Name: _____ Packet Due Date: _____

Science

Module 7	**Ecosystem Disruptions**
Lessons 1 - 8	**Analyzing Invasive Species** *What is the impact of an invasive species on an ecosystem?*

Lessons & Objectives

Lesson 1: Introducing a new species
- ❑ I can… use what I already know about ecosystems to make predictions about the impact of introduced species.

Lesson 2: Introducing a new species part 2
- ❑ I can… make connections between previously learned material and new material to determine how an introduced species will affect an ecosystem.

Lesson 3: Hudson River ecosystem
- ❑ I can… understand more about the impact of introduced species' by constructing a food web.

Lesson 4: Hudson river ecosystem part 2
- ❑ I can… determine what abiotic and biotic factors are affected by introduced species.

Lesson 5: Gathering data that shows zebra mussel impact
- ❑ I can… gather data that shows how an invasive species affects an ecosystem.

Lesson 6: CER Writing
- ❑ I can… make connections between previous data and newly gathered evidence.

Lesson 7: Peer-Review Process

Lesson 8: Final CER Piece

Packet Completion Rubric

4	3	2	1	0
Nothing in packet is missing. Responses consistently meet ALL of the criteria for high quality work. Exemplary effort is evident throughout entire packet.	Packet is 75-100% complete/accurate. Work/effort misses the criterion for high quality consistently.	Packet is 50-75% complete/accurate. Work/effort has evidence of quality but not consistently.	More than 50% of the packet is incomplete or incorrect. Work does not meet the expected level of quality.	Packet is entirely incomplete or not turned in.

Grading Breakdown: 0 - 1.9 = F 2 - 2.4 = D 2.5 - 2.9 = C 3 - 3.4 = B 3.5 - 4 = A

Lesson 1: Introducing a new species

Objective: I can… use what I already know about ecosystems to make predictions about the impact of introduced species.

Lesson 7.1 Introduction

There are many different ecosystems in the world. You have already learned about several, including coral reefs. You have also learned about some of the challenges faced by ecosystems. One challenge is the introduction of new species to an ecosystem. If a new species survives and its population increases, it can disrupt the ecosystem. This can affect the health of the ecosystem. In this activity you will learn about the zebra mussel, a species that has been introduced to the ecosystems of the Great Lakes and the Hudson River. You will predict what effect the zebra mussel might have on the health of these ecosystems.

Guiding Question: How might the introduction of the zebra mussel affect the health of the Great Lakes and Hudson River ecosystems?

Lesson 7.1 *Do Now*

What do you already know about ecosystems and how organisms interact within them? Use your knowledge of interdependent species, food webs, symbiotic relationships, competition, and more to fill in this chart.

Know	Want to Know	Learned

Video Notes: Invasive Species

As you watch the video, take notes on the impact that invasive species can have on an ecosystem.

1) _____

_____

2) _____

_____

3) _____

_____

4) _____

_____

Discuss: Why were European rabbits fine in Europe, but a problem in Australia?

_____

_____

_____

_____

_____

Lesson 7.1 *An Unwelcome Newcomer Article*

The zebra mussel is a small freshwater animal with two shells like a clam. It is named for its striped shell. This tiny creature may look harmless, but it can cause big problems. The zebra mussel is not native to North America but arrived in this part of the world about thirty years ago. Zebra mussels cling to any hard surface—including native mussels and other animals with shells. This can cause these animals to die because they can't eat. Zebra mussels are filter feeders. They pump water through their gills and strain out microscopic animals and plants called plankton. Zebra mussels can quickly clear the plankton from huge bodies of water, leaving little food for the native mussels and other animals. Zebra mussels can also cause millions of dollars in damage. The mussels clog water pipes to businesses and power plants. They damage boats, docks, and other structures.

