



BIOLOGICAL CARRYING CAPACITY



educational partners



GRADE LEVELS

Middle School - Grades 6-8

CONTENT AREA

Life Science

UNIT THEME

Ecology

TOPIC

Carrying Capacity

TIME REQUIRED

60 minutes



OVERVIEW

Fish and wildlife biologists manage natural resources for the overall health of certain species and the ecosystem where they live. But sometimes a healthy ecosystem can become damaged when too many of a certain species over-consume or somehow damage food sources. Once an ecosystem gets damaged, it can impact the health of all the species living there. So managers are faced with the question, "What's the right balance of certain species within an ecosystem?" Biologists call the right balance the "biological carrying capacity". It's the capacity of an ecosystem to "carry" or support a healthy number of a certain species without long-term damage to the ecosystem.

Another type of carry capacity is called "Social Carrying Capacity". It's the number of a species that society is willing to tolerate. For instance, even though a forest may biologically support 4 bears per square mile, society (the people also living there) may only tolerate sharing the landscape with 1 bear per square mile. So the Social Carrying Capacity may be less than the Biological Carrying Capacity.

In this lesson, students will develop an understanding of the concept biological carrying capacity by graphing a musky population under different scenarios.

CONCEPT Biological Carrying Capacity

ENDURING UNDERSTANDING:

Students will understand that the different parts of ecosystems are complicated and interconnected. The smallest change in one part can impact different species populations.

CONTENT OBJECTIVES:

Students will be able to define Biological Carrying Capacity in their own words as well as describe factors that can affect the carrying capacity of a species.

LEARNER OBJECTIVES:

Students will use pictures and graphs to help develop and support their understanding of the concept of Biological Carrying Capacity.

PROCESS OBJECTIVES:

Students will work in small and large groups to process new information and use evidence to come to a conclusion.

MATERIALS NEEDED (each group, each student):

1. Student Worksheet
2. Writing Utensils
3. Poster Paper and Markers for each group



PROCEDURES

Discuss a lake ecosystem as a class. Draw one on the board with the class. If students don't offer, make sure the human, musky, trout, and zooplankton food chain are part of your drawing. Prior knowledge of a lake ecosystem is helpful to this activity.

Pose the question, "What types of things affect the population size of these different species?" Do a Think-Pair-Share with the class. Students take a few minutes to think or write their answers individually, then share it with a partner, and finally share out to the whole class.

Put students in groups of 2-3 and handout the Biological Carrying Capacity worksheet to each student.

Describe Box Lake and the rules of Box Lake to them. You may opt to do Scenario 1 Map and Graph as a class (or check each group's graph before they start answering questions to ensure they understand the rules to Box Lake).

Before moving onto Scenario 2, there should be a class discussion about questions 1-3 to help reinforce the idea of carrying capacity by hearing other thoughts and ideas about it.

If the concept of invasive species is new to your class, you may want to describe Scenario 2 to your class. Otherwise, student groups may continue working until question 6. Monitor and check graphs/answers as students work. If a group is producing wrong answers, clarify and redirect them.

PROCEDURES *(continued)*

Have each group share one idea they brainstormed in question 6. Record their answers on the board. Label the list “Factors that can Lower Carrying Capacity.”

Groups can then continue on to Scenario 3 in the activity and answer questions through question 9.

Have each group share one idea they brainstormed in question 9. Record their answers on the board. Label the list “Factors that can Increase Carrying Capacity.”

Students should answer questions 10-13 with their partner. They can consult the brainstormed lists on the board to help them answer questions. When they are done, select a problem for them to present to the class. They should write their answers on poster paper. The answers should be large enough for other students to read across the room. Make sure that a few groups are presenting each problem and select groups with differing answers to deepen the class discussion. While groups present, make sure they explain why and what evidence they are using to support their answer. Use the presentations to spark class discussions about carrying capacity. Encourage students to add and improve their answers as other groups present.

