# Tragedy of the Goldfish

***Sustainably managing a common pool resource***

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**Field Tested:** 11th grade Biology, Watsonville High School, CA (Spring, 2014)

**Module Type:** Classroom activity

**Duration:** One 2-h class session

**Key Materials:**

* Access to internet for video
* A stopwatch
* A box of straws (one straw per student)
* A large box of goldfish crackers
* Group Handouts (1 per group of 4)
* A form of artificial currency (e.g. Hershey’s Kisses, jelly beans, monopoly money etc.)

**Concepts:** Tragedy of the commons, common pool resources, open access resources, resource management, profit maximization, overexploitation, cooperation, regulation, property rights

**Skills:** Students will learn about the behavioral mechanisms that contribute to the overexploitation of common pool and open access resources and create methods to manage these issues.

**Next Generation Science Standards (NGSS):**

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience (HS-LS2-7, HS-LS2-8)

Crosscutting Concepts

### Stability and Change

Science and Engineering Practices

### Constructing Explanations and Designing Solutions

**Overview:**

This module is an opportunity for students to learn:

* How human activities can cause resource depletion
* How interactions between individual actors are important in natural resource management
* How to observe changes in resource availability/supply based on consumption patterns
* How to use data to make graphs
* How to use data to discover trends over time

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**Background for Teachers**

**Why this matters:** The tragedy of the commons is a dilemma when multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared limited resource even when it is clear that it is not in anyone's long-term interest for this to happen. This dilemma was first described in an influential article titled "The Tragedy of the Commons," written by Garrett Hardin and first published in the journal *Science* in 1968.Hardin's Commons Theory is frequently cited to support the notion of sustainable development, meshing economic growth and environmental protection, and has had an effect on numerous current issues, including the debate over global warming, fisheries depletion, deforestation, water consumption and water quality.

Articulating solutions to the tragedy of the commons is one of the main problems of environmental policy and natural resource scholars and managers. In the absence of enlightened self-interest, altruistic or cooperative behavior, some form of authority is needed to solve the collective action problem. In a typical example, governmental regulations can limit the amount of a common good that is available for use by any individual. Permit systems for extractive economic activities including mining, fishing, hunting and timber production are examples of this approach. Similarly, limits to pollution are examples of governmental intervention on behalf of the commons. Alternatively, resource users themselves can cooperate to conserve the resource in the name of mutual benefit. Another solution for some resources is to convert a common pool resource into private property, giving the new owner an incentive to enforce its sustainability.

**Assumed background:** Although prior exposure to the areas listed below would be ideal, experience is not required for students to successfully participate in this activity:

* Economics: concepts of profit and utility
* Government: concepts of monitoring and enforcement of laws
* An understanding of natural resources and the concept of renewable resources
* Ability to plot data and interpret data

**Special context:** This activity applies the basic concept of the **Tragedy of the Commons** to fisheries. Overexploitation of **common pool** and **open access fisheries** is a well-known natural resource issue that has important implications for **local and global economies** as well as **marine biodiversity**. Students will represent independent actors seeking to catch fish to support their livelihood from a shared fish population.

**Scaffolding supplements:** Teacher Instruction form, Group handouts.

# Module Description

## Materials

* Access to internet for videos
* A stopwatch
* A box of straws (one straw per student)
* A large box of goldfish crackers
* Group Handouts (1 per group of 4)
* A form of artificial currency (e.g. Hershey’s Kisses, jelly beans, monopoly money etc.)

## Preparation

* Copies of Group Handouts (1 for each group of 4), a large box of goldfish, a sufficient amount of artificial currency (e.g. Hershey’s Kisses, jelly beans, monopoly money etc.), and enough straws for each student that will participate in the activity

## Timeline

1. Form student groups and distribute materials 5 min.
2. “Open Access” Scenario Activity 25 min.
3. Tragedy of the Commons video and discussion 15 min.
4. Group Discussion and Resource Management Rule Writing 5-10 min.
5. “Managed Commons” Scenario Activity 25 min.
6. Completion of Student Handouts 20 min.
7. Review Results and Class Discussion 15 min.
8. Cleanup 5 min.

