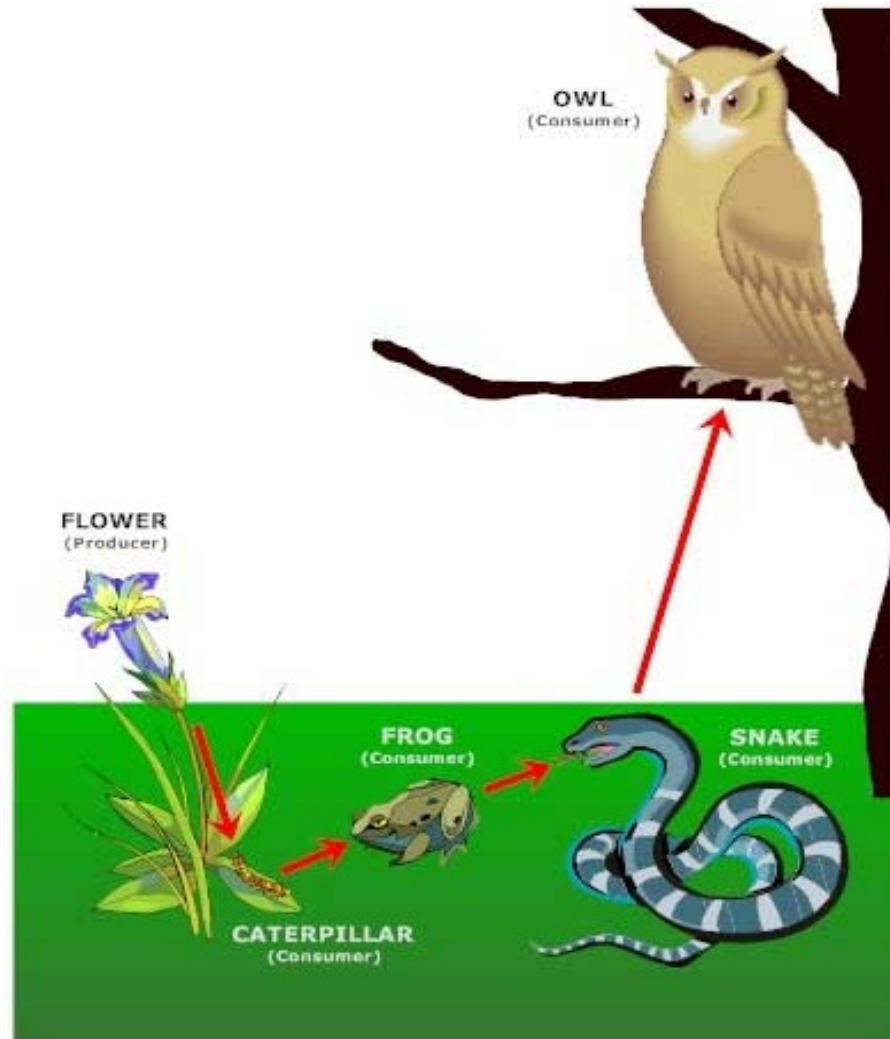
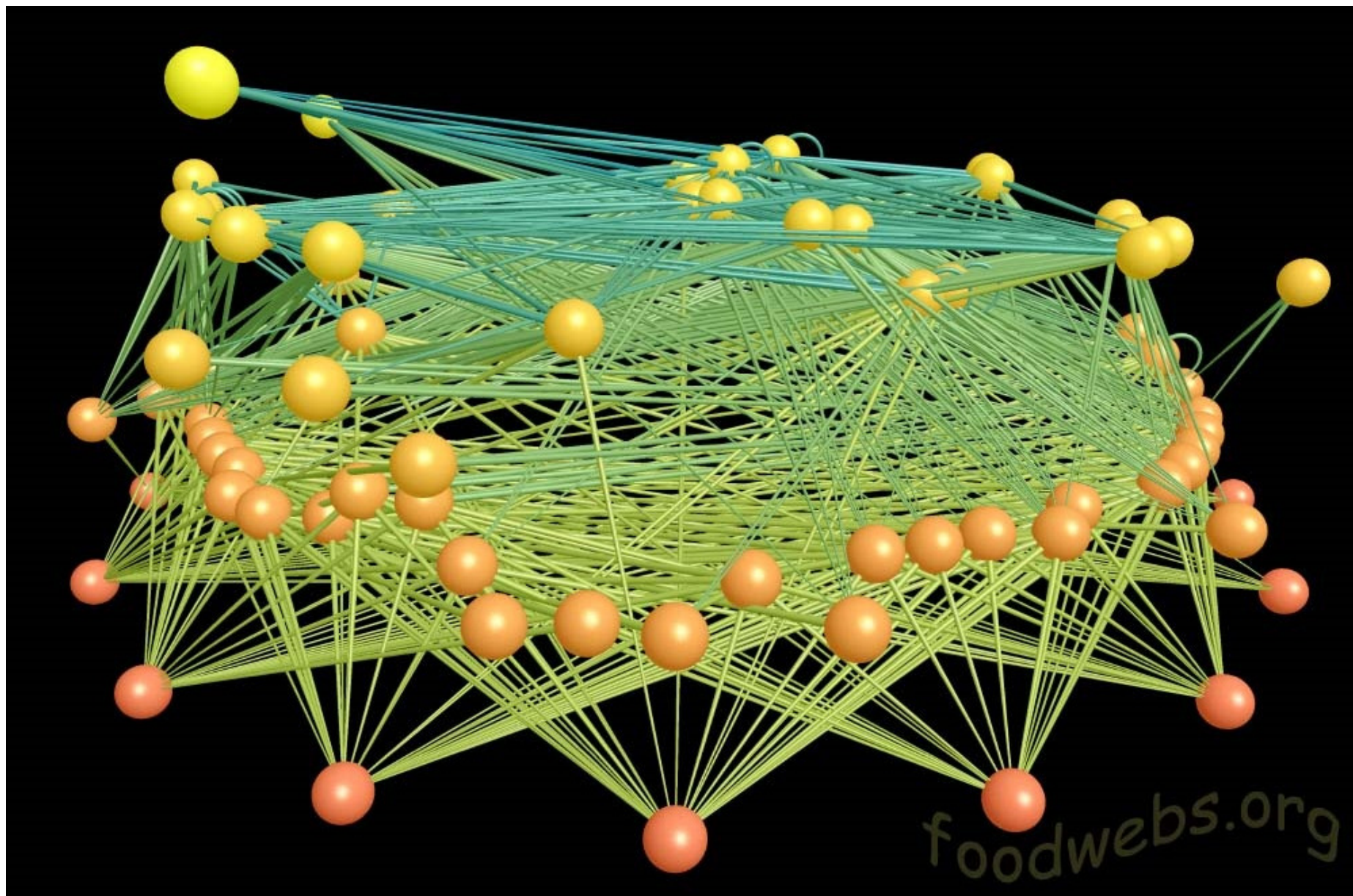


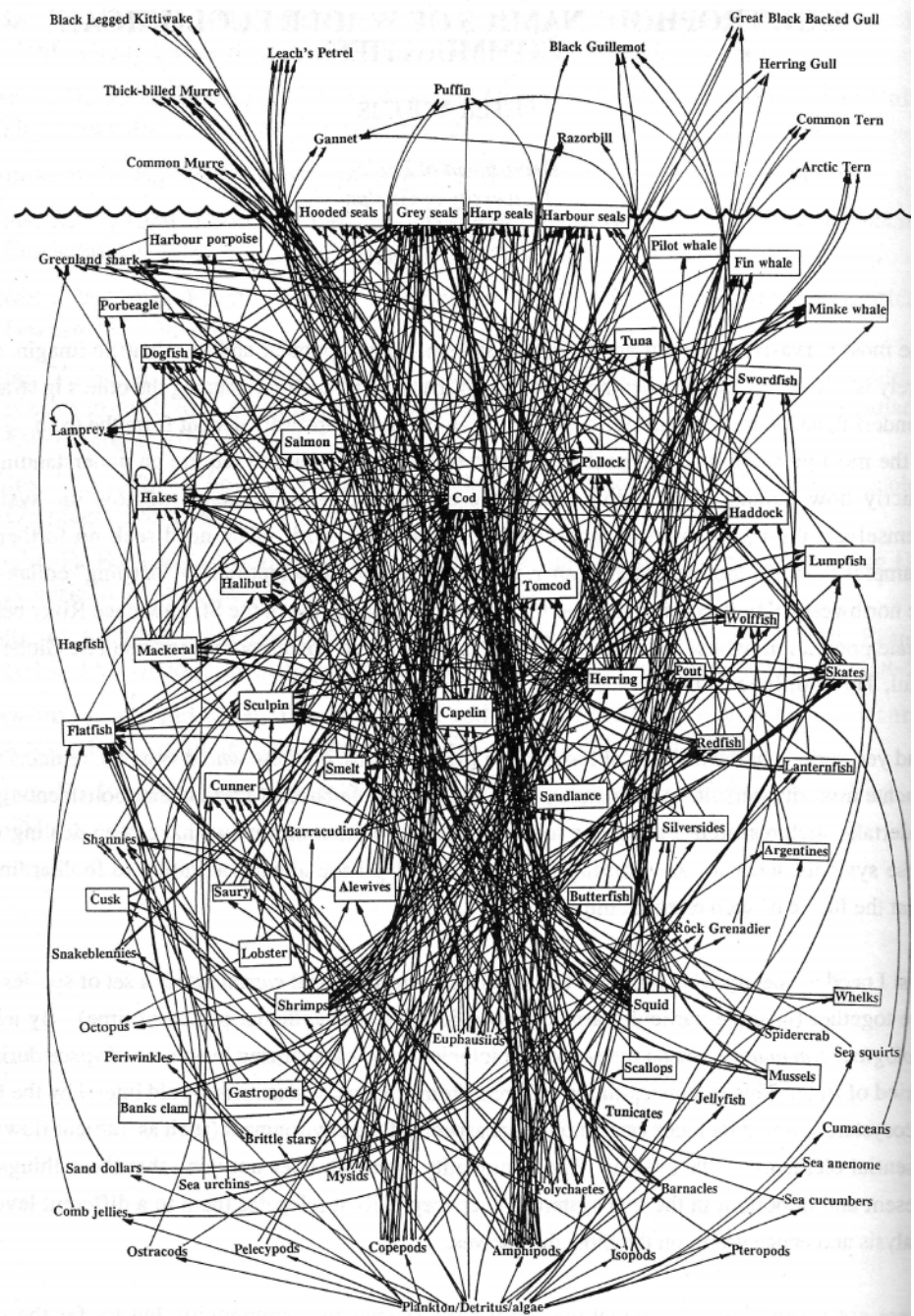
Hudson as an Ecosystem: Focus on Food Webs



