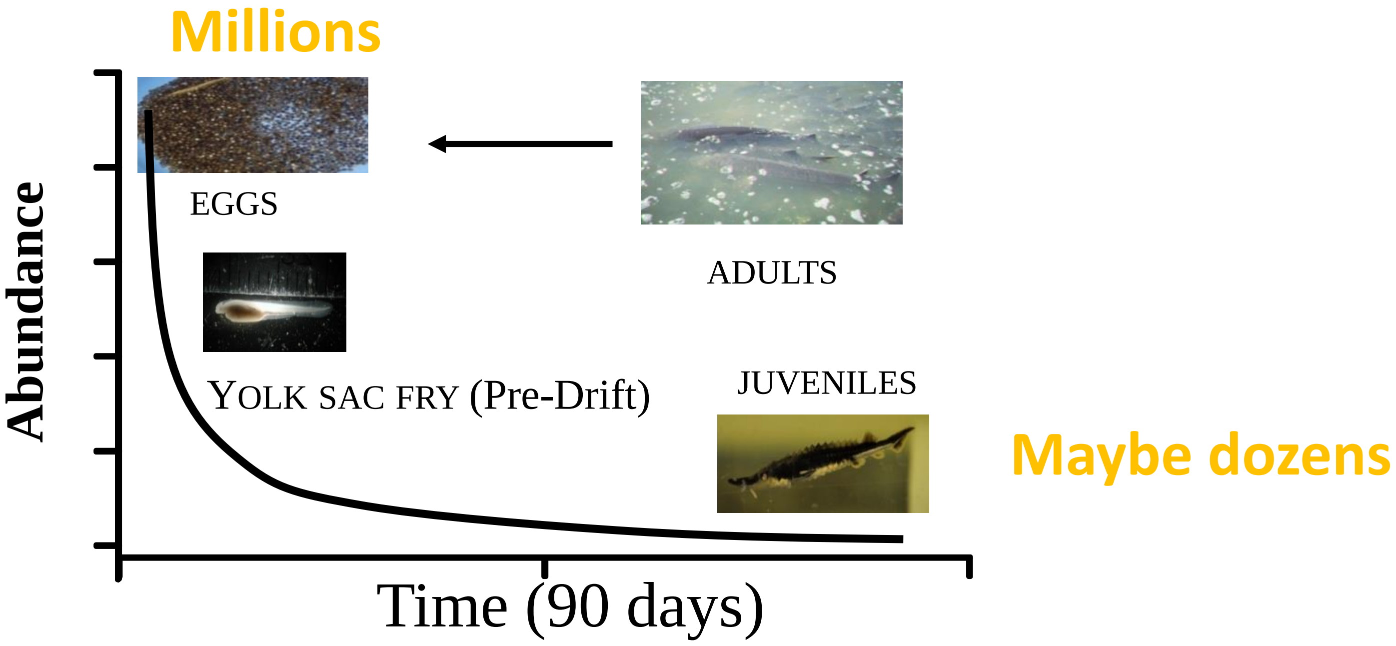
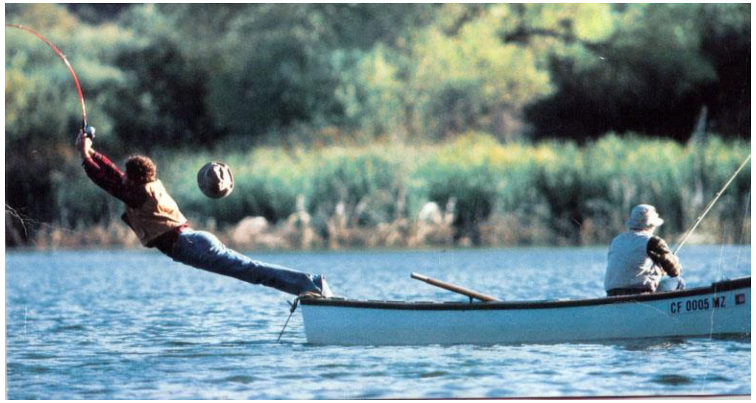


Why Should We Restore Lake Sturgeon?

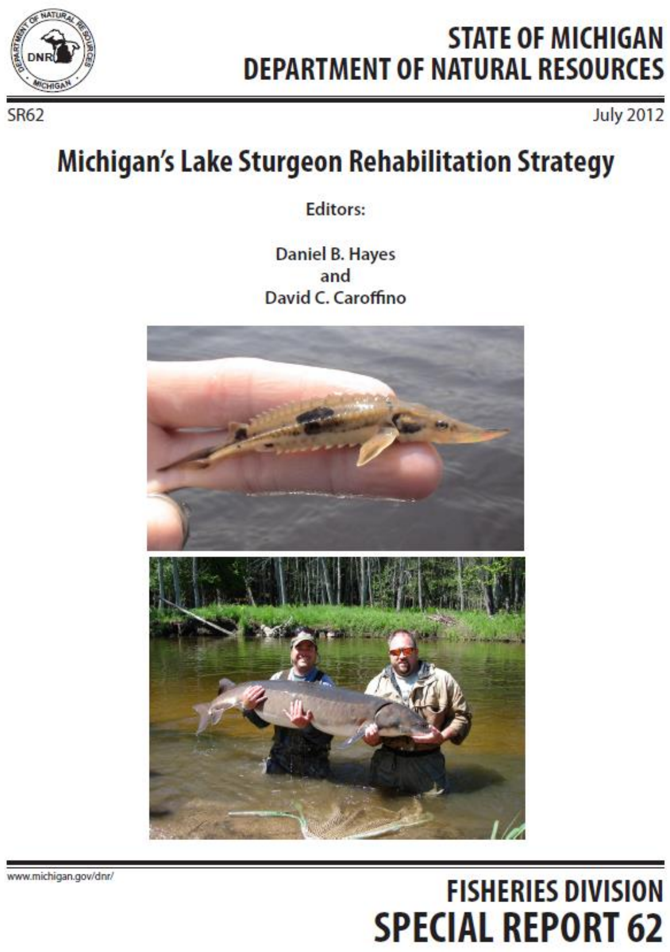
- Globally imperiled group of fish
- Species is an important part of the ‘benthic’ community in the Great Lakes and historically one of the most abundant fish
- <u>Native species</u> that grows to a large size and can be caught by anyone
- Water quality and quantity impediments have been greatly reduced
- General attitudes on fish values have changed and the general public is gaining interest in the species
- Natural Resource Agencies are responsible for all aquatic species-not just those of interest to anglers



E. Baker (2013)

How do we restore lake sturgeon populations?

- Re-connect important habitats
- Restore degraded habitat
- Reduce or eliminate fishing mortality
- Restore degraded and maintain good water quality
- Rebuild remnant populations and reestablish extirpated populations
- <u>*First need accurate information on current status*</u>
  - Distribution, abundance, mortality sources, etc.



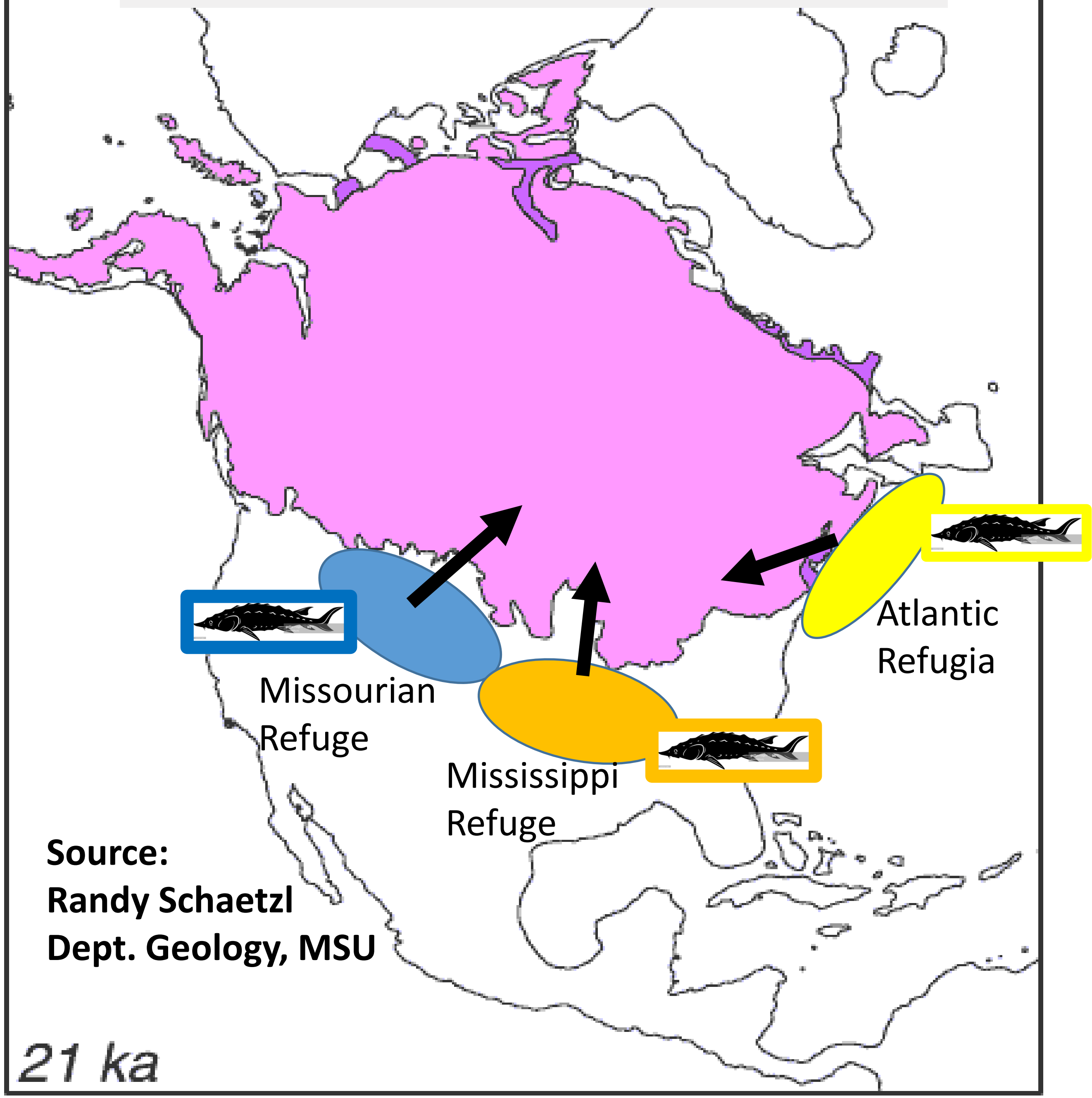
E. Baker (2013)

Streamside Rearing as a Restoration and Rehabilitation Tool

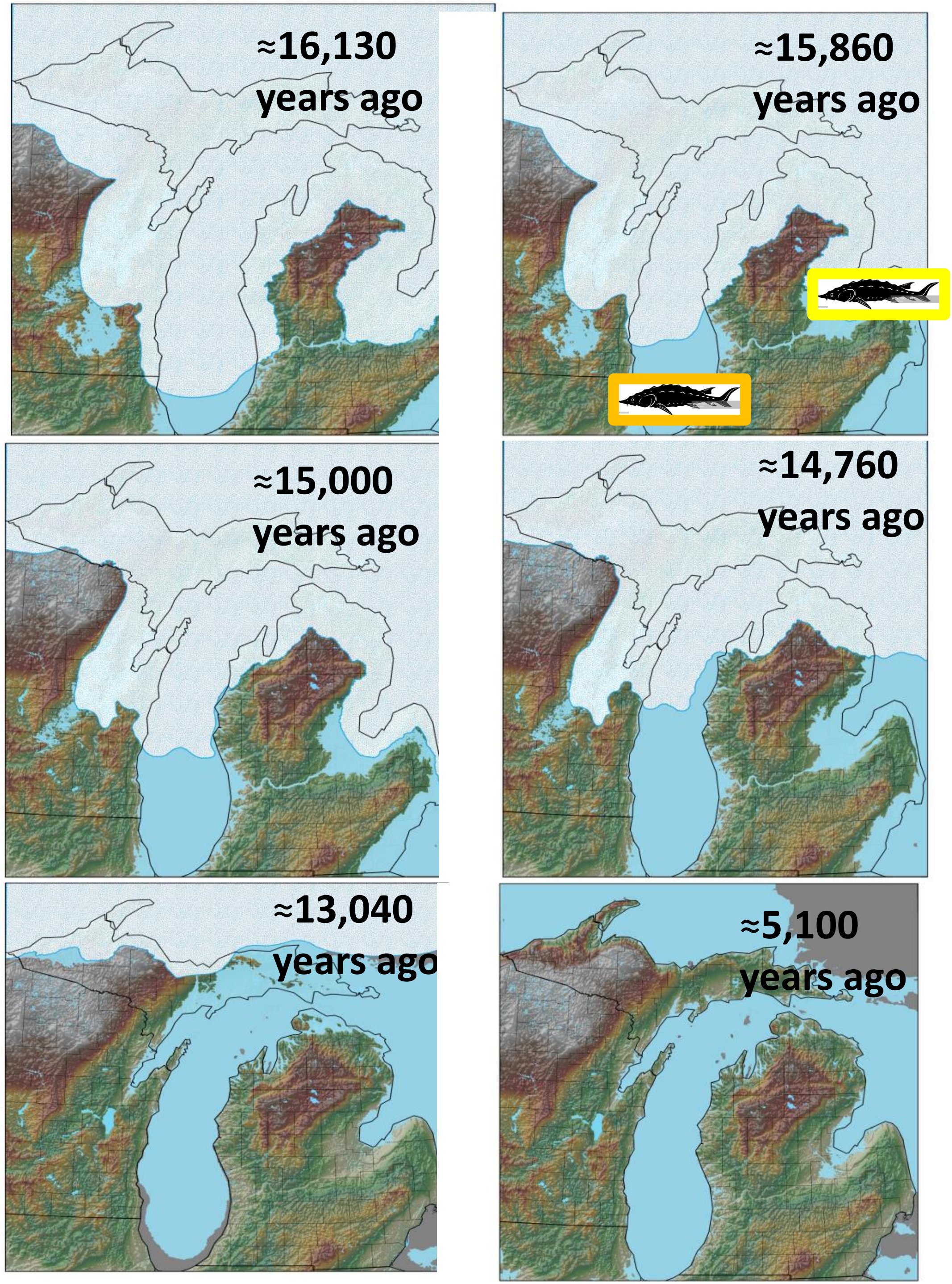
E. Baker (2013)

Background Part I – Distribution, threats and ecological and demographic characteristics of lake sturgeon in the Great Lakes region

