WF4133-Fisheries Science

Class 23 – System interactions continued

Housekeeping

- 1st drafts due today 4/22 by 5pm
  - Learning objective: technical writing is bland, don't overthink it…
- Presentations will be Monday 4/24
  - 5 groups @ ~15 minutes per group = 1.25 hrs
- Final draft due May 4th 11 am.

Housekeeping

- Final Exam Wednesday May 3rd 8-11 am

MWF, MW, M, W, F CLASSES

If Class Meets		Exam Will Be		
8:00 am	MWF	Thu	May 4	8:00 am to 11:00 am
9:00 am	MWF	Wed	May 3	8:00 am to 11:00 am
10:00 am	MWF	Tue	May 2	8:00 am to 11:00 am
11:00 am	MWF	Thu	May 4	12:00 pm to 3:00 pm
12:00 pm	MWF	Fri	Apr 28	12:00 pm to 3:00 pm
12:30 pm	MW	Fri	Apr 28	12:00 pm to 3:00 pm
1:00 pm	MWF	Mon	May 1	12:00 pm to 3:00 pm
2:00 pm	F	Thu	May 4	3:00 pm to 6:00 pm
2:00 pm	W	Thu	May 4	3:00 pm to 6:00 pm

http://www.registrar.msstate.edu/students/schedules/exam-schedule/s/?year[value][year]=2017&semester=spring

Homework (20 points)

- Provide 1 multiple choice question you believe is a good candidate for a final exam question
- Provide 1 question, that is not multiple choice, you believe is a good candidate for a final exam
- Provide 1 question or topic you would like to see reviewed prior to the final exam. (Optional)
- http://goo.gl/forms/OppPJlMzOc
- For full credit your responses are due by 5pm 4/24/2016.


WFA4133-Final Homework (20 Points)

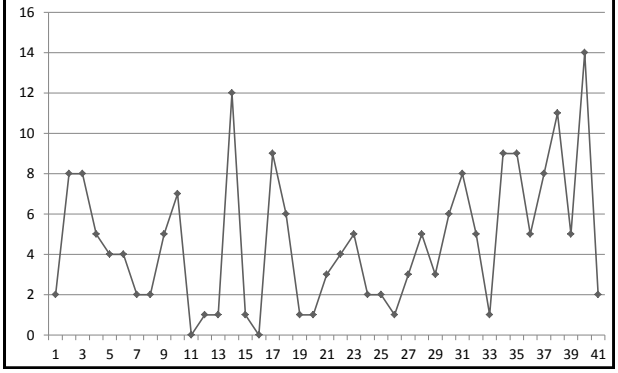
Enter your netid *

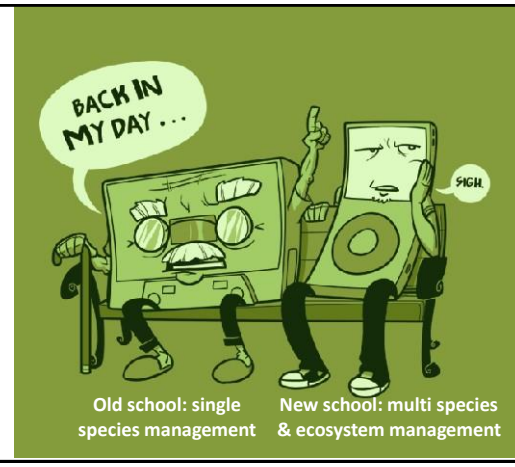
1) Provide 1 multiple choice question you believe is a good candidate for a final exam question (10 points).

2) Provide 1 question, that is not multiple choice, you believe is a good candidate for a final exam (10 points).

3) Provide 1 question or topic you would like to see reviewed prior to to the final exam.