East River Valley - Colorado



Northwest Atlantic cod food web

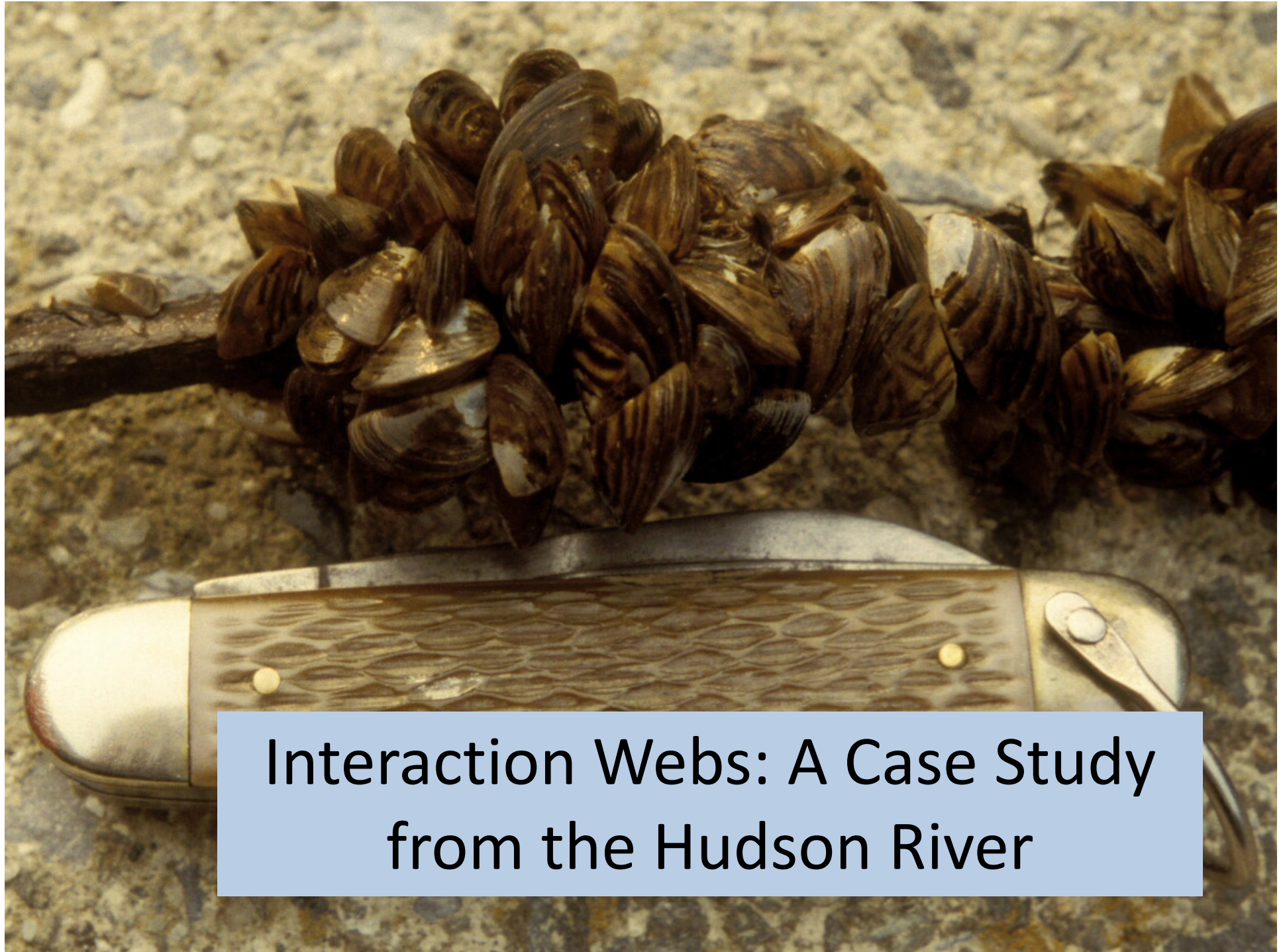


Everything is connected



Everything is connected..sort of





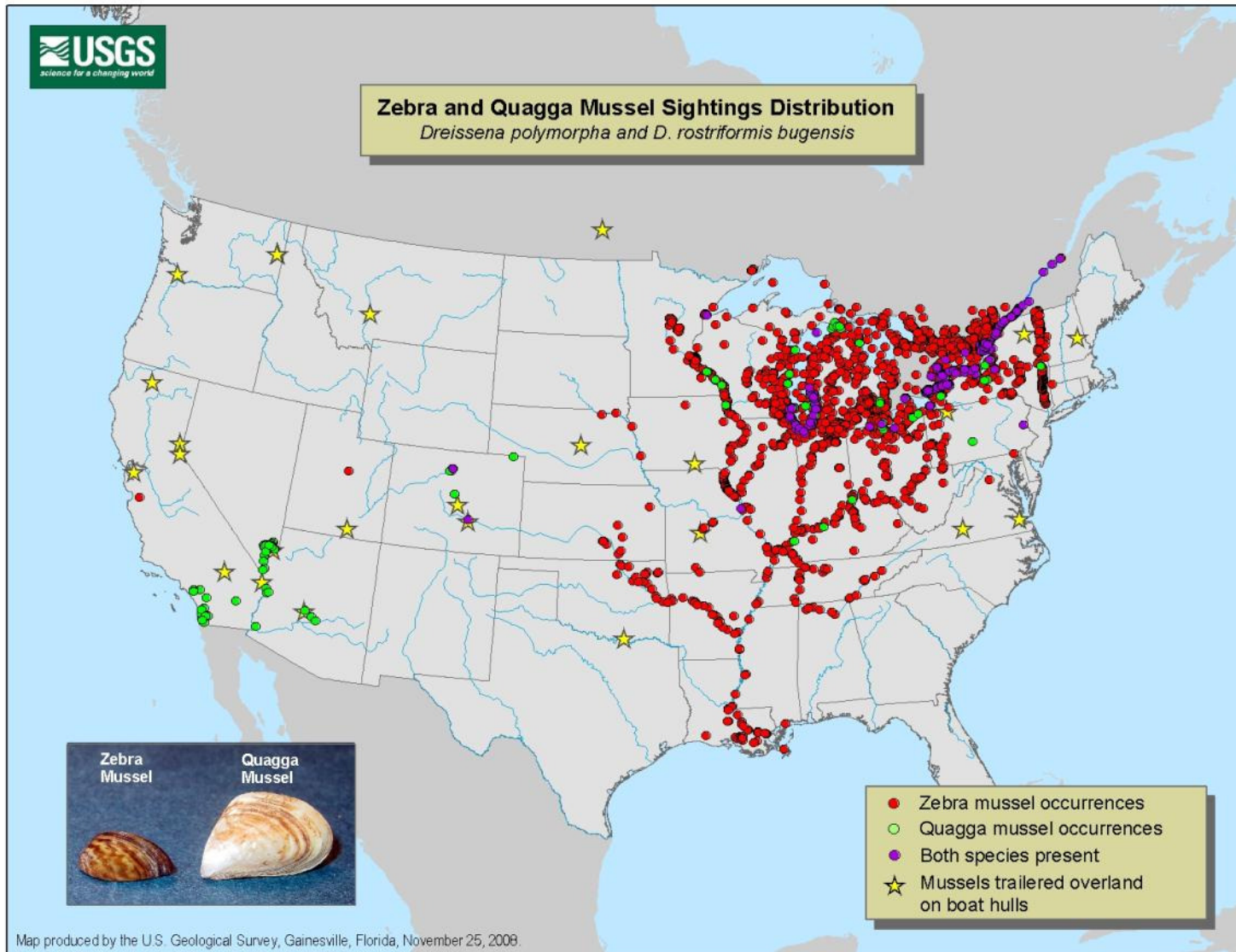
Interaction Webs: A Case Study
from the Hudson River