ASSESSMENT

Students should complete an exit slip before they leave class in which they answer the following questions:

- Describe why population sizes cannot increase forever.
- How can human activity affect carrying capacity? Give one example in which it can increase it and one example where it can decrease it.
- If the carrying capacity of trout is 50 for a lake, could 55 trout survive? Could 40 trout survive? Explain.

EXTENSION ACTIVITIES

- Have students research current management techniques on the state DNR website or National Park Service website www.nps.gov to help struggling populations. Students can evaluate current management plans and propose new ones.
- Explore the Sunny Meadows Population Simulation. <http://puzzling.caret.cam.ac.uk/game.php?game=6&age=1> Students play the game by selecting the population size of grass, rabbits, and fox. They can monitor the graphs of each population over time to see how the amount of grass, rabbits, and fox affect each other. The goal of the game is to create stable populations. They can see the carrying capacity of each organism if a stable population is created.



SPECIAL CONSIDERATIONS:

This activity is richest when completed in groups with answers shared to a whole class. This worksheet is not a typical worksheet as it encourages students to construct knowledge as they answer questions. The questions build off of each other.



RESOURCES

- <http://dnr.wi.gov/topic/fishing/musky/>
- <http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?scode=B003#lifeHistory>
- <http://limnology.wisc.edu/personnel/jakevz/ais/rainbowmelt.html>
- <http://dnr.wi.gov/topic/fishing/trout/>
- <http://dnr.wi.gov/topic/fishing/vhs/index.html>

ADDITIONAL RESOURCES

- www.nps.gov
- <http://puzzling.caret.cam.ac.uk/game.php?game=6&age=1>

The following **Student Proficiency Standards** can be met by teaching **BIOLOGICAL CARRYING CAPACITY**:

WISCONSIN STATE STANDARDS AND BENCHMARKS

F.8.8 Show through investigations how organisms both depend on and contribute to the balance or imbalance of populations and/or ecosystems, which in turn contribute to the total system of life on the planet

H.8.2 Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to arrive at a group decision



The following **National Common Core Standards** can be met teaching **BIOLOGICAL CARRYING CAPACITY**:

NATIONAL COMMON CORE STANDARDS

College and Career Readiness (CCR) Anchor Standard 1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

Grade 8

Write arguments to support claims with clear reasons and relevant evidence.

- a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
- b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text.
- c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.
- d. Establish and maintain a formal style.
- e. Provide a concluding statement or section that follows from and supports the argument presented.

The following **Wisconsin Teacher Standards** which may be met teaching **BIOLOGICAL CARRYING CAPACITY**:

Standard 1: Subject matter

This curriculum provides information not readily available in other forms. A teacher using this material will be well-informed about the subject matter.

Standard 2: Broad range of ability

This curriculum provides instruction that supports their intellectual, social, and personal development.

Standard 3: Adapt instruction

This curriculum provides suggestions for learners with a variety of intelligences and levels of ability.

Standard 4: Instructional strategies

This curriculum includes the use of technology to gain information and suggestions for using research in extending learning.

Standard 5: Individual and group motivation

Both prior knowledge and carefully designed group projects promote motivation for students to learn.

Standard 6: Verbal and nonverbal communications

Instructional media and technology that promotes active learning are key parts of this curriculum.

Standard 7: Organizes and plans systematic instruction


This curriculum is organized to support teacher knowledge, to draw on and motivate students to engage in active learning, and promotes active inquiry, collaboration, and supportive interaction in the classroom.

Carrying Capacity

How big can a population get?

In this activity you will study the effects of environmental stresses (loss of habitation, predation, etc.) on a size of a Musky population in Box Lake. You will keep track of this population using pictures and graphs.