Question level results

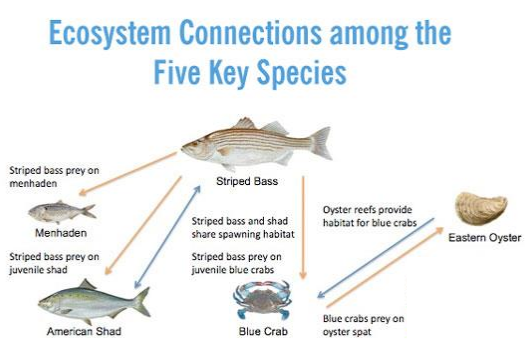




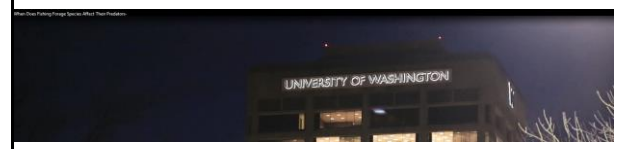
Old school: single species management

New school: multi species & ecosystem management

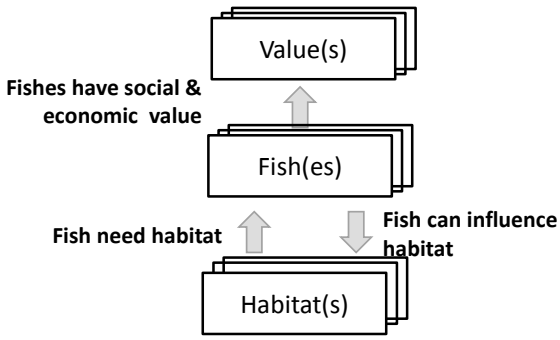
Holistic view



Fishing for forage fish

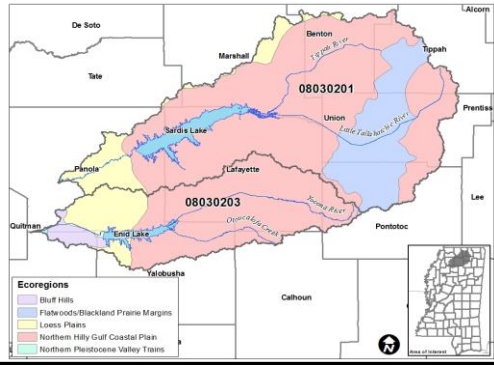


The even bigger picture

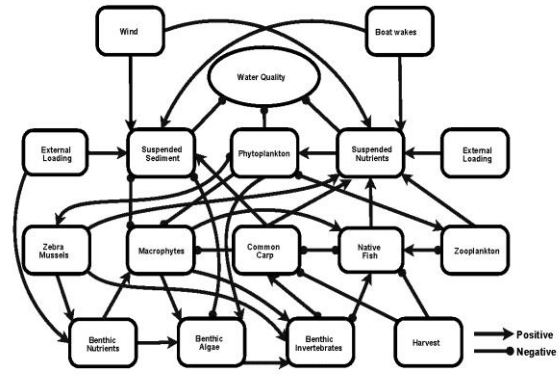


Fisheries are embedded in aquatic ecosystems

Aquatic ecosystems are embedded in terrestrial landscapes



A lake, conceptually



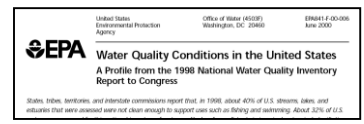
Lake water quality

Lake integrate events in their catchments and landscapes they are embedded in—Schindler 2009

• *external loading is a component of lake water quality*

Landscape inputs to lakes

- Decades of anthropogenic disturbance has lead to eutrophic conditions
  - Excess nutrients, sediment and phytoplankton
- Especially in intense agrarian landscape
- 45% of lakes impaired



Food web effects

Nitrogen and phosphorus recycling by the zebra mussel (*Dreissena polymorpha*) in the western basin of Lake Erie

Diane L. Arnott and Michael J. Vanni

NUTRIENT CYCLING BY ANIMALS IN FRESHWATER ECOSYSTEMS

Michael J. Vanni
Department of Zoology, Miami University, Oxford, Ohio 45056;
email: vannimj@muohio.edu