Native range of zebra mussels

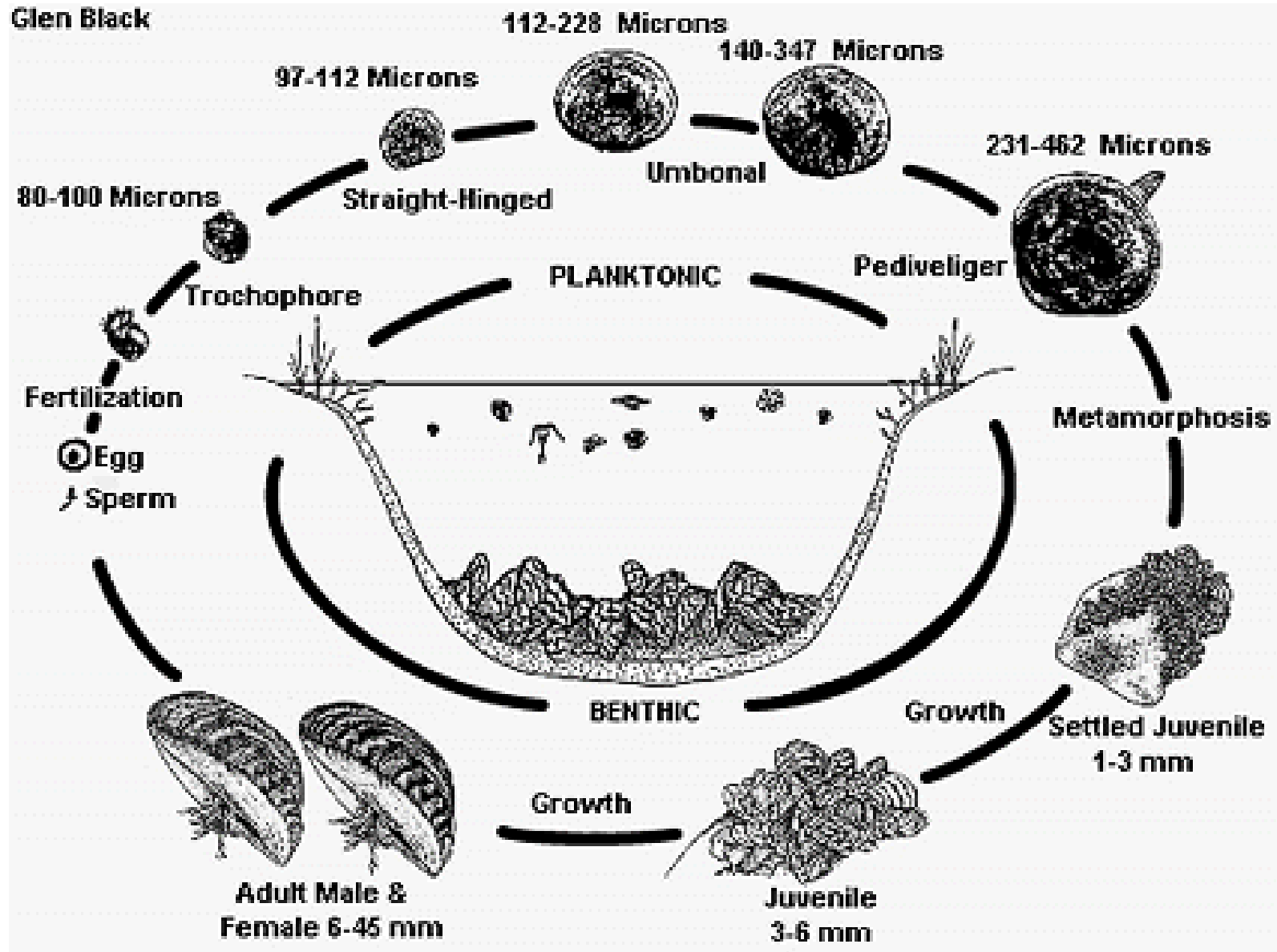


Eastern Europe

Zebra mussel range 2009

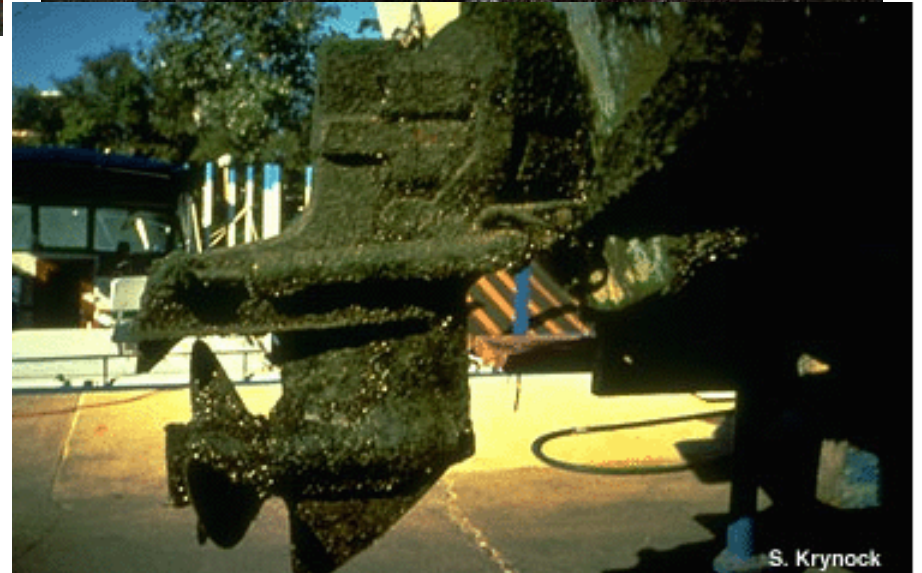


First detected in the Hudson Valley in 1991

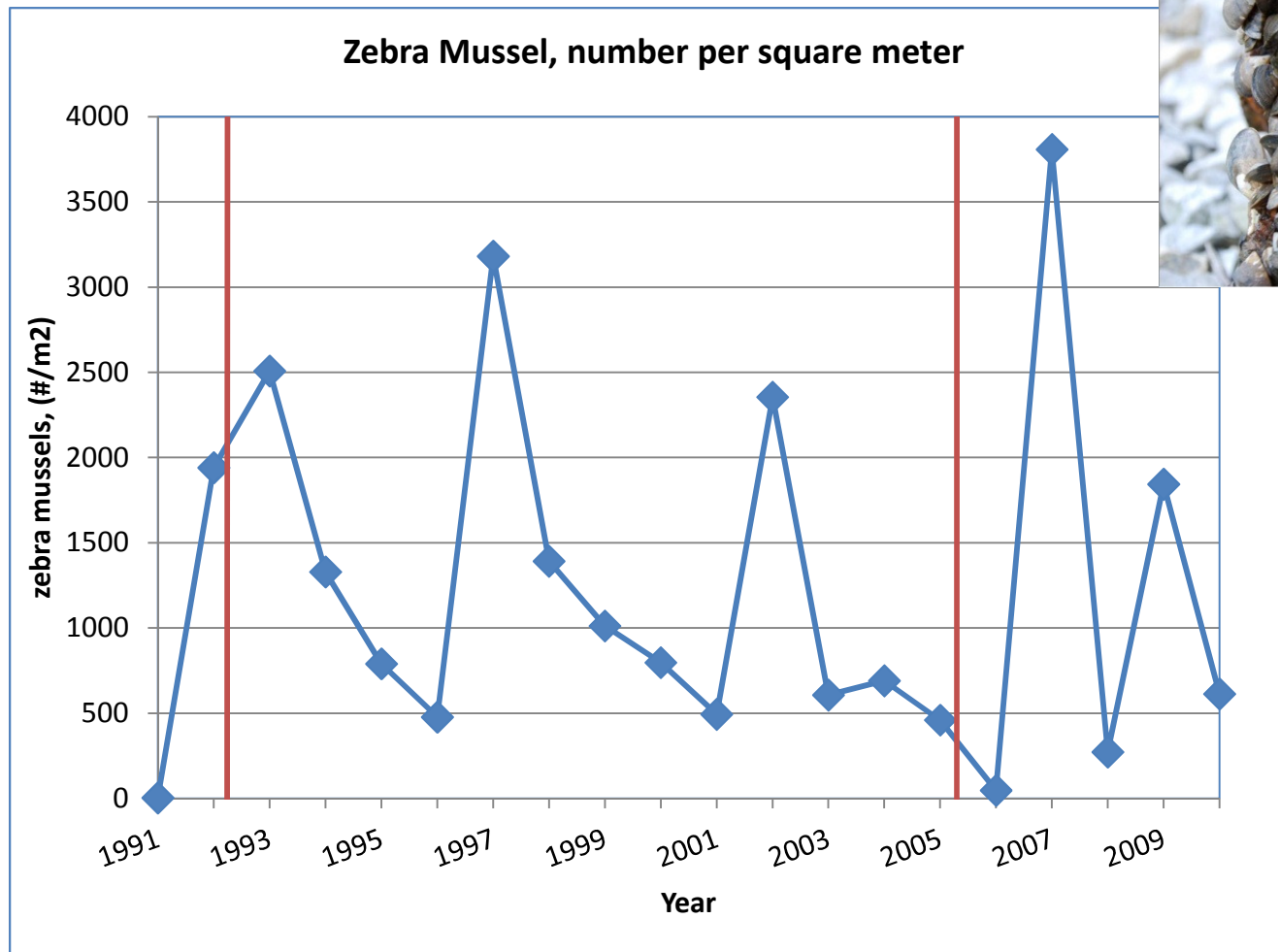


Zebra Mussel Life Cycle

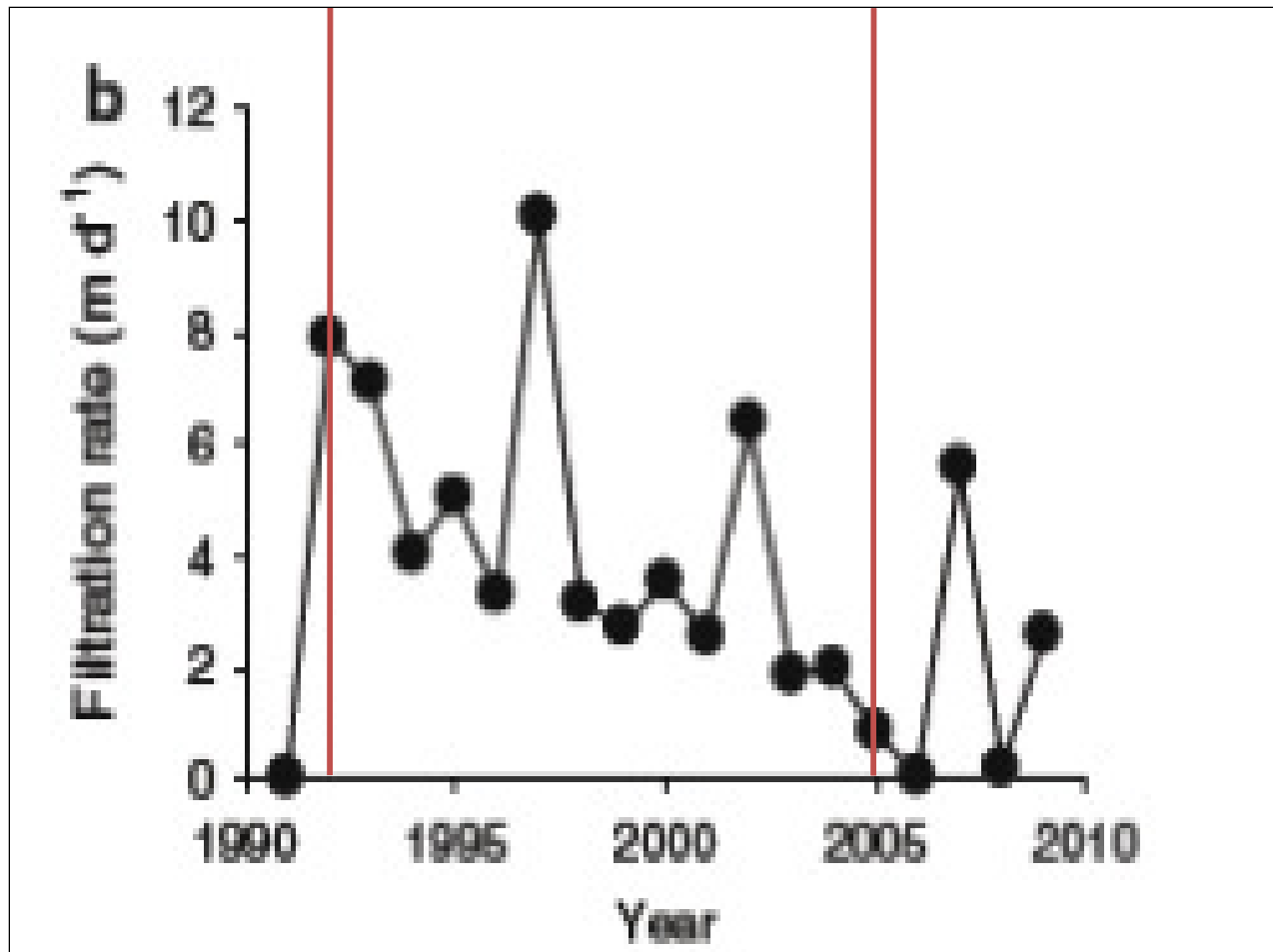
Zebra mussels cause economic damages



How many zebra mussels fit inside one square meter?



How much water do zebra mussels filter?



Zebra mussels filter all the water in the Hudson River basin every 1-4 days.

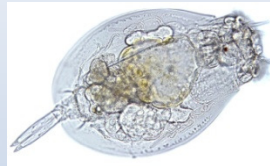
Zebra mussels filter water to capture their food – phytoplankton and small zooplankton.

Zebra Mussels arrived in the Hudson River in 1992.

How do you think this affected other organisms?
Why do you think they affected other organisms?



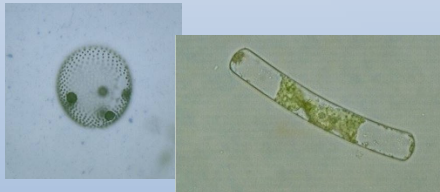
copepod



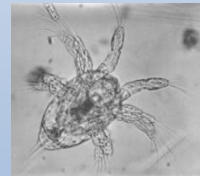
rotifer



Cladoceran
(daphnia)



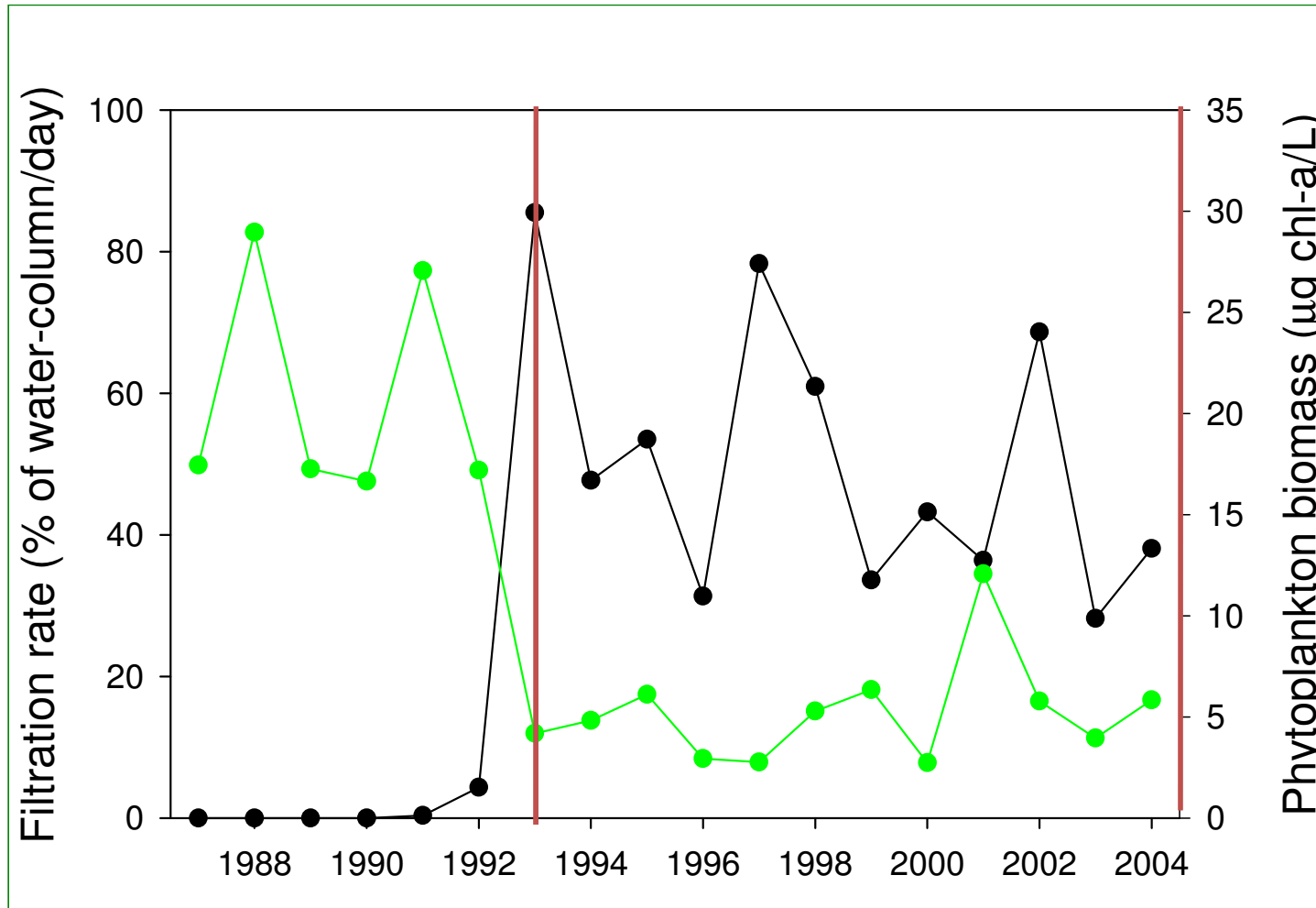
Phytoplankton
(algae)