Rules to Box Lake:

1. Musky eat smaller fish like perch. There is enough perch in each square of Box Lake to keep one Musky alive. Therefore, only one Musky  can occupy a square within Box Lake at a time.
2. For every two Musky, one new offspring will survive predators (birds, fisherman, etc.) each generation or season. Add a new Musky each generation.
3. If all of the squares are filled in Box Lake with Musky during a generation, there will not be enough perch to eat and no additional Musky will survive.
4. If all of the squares are filled with Musky at the *start* of the generation or season, the perch population will start to decline. Two Musky will starve and need to be removed from Box Lake. No additional offspring will survive.

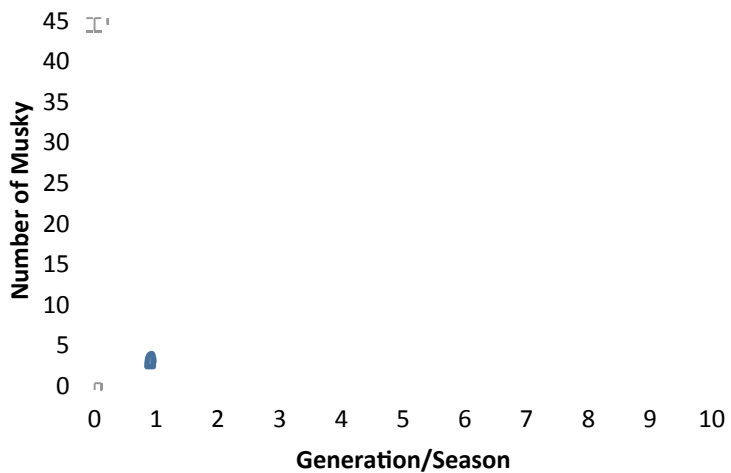
Scenario 1: Normal Conditions

Generation 1 in this scenario has 4 Musky in it. Follow the rules to Box Lake above. For each generation, draw additional Musky on the Box Lake Map. For example, since there are 4 Musky, 2 offspring would be added. The total number of Musky will now equal 6. On the Musky Population Graph, record 5 Musky for Generation 2. Continue for 10 generations.

Box Lake Map

Musky Population Graph



1. Does the Musky population continue to increase overtime? Why?

2. The maximum number of organisms that an environment can support without ruining the environment is called the "Carrying Capacity."
 - a. The carrying capacity for Musky in Box Lake is about 19 Musky. Draw a line across your graph at 19 Musky and label it "Carrying Capacity."





 - b. Describe how you can determine the carrying capacity of an organism by just looking at a Population vs. Time graph.

3. Populations tend to fluctuate naturally around the carrying capacity. Why do you think populations fluctuate?

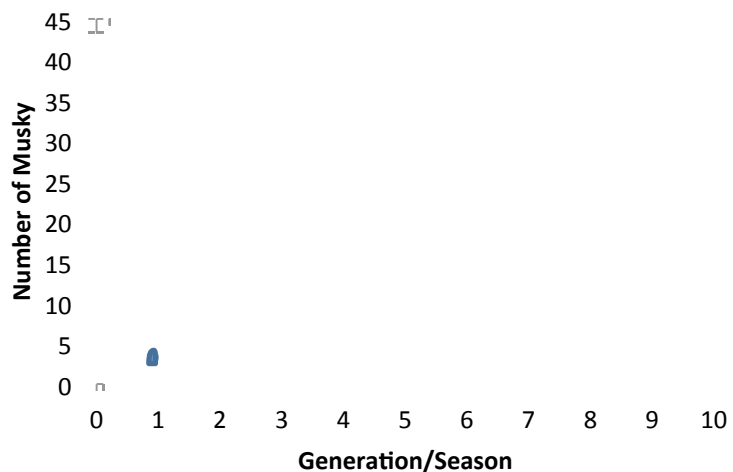
Scenario 2: Invasive Species

Rainbow smelt, an invasive (non-native) fish species, has been introduced into Box Lake. Rainbow smelt and trout compete to eat enough zooplankton to survive. This competition over resources leads to a decrease in zooplankton and trout populations. Follow the rules to Box Lake to complete the Map and the Graph only this time there can only be one Musky for every 2 squares due to the decrease in trout. Complete 10 generations.