Food Web Structure and Phosphorus Cycling in Lakes

DANIEL E. SCHINDLER AND JAMES F. KITCHELL
Center for Limnology, University of Wisconsin Madison, Wisconsin 53706, USA

Nitrogen and phosphorus excretion by detritivorous gizzard shad in a reservoir ecosystem

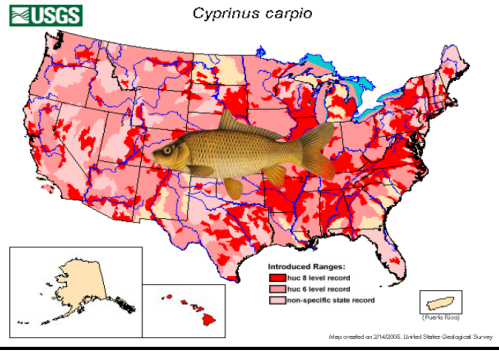
M. H. Schaus, M. J. Vanni, and T. E. Wissing
Miami University, Department of Zoology, Oxford, Ohio 45056

M. T. Bremigan,[1] J. E. Garvey, and R. A. Stein
The Ohio State University, Department of Zoology, Aquatic Ecology Laboratory, 1314 Kinnear Road, Columbus, Ohio 43212-1194

Other threats to water quality

Non-native species
- Modify food webs
- Alter water quality

Common carp



History of common carp

- Brought over from Europe early 1900's
  - food supply
- Lots of debate 1900s

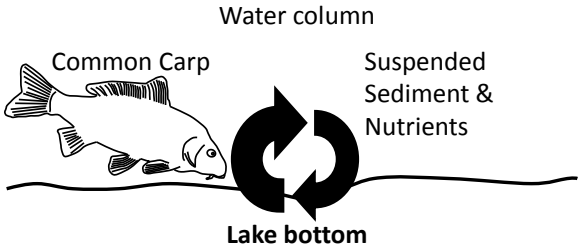
114 *Thirtieth Annual Meeting*

DISCUSSION ON CARP.
LED BY DR. S. P. BARTLETT.

THE STATUS OF THE CARP IN AMERICA.
BY LEON J. COLE.
(Read by Dr. Evermann.)

THE FUTURE OF THE CARP
By S. P. Bartlett,
U. S. Fisheries Station, Quincy, Ill.

Common carp and water quality



Common carp impacts

Removal by harvest in 1920's

ECOLOGY

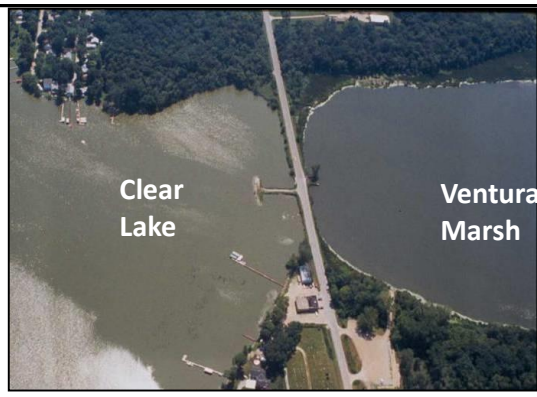
Vol. X JULY 1929 No. 3

THE EFFECT OF CARP ON A SMALL LAKE: THE CARP AS A DOMINANT[1]