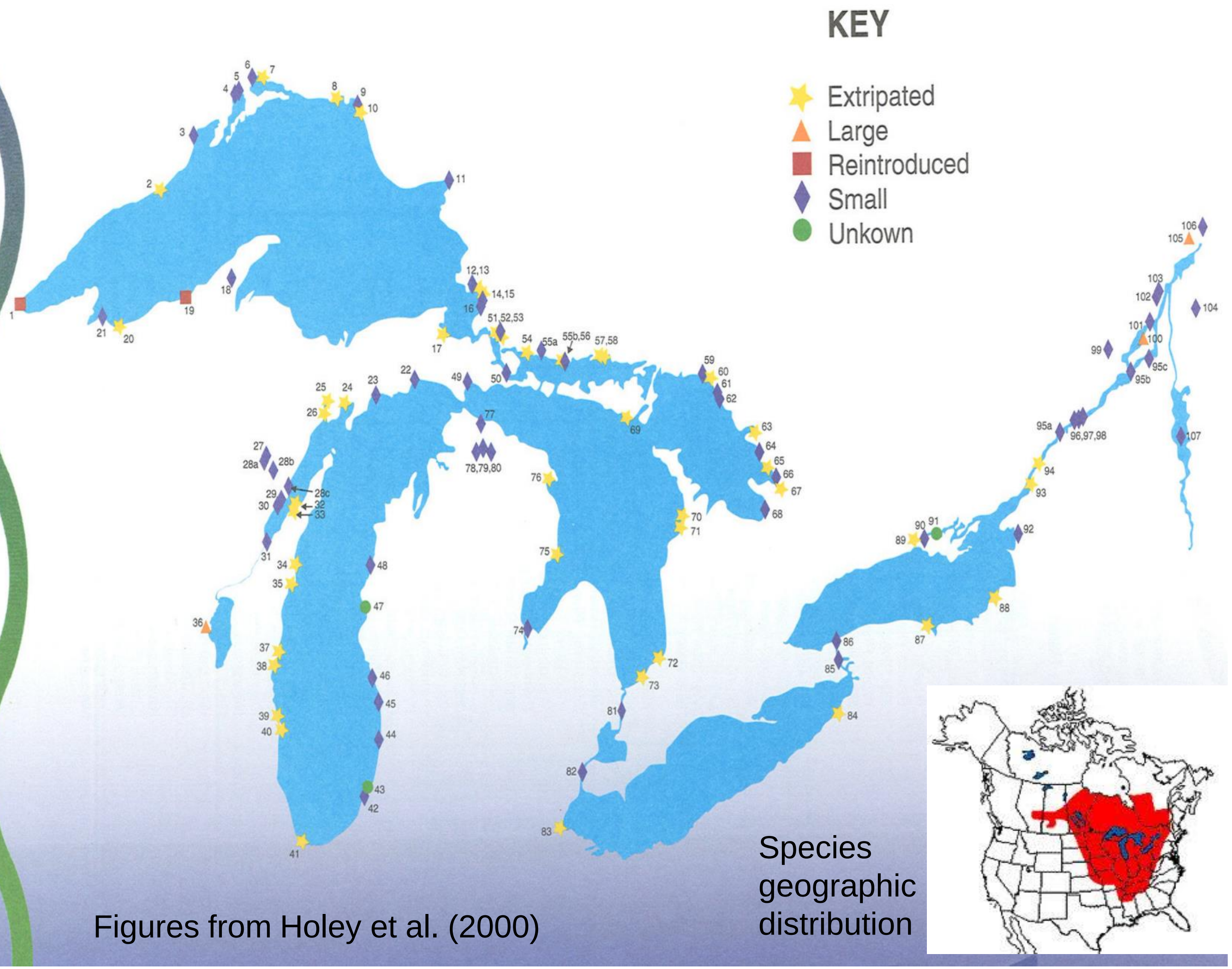
Deglaciation of North America



Source:
Randy Schaetzl
Dept. Geology, MSU



Lake Sturgeon Distribution and Abundance



Figures from Holey et al. (2000)

Species geographic distribution

- Lake Sturgeon are native to the north central region of North America.
- Historically, Lake Sturgeon were one of the most numerous fish in the Great Lakes.
- In the Great Lakes region, Lake Sturgeon live most of their lives in open and near-shore regions of the Great Lakes.
- They return to spawn in larger tributaries to the Great Lakes in the spring; typically mid-April through early June
- >95% of breeding populations have been lost. Currently, Lake Sturgeon are less than 1% of their historical abundance.

Black River lake sturgeon web site at: https://www.glsturgeon.com/sturgeon/natural-history/

Lake Sturgeon (*Acipenser fulvescens*)

- Sturgeons are believed to have evolved over 170 million years ago (first fossil evidence)
- Privative characteristics– cartilaginous skeleton, heterocercal tail, body covered by rows of bony scutes
- Known to reach large sizes
- Long lived – can live >100 yrs
- Historically found in 18 states and 5 Canadian provinces

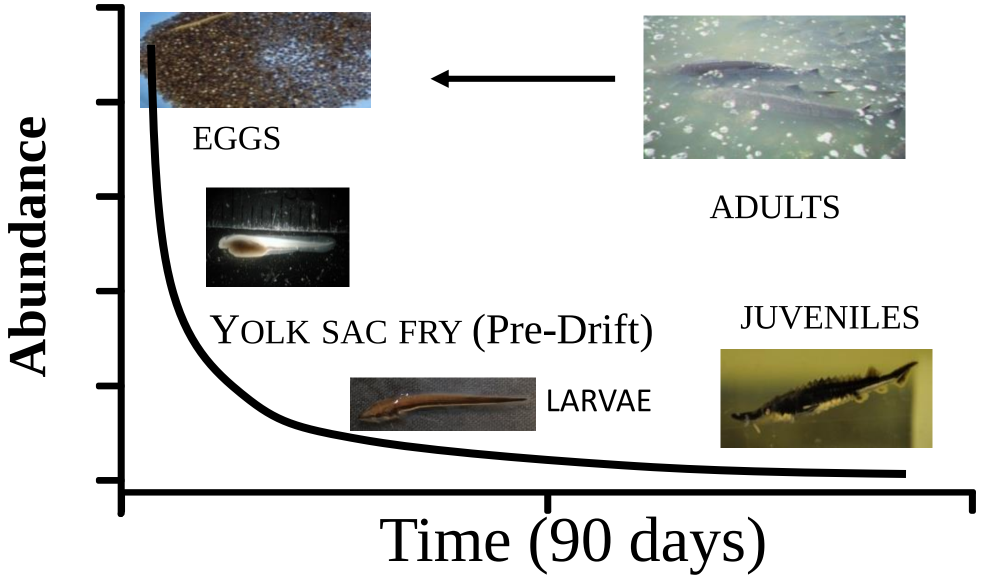
– Lake Sturgeon

Life history traits

- Long lived: 40 to >100 yrs. Reproduce many times
- Delay sexual maturity: Male: 12-15 yrs.   Female: >18 yrs.
- Fish don't reproduce every year. Males on average reproduce every 2 years and females on average reproduce ever 3 years
- Spawning occurs over rocky stream substrates. Eggs and sperm are 'broadcast'.
- Females produce many eggs (~11,000 eggs per kg of body weight)
- Low natural recruitment. Extremely high mortality at each early life stage

- Spawning activities dependent on environmental cues (temperature and river flow)
- Embryonic and larval development dependent on rearing environment, especially temperature. Higher temperatures lead to faster development of eggs and larvae.

Lake Sturgeon have high reproductive capacity (many eggs and larvae) but very few survive during each life stage to adulthood

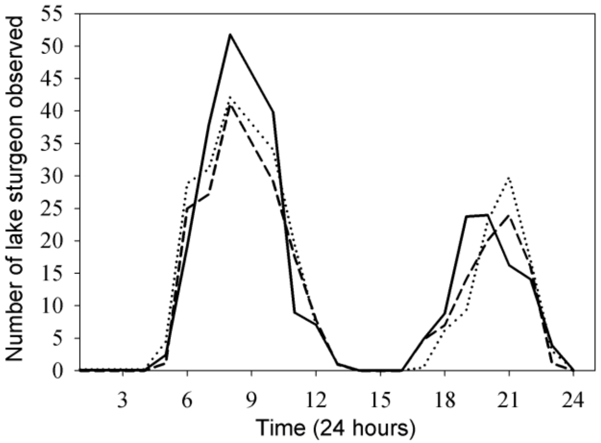


Lack of natural recruitment a high priority for management

<u>Life History Stage</u>	Adult: spawning	Egg: incubation	Free embryo: development in substrate	Larval: emergence and dispersal	Juvenile

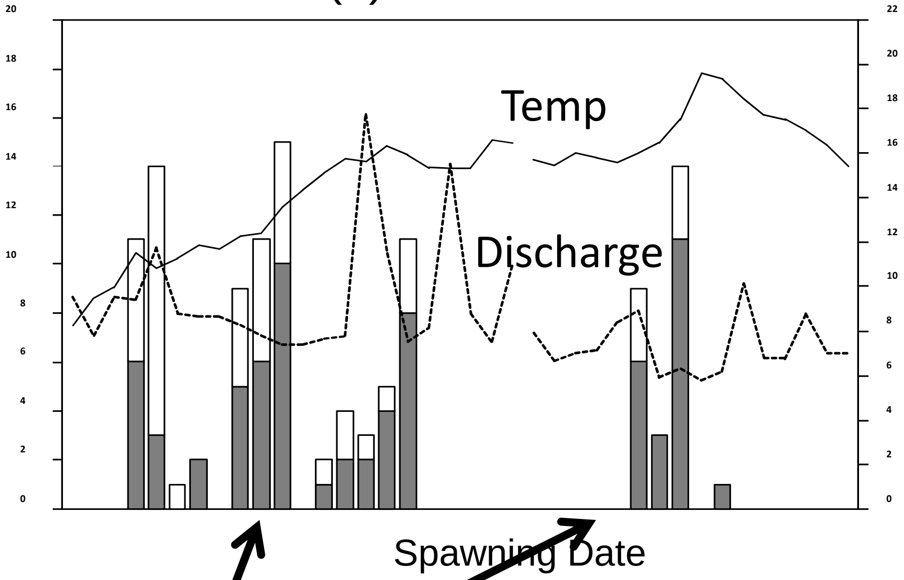
You can learn more about Lake Sturgeon at each life history stage on the Black River lake sturgeon website at https://www.glsturgeon.com/sturgeon/life-history/

Adults



Here is an example of your videograph data

(b) Isolation in Time

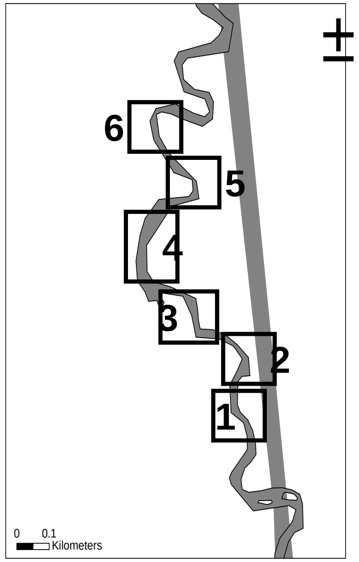


“Early Spawners”

“Late Spawners”

Evidence for reproductive isolation within a river

Areas

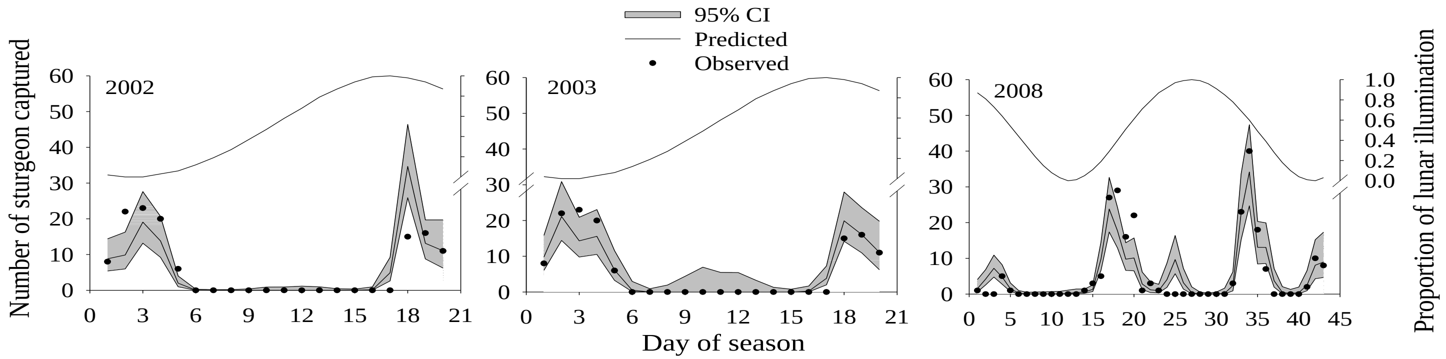


Location of spawning varies within a season

Late spawning

Early spawning

Timing of adult spawning tied to environmental cues



Important variables associated with timing of spawning

- Changes in river discharge (-)
- Changes in river temperature (+)
- Period in the lunar cycle (new moon)

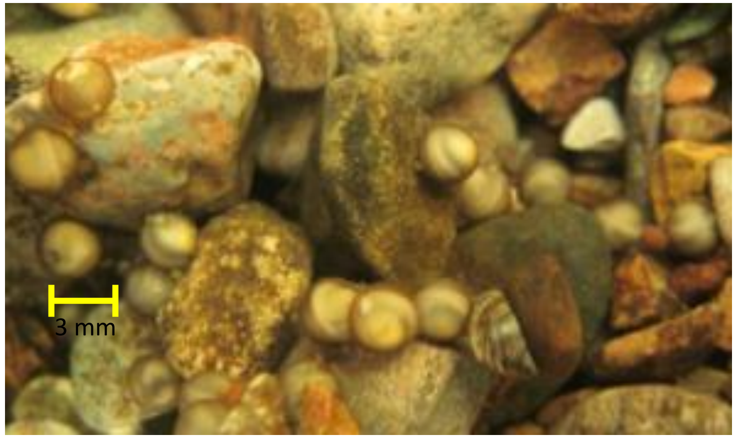
Time Periods (years)

Adult: spawning | **Egg: incubation** | **Free embryo** | **Larval** | **Juvenile**

Life Stages/Ages

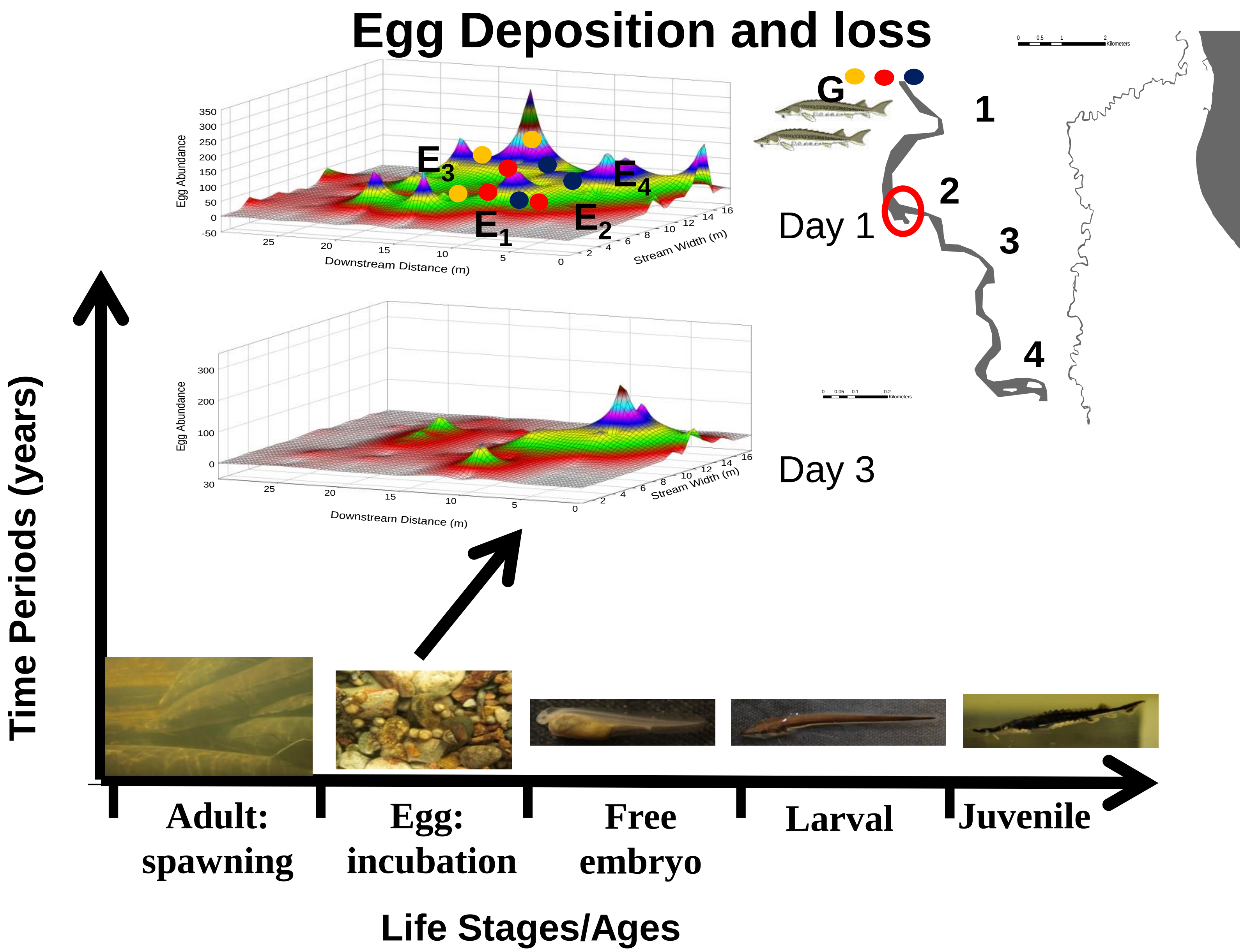
Data from Forsythe et al. (2012b)