The Great Lakes Invasion

The Great Lakes are a system of connected freshwater lakes and waterways in northeastern North America, between Canada and the United States. It is the largest group of freshwater lakes on Earth, and holds about 20% of the world's fresh water. In many places, if you stand on the shore of one of the Great Lakes you cannot see to the other side. Zebra mussels were first discovered in a small lake in the Great Lakes system, Lake St. Clair, in 1988. Scientists believe the mussel was introduced by one of the large ships that travel across the Atlantic Ocean carrying cargo between countries. Soon scientists were finding zebra mussels in other areas of the Great Lakes systems and rivers connected to the Great Lakes, such as the Mississippi and Ohio Rivers. Even today, scientists continue to find new zebra mussel invasions in ecosystems as far away from the Great Lakes as Texas and California. How do these mussels spread so quickly? A single female can produce up to one million eggs each year. The young mussels float along water currents and eventually attach themselves to hard surfaces like rocks on the riverbeds and the bottom of boats. They form dense colonies, with as many as 10,000 mussels in a single square foot.

The Hudson River Invasion

The Hudson River flows south through New York State, from the mountains to New York City. Because the river is connected to the Great Lakes, scientists predicted it would not be long before the zebra mussel would arrive in the Hudson. The Hudson River's ecosystem is very different from the Great Lakes. Lake water

settles into layers, with cool water near the bottom and warm, clear water above. In the Hudson River water flows from the mountains to the Atlantic Ocean. The last 150 miles of the Hudson River is significantly affected by water from the Atlantic Ocean. The salt water from the ocean mixes with fresh water from the river. The tides from the ocean mix the water from top to bottom. This area of mixed salt and freshwater is called an estuary. In the estuary, tides also stir up material from the riverbed, making the water cloudy- little sunlight can pass through the water. Less sunlight means fewer plants and phytoplankton. Scientists wondered how zebra mussels might affect the ecosystems of the Great Lakes and the Hudson River. They also wondered if different biotic and abiotic factors in ecosystems might lead to different effects from the zebra mussels. Soon they would find out.

Exit Slip

1) What species are zebra mussels competing with?

_____

_____

2) Describe Zebra Mussel fecundity

_____

_____

3) Predict what would happen if a small population of Zebra Mussels were placed in the Gulf of Mexico?

_____

_____

Lesson 2: Introducing a new species part 2

Objective: I can…make connections between previously learned material and new material to determine how an introduced species will affect an ecosystem.

Do Now: Use what you remember from yesterday's exit slip and answer the following questions

1. How do you think the invasion of Zebra Mussels will change the Hudson River ecosystem?

_____

_____

_____

_____

2. Suppose a group of scientists wants to monitor the effect of zebra mussels on an ecosystem. What data about the ecosystems might scientists collect to investigate this question?

_____

_____

_____

Breakout and Discussion: **As you answer the question in your given group, consider what will happen if a fish at the top of the food chain is taken from the Colorado River in North America, and introduced to the Hudson River Ecosystem**	
What conditions and factors does it need to survive? (provide explanations)	How might it affect other species already living in that environment? (provide explanations)
What biotic factors might keep the species in check? (provide explanations)	What abiotic factors might keep this species in check? (provide explanations)

Exit slip:

How might the introduction of the zebra mussel affect the health of the Great Lakes or Hudson River ecosystem? Consider the four questions we discussed today to construct your answer.

_____

_____

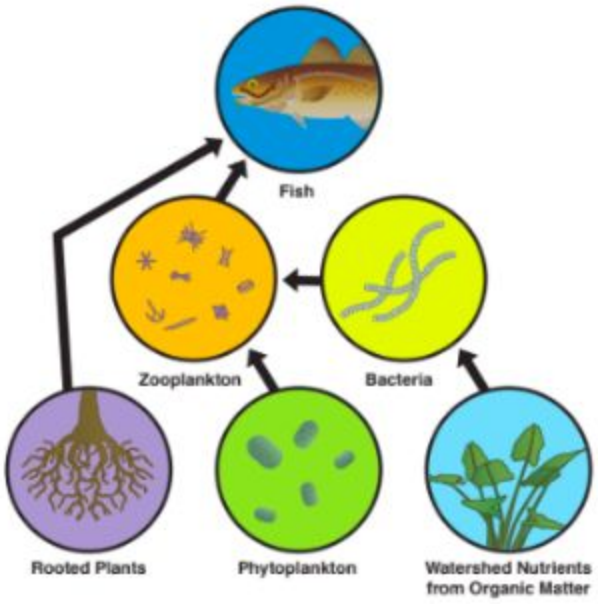
_____

_____

Lesson 3: Hudson River ecosystem

Objective: I can… determine how abiotic and biotic factors can be affected by an invasive species.