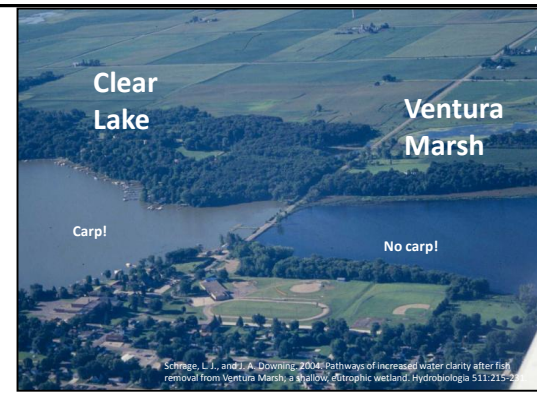
Alvin R. Cahn
University of Illinois

THE INCREASE IN GAME-FISH POPULATIONS IN EAST OKOBOJI LAKE, IOWA, FOLLOWING INTENSIVE REMOVAL OF ROUGH FISH

Earl T. Rose and Tom Moen
Iowa State Conservation Commission
Des Moines, Iowa



Carp effects on water quality

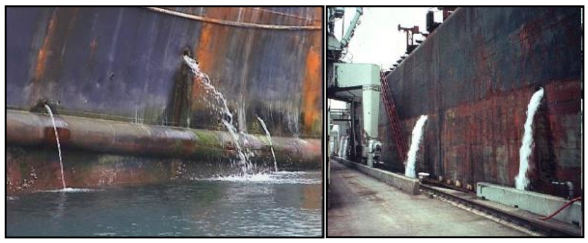


Schrage, L. J., and J. A. Downing. 2004. Pathways of increased water clarity after fish removal from Ventura Marsh, a shallow, eutrophic wetland. Hydrobiologia 511:215-2

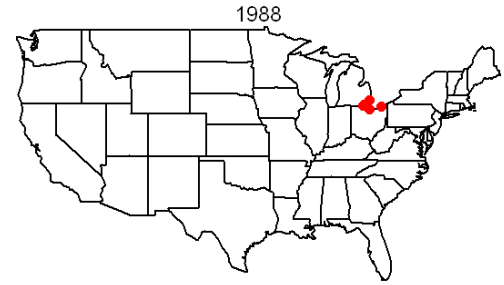
Carp effects on water quality

Zebra mussels

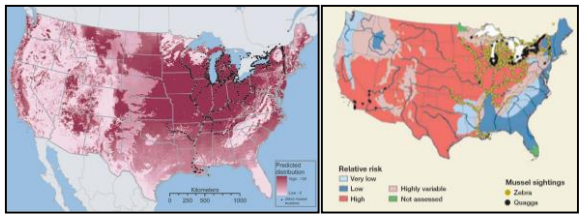
- 1988 Lake St. Clair, MI
- Ballast water
- Secondary spreading to inland waters



Zebra Mussel Spread



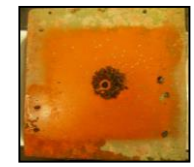
Future of zebra mussels



Drake, J. M., and J. M. Bossenbroek. 2004. The potential distribution of zebra mussels in the United States. BioScience 54:931-941.
Whittier, T. R., P. L. Ringold, A. T. Herlihy, and S. M. Pierson. 2007. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena spp*). *Frontiers in Ecology and the Environment* 6:180-184.

Zebra Mussels: water quality

- Filter large quantities
  - Especially at high densities
- Selective feeding
  - Limits quality food for secondary production (e.g., zooplankton)
- Can promote toxic algal blooms



Prevention

Zebra mussels found on boat at Rathbun

RATHBUN (AP) — Zebra mussels found on a boat docked at Rathbun Lake is raising concerns that the invasive species might have spread to the southern Iowa lake.

The exotic zebra mussels are found along the Mississippi river and have been found in only two Iowa lakes — Lake Delhi in Delaware County and Clear Lake in Cerro Gordo County.

The boat found with about 100 adult zebra mussels on a boat at Rathbun Lake on Oct. 26, but they don't know if the thumbnail-sized pests spread to the rest of the lake. [illegible] identified, could be fined $100 for transporting zebra mussels.

"We cannot allow the careless behavior by a few individuals and businesses to permanently impact a resource used by 600,000 visitors," said Rich Leopold, the state agency's director.