Egg Life History Stage

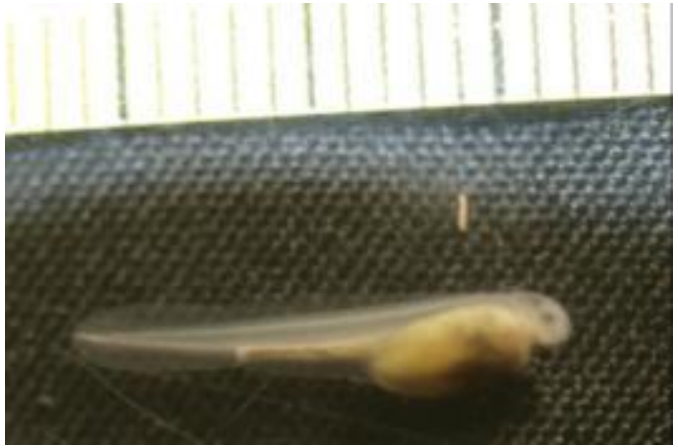


- During spawning eggs are ‘broadcast’ onto rocky substrate
- On contact with water, eggs become ‘sticky’ and adhere to rocks
- The incubation period can last between 5-12 days depending on water temperature
- During incubation eggs are highly vulnerable to predation and suffer very high mortality

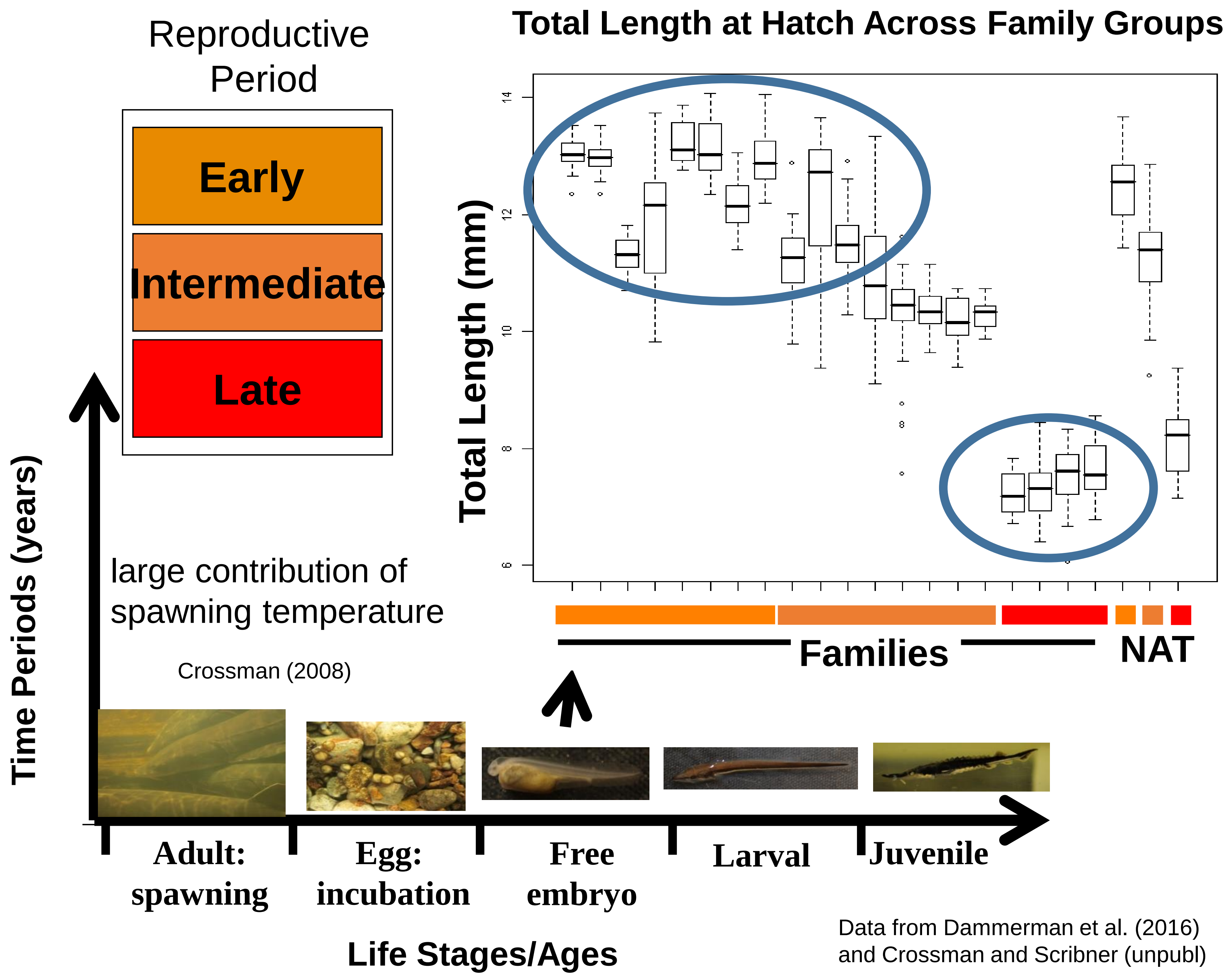
Egg survival is very low



Free Embryo Period



- As sturgeon hatch, the “free embryo” immediately burrows into substrate to find cover
- Lake sturgeon embryos are negatively phototaxic, which means that they avoid light sources
- After their yolk-sac is absorbed, which usually takes up to 5 to 7 days depending upon temperature, the embryo begins exogenous feeding and disperses down stream


Reproductive Period
Early
Intermediate
Late
Time Periods (years)
large contribution of spawning temperature
Crossman (2008)
Total Length at Hatch Across Family Groups
Total Length (mm)
14
12
10
8
6
Families
NAT
Adult: spawning
Egg: incubation
Free embryo
Larval
Juvenile
Life Stages/Ages
Data from Dammerman et al. (2016) and Crossman and Scribner (unpubl)

Larval Life Stage

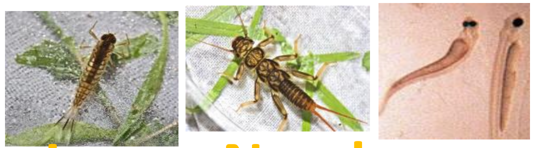
- Lake sturgeon larvae begin feeding and emerge from the substrate during evening hours (9:00 PM to 2:00 AM)

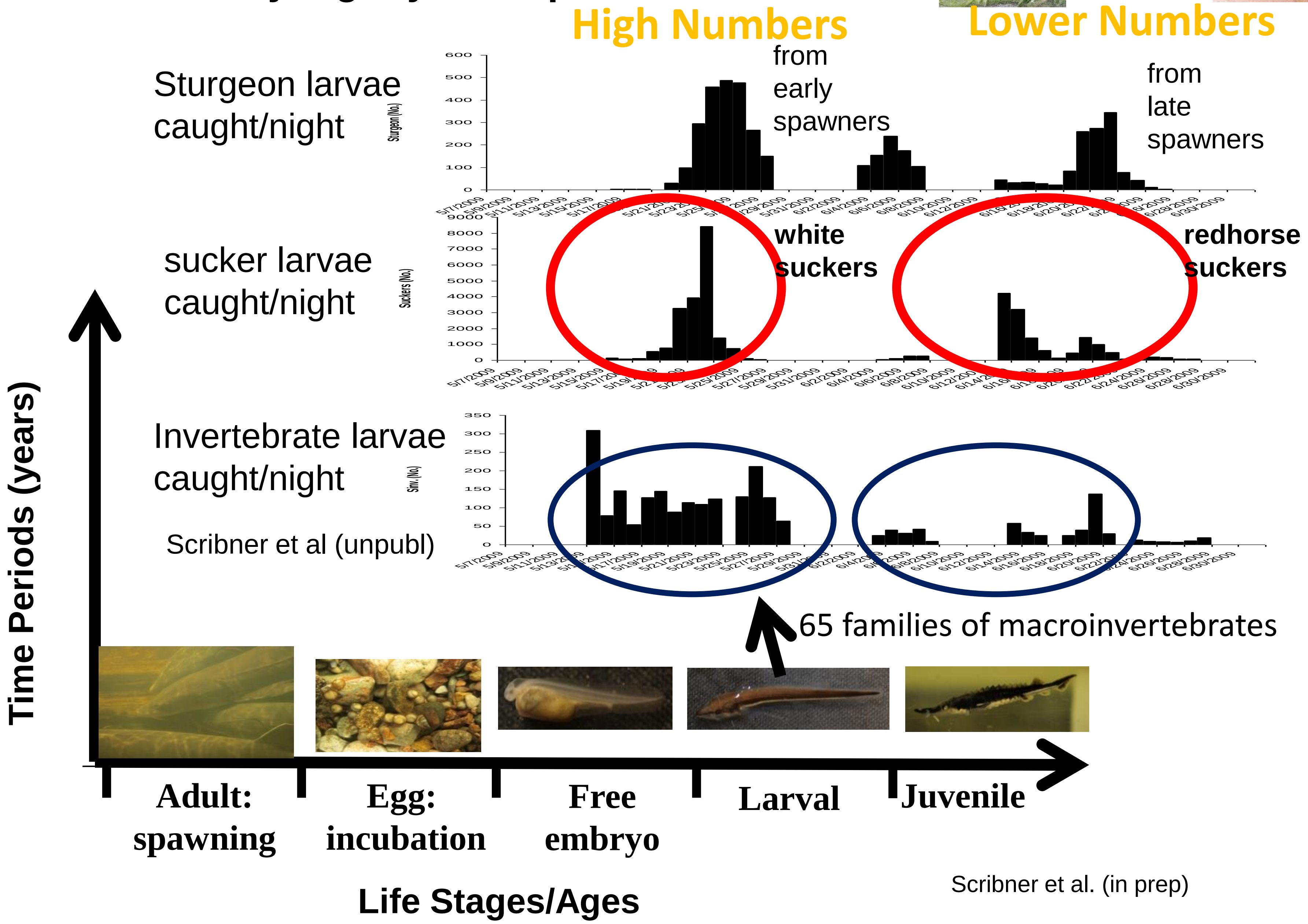
- Similar to peaks associated with adults spawning, drifting lake sturgeon also occurs in peaks. The drift period may last 30 to 40 nights.

- Mortality at this life period is significant due to predators. ***

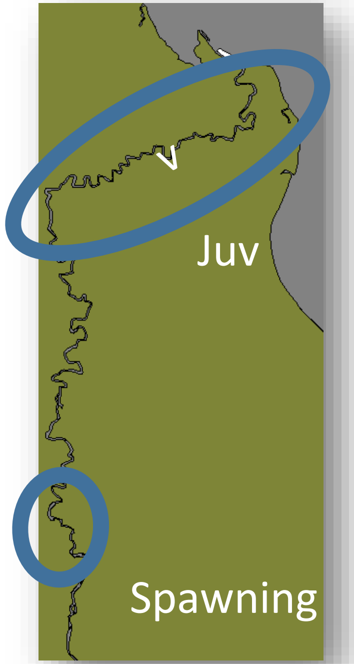
Lunar phase

Nightly estimates of composition and abundance of co-distributed benthic drift vary nightly – see presentation 4



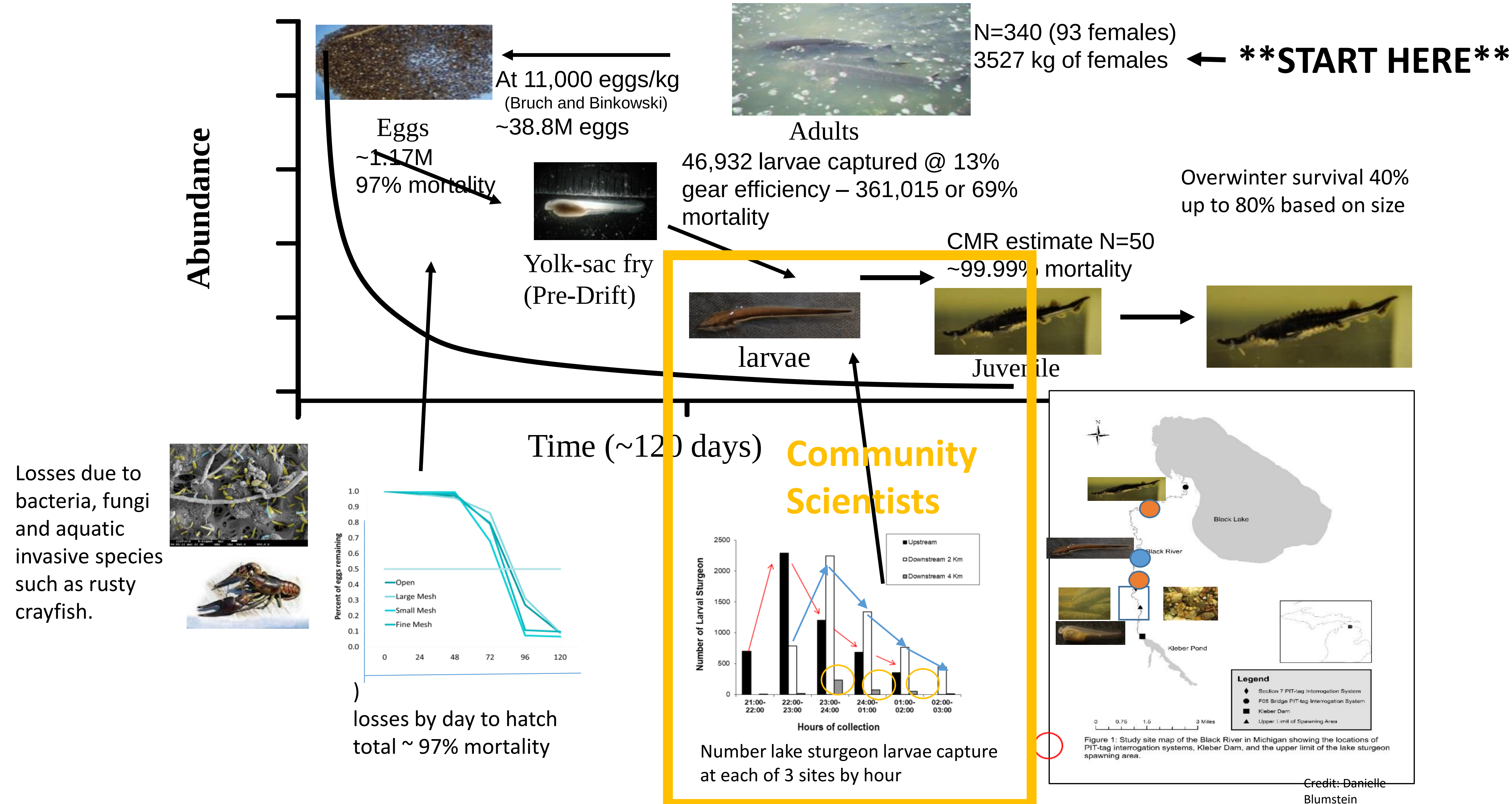


Juvenile Life History Stage



- Lake sturgeon grow rapidly through the first spring and summer of life.
- During the spring and summer, lake sturgeon live in the lower parts of rivers with sand bottom where they feed on insects
- During the juvenile phase individuals develop a bony exterior and become less vulnerable to predation by most fish predators.
- Rates of mortality decrease as a function of age.

A lake sturgeon stage by stage working example of where mortality occurs in the Black Lake population (for 1 year- 2018)




Have Fun With Sturgeon!