Lesson 3: Do Now
Watch the video and answer the following question: What abiotic factor is important in the Hudson River Ecosystem and why is it so important? _____ _____ _____ _____ _____

Lesson 3
When scientists realized that zebra mussels were likely to show up in the Hudson River, they were in a unique position to investigate the impact of the invasion. Scientists don't usually have data about a lake or river until after the new species appear. However, scientists began collecting data on the Hudson River's ecosystem in 1986. They started studying the whole Hudson River ecosystem to see how it was changing. Ecosystems are constantly changing for many reasons. You have learned that ecosystems have many interactions between living organisms and between biotic and abiotic factors. These interactions can cause an ecosystem to change. Natural and human-caused disturbances can also cause changes in ecosystems. Scientists use the phrase dynamic ecosystem to describe this phenomenon because dynamic means constantly changing. In this activity, you will explore the Hudson River ecosystem and predict how this dynamic ecosystem might be affected by the introduction of the zebra mussel.   

Lesson 3: Consider short term effects zebra mussels might have on an ecosystem.

As you study this chart, consider three organisms that you can add to the food web in the back of the packet. Consider previous readings we have covered and what you know so far about predator-prey relationships the zebra mussel might be a part of.

Short-Term Effect of Zebra Mussel Invasion on Biotic and Abiotic Factors in the Hudson River Ecosystem

Factor	Clear Effect	Some Effect	No Effect
Alosa (pelagic fish)	✔		
Bacteria	✔		
Centrachidae (littoral fish)	✔		
Cladocera (zooplankton)	✔		
Copepods (zooplankton)		✔	
Dissolved Oxygen			✔
Phytoplankton	✔		
Rotifers (zooplankton)	✔		
Sphaeriidae (mollusk)	✔		
Suspended Solids		✔	
Unionidae (mollusk)	*no data available*	*no data available*	*no data available*
Water Clarity	✔		
Water Temperature			✔

What three organisms can you definitely add to your food web and why? Quote evidence from "An Unwelcome Newcomer" to support your answer:

Evidence:

_____

_____

_____

.

Lesson 7.3

1. With a partner, choose two organisms (biotic factors) from your food web that you think might be affected by the zebra mussels that you would like to investigate further. Have your teacher approve your choice of factors.
2. Following your teacher's directions, develop a testable question and a prediction for how each factor you selected will change after the zebra mussels' arrival in the river. Write down why you chose these factors and your prediction for each factor.

Choose 2 biotic and 1 abiotic factor to investigate further.

Biotic factors: _____ & _____

Abiotic factor: _____

Testable Question:

_____

_____

Prediction:

_____

_____

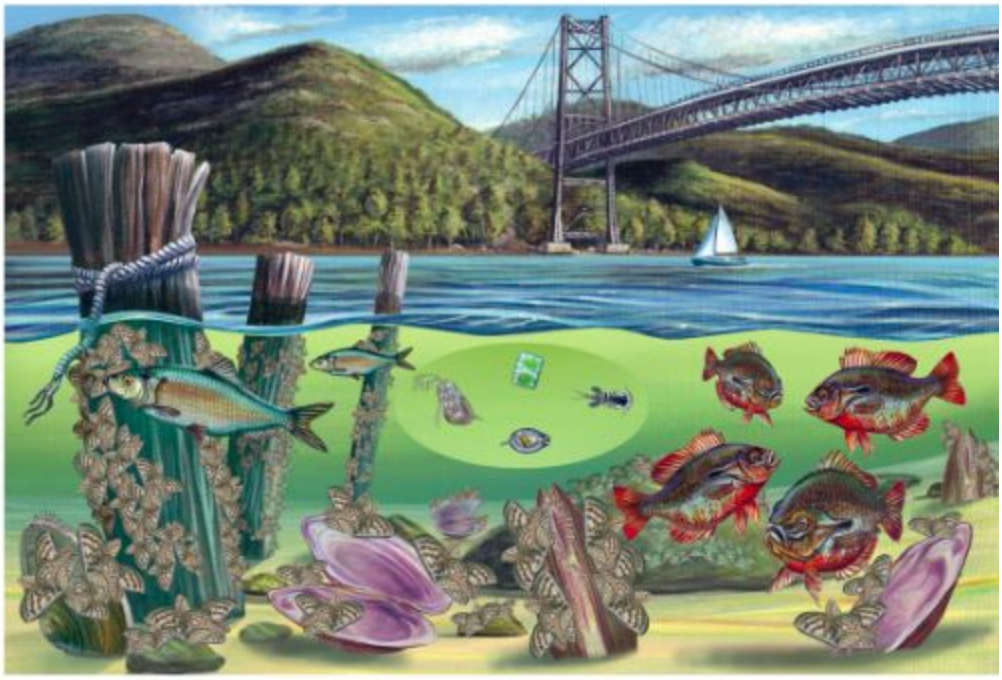
Lesson 4: Hudson river ecosystem part 2

Objective: I can… determine what abiotic and biotic factors are affected by introduced species

Lesson 4 Do Now: "Changing Ecosystems"

In May 1991, a few years after they were first found in the Great Lakes, zebra mussels appeared in the Hudson River. Within a year scientists estimated the zebra mussel population had reached 500 billion! If you had a huge balance and put zebra mussels on one side, they would outweigh all the other consumers in the ecosystem combined: all the fish, zooplankton, worms, shellfish, and bacteria. Scientists wondered how the zebra mussels would affect the river ecosystem. One measurement scientists use to monitor ecosystem health is the biodiversity in the ecosystem. Biodiversity is the diversity of life at every level, including variation within a species, variation between species, and variation between populations of species. For example, if an area has many healthy populations of a range of organisms scientists say it has more biodiversity than a region with a smaller number of healthy populations of organisms. The biodiversity of an ecosystem is affected by biotic and abiotic factors. Over time, the biodiversity of a particular ecosystem may change depending on the health of the ecosystem.

To measure the biodiversity of the Hudson River ecosystem scientists count the number of different species and how large their populations are.



Lesson 7.4 Do Now

What biotic and abiotic factors are affected when a new species is introduced to an ecosystem?

_____

_____

_____

_____

7.4: Investigating Zebra Mussel Impact

1. With your partner, review the testable questions and predictions you developed for your three chosen factors from the previous activity.

2. With your partner, go to the "Overview" page of the "Graph the Data" section of the River Ecology website: http://www.amnh.org/education/hudsonriver

3. You will examine data from the Kingston location. Select "Over Time" and use the map to choose the Kingston location.

4. Set the first parameter to "Zebra mussel" and set the second parameter to one of the factors that you chose in the previous activity. Use the table below to determine which parameter matches with the factors you

chose.

Factor	Graph Parameter
Alosa: Fish	Alosa (pelagic fish)
Bacteria	Bacterial abundance
Centrarchidae: Fish	Centrarchidae (littoral fish)
Cladocera: Zooplankton	Cladocera
Copepods: Zooplankton	Copepods
Dissolved Oxygen	Dissolved oxygen
Phytoplankton	Chlorophyll a
Rotifers: Zooplankton	Rotifers
Sphaeriidae: Freshwater Mollusks	Sphaeriidae
Suspended Solids	Total suspended solids
Unionidae: Freshwater Mollusks	Unionidae
Water Clarity	Secchi depth
Water Temperature	Temperature

5. Examine the section of the graph from 1988 to 1996. Look for any patterns and record your observations.
6. Repeat Procedure Steps 4 and 5 for each of the other two factors you chose.

Observations :

Guiding Questions

Abiotic Impacts:

1. How did the zebra mussels affect secchi depth? Why do you think it changed?

2. What other abiotic parameters were affected? Were any?

Biotic Impacts:

1. What happened to the rotifers when zebra mussels were introduced?

2. What about the level of chlorophyll a? Why do you think this is the case?

3. Why do you think the level of chlorophyll a fluctuates ***every*** year in this temperate climate?

4. What happened to the Alosa spp? Why do you think there is no more data after 2001? Does that mean that they died out? Think about how we would sample for zebra mussels vs. sample for Alosa.