The small pests attach to boats and can clog water intake pipes at water treatment plants, kill native mussels, coat boat bottoms and spoil food for smaller fish.

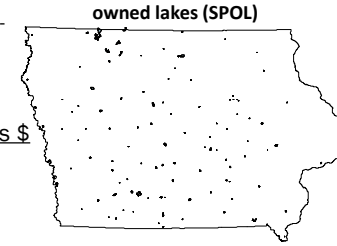
"If zebra mussels become established here, there is no permanent fix — we will have to learn how to [illegible]

Value of Iowa lakes

- **Iowa Lake Use**
  - 62% of Iowa households visited a SPOL
  - 8 trips year $^{-1}$

Visitors spend millions $ per lake

132 Significant publicly owned lakes (SPOL)



Lake restoration in Iowa

State Legislation HF2782 (2006)

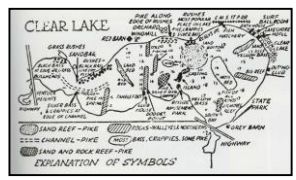
- Control watershed phosphorous and sediment loading
- 1.4 m Secchi disc transparency
- Maintain a diverse and sustainable aquatic community
- Water quality and public use benefits sustained at least 50 years.

Water quality is valuable

- Lakes with good water quality are worth more
  - Jobs & recreation
  - Local economic impacts
- Fisheries
  - > 300 million dollars in Iowa
  - 1-2.5 million on Clear Lake
- Understanding impacts of non-native species and lake restoration is important

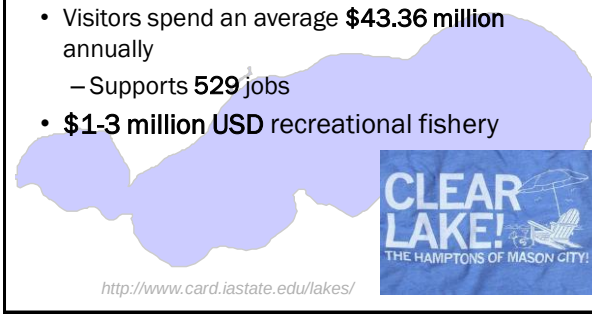
Clear Lake

- Shallow: Z_{mean} = 2.9 m
- Good water quality
- Expansive & diverse Macrophyte community
- Productive & diverse fishery



Clear Lake is valuable

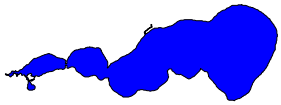
- Averaged **432,312** visitors annually
- Visitors spend an average **$43.36 million** annually
  - Supports **529** jobs
- **$1-3 million USD** recreational fishery

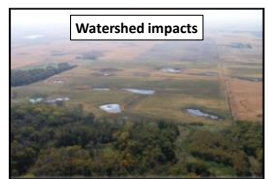


http://www.card.iastate.edu/lakes/

Water quality: external processes

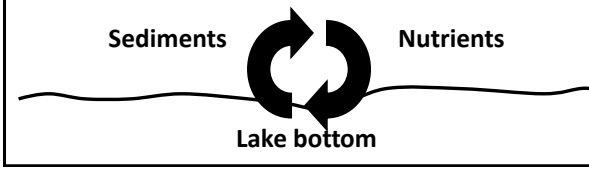
- Watershed
- Ground water
- Ventura marsh
- Urban inputs
  - Lawn fertilization





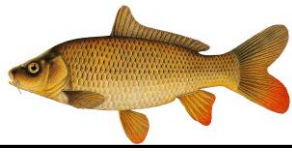
Water quality: internal processes

Water column



Common carp and Clear Lake

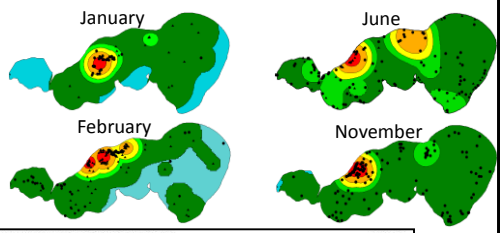
- Date of entry to Clear Lake unknown; but established by early 1900's
- Removal by harvest in 1920's
- 433 tons of carp removed since 2000
- Excess of 2.3 million pounds harvested
- Impacts associated with biomass