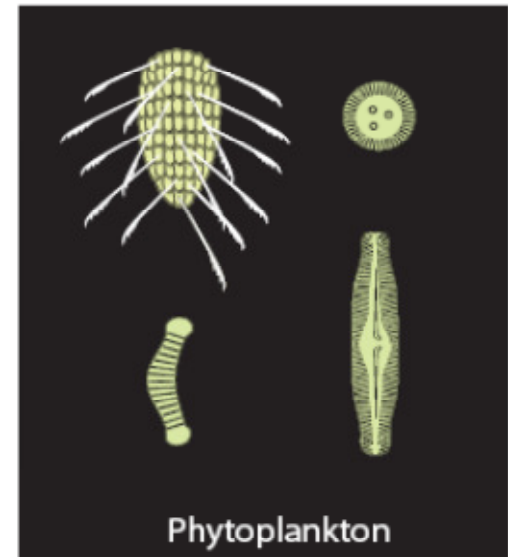
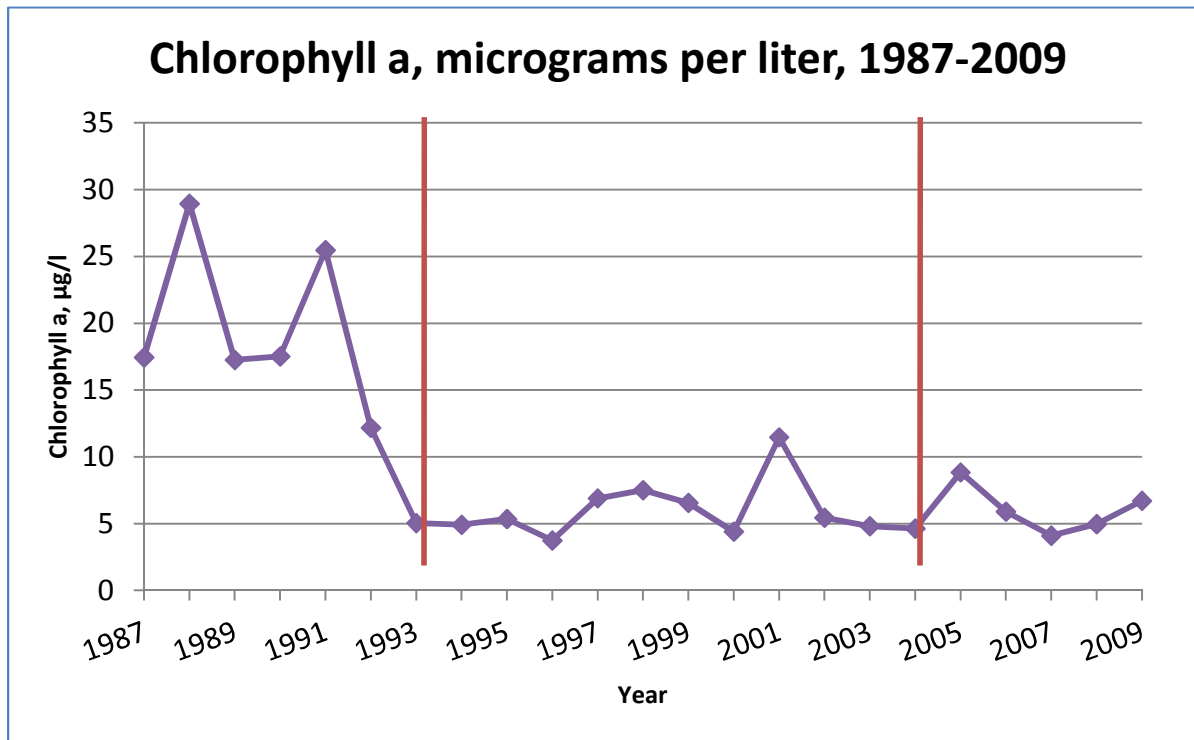
Nauplius
(immature copepod)

Find out in Part 2: Invasion of the Zebra Mussels -- Population Changes

Zebra mussels ate the phytoplankton (and zooplankton)



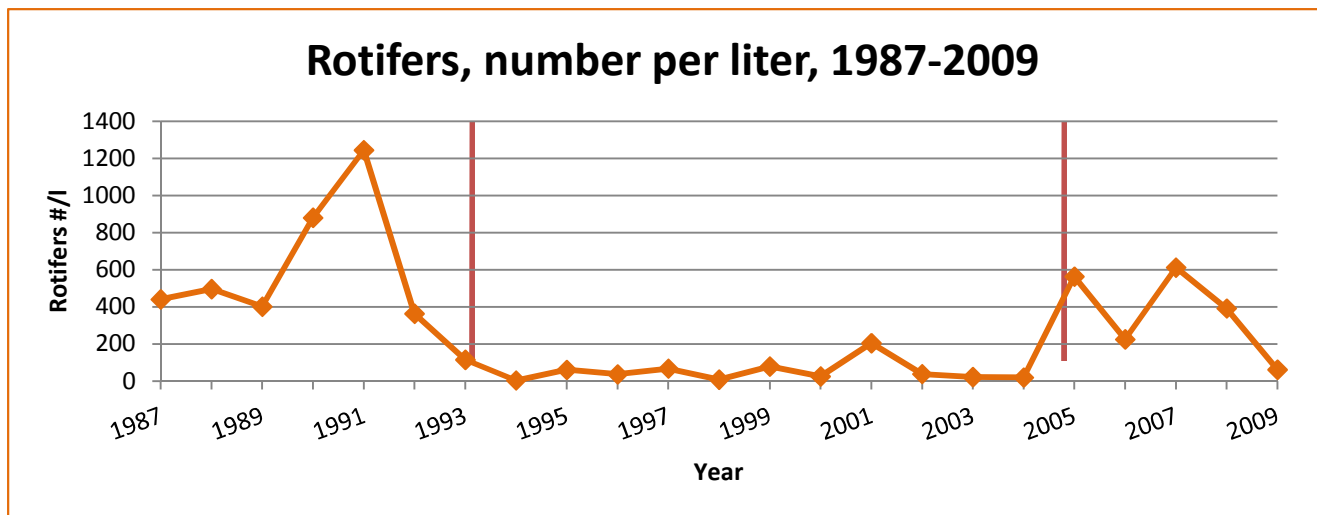
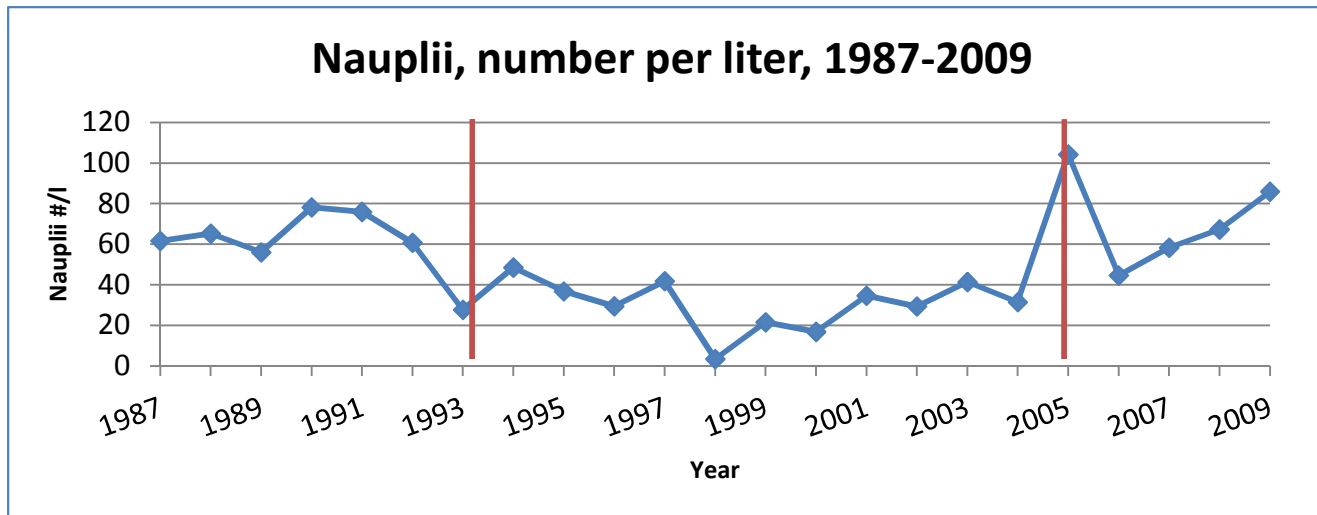
Phytoplankton (algae & protists) photosynthesize and produce chlorophyll



Phytoplankton → eaten by bivalves and zooplankton

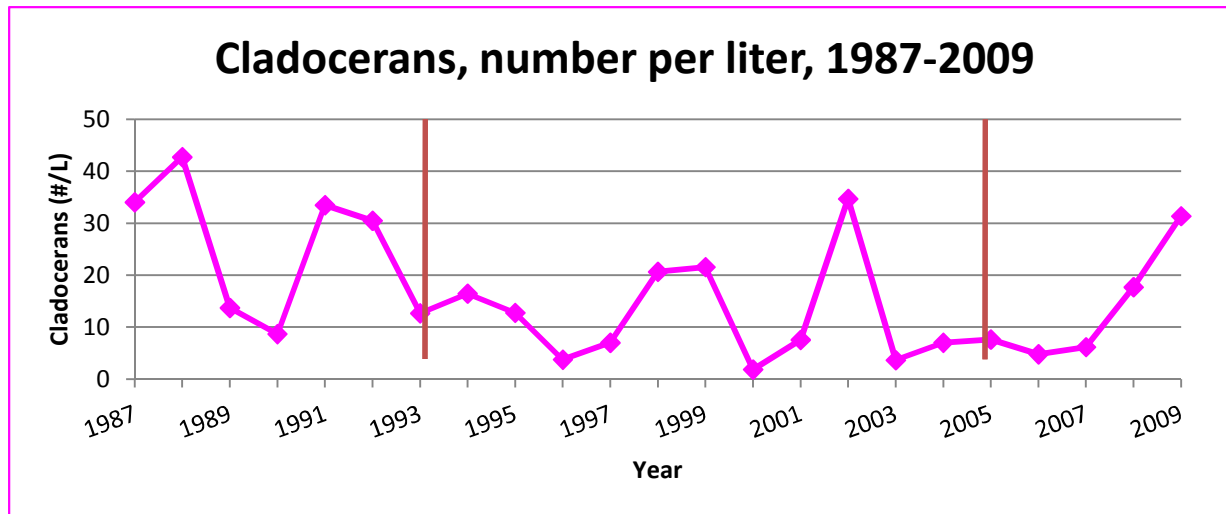
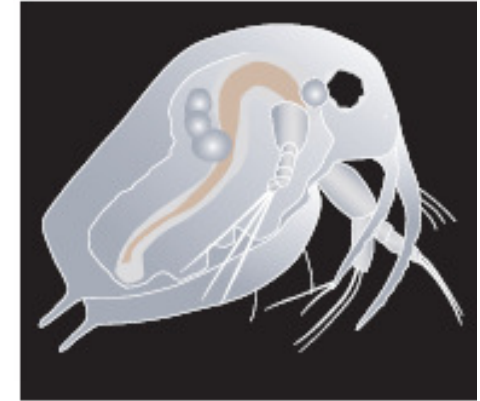
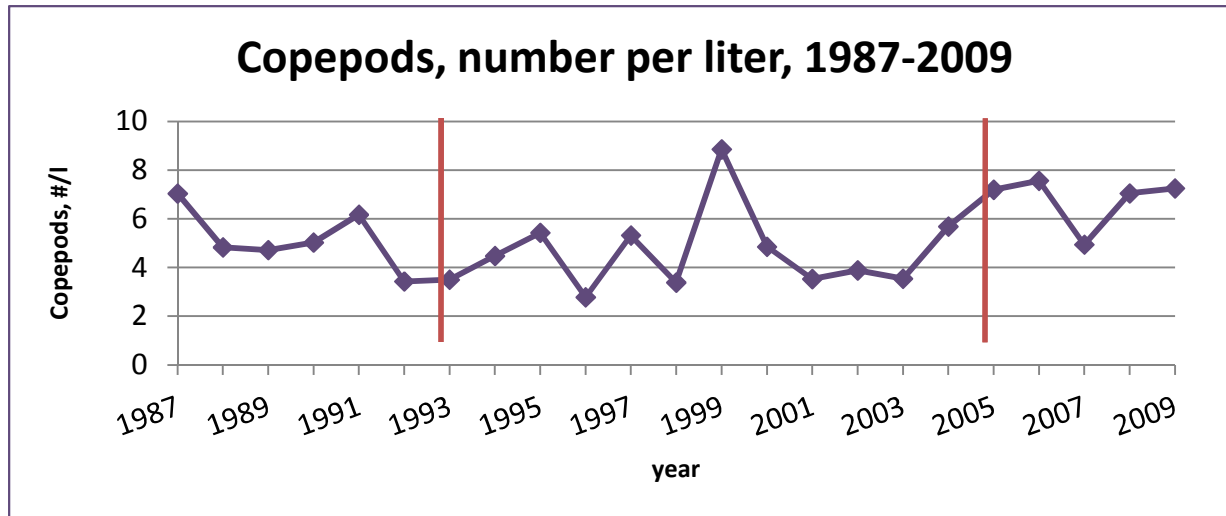
Micro-zooplankton

nauplii (immature copepods), rotifers, and tintinnids



Algae & bacteria → eaten by micro-zooplankton → eaten by mussels & meso-zooplankton

Meso-zooplankton: copepods and cladocerans



Algae & bacteria → eaten by meso-zooplankton → eaten by larger plankton & fish larvae



Part 3:



What about abiotic factors and other organisms in the Hudson River?

- Look at the chart in Part 3 of your worksheet packet.
- What abiotic factors are included in the chart?
- First you will learn about how these abiotic factors and other organisms responded during the **early invasion years**.
- Predict: How do you think these were affected by zebra mussels?