Enhancing Michigan's virtual and place-based educational opportunities and community stewardship using charismatic Lake Sturgeon in connected Great Lakes - tributary ecosystems

Community Ecology– Predators and Prey and Your Data

Project Investigators – Kim Scribner, Brandon Schroeder, Douglas Larson, Edward Baker
MI Sea Grant and MSU Extension Collaborators – Meaghan Gass, Brandon Schroeder
Teacher Consultant – Brooke Groff

Funding and Logistical Support

Great Lakes Fishery Trust
Michigan State University Extension
Sea Grant Michigan
Michigan State University AgBioResearch
DNR
U.S. Fish & Wildlife Service
Department of Fisheries and Wildlife • Michigan State University •

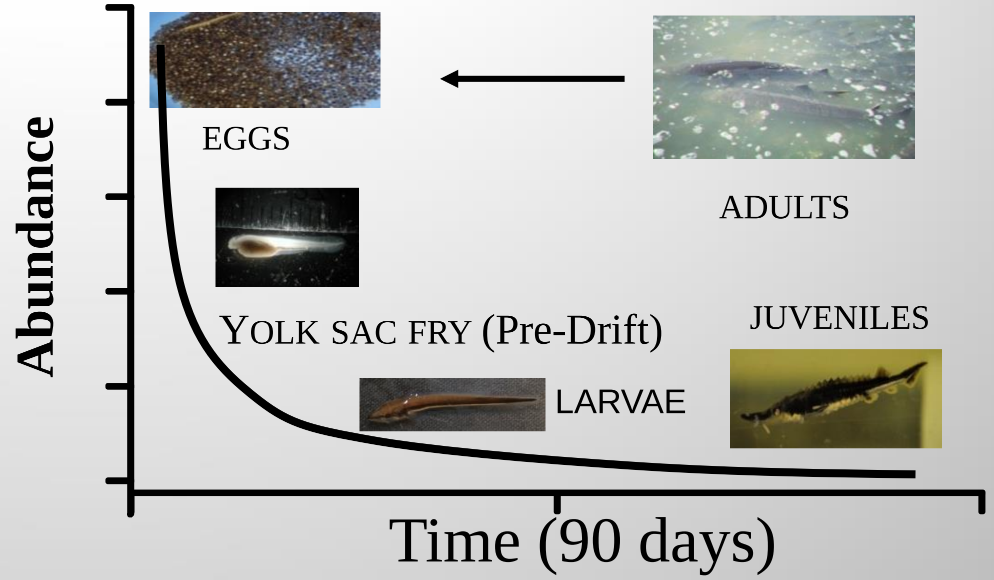
Background Part III – Who eats Who?

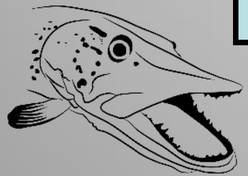
Many different fish in the river - who is eating larval Lake Sturgeon?
Who is producing young fish to 'buffer lake sturgeon predation?

Introduction to Topics

- **What is a predator? ...what is their ecosystem role?**
- **Biodiversity: Can fish and aquatic insect diversity benefit sturgeon survival (*clue:* they also get eaten!)?**
- **Physical stream features (like gravel stream bottom) are also important for lake sturgeon survival**

Many predators eat sturgeon during early life periods (as eggs and larval fish)

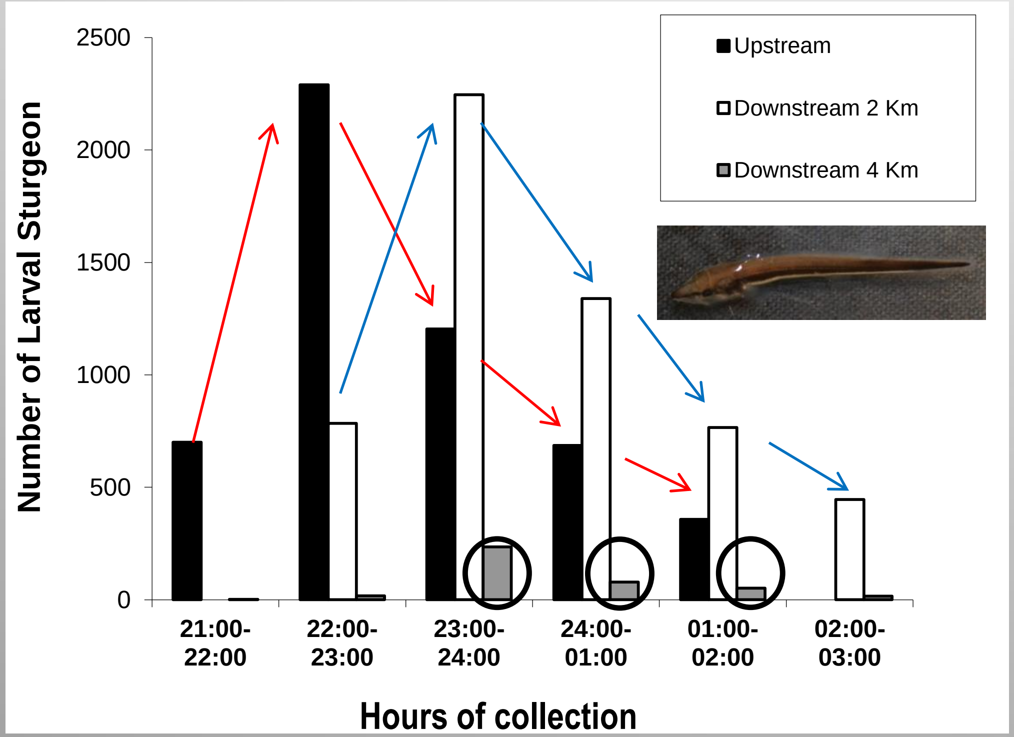


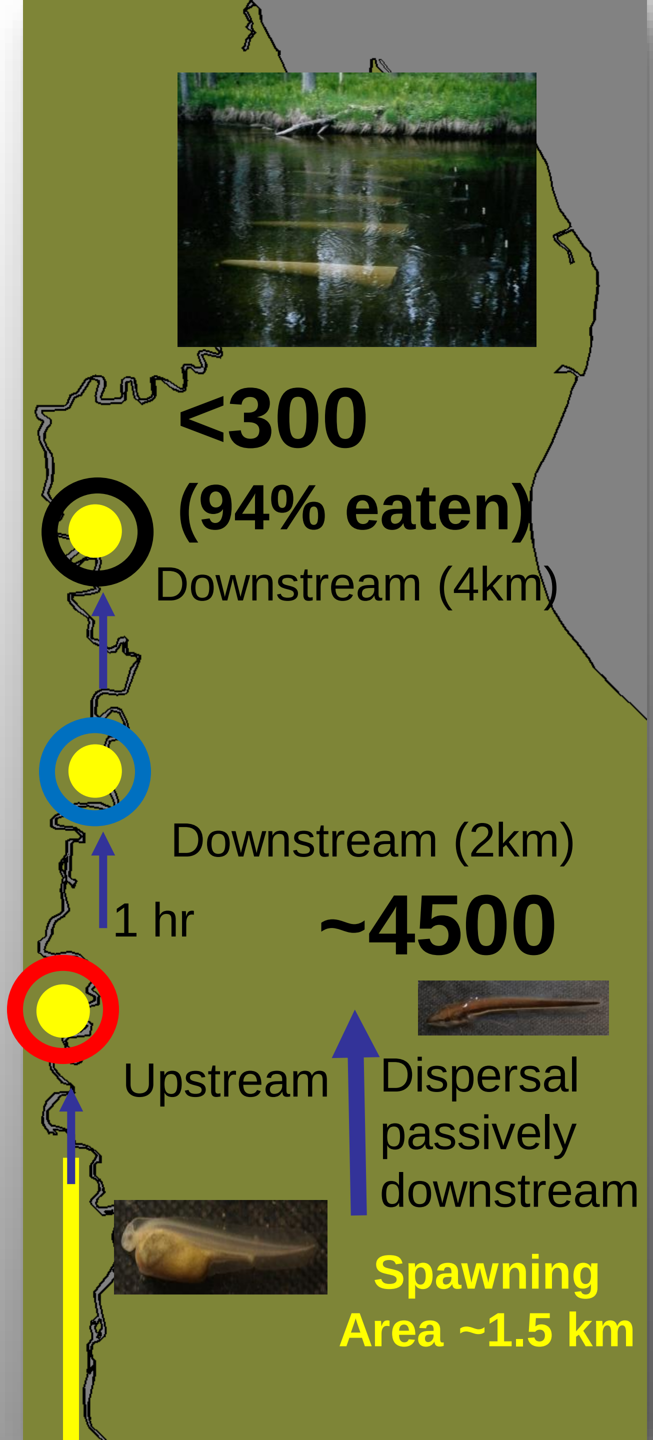


Scientists seek your help to collect information to help more lake sturgeon survive at each vulnerable life period

period	Adult: Spawn	Egg: Incubate	Newly hatched: Hide in substrate	Larval fish: Emerge and disperse	Juvenile: Migrate back to lakes

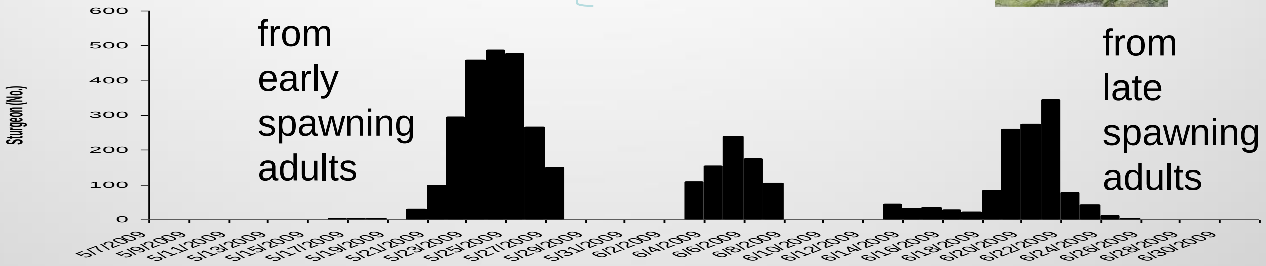
Larval Lake Sturgeon Captures by Hour at Different Sites





Nightly estimates of species composition and abundance of co-distributed drift available to predators

Sturgeon larvae caught/night



from early spawning adults

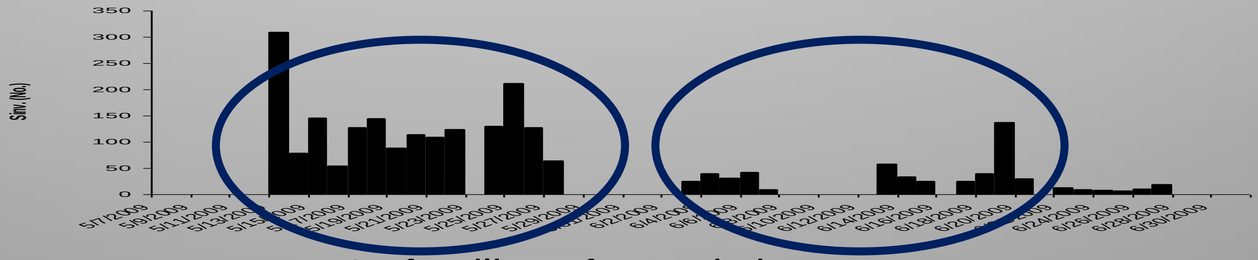
from late spawning adults

Sucker larvae caught/night

white suckers

redhorse suckers

Invertebrate larvae caught/night



65 families of aquatic insects

Early

Late

Lake Sturgeon Dispersal

(young fish emerge from safety of rocks and float or 'drift' downstream and are vulnerable to predators)

Early drift

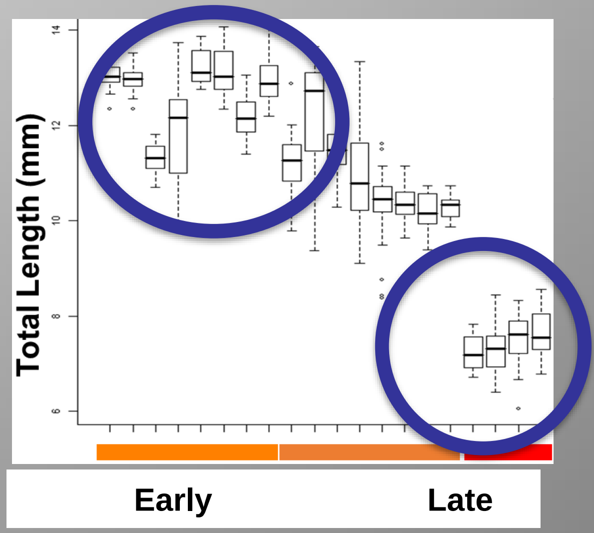
- Larger fish (cold temp)
- Fish drifting (hidden among) other species
- Timed with new moon (drifting under the cover of darkness!)

Late drift

- Smaller fish (warm temp)
- Fish drift with fewer alternative prey
- Moon less important (moving during nights with more light!)

Lunar phase

VS



Black River predator fish community variable across seasons, habitats, and years



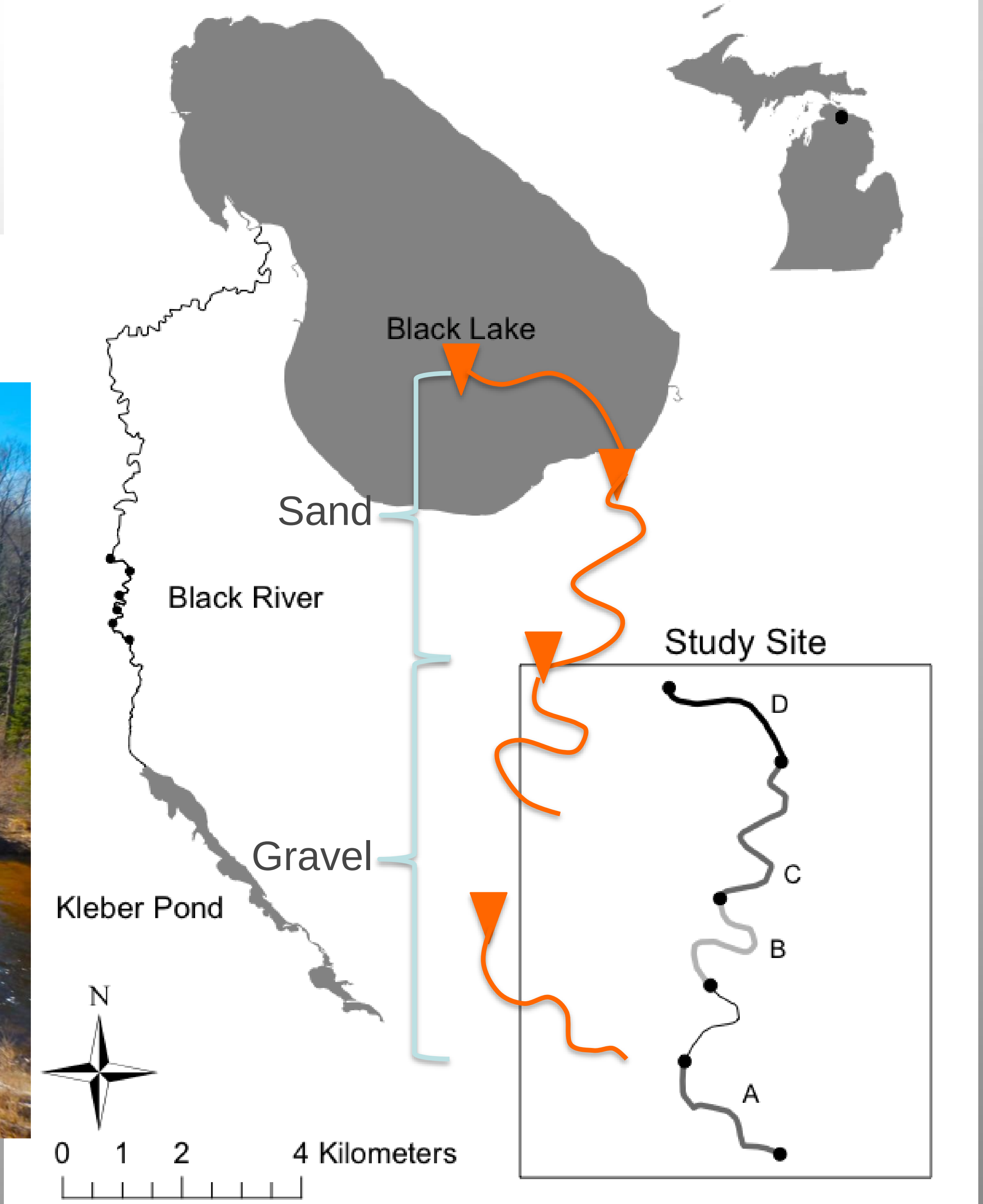






The study site:

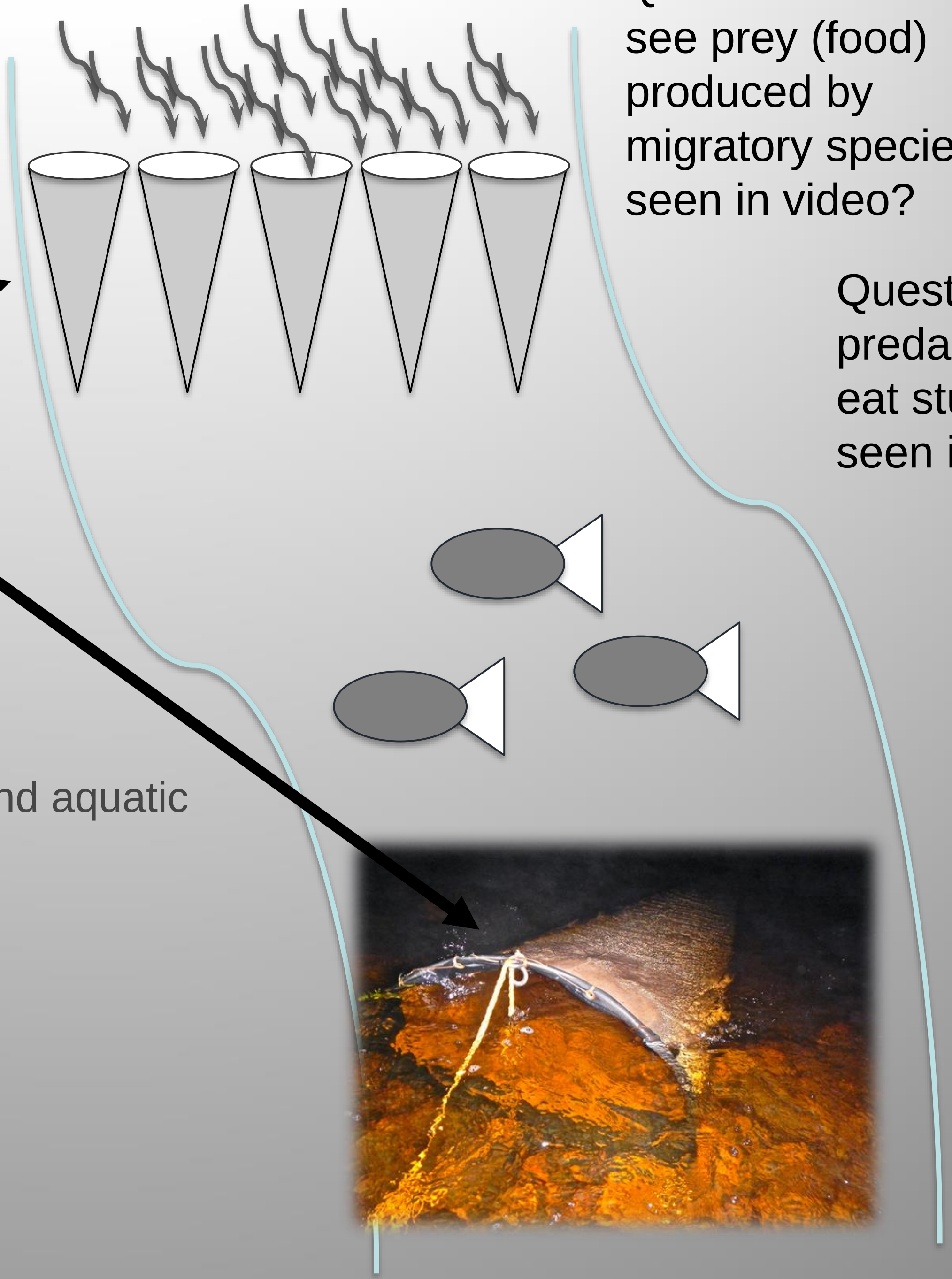
Black River, Cheboygan Co., MI



Larval drift survey

- 3 week experiment
- 5 nets at each site
- Collect samples for 5 hours (at nighttime 9PM to 2AM)
- Data
  - Discharge of river and nets
  - # and sizes of larval sturgeon
  - # and sizes of larval suckers and aquatic insects

Prey “available" as FOOD
(what's on the menu for predators)



Question - do we see prey (food) produced by migratory species seen in video?

Question - are predators that eat sturgeon seen in video?

Electrofishing to Study Predators

(YES, fish scientists sample fish using electricity in water?! ...how does that work?)

Electrofish each sample area the day after young sturgeon drift down stream. Data we collect:

- Species (what we caught)
- Length of each fish predator
    - 27 different species of possible predators observed (WOW - biodiversity!)
- A sample of predators to dissect (wondering - what is in their stomachs?)
    - 1140 diet samples collected (what did they eat?)

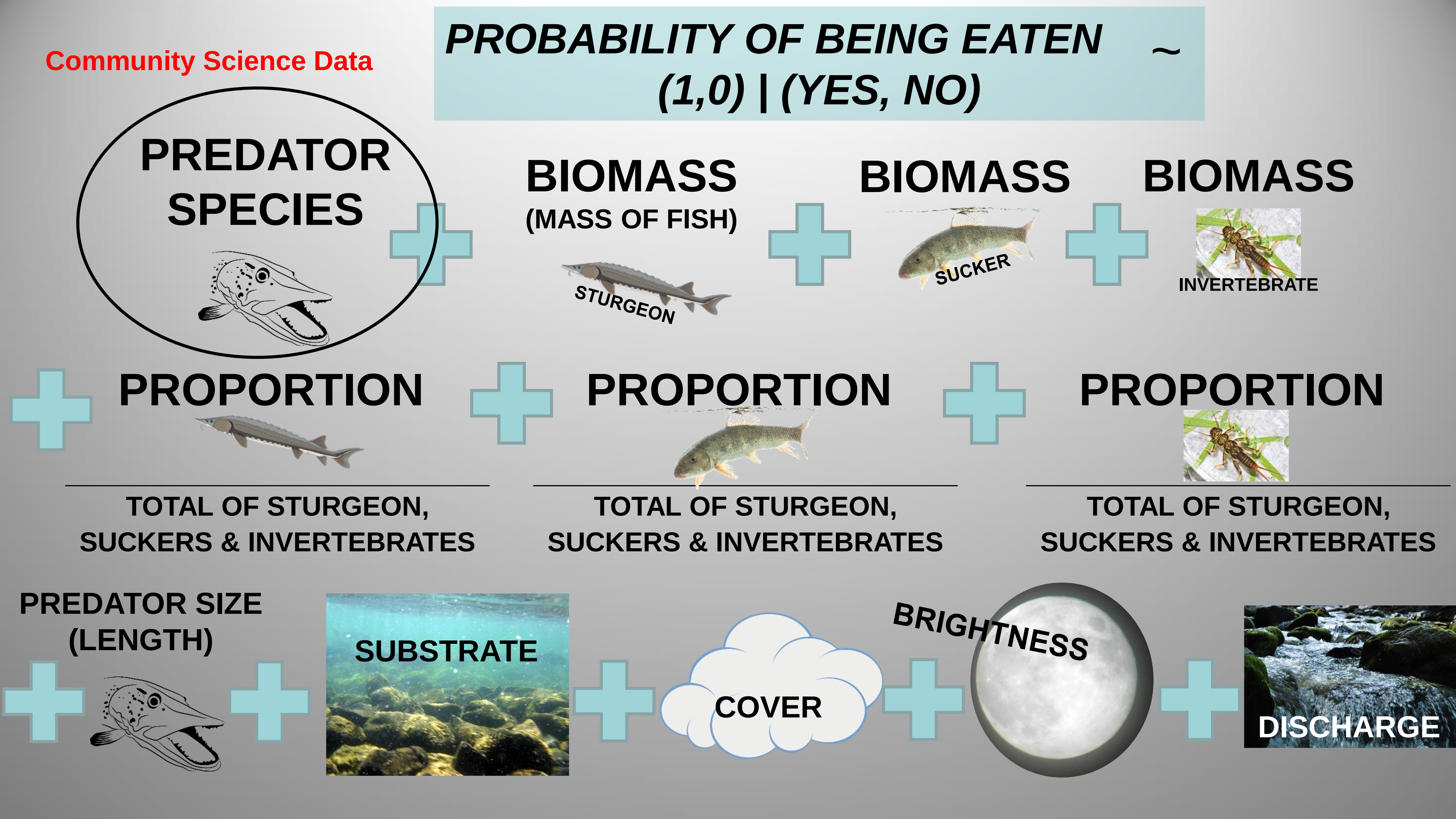
Can we predict sturgeon predation (probability of getting eaten = yes/no or 1/0) by studying the diets of predator fish??

$$P(0,1) \sim \text{Predator Species} + \text{Biomass}_{sturgeon} + \text{Biomass}_{suckers} + \text{Biomass}_{invertebrate} + \text{Proportion}_{sturgeon} + \text{Proportion}_{suckers} + \text{Predator size} + \text{Substrate} + \text{Cloud Cover} + \text{Moon Illumination} + \text{River Discharge}$$

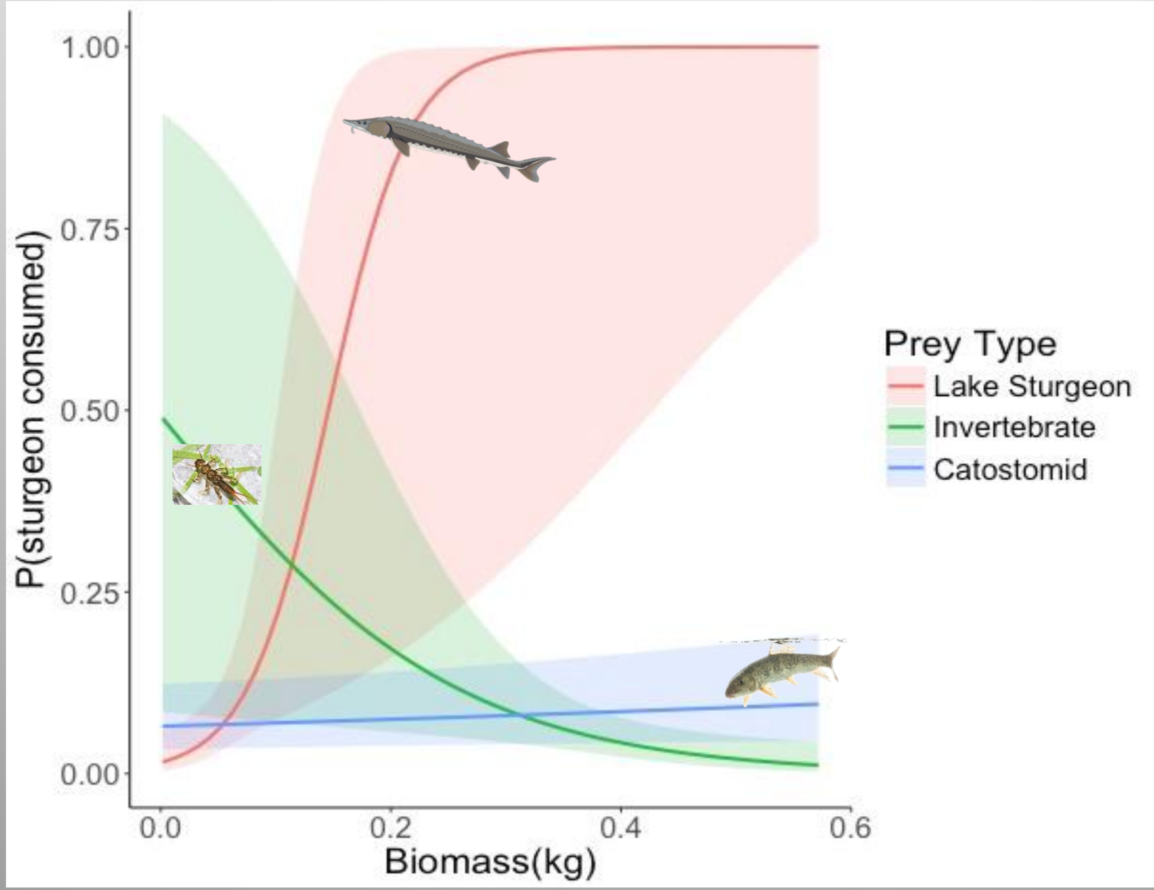
- **Variable of interest:** presence/ absence of sturgeon in predator stomach
- **Predictor variables:**
  - Predator species
  - Predator Total Length
  - Biomass and proportion of drift made up of larval sturgeon
  - Biomass and proportions of drift made up by sturgeon and larval suckers and aquatic macroinvertebrates
  - Substrate – sand or gravel
  - Lunar illumination(% illuminated)
  - Cloud cover (avg % clear sky by night)

Community Science Data Provided → Predator species, Predator Total Length

Waraniak et al. (2018) J. Fish Biol.


Community Science Data
PROBABILITY OF BEING EATEN ~
(1,0) | (YES, NO)
PREDATOR SPECIES
+
BIOMASS
(MASS OF FISH)
STURGEON
+
BIOMASS
SUCKER
+
BIOMASS
INVERTEBRATE
+ PROPORTION
TOTAL OF STURGEON, SUCKERS & INVERTEBRATES
+ PROPORTION
TOTAL OF STURGEON, SUCKERS & INVERTEBRATES
+ PROPORTION
TOTAL OF STURGEON, SUCKERS & INVERTEBRATES
+ PREDATOR SIZE (LENGTH)
+ SUBSTRATE
+ COVER
+ BRIGHTNESS
+ DISCHARGE

“Prey shielding” = hiding among a diversity of other prey



When sturgeon can hide among diversity of other prey species – like insects and suckers - they are less likely they get eaten.

Sorry, insects! 

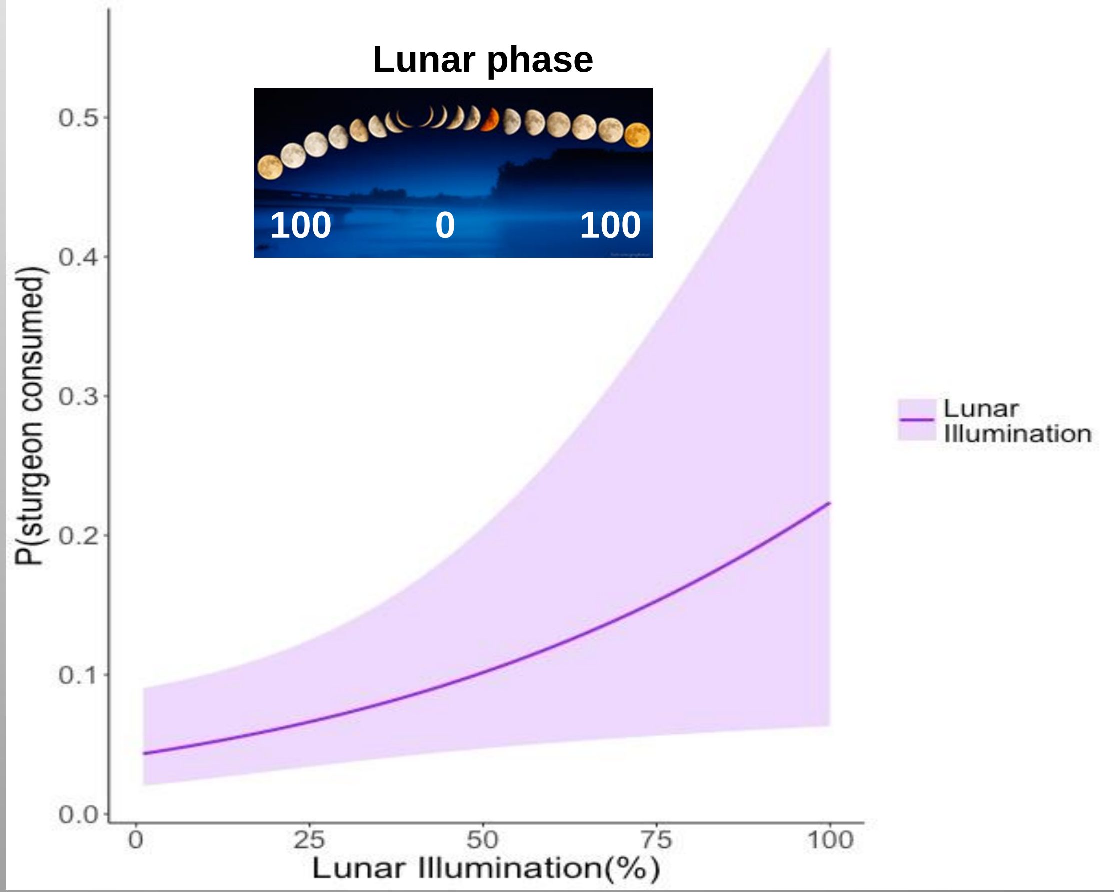
Waraniak et al. (2018) J. Fish Biol.