Managing carp biomass

- Pulsed intense removals over a short period
  - Large removals
  - Short duration
  - Spring and fall

Improving harvest



Transactions of the American Fisheries Society 137:1050–1062, 2008
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DOI: 10.1577/T07-112.1

[Article]

Seasonal Distribution, Aggregation, and Habitat Selection of Common Carp in Clear Lake, Iowa

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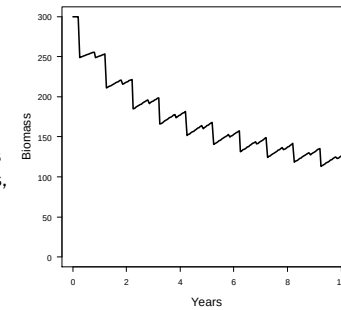
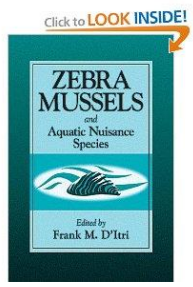
CLAY L. PIERCE
U.S. Geological Survey, Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, Iowa 50011-3228, USA

Managing fish biomass harvest

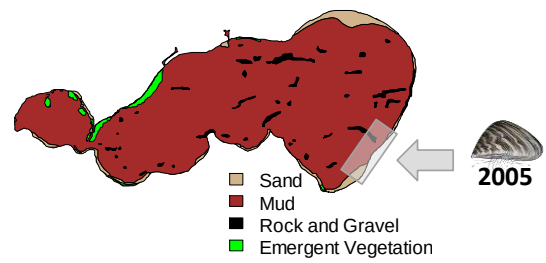
- Biomass dynamics model
  - Simple
  - Biomass based
- dB/dt = f(B) – C
- Assumes processes (recruitment, losses, harvest) occur continuously



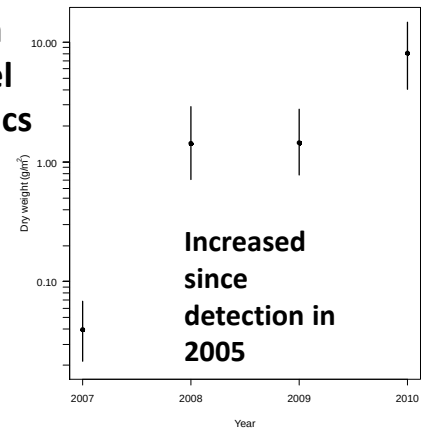
A NEW CHAPTER FOR CLEAR LAKE



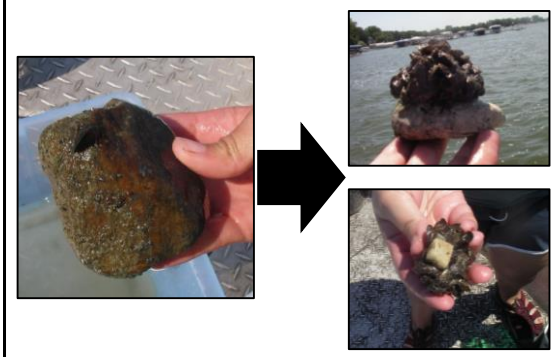
A New Chapter: Zebra Mussels



Zebra mussel dynamics



Increased since detection in 2005



Food web impacts?