## Starting Point For Inquiry

To save time, it may be worthwhile to organize the materials for each group (i.e. place 60 fish on each plate) prior to the beginning of class.

Begin the activity with very little information regarding the purpose of the exercise. The goal is to allow the students to experience the consequences of the tragedy of the commons. Be sure to emphasize the fact that students will be “rewarded” for the number of fish caught each round.

Once the students have completed the “Open Access” scenario, use the first YouTube video to introduce the concept of the Tragedy of the Commons and facilitate a discussion of this issue. Use the second YouTube video to introduce methods for solving the Tragedy of the Commons. The videos are an essential component of the lesson and are useful for stimulating classroom discussion. Before the students begin discussing and formulating their own rules for managing the fishery, let them know that the rules have to be something that can be applied to the activity they are playing (i.e. they have to be able to actually implement them) and that the goal of the rules is to create a sustainable fishery.

After the second scenario has been completed and each group has finished their worksheet, you will discuss some of the results that different groups had based on the rules they created. Begin by asking about the different rules that groups came up with. Discuss how different sets of rules may produce a sustainable fishery, but may distribute profits from fishing unevenly. For example, setting a cap on the total number of fish that may be harvested as a rule may distribute profits inequitably because one student may be faster at extracting fish than other members of the group. Whereas, a rule that establishes a maximum on the total number of fish that may be extracted, and a maximum on the number of fish extracted by each student will provide a more equitable outcome.

## Detailed Procedure

**Activity Preparation**

1. At the beginning of class, have the students organize into groups of no more than 4 students.
2. Provide each group with:
	1. A copy of the “Group Handout”
	2. A paper plate
	3. One straw per student
	4. 60 goldfish for each group (15 fish per student in groups with less than 4 students)
3. Each group should have all of the goldfish distributed evenly on the paper plate.
4. Orally review the activity instructions on the “Group Handout” files.
	1. ***Ask the students why the number of fish may be limited in a particular pool. What ecological concept would limit the number of organisms inhabiting a particular location (the answer is: Carrying Capacity).***
	2. ***Ask the students to explain what factors contribute to carrying capacity.***
5. Review the table provided in the “Group Handout” and have each group record the names of the members in the appropriate box, and fill in the “Starting #” of fish for “Round #” 1.
6. Begin with the “Open Access” Scenario (See “Teacher Info” file).
	1. ***Emphasize that students are not to communicate with those in their group regarding how much fish they plan to catch.***

**Class Activity I**

1. Begin the first round of fishing:
	1. Students will be given 15 seconds to fish using the straws.
	2. Count down when the students have 5 seconds left to encourage them to keep fishing.
2. After the round has finished, have the students record their individual catch and profits (i.e. number of Hershey’s Kisses) into the corresponding row of the table provided in the “Group Handout”. Each column of the table, including the “# Remaining” should be recorded.
3. Before beginning Round 2 of “Open Access”, ask each group how many fish they had remaining.
	1. Provide one fish for every fish that each group has remaining (e.g. if Group 1 has 4 fish remaining, give them 4 additional fish).
		* ***Ask the students, “why are additional fish added to the resource pool?” What does this represent (Answer: Reproduction)?***
	2. Provide “$2” (i.e. two Hershey’s Kisses) to each student for every fish that was caught. *Note: If distributing fish and profits simultaneously is a challenge due to class size, inform the students that they will be provided with their profit following the completion of the activity.*
		* ***Ask the students what the Hershey’s Kiss represents in the real world.***
4. Begin Round 2. Students will have 15 seconds to continue collecting fish.
5. Repeat steps 8-9.
6. Continue this scenario for 5 rounds, or until all groups have run out of fish.