Moon (light), substrate (shelter), & discharge (flow of river) ALSO affect larval lake sturgeon predation

(or rather survival if you can avoid getting eaten!)

- Moon light may help predators see (and eat) sturgeon more easily.
- Sturgeon can't hide as easily in sand compared to rocks. Also different insects in sand vs rock substrate.
- Faster flowing rivers may help sturgeon escape predators

How probability of sturgeon predation is affected by amount of moon light



Waraniak et al. (2018) J. Fish Biol.

Conclusions: Species availability, biodiversity, and abundance in river have important effects on predator diets

Important take away ideas:

- High prey numbers/*biodiversity* reduces lake sturgeon predation
- Migrant (M) and resident (R) fish predators eat lake sturgeon, suckers, and mayflies
- Prey abundance changes over time. High numbers of migrating suckers enhance lake sturgeon survival
- Sturgeon in 7% of predator fish stomachs. Predators tend to consume aquatic insects (especially mayflies)
- **Conclusions**: ***Community scientists are important*** - abundance of migratory (M) predators and species composition and abundance of drifting migratory (M) prey have important effects on larval lake sturgeon survival

Conclusions and Management Implications

- Predation rates are high on larval lake sturgeon
  (we can't remove predators from rivers)
- Levels of moonlight during drift affects survival
  (we can't change the moon periods either!)
- Large bodied (cold-reared) sturgeon survive better
  (how might climate change affect sturgeon survival?)
- Diversity and numbers (mass) of other drifting prey increases chances of sturgeon surviving
- **We <u>can</u> increase the abundance of prey (like mayflies):**
  (a) Improving water quality (habitat) in streams = higher abundance and biodiversity of larval fish and invertebrates
  (= more sturgeon survive)
  (b) Maintain '*connectivity*' to allow migration of prey into rivers

Question – what are some important species to look for in videos?

Have Fun with Lake Sturgeon!

Enhancing Michigan's virtual and place-based educational opportunities and community stewardship using charismatic Lake Sturgeon in connected Great Lakes - tributary ecosystems

Human Disturbance in Great Lakes – Tributary systems

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DNR
U.S. Fish & Wildlife Service, Department of the Interior
Department of Fisheries and Wildlife, Michigan State University

Climate and Environmental Changes

Changes in thermal regimes alter cues

Environmental Changes

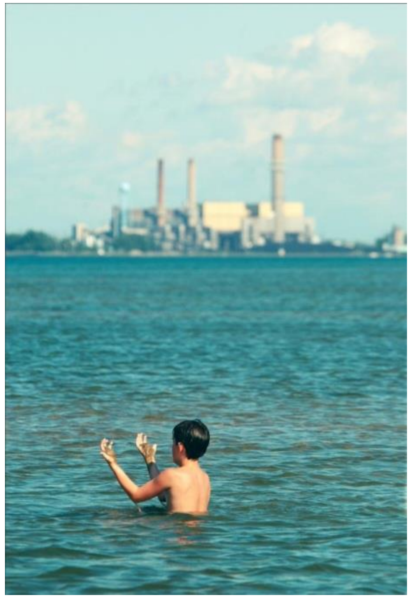
- Higher average temperatures
- Increased chance of change (**AND *variability***) in temperatures, precipitation, etc.
- More extreme weather events
- Changes in water levels and ice cover

… can lead to …

Direct effects – lower survival, changes in growth
Indirect effects – behavior changes for different species (timing of reproduction, habitat selection, activity)

Great Lakes Stressors

Human development



Invasive species

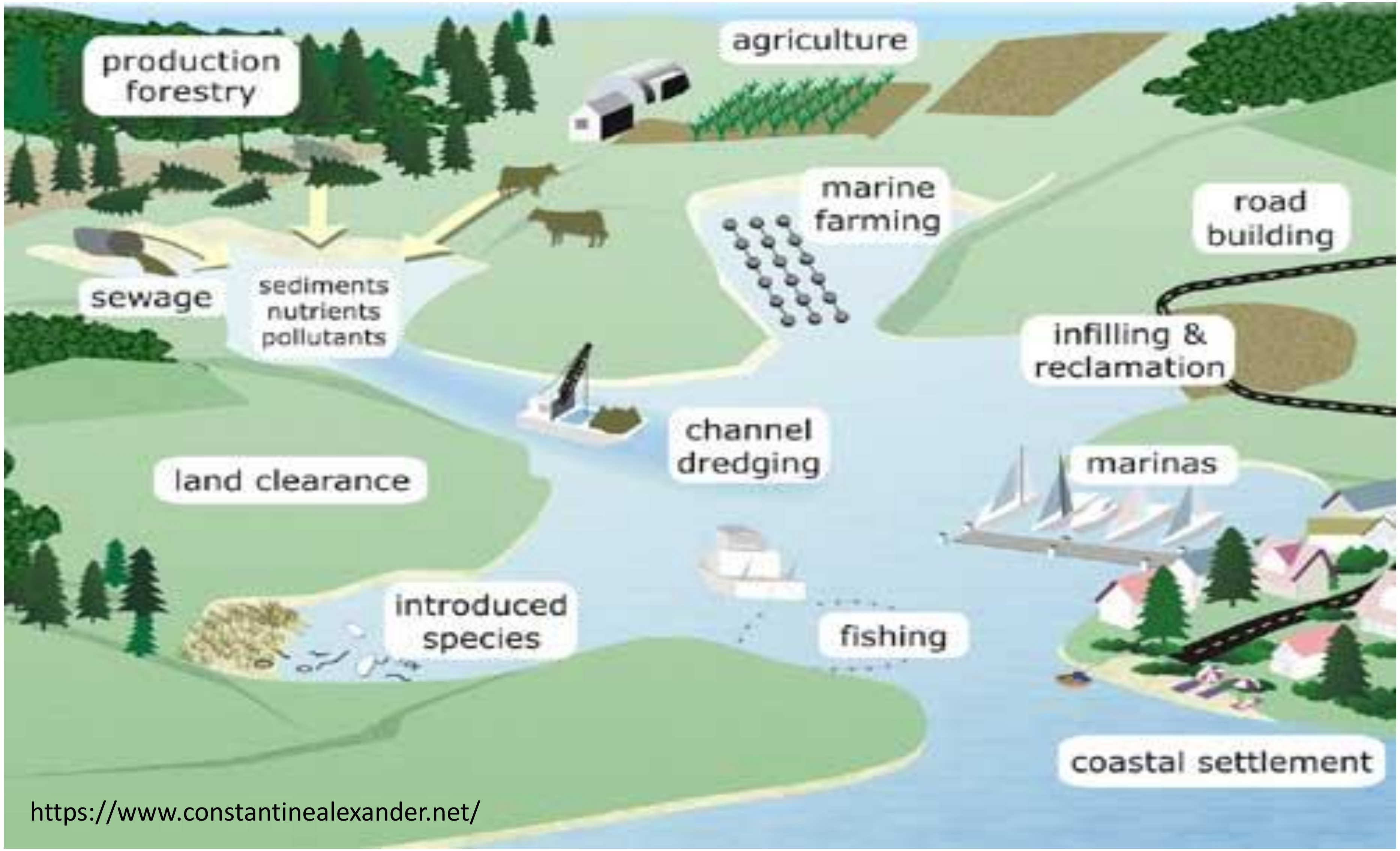
Pollution

Photos from Great Lakes Environmental Assessment and Mapping Project (GLEAM) website

Examples of human activities that have negative effects on aquatic communities

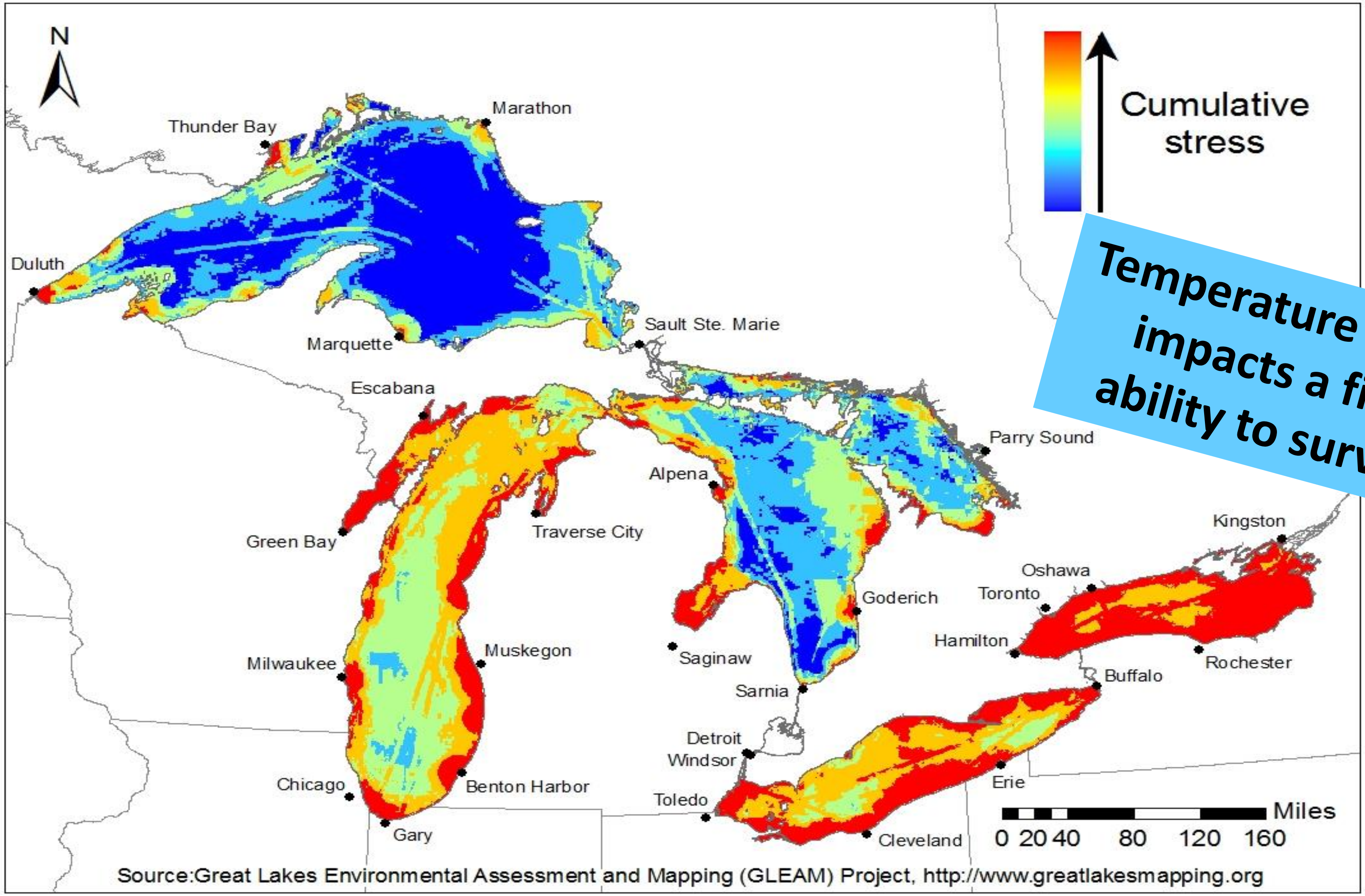






https://www.constantinealexander.net/

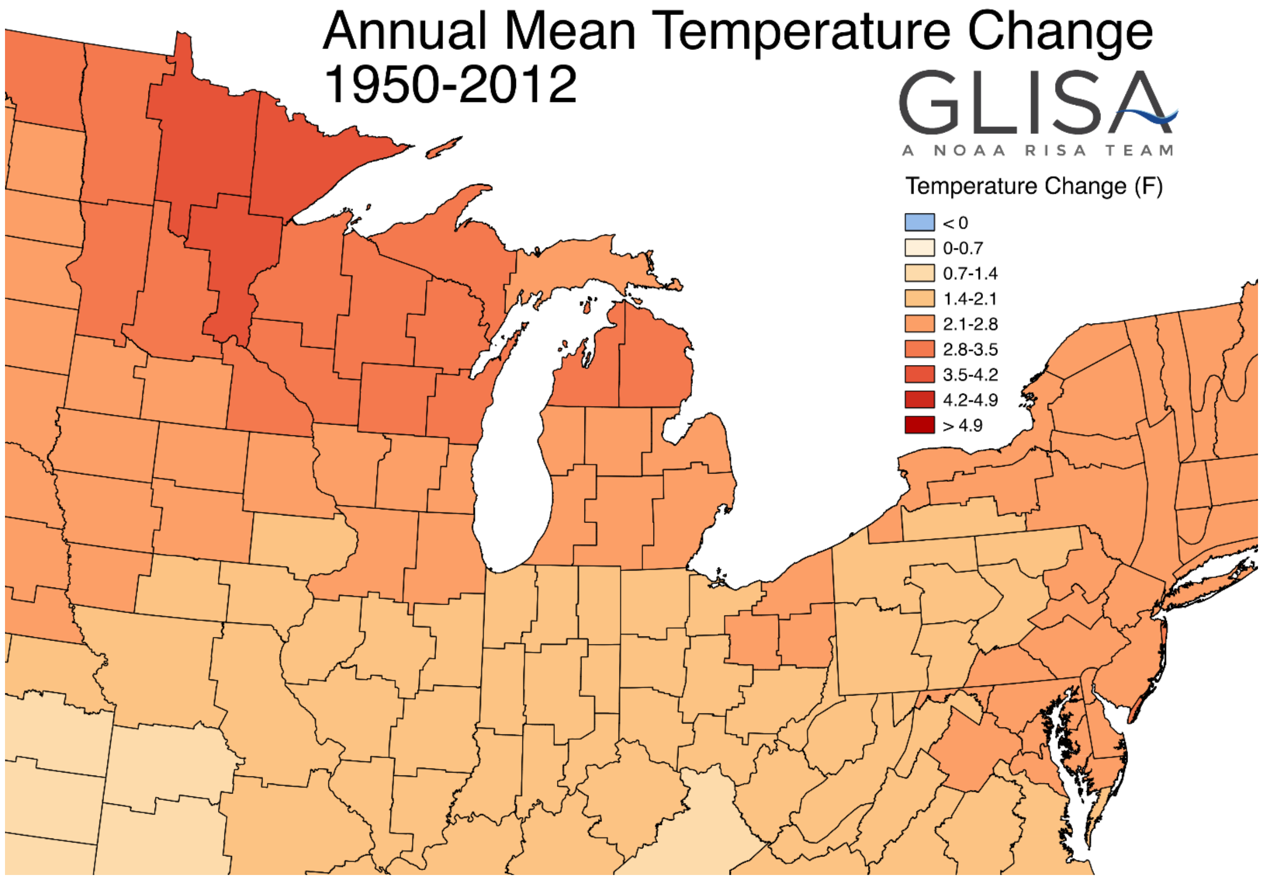
Predictions of surface water changes in the Great Lakes