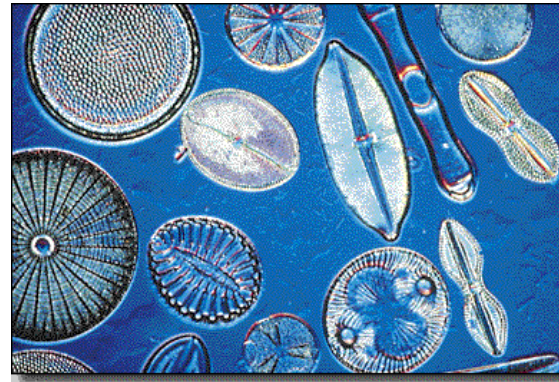
**Zebra Mussels caused many changes
to the Hudson River ecosystem in the
early invasion years . . .**

Zebra mussels



Phytoplankton was reduced by 80% during the early invasion years.

Phyto-plankton
-80%



What do you think happened to the native pearly mussel population when the zebra mussels invaded?



M. C. Barnhart

Pearly Mussels Lure Fish then release their larvae (glochidia) which attach to the gills of the fish!

©M. C. Barnhart 2000





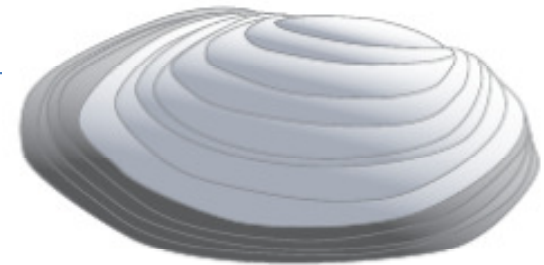
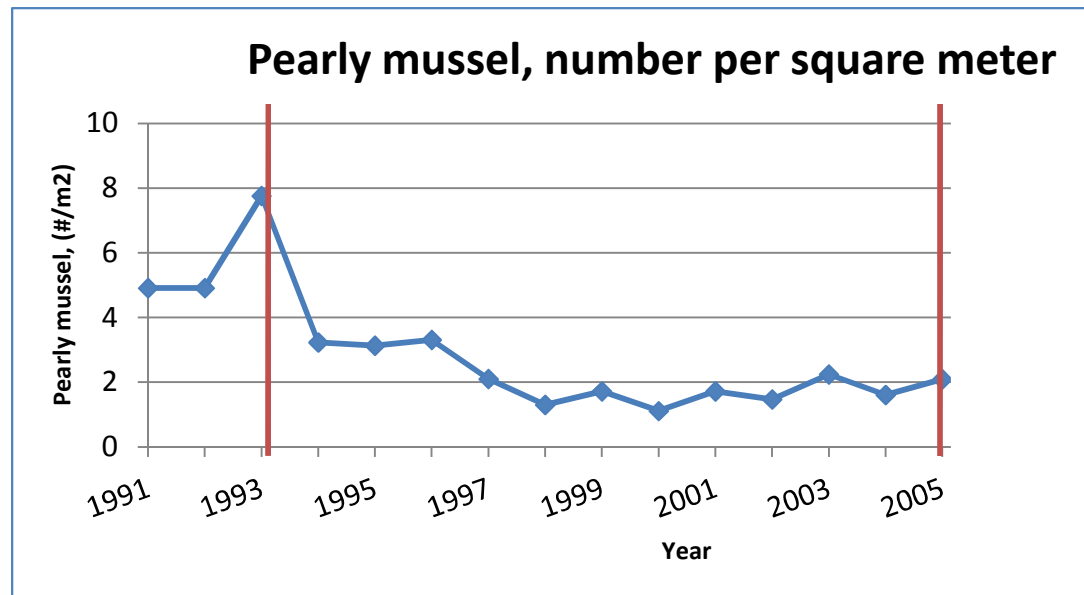
**Host capture by
snuffbox mussel**

Epioblasma triquetra

M. C. Barnhart 2005

Pearly Mussels, Other Mussels, and Clams

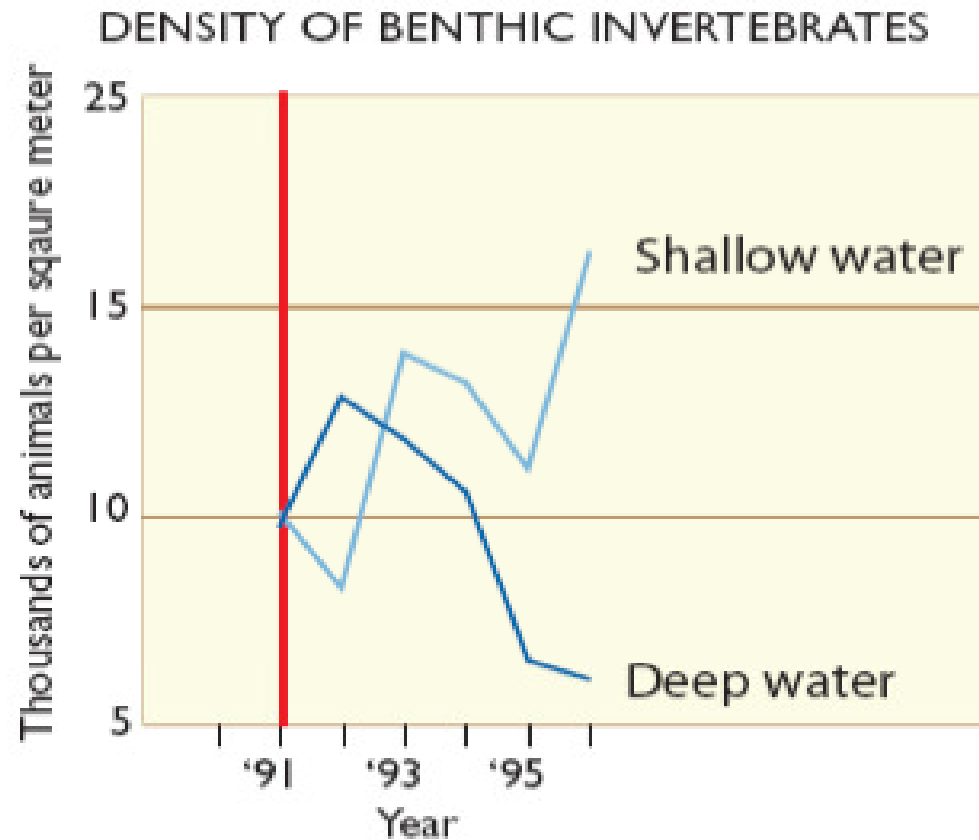
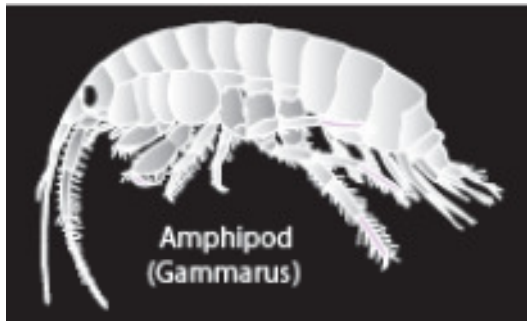
Native Bivalves



Plankton → eaten by mussels and clams → eaten by pelagic (deepwater) fish

Predict: What do you think will happen to pearly mussels and other native bivalves now that there are very few adult zebra mussels?

Benthic (bottom dwelling) Invertebrates



Algae & bacteria → eaten by benthic invertebrates → eaten by both pelagic and littoral fish

Predict: How will pelagic (deepwater) fish and littoral (shallow water) fish be affected by the changes in benthic invertebrate numbers?

Early Invasion Years, 1993-2004



Zebra mussels



Native bivalves
-72%

Deepwater zoobenthos
-40%

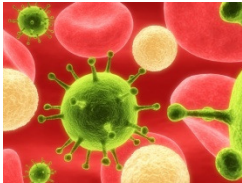
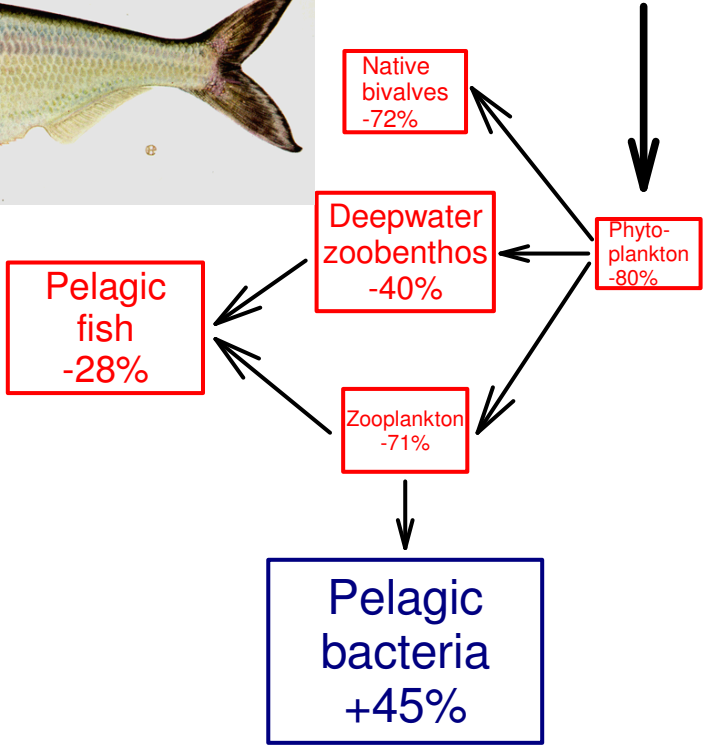
Phytoplankton
-80%