Lesson 7.4 Exit Slip

What biotic and abiotic factors are affected when a new species is introduced to an ecosystem?

_____

_____

_____

_____

Lesson 5: Gathering data that shows zebra mussel impact

Objective: I can… gather data that shows how an invasive species affects an ecosystem.

Lesson 7.5 Do Now
_____ _____ _____ _____

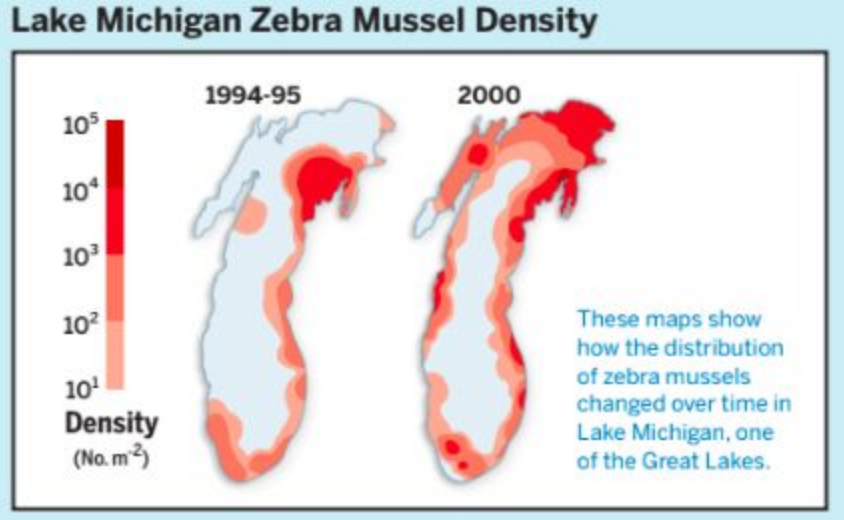
Video Notes
What impact are the zebra mussels having on the ecosystem? What is beginning to happen to the zooplankton and zebra mussels in 2004? What is happening to the lifespan of the zebra mussles?
Discussion: Think, Pair, Share
Why do you think the zebra mussels are beginning to experience shorter lifespans? Why do you think zooplankton populations are beginning to rise again?

Exit Slip: Read and Annotate "Zebra Mussels Invade" Article

There are many characteristics of the zebra mussel that help them thrive in North American lakes and rivers. Zebra mussels can reproduce when they are less than a year old. Just one female can lay up to 1 million eggs every year. Zebra mussels will eat most types of plankton and will attach to nearly any hard surface. They can grow in water as cold as 3°C and as warm as 30°C.

Zebra mussels are sensitive to several abiotic factors, which limit their spread. They can only live in freshwater or water that has very little salt (less than 0.4%). They cannot survive in water with low oxygen levels. They also are not found in water that moves faster than about two meters per second, so you won't find them in fast-moving streams or rivers. They will only reproduce if the water is 14-16°C or warmer.