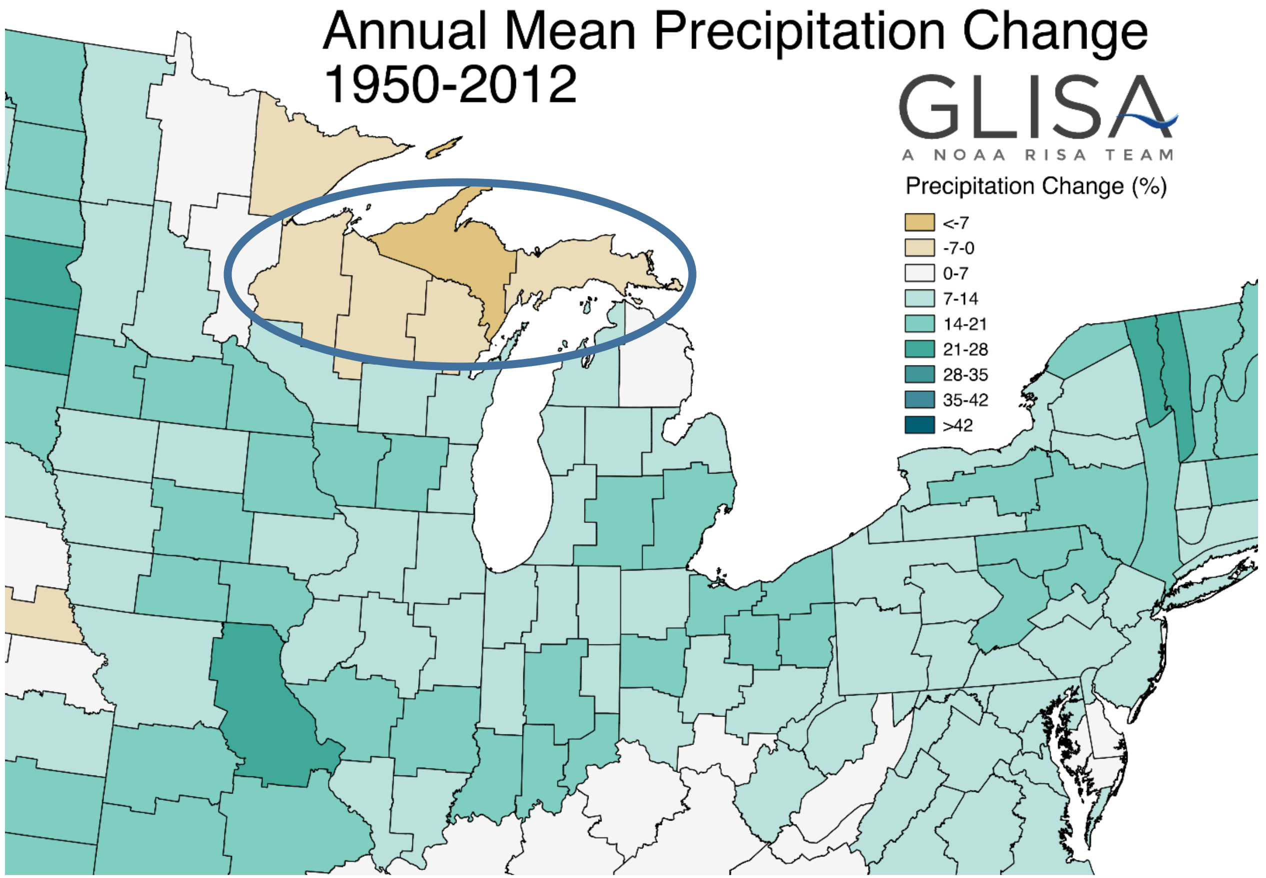


Temperature change impacts a fish's ability to survive.

Because fish are 'cold blooded' (Poikilothermic), their behavior and physiology (including metabolism and growth) are greatly affected by water temperature.

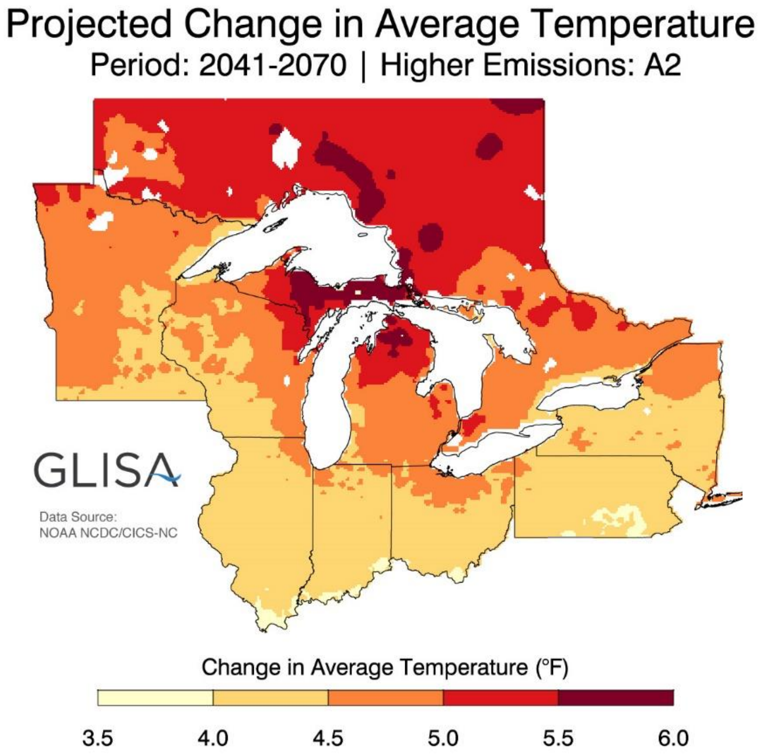
Recent Climate Changes

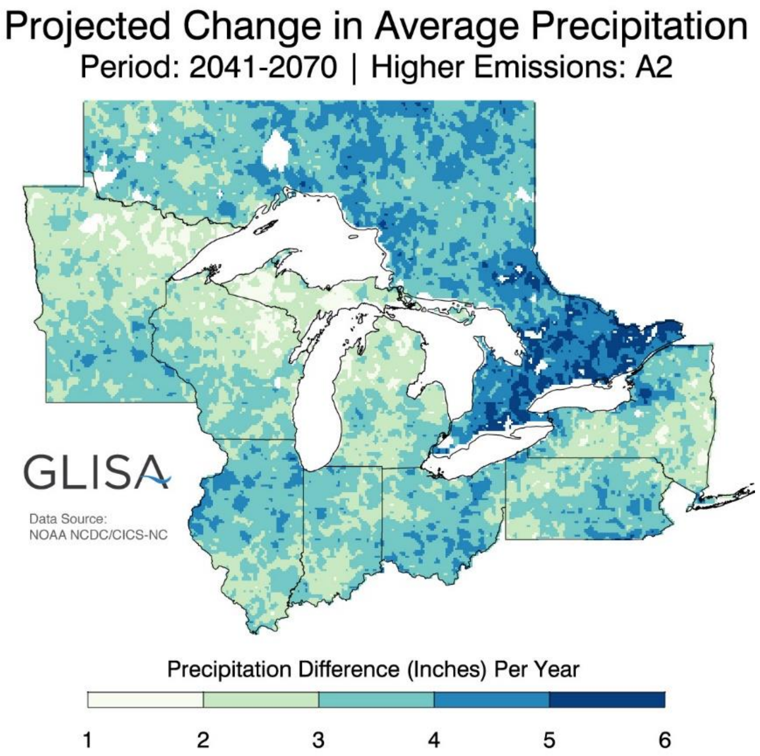


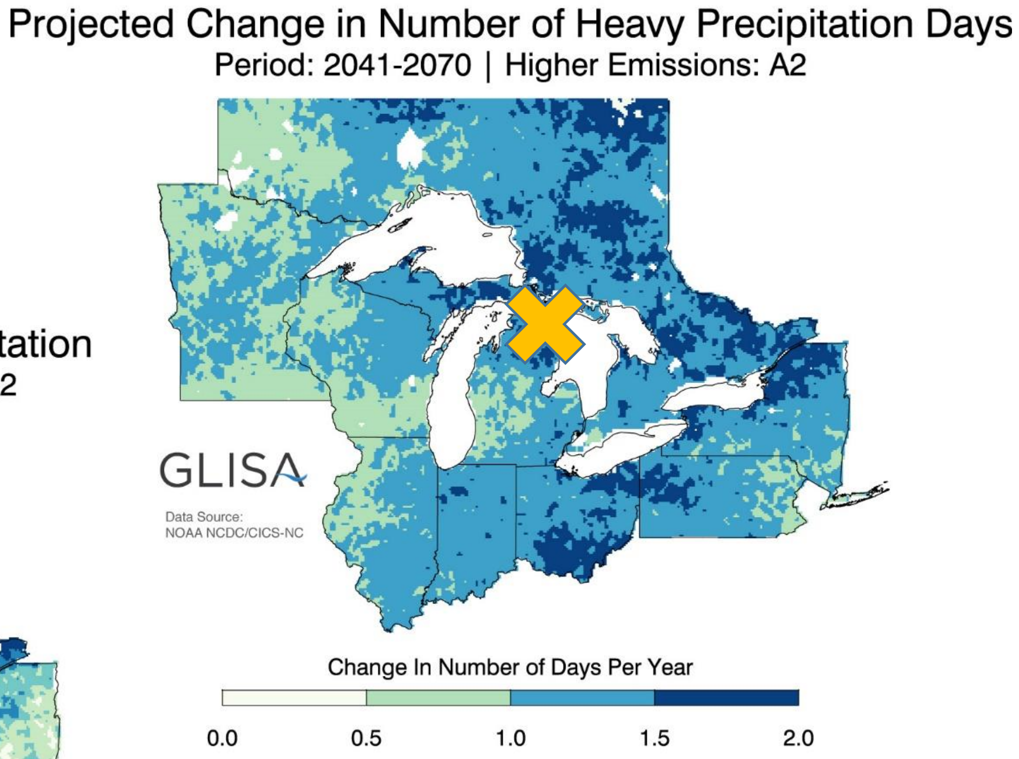


http://glisa.umich.edu/resources/great-lakes-climate-divisions#maps

Anticipated Climate Changes

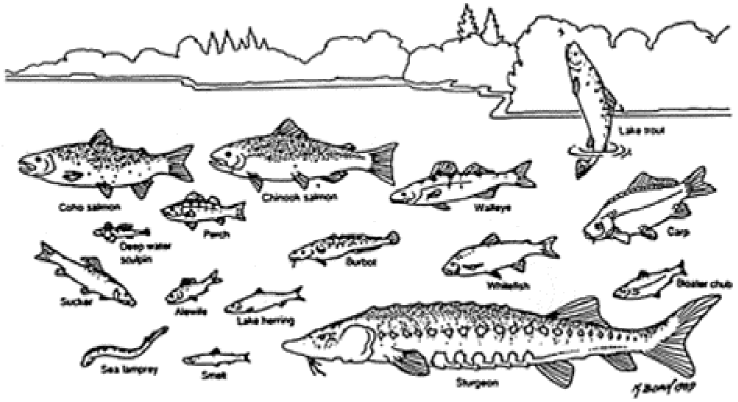






http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps

Great Lakes Fish Populations



*GVSU Annis Water Res Inst.

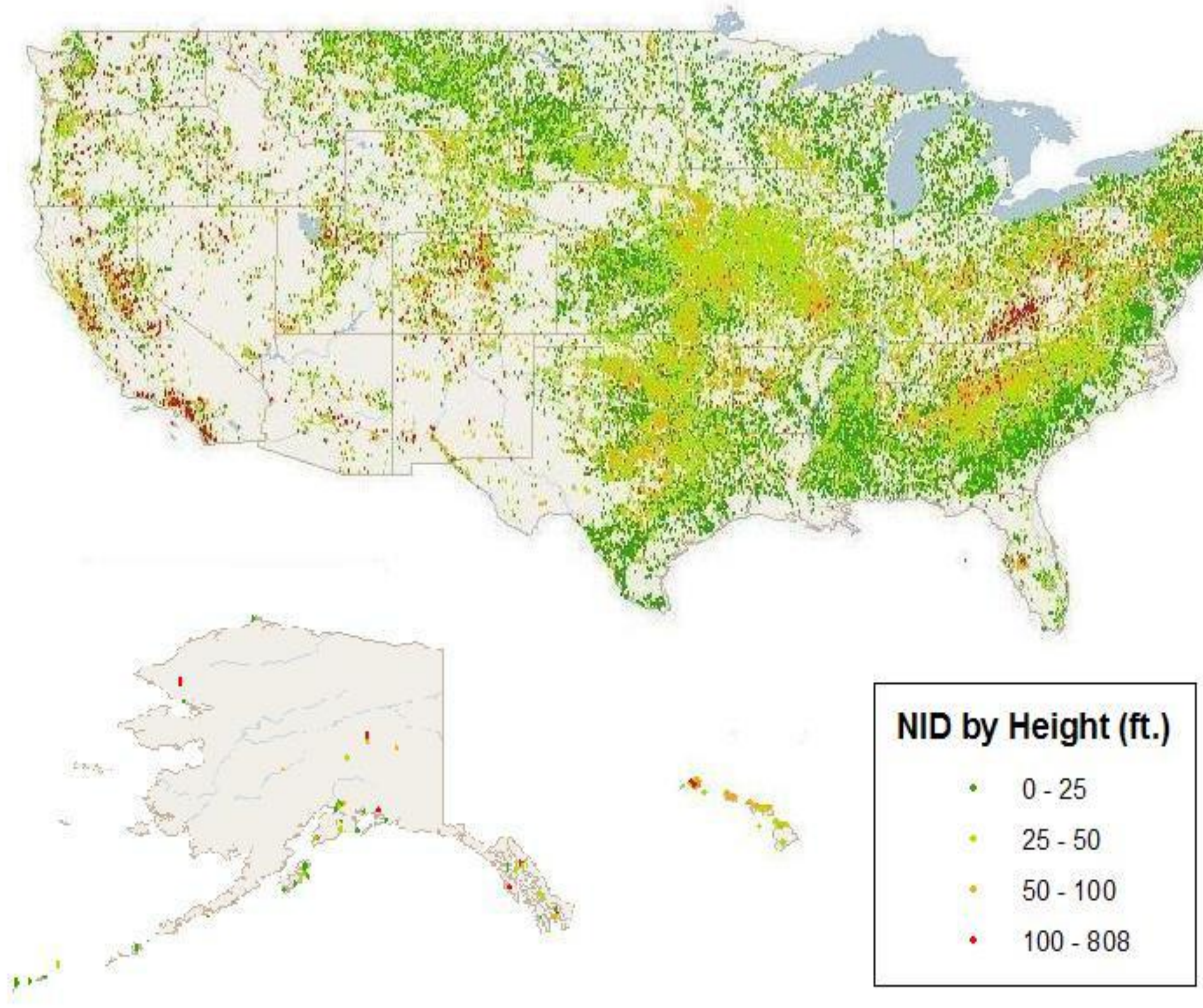
“[Temperature changes] affect the metabolism and possibly the growth rates of ectothermic organisms, especially fish.”
– GLEAM Project

There is much to learn about how temperature change impacts fish

Early life stages of fish are critical periods of growth and development.

Fish are at a higher risk of death (or mortality) in these life stages.

Dams can block fish passage while also affecting water temperature and flow that can impact reproduction.