Zooplankton
-71%



Early Invasion Years, 1993-2004

Zebra mussels



Early Invasion Years, 1993-2004



Dissolved oxygen
-12%

Zebra mussels

Native bivalves
-72%

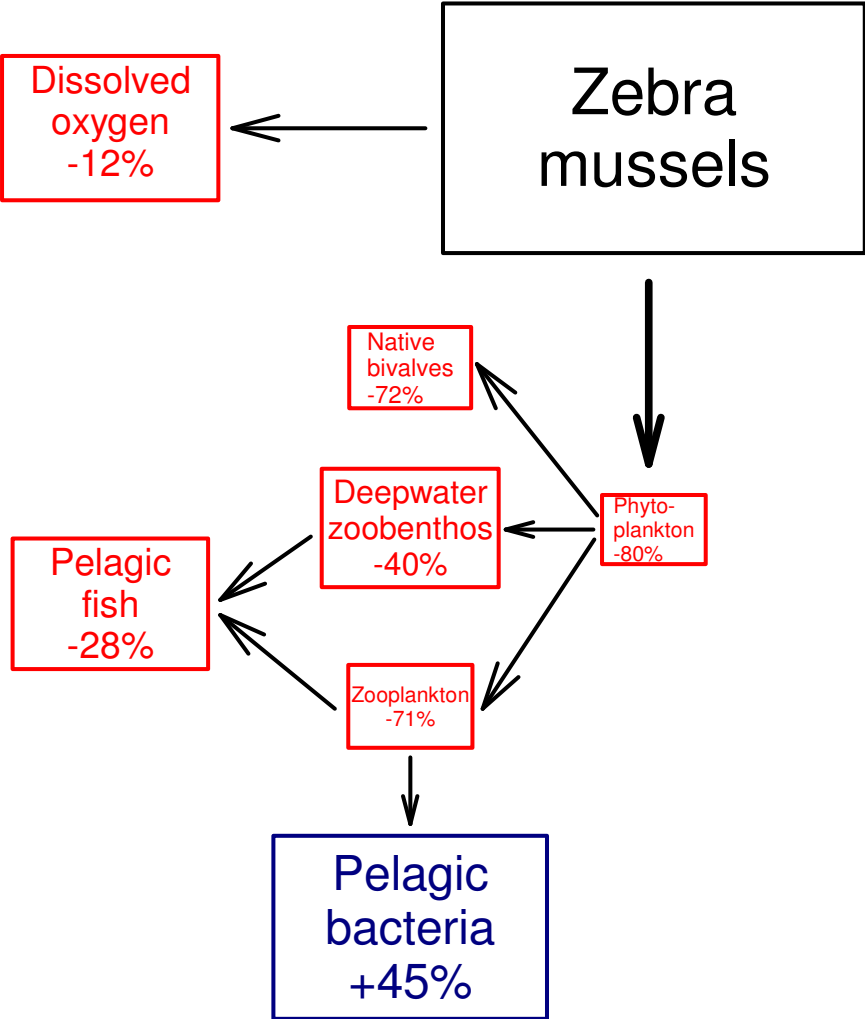
Deepwater zoobenthos
-40%

Phyto-plankton
-80%

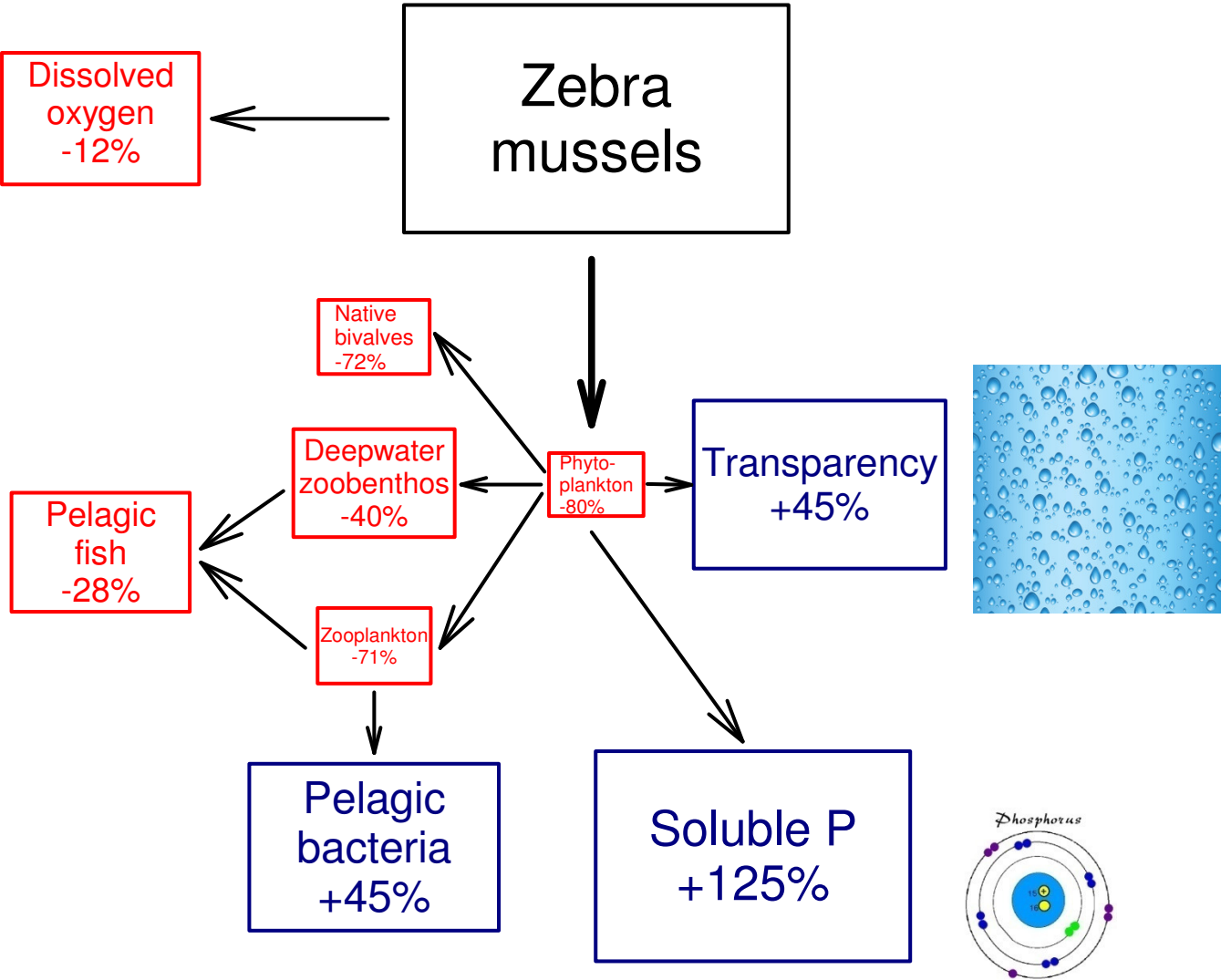
Pelagic fish
-28%

Zooplankton
-71%

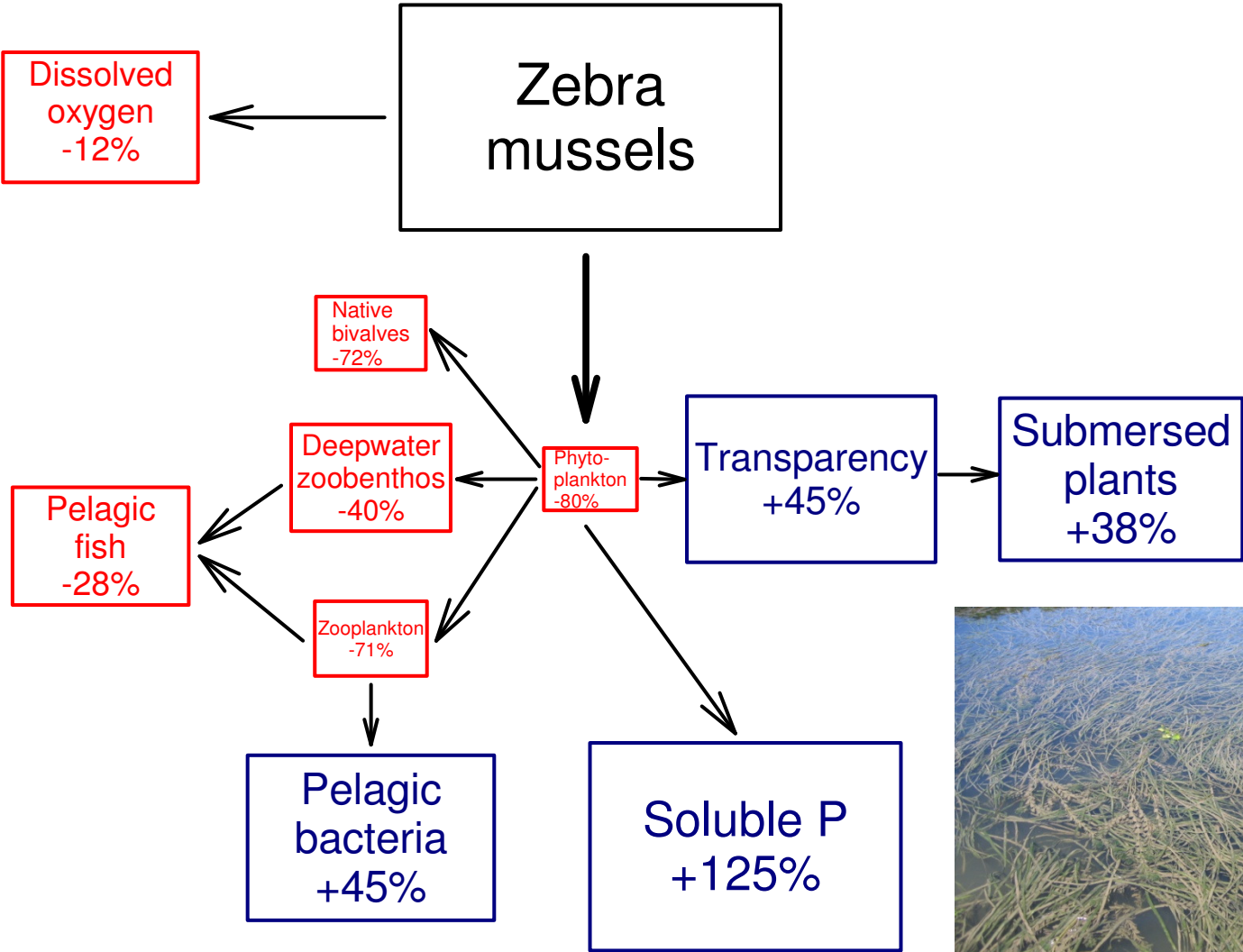
Pelagic bacteria
+45%



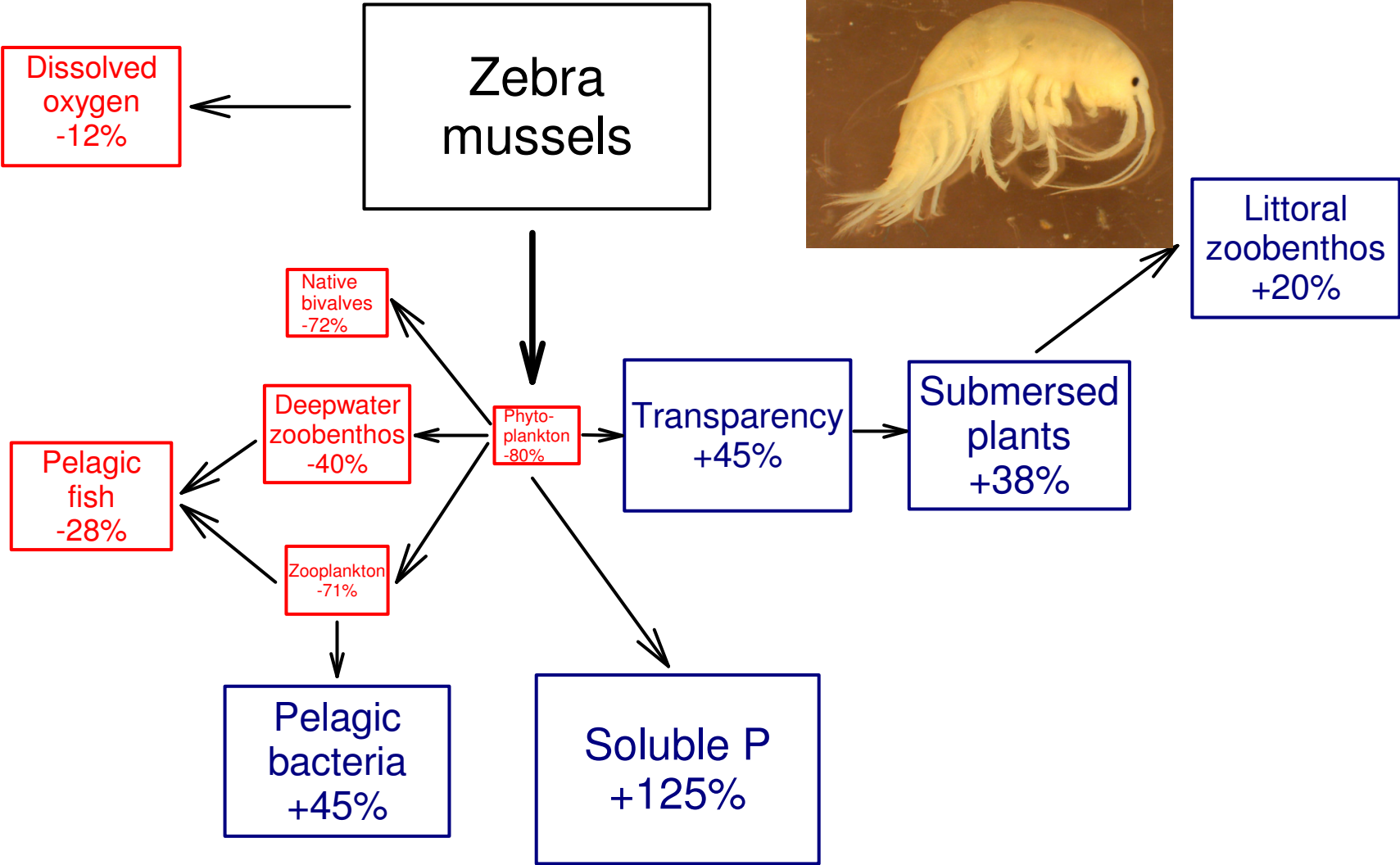
Early Invasion Years, 1993-2004



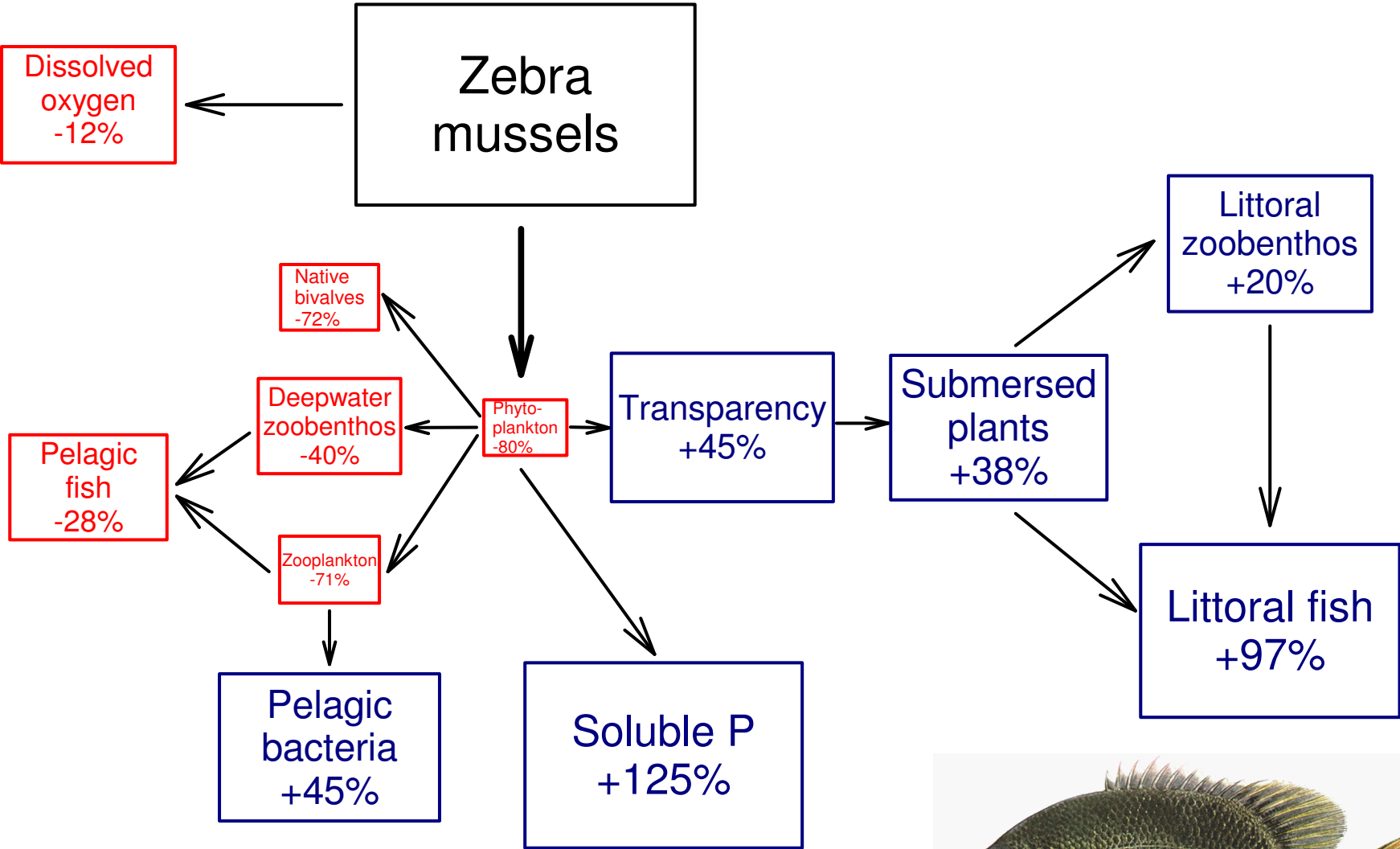
Early Invasion Years, 1993-2004



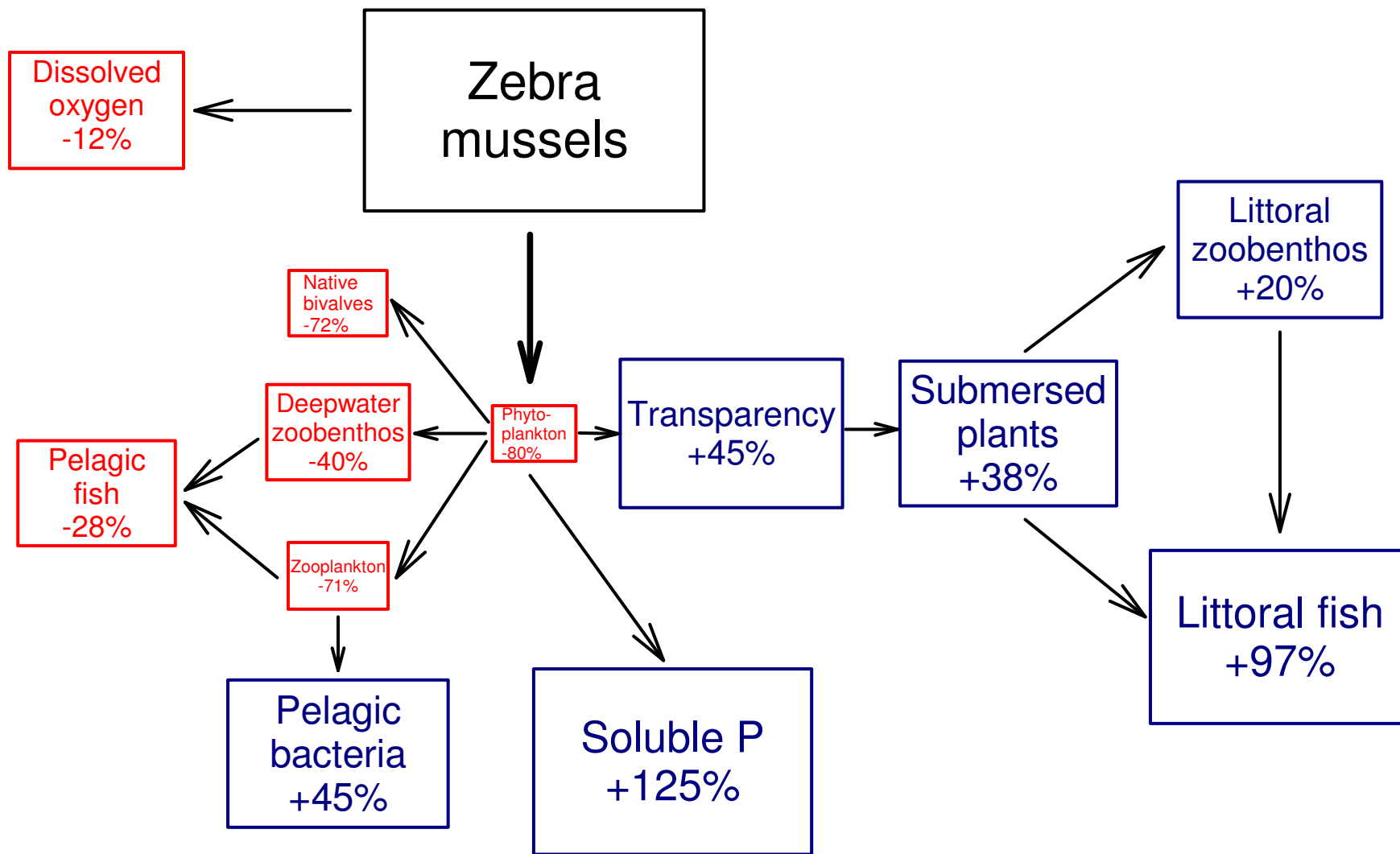
Early Invasion Years, 1993-2004



Early Invasion Years, 1993-2004



Early Invasion Years, 1993-2004



Food web in the open water