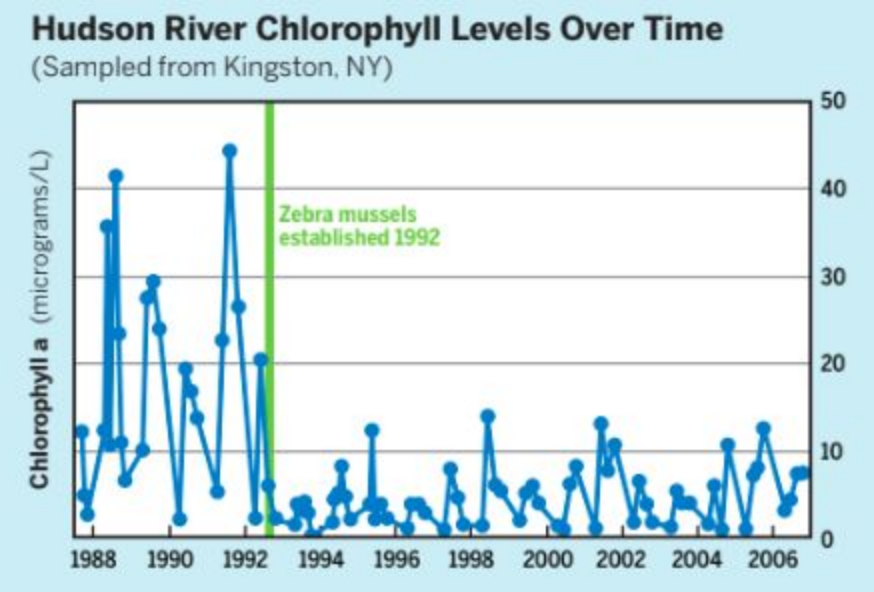
In the Hudson River and Great Lakes, the conditions for a zebra mussel invasion were just right. There were lots of plankton for the zebra mussels to eat, many hard surfaces for the mussels to attach to, and in spring and summer the temperatures were just right for zebra mussels to reproduce. This means that once the zebra mussels were introduced, it was easy for them to spread out.



Changes Caused by Zebra Mussels

By 1992, there were so many zebra mussels in the Hudson River that scientists estimate they were filtering a volume of water equal to all of the water in the estuary every 1-4 days during the summer. In the years right after their arrival, phytoplankton fell by 80-90 percent. Zooplankton (which eat phytoplankton) declined by half.

The plankton populations in the Great Lakes also dropped dramatically. Some research showed the zebra mussels were rejecting certain types of harmful blue-green algae as food. This meant the blue-green algae population increased, while other plankton decreased, causing changes in the biodiversity and the food availability for other filter feeders.



In both locations the populations of native mussels, also filter feeders, shrank dramatically. Native mussels could not compete with the zebra mussels, and their populations dropped as the plankton populations dropped. In the Hudson, native mussel populations fell from more than one billion to almost none. Many fish species also eat plankton. With the decline in plankton populations, there were fewer—and smaller—fish in the open river as well as the open lakes. The biodiversity of the Hudson was changing.

But some populations in the Hudson River increased—likely due to the change in the river's water clarity. With far less phytoplankton, the water got clearer. During the summer, visibility went from 3-4 to 4-8 feet from the surface. Since sunlight reached deeper into the water, rooted aquatic plants increased by up to 40 percent. Populations of fish living in these shallow weeds increased, and they were also found further upriver than before the invasion. Another surprising result was that dissolved oxygen in the river fell by about 15 percent. Scientists think the enormous zebra mussel populations were consuming a lot of oxygen very quickly. At the same time, the mussels were removing the phytoplankton that produce oxygen.

In the Great Lakes, most of the species that increased after the zebra mussel invasion were considered "nuisance" or even harmful species, like the blue-green algae. The zebra mussel increase also seemed to cause an increase in the bacteria that produces botulism toxin, and more than 52,000 waterbird deaths due to botulism toxin occurred between 2002 and 2006.

The Effect on Ecosystem Services

The organisms living in the Hudson River and the Great Lakes are not the only organisms depending on those ecosystems. Humans depend on, and benefit from, these two ecosystems in many ways. When humans benefit from an ecosystem, scientists call these benefits ecosystem services. For example, a lake might provide people with drinking water, fish to eat, and a place to go sailing and relax. All of these benefits are ecosystem services. When scientists study the effect of a non-native species, like the zebra mussel, they study

how it affects the ecosystem in all ways, including how it affects ecosystem services.

In both the Great Lakes and the Hudson River, the zebra mussels have affected many ecosystem services. One effect has been on power plants and water treatment facilities built on the shores of large lakes and rivers. These facilities have large pipes to take in and release water. The zebra mussels attach to the pipes and other equipment. The number of mussels that attach to the pipes is so great that the pipes become clogged, causing large increases in maintenance and repair costs. Another effect is that the blue-green algae that increased after the zebra mussel invasion releases harmful toxins into the water in the Great Lakes, causing beaches to be closed and preventing people from going swimming. Also, several fisheries, including the Lake Whitefish, have declined dramatically due to the zebra mussel invasion, causing people to lose income and jobs. However, some fisheries on the Hudson River that rely on littoral fish have increased.