*National Inventory of Dams, U.S. Army Corps of Engineers

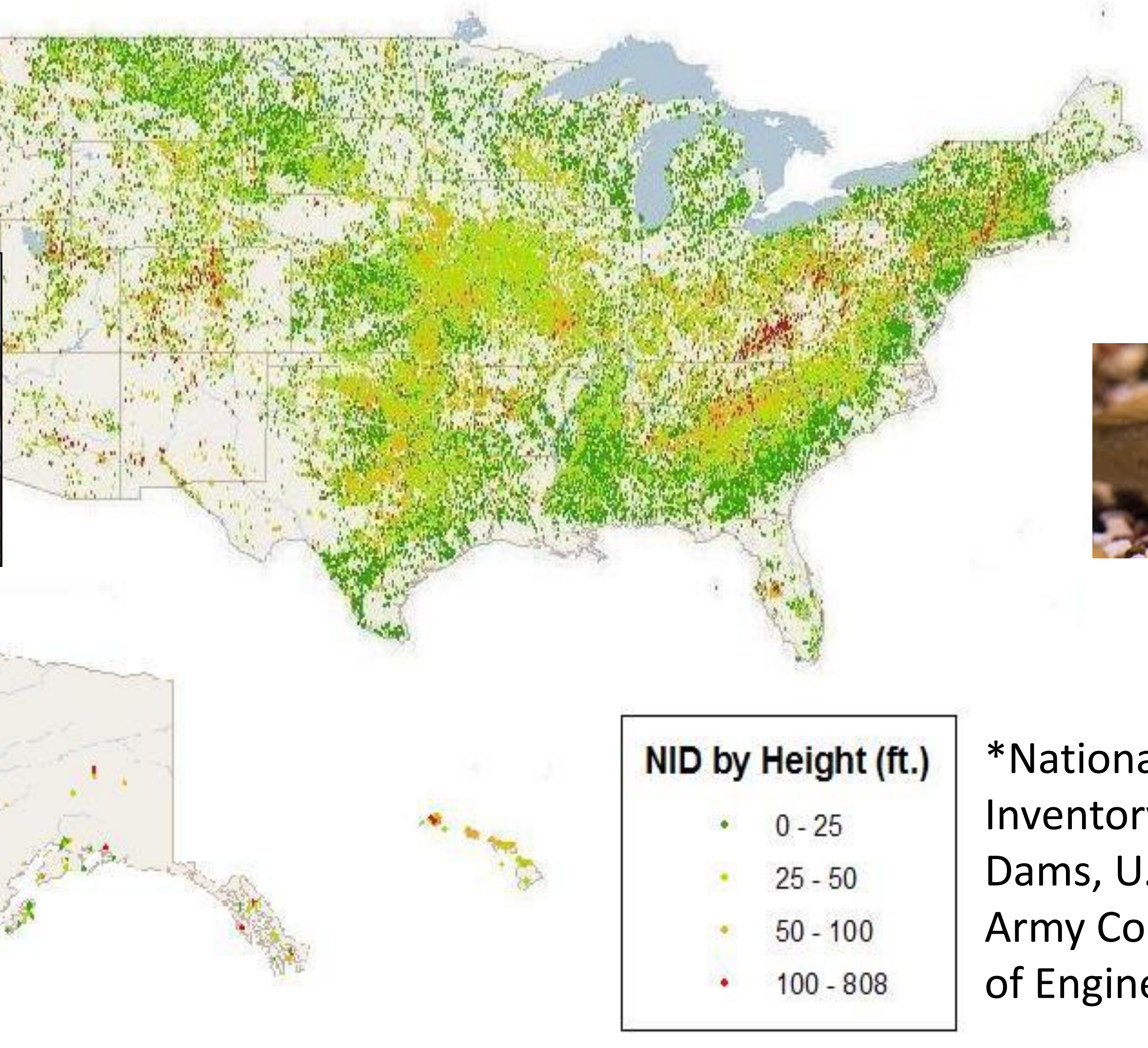
Kleber Dam on Upper Black River

Dams can also create habitat for invasive species (rusty crayfish, round goby, zebra mussels) which are known to eat lake sturgeon eggs and larvae.







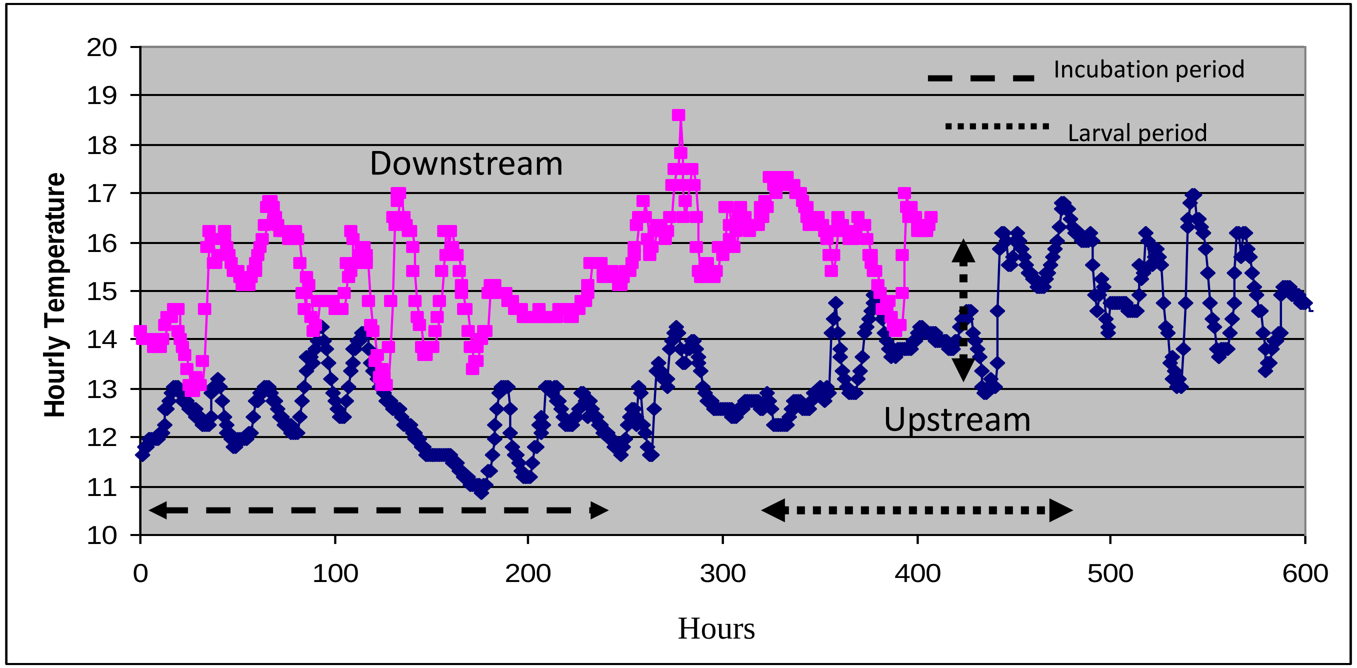



*National Inventory of Dams, U.S. Army Corps of Engineers


Kleber Dam on upper Black River

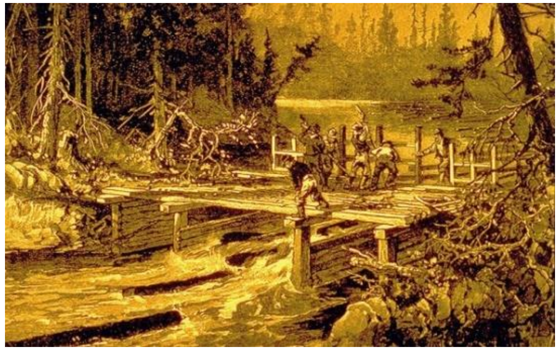
These factors can change and affect Lake Sturgeon survival when rivers are dammed and reservoirs are formed.

- Temperature
- Nutrients – dissolve organic carbon
- Current/dissolved O_2
- Microbial communities
- River flow



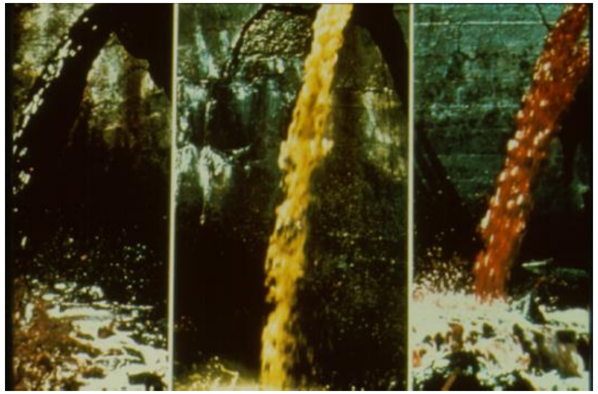
Downstream temperatures are higher and more varied. This section of the river is dammed. **Upstream temperatures** are lower and less varied. This section of the river is free flowing and not dammed.

Factors affecting lake sturgeon distribution, abundance and recruitment mostly chronicle effects of disturbances within tributary habitats

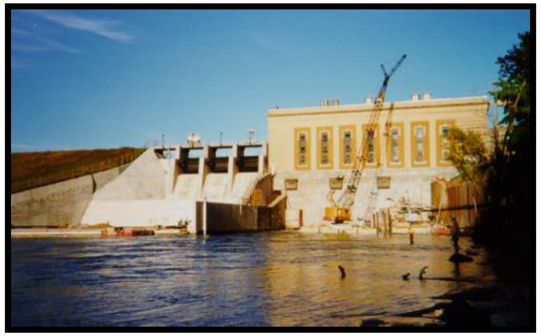


Land use & Land Cover Changes

Climate change & variability



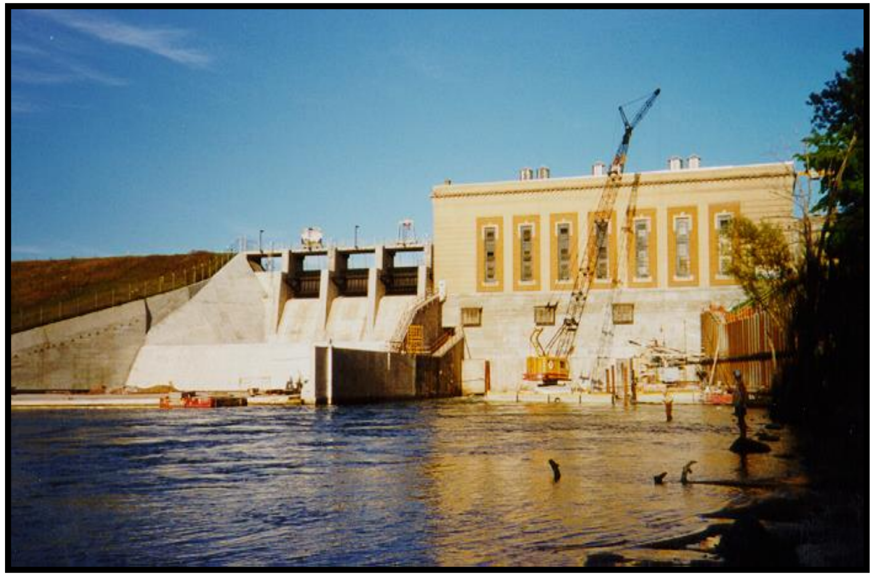
Waterway Uses & Pollution



Barriers to Spawning Migration

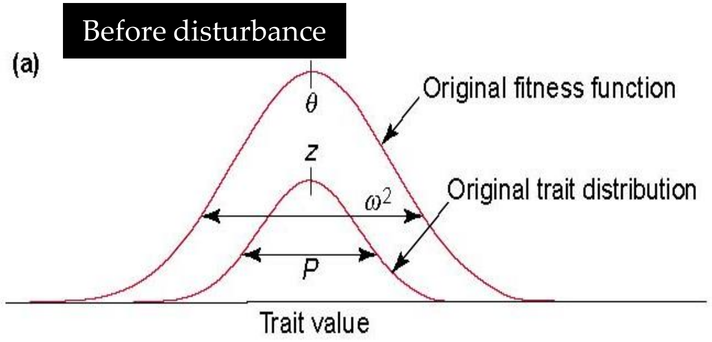
Over Exploitation

Human Disturbances

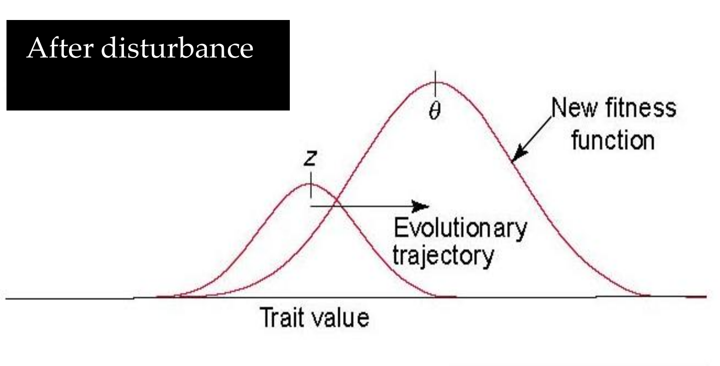


Impacts of Dams

- Long-term disruption in natural conditions
- Habitat loss and fragmentation
- Altered selection regimes



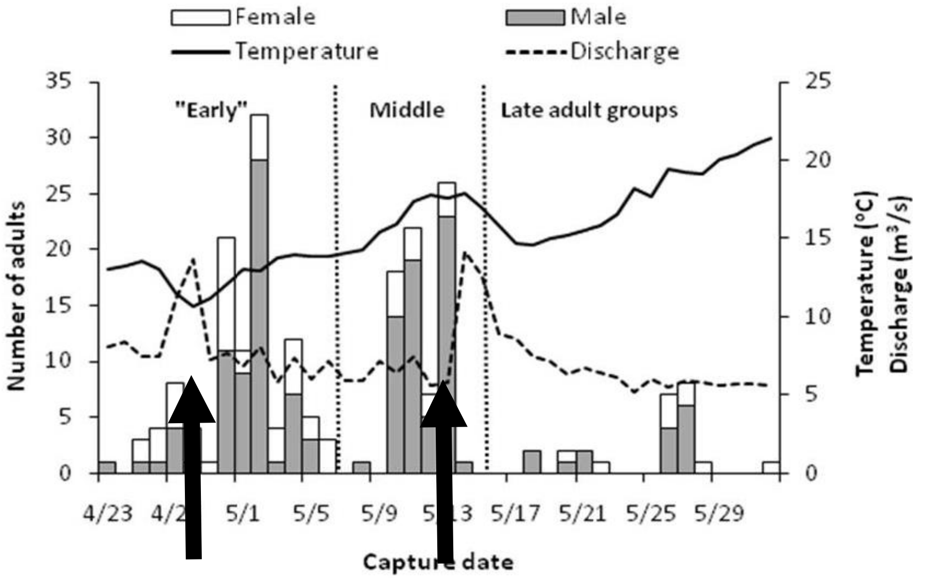
In natural systems, traits, like body size, have a normal distribution with an average and range that reflects their environmental conditions.



Stockwell et al. 2003

Dams can impact water temperature and other environmental changes. Temperature change can results in a new selection regime that favors different traits, or phenotypes (like body size).

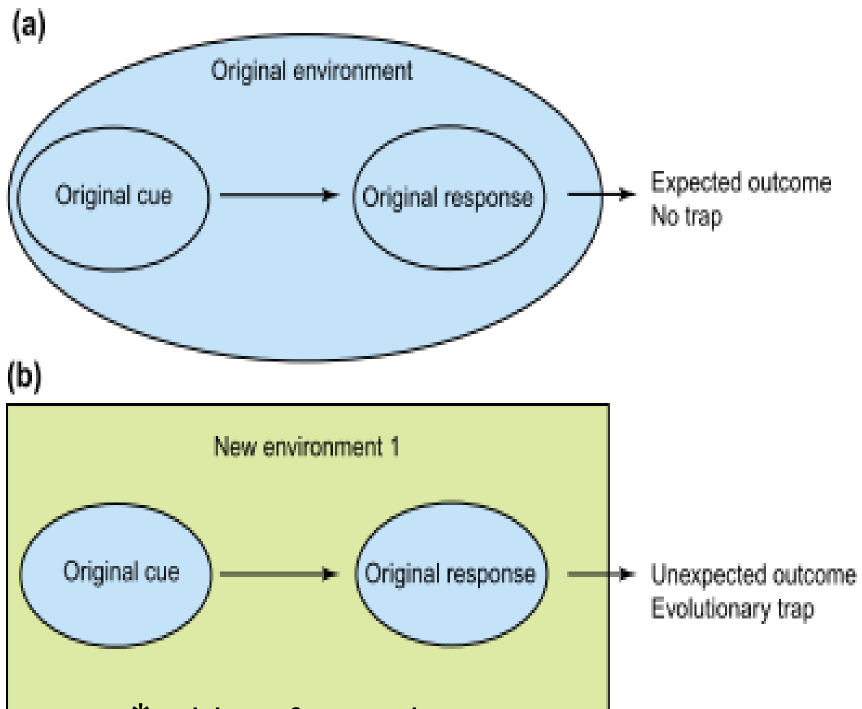
Changes in Environmental Cues and Spawning Impacts



As ↑Temperature + ↓ River Flow Rates = ↑ Lake Sturgeon spawning

If there is temperature or flow rate change, which is more likely with climate change, then spawning could be followed by changes in river conditions.

<u>This change could be deadly for eggs and larvae.</u>



*Schlaepfer et al. 2002


Lets Have Fun With Lake Sturgeon
------ Even During Covid-19!