Box Lake Map

Musky Population Graph



4. What is the new carrying capacity for Musky after Rainbow smelt have been introduced? Support your answer using evidence from your population graph.



5. Why did the carrying capacity of Musky lower in this scenario than in scenario 1?

6. Brainstorm two other scenarios or changes to the Box Lake environment that would also lower the carrying capacity of Musky.

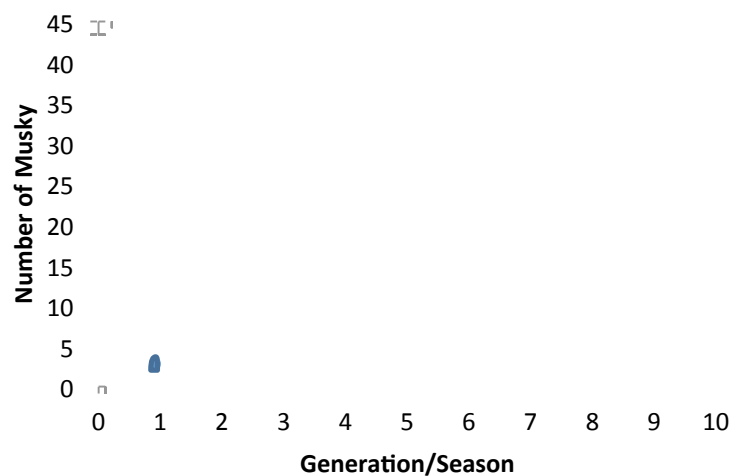
Scenario 3: Fishing Regulation Change

The minimum length needed to keep a trout caught through fishing has increased to 13" at Box Lake. This means more trout survive from generation to generation, providing more food for Musky. Follow the Rules to Box Lake to complete the Map and Graph only this time two Musky can fit in a square due to the increase in trout population.