The Hudson River provides many ecosystem services to the nearby communities, including a place for recreation.

Questions about the long-term impact

Once scientists had a clear picture of the invasion's immediate impact, they started to wonder about long-term effects the zebra mussels might cause in these two ecosystems. Would the systems continue to change, or would they recover? Would native species eventually tolerate or even feed on the zebra mussel? Perhaps another species might arrive that would change the effects of the invasion? Should people try to control the zebra mussel invasion or see if the ecosystem would eventually stabilize? Only continued studies would allow scientists to determine how the zebra mussel might change these ecosystems in the long term.

Lesson 6: Making connections with data

Objective: I can… make connections between previous data and newly gathered evidence.

Lesson 7.6 Guiding Questions

1. What characteristics of zebra mussels make them likely to succeed in a new area?

_____

_____

2. Why did the introduction of one species, the zebra mussel, cause changes to so many of the other populations in the Great Lakes and Hudson River?

_____

_____

_____

3. Describe some of the biotic and abiotic factors that were affected by the zebra mussels in the Great Lakes and Hudson River.

_____

_____

_____

4. Why might people be concerned about the effects of zebra mussels on ecosystem services?

_____

_____

_____

Lesson 7.6 Exit Slip/ Homework

Has the Zebra mussel had a positive or negative effect on the Hudson River ecosystem? Cite at least two pieces of evidence from your readings. (Heads up- you'll be using this question for your CER!)

_____

_____

_____

_____

_____

_____

_____

_____

Zebra Mussels Food Web

As you Read through articles, watch videos, or engage in classroom conversation, use this space to construct a food web based on the Zebra Mussels. (don't forget to show the appropriate direction of energy transfer)

Evidence Bank

Evidence	Beneficial/ Harmful	Interpretation

Evidence	Beneficial/Harmful	Interpretation

Zebra Mussel CER (Rough Draft)

Feedback given by:_____

Grade your partner's CER on each category- claim, evidence, reasoning, and conventions. Highlight the score you give them on each and describe why below.

Rubric Categories	4	3	2	1	0
Claim **W2a**	Writes a one-sentence claim that is clearly communicated, uses the language from the question, and accurately responds to the writing prompt. **Does not contain an "I" statement.**	Writes a correct one sentence claim that accurately responds to the writing prompt but **does not fully use the language from the writing prompt.**	Writes a claim sentence that **somewhat** responds to the writing prompt, but is **incomplete or disorganized**.	Writes a claim sentence that **does not respond to the writing prompt.** Claim may be **confusing, unclear, or inaccurate.**	*Claim is missing entirely.*
Evidence **W2b**	Selects multiple pieces of evidence (direct quote) that strongly supports the claim. All evidence is introduced and cited correctly with the source title and page numbers.	Selects multiple pieces of evidence (direct quotes) that is supportive of the claim. All evidence is introduced and cited correctly with the source title and page numbers.	Selects evidence that supports the claim but not a direct quote (paraphrased). **Some evidence might be incorrect or inappropriate for the claim.** Evidence is missing introduction and citation.	Selects evidence that does not support the claim.	*Evidence is missing entirely.*
Reasoning **W1c**	Clearly explains the main idea of the evidence in your own words. Clearly explains how the evidence supports the claim.	Explains the main idea of the evidence in your own words. Explains how the evidence supports the claim.	Missing or weak explanation of main idea of the evidence. OR Missing or weak explanation of how the evidence supports the claim.	Reasoning is unclear or confusing.	*Reasoning is missing entirely.*
Conventions **L.2**	Has very few or no errors in usage and/or conventions that interfere with meaning	Has few or minor errors in usage and or conventions with no significant effect on meaning	Has frequent errors in usage and conventions that sometimes interfere with meaning.	Has frequent major errors in usage and conventions that interfere with meaning.	*CER is missing entirely.*

Category	Score I gave you	Why
Claim		
Evidence		
Reasoning		
Conventions		