Food web in the shallows

Zebra Mussel Size Classes: The Later Invasion Years

Watch the [video clip](#), “Going Further”
from the American Museum of Natural History

Zebra Mussels

Small
Medium
Large

- Scientists noticed a change in the numbers of different size classes beginning about 2005.
- What do you notice?
- Think about the food web: What do zebra mussels eat?
- Do different size classes eat different organisms?

Zebra Mussel Population Dynamics: Size Classes

PACE ET AL.

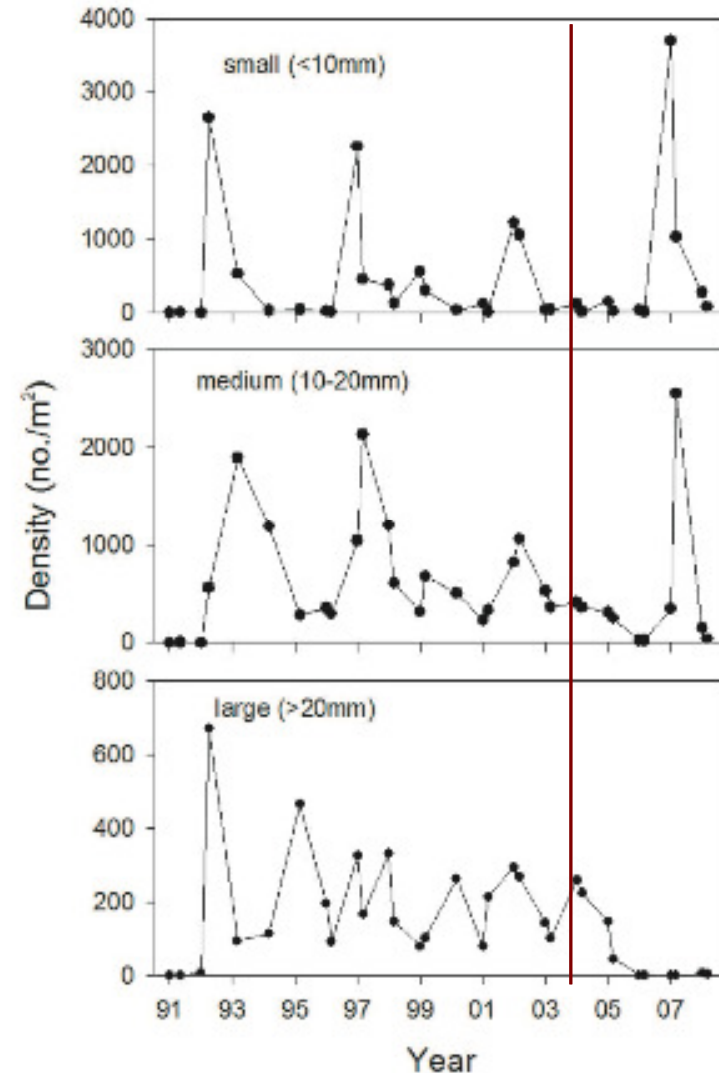
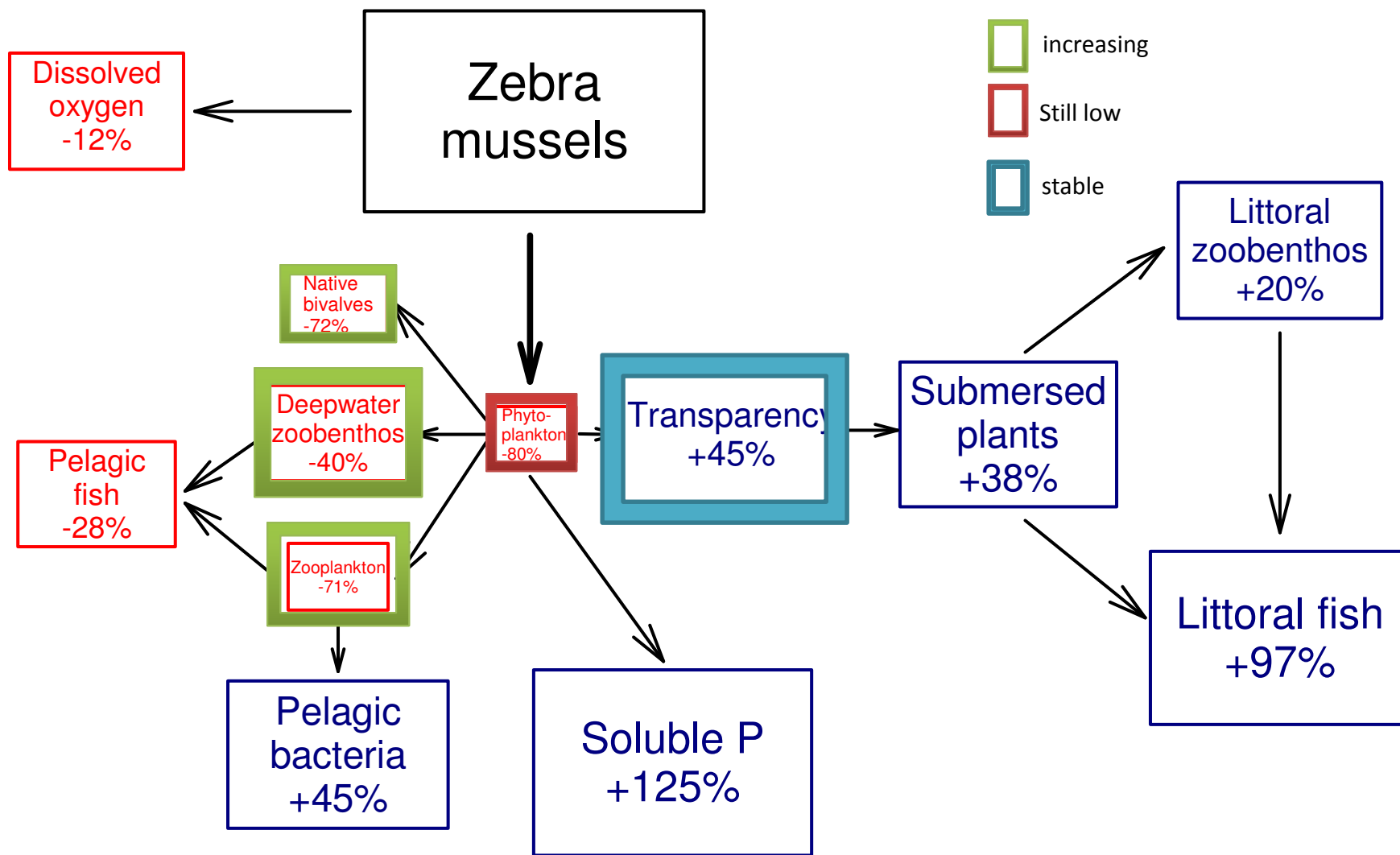


Fig. 1. Zebra mussel population dynamics for small 0–10 mm, medium 10–20 mm, and large 20–30 mm size classes. Data are for the freshwater Hudson River estuary.