Box Lake Map

Musky Population Graph

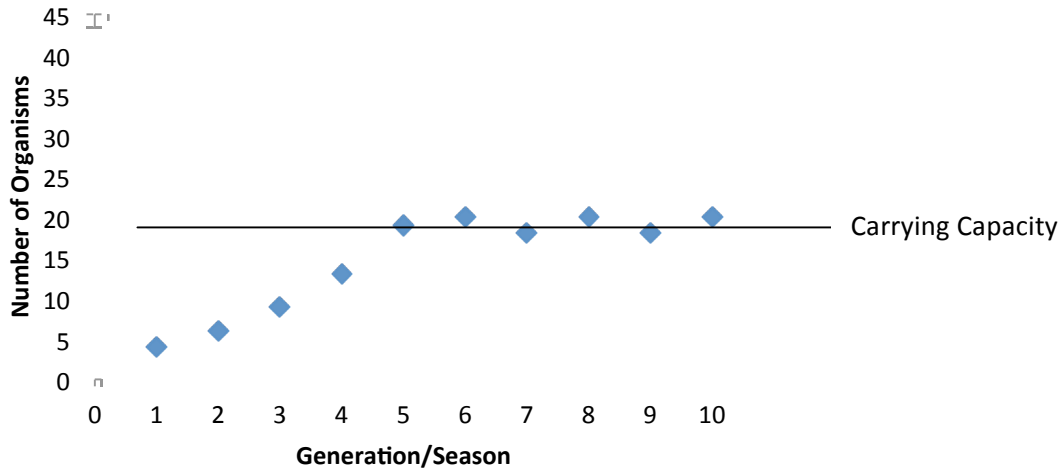


7. What is the new carrying capacity after the fishing regulation change? Support your answer using evidence from your population graph.
8. Why did the carrying capacity of Musky higher in this scenario than in scenario 1?
9. Brainstorm two other scenarios or changes to the Box Lake environment that would also increase the carrying capacity of Musky.
10. Viral Hemorrhagic Septicemia (VHS) is a deadly fish virus that infects many fish species including Musky and trout. While most of the infected fish die, some survive and produce antibodies to help protect them from future exposure to the virus. Sketch a Musky Population graph for this scenario. Make sure it is obvious if the carrying capacity is lower, higher, or the same as the normal carrying capacity at Box Lake. Explain your reasoning behind your graph.
11. A student states "There are 20 wolves living in this forest so therefore the carrying capacity of wolves in this forest is 20. No more than 20 wolves could live here." Why is this statement incorrect and how could someone determine the carrying capacity of the wolf population in this forest? Use evidence from this activity to support your answer.
12. The whooping crane is one of the tallest birds in North America. It is a migratory bird that lives in wetlands and eats plants, insects, small amphibians and rodents. Their population is endangered. Brainstorm two management techniques that we (humans) could do to help increase the population of whooping crane in North America.
13. Summarize the concept of "Carrying Capacity" in your own words. Be sure to include factors that affect it.

ANSWER KEY

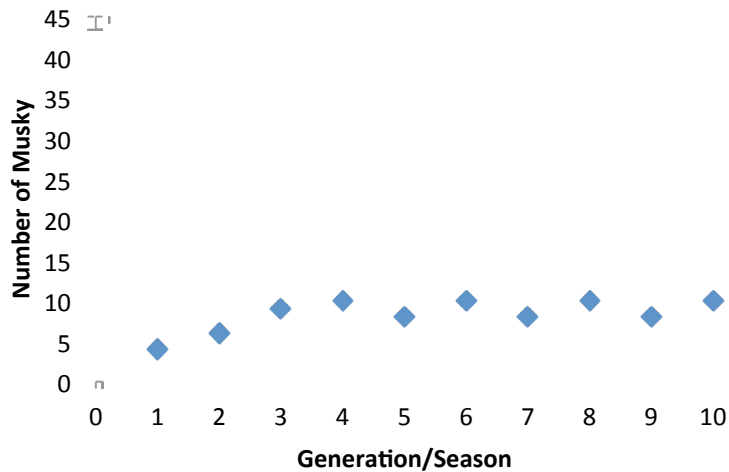
Scenario 1 Sample Graph:

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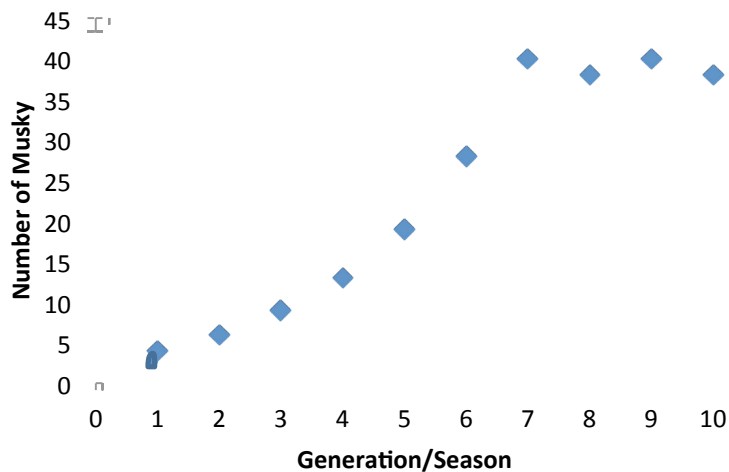
1. Does the Musky population continue to increase overtime? Why?
No. The Musky population eventually flattens out, never going above 20 Musky.
2. The maximum number of organisms that an environment can support without ruining the environment is called the "Carrying Capacity."
 - a. The carrying capacity for Musky in Box Lake is about 19 Musky. Draw a line across your graph at 19 Musky and label it "Carrying Capacity."
See Graph.
 - b. Describe how you can determine the carrying capacity of an organism by just looking at a Population vs. Time graph.
Look for an area in which the graph flattens out or fluctuates around a certain number.
3. Populations tend to fluctuate naturally around the carrying capacity. Why do you think populations fluctuate?
Answers will vary: New offspring are born, Musky get by eating less/more than normal, predators may kill slightly faster/slower than the birth rate for a while.