A lake ecosystem model

- Lakes are **complex**
- Learn about the system
- Explore management and restoration scenarios

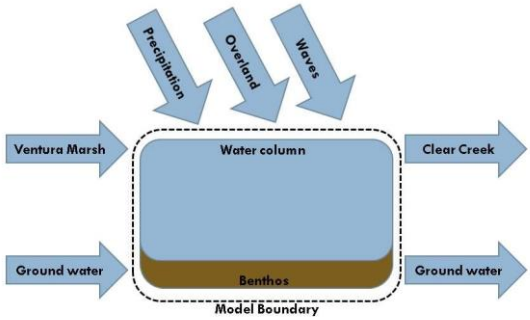
Evaluate long term actions?

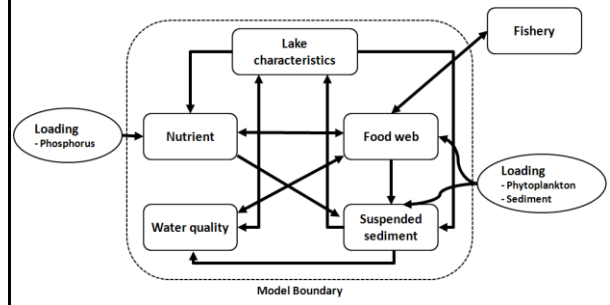
- State Legislation HF2782 (2006)
  - Water quality and public use benefits sustained at least **50 years**
- Difficult to evaluate potential restoration actions without a model
- In light of potential effects of invasive species

CLESM overview

- Dynamic simulation model
- Constructed in STELLA
- Extends ECOSIM
  - Environmental limitations (light)
  - Nutrients

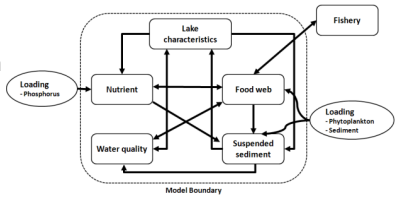
External factors effecting aquatic systems





Lake characteristics

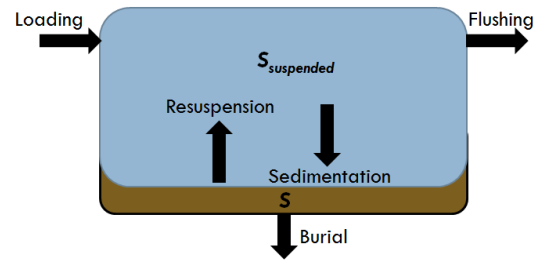
- Morphology
  - Mean depth
  - Volume
  - Area
- Calculations
  - Photic zone
  - Area susceptible to suspension



Suspended solids

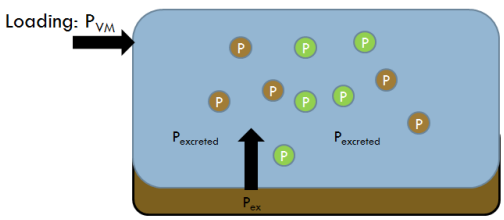
$$\frac{dS_{suspended}}{dt} = Suspension + Loading - Settling - Flushing$$