What organisms recovered when there were fewer zebra mussel adults?

Phytoplankton are not recovering.
Why do you think that might be?

Later Invasion Years, 2005-2009



Food web in the open water

Food web in the shallows

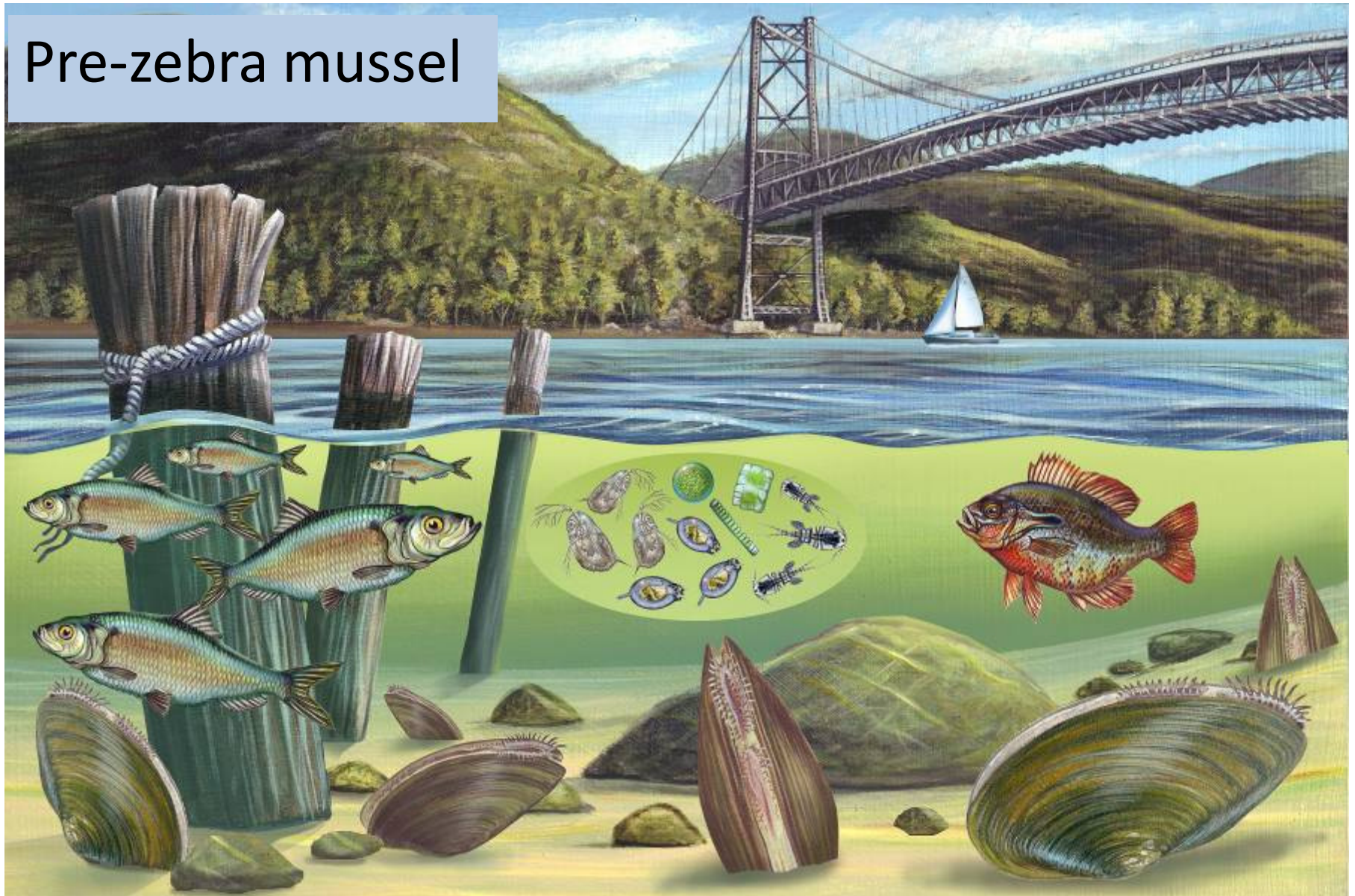


**Blue crabs
and
pumpkin seed fish**

**What was
eating the
large zebra
mussels?**

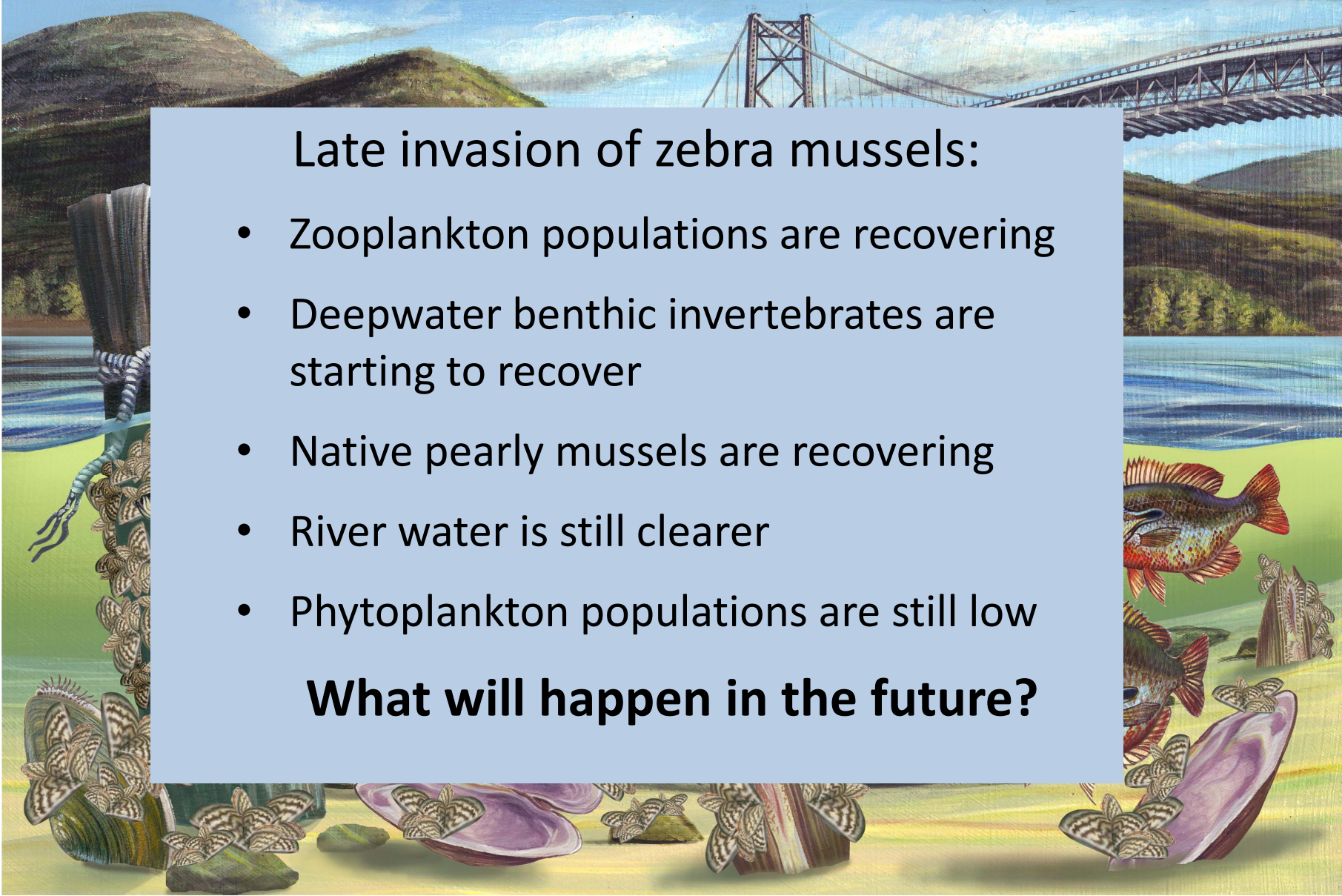


Pre-zebra mussel



Early invasion of zebra mussel

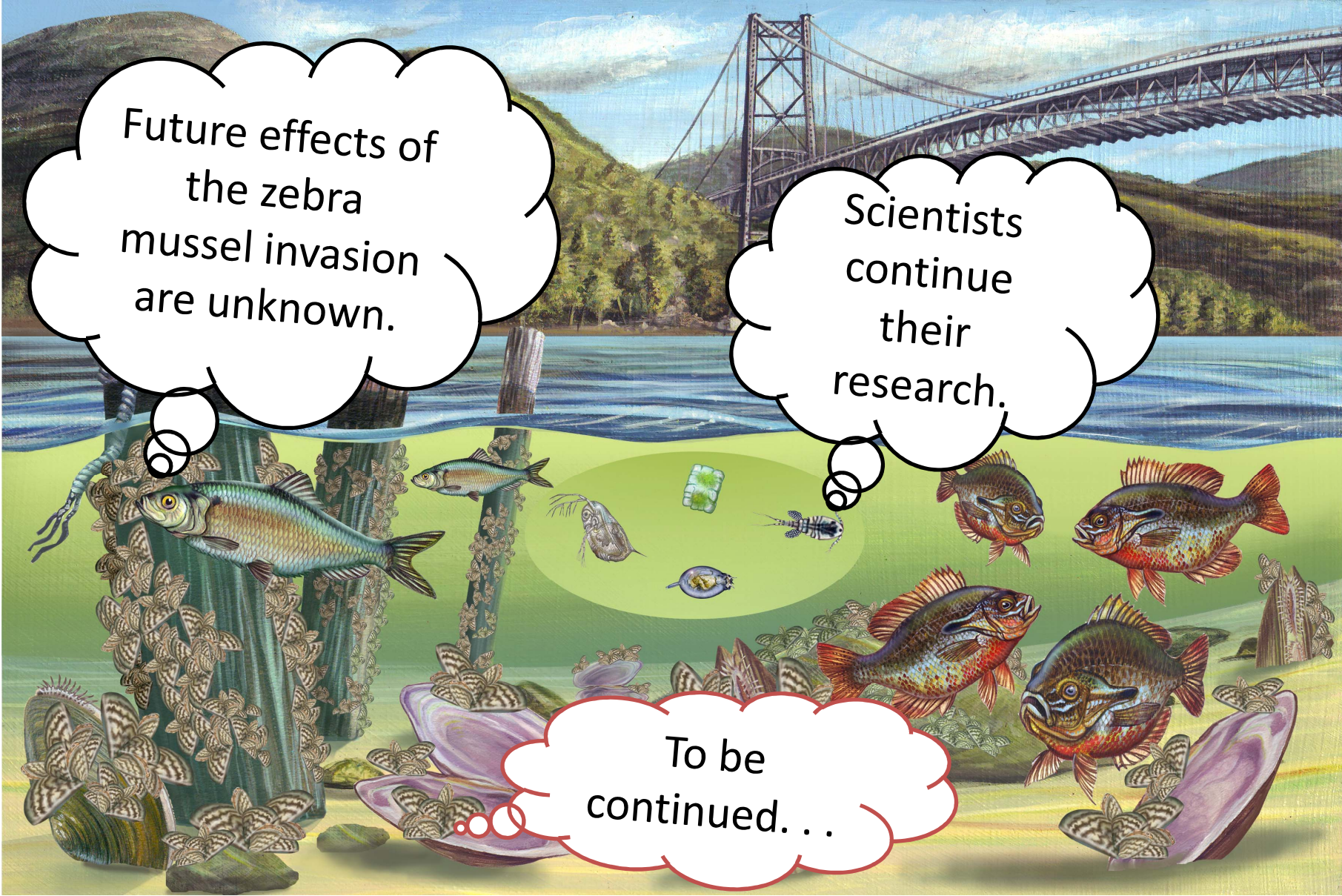




Late invasion of zebra mussels:

- Zooplankton populations are recovering
- Deepwater benthic invertebrates are starting to recover
- Native pearly mussels are recovering
- River water is still clearer
- Phytoplankton populations are still low

What will happen in the future?



Future effects of
the zebra
mussel invasion
are unknown.

Scientists
continue
their
research.

To be
continued...