Scenario 2 Sample Graph:



4. What is the new carrying capacity for Musky after Rainbow smelt have been introduced? Support your answer using evidence from your population graph.
The carrying capacity is 9. I determined this by looking at where the graph leveled out and found the number of Musky the graph was fluctuating around.
5. Why did the carrying capacity of Musky lower in this scenario than in scenario 1?
The carrying capacity lowered because there were less resources or food in the lake to eat. This resulted in less Musky that could survive.
6. Brainstorm two other scenarios or changes to the Box Lake environment that would also lower the carrying capacity of Musky.
Answers will vary: Drought, less zooplankton or trout due to disease or contaminants, competition from other fish species, more predators, decrease size of the lake

Scenario 3 Sample Graph:



7. What is the new carrying capacity after the fishing regulation change? Support your answer using evidence from your population graph.

The new carrying capacity is 39. I looked at the graph and found where it leveled off. It is centered around 39.

8. Why did the carrying capacity of Musky higher in this scenario than in scenario 1?

There is more food for the Musky to eat, increasing the amount of Musky that can survive in the lake.

9. Brainstorm two other scenarios or changes to the Box Lake environment that would also increase the carrying capacity of Musky.

Answers will vary: Increase the size of the lake, stock more trout in the lake, introduce new fish species to eat, increase the zooplankton population size, decrease the amount of predators, change fishing regulations to limit number of fish caught

10. Viral Hemorrhagic Septicemia (VHS) is a deadly fish virus that infects many fish species including Musky and trout. While most of the infected fish die, some survive and produce antibodies to help protect them from future exposure to the virus. Sketch a Musky Population graph for this scenario. Make sure it is obvious if the carrying capacity is lower, higher, or the same as the normal carrying capacity at Box Lake.

The carrying capacity on the graph should be lower since more Musky die. The graph will be similar to the graph in scenario 2. Some students may hypothesize an eventual comeback of the Musky number due to an increase in resistance to the virus over time. Ecosystems are complex, other answers may be accepted if strong rationale and evidence is provided.

11. A student states "There are 20 wolves living in this forest so therefore the carrying capacity of wolves in this forest is 20. No more than 20 wolves could live here." Why is this statement incorrect and how could someone determine the carrying capacity of the wolf population in this forest?

This statement is incorrect because we do not know if this is the maximum that this forest can support. We could determine the carrying capacity by monitoring the number of wolves over many generations to see if the population is increasing, decreasing or stable. Once the population numbers are pretty level, we can determine the carrying capacity, keeping in mind that any change in the environment might change the carrying capacity. Even if the population is stable at 20 wolves, more than 20 could survive for a short period of time by consuming a little less.

12. The whooping crane is one of the tallest birds in North America. It is a migratory bird that lives in wetlands and eats plants, insects, small amphibians and rodents. Their population is endangered. Brainstorm two management techniques that we (humans) could do to help increase the population of whooping crane in North America.

Answers will vary: Decrease insecticide use, increase the amount of wetlands, prevent hunting, raise in captivity and then release to the wild, prevent building on wetland areas, do not put wind turbines in migratory paths

13. Summarize the concept of "Carrying Capacity" in your own words. Be sure to include factors that affect it.

Answers will vary: Carrying capacity is the maximum number of a given species that can be supported by the ecosystem. It is dependent on availability of resources, how quickly the resources can be replenished, how much each organism needs to survive, etc.