$$\frac{dS}{dt} = Settling - Suspension - Burial$$

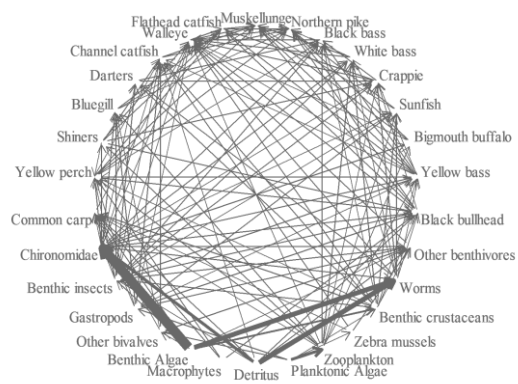


Nutrients

$$TP = P_{VM} + P_{excreted} + P_{Suspended} + P_{phyto} + P_{ex}$$



The food web



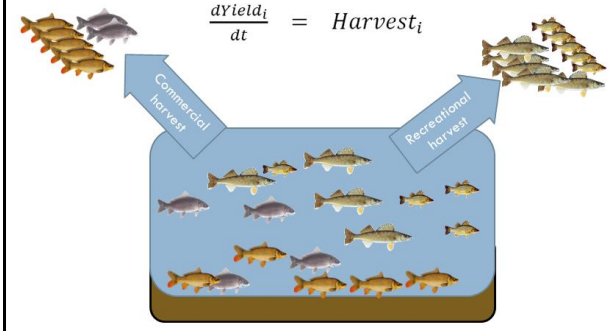
Food Web

$$\frac{dBiomass_i}{dt} = Production_i - (Net\ migration_i + Harvest_i + Predation_i + Other\ mortality_i)$$

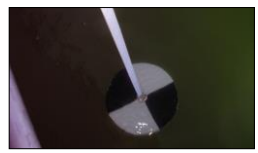
Dynamic representation of ECOPATH model

- Primary Production is big difference in CLESM and ECOSIM
- CLESM allows light and nutrient limitation

Fisheries



Secchi Transparency

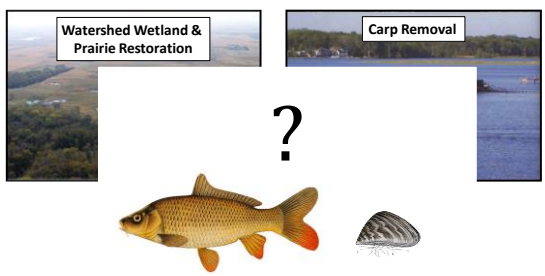


1/[Zsd] = 0.77
+ 0.05[Edible algae]
+ 0.001[Inedible algae]
+ 0.02 [Total suspended solids]

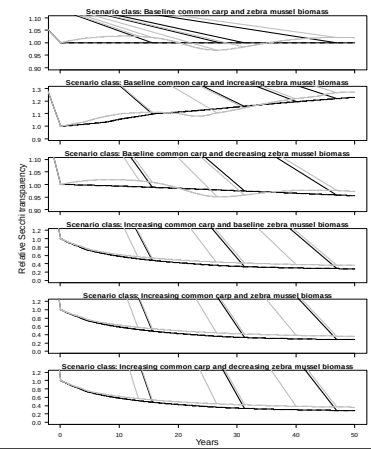
Using CLESM

- A tool to **rank** potential management and restoration decisions in an **ecosystem context**
- Evaluate **potential direct and indirect** effects of ecosystem change
- Evaluate restoration actions impacts in light:
  - Invasive species (e.g., zebra mussels)
  - Ongoing restoration
- Up to 50 year simulations

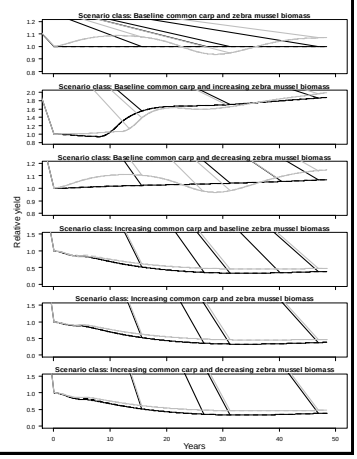
Ongoing Clear Lake restoration



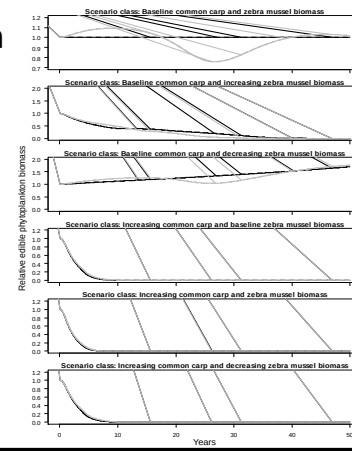
Water quality



Recreational fishery yield



Phytoplankton



Macrophytes