**Tragedy of the Commons Video and Discussion**

1. Following the class activity, open the Tragedy of the Commons PowerPoint and play the following YouTube video:
	1. Chalk Talk: Tragedy of the Commons, Part 1, NSF
	* (<https://www.youtube.com/watch?v=KZDjPnzoge0>)
2. Following the presentation of the videos engage the class by posing the following questions:
	1. ***What is a commons?***
		1. ***Answer:*** The "commons" is any resource that is shared by a group of people, cities, states or countries. Such things as the air we breathe and the water we drink come from commons. In many parts of the world; new land for farming and grazing land for stock, fish from the sea, and wood for fuel and housing are treated as commons.
	2. ***What is the primary problem that creates the Tragedy of the Commons?***
		1. ***Answer:*** Individuals competing for the use of a shared finite resource and acting in their own self-interest are likely to overexploit the common resource.
	3. ***How does the fishing game represent a tragedy of the commons?***
	4. Have each group spend a few minutes brainstorming at least one example of a “Tragedy of the Commons” problem. The problem can be something related to environmental quality or resource management (i.e. deforestation) or can be something they experience on a more personal level (i.e. large lunch lines at local restaurants during school).
	5. Ask one member from each group to write at least one example they came up with on the board.
	6. Once each group has included an example, go around the room and have each group explain the example they chose.
3. Show the following video:
	1. Chalk Talk: Tragedy of the Commons, Part 2, NSF
	2. (<https://www.youtube.com/watch?v=IVwk6VIxBXg>)
4. Discuss different methods of solving the tragedy of the commons problem. A brief overview of each is provided below:
	1. Cooperation: Self-governance over the shared local resource.
	2. Regulation: An external government agency imposes regulations on the group in an attempt to establish a sustainable fishery.
	3. Private property: Each user is assigned a right to use a particular area, or extract a specific number of the given resource.

**Class Activity II**

1. Give each group 5-10 minutes to discuss and establish rules to establish a sustainable fishery.
	1. Each group should record their rules in the space provided on page 2 of the group handout.
2. While students are discussing their rules, replenish each groups fish population with 60 fish (15 fish per person in groups less than 4 students).
3. Once each group has established their rules and each fish population has been replenished, have them begin recording their information in the “***Scenario #2***” table on page 2 of the handout begin the first round of fishing:
	1. Students will be given 15 seconds to fish using the straws.
	2. Count down when the students have 5 seconds left to encourage them to keep fishing.
4. After the round has finished, have the students record their individual catch and profits (i.e. number of Hershey’s Kisses) into the corresponding row of the table provided in the “Group Handout”. Each column of the table, including the “# Remaining” should be recorded.
5. Before beginning Round 2 of “Scenario 2”, ask each group how many fish they had remaining.
	1. Provide one fish for every fish that each group has remaining (e.g. if Group 1 has 4 fish remaining, give them 4 additional fish).
	2. Provide “$2” (i.e. two Hershey’s Kisses) to each student for every fish that was caught. *Note: If distributing fish and profits simultaneously is a challenge due to class size, inform the students that they will be provided with their profit following the completion of the activity.*
6. Begin Round 2. Students will have 15 seconds to continue collecting fish.
7. Repeat steps 21-22.
8. Before beginning the final round, inform the students that “this will be the last round”.
	1. Knowing that the last round of fishing is being played, students may choose to “cheat” or break the “rules, and the fishery may be depleted.
9. Continue this scenario for 5 rounds.

**Analysis**

1. Following the completion of Activity II, ask the students to complete pages 3-5 of the group handout.

**Discussion**

1. Once student complete the graph and questions, Discuss the following questions as a class:
	1. Based on your group’s experience, what is the most appropriate form of governance for managing the commons?
	2. Do you think the most appropriate form of governance may be different depending upon the spatial scale of the resource or environmental problem?
2. Each group should submit their handout to the teacher at the end of class

## Assessment Methods:

Students will be assessed as a group using the group handout. Data from all rounds participated in during each scenario should be included in the tables, and the graph should be completed. Discussion questions should include thoughtful responses that reference the group’s data and figure.

Additional assessment can be garnered by asking specific groups questions during the class discussion at the end of the activity. This may be particularly useful for groups that seemed to be less engaged or exhibited little participation during the activity.

## Possible pitfalls

Students may not initially understand how to record their data in the worksheet or produce the graph. It may be useful to use a projector or the board to provide the class with some brief examples of how record the data they collect and organize the graph for plotting data.

## Glossary

Common Pool Resource (common property resource) - a type of good consisting of a natural or human-made resource system (e.g. an irrigation system or fishing grounds), whose size or characteristics makes it costly, but not impossible, to exclude potential beneficiaries from obtaining benefits from its use. Common pool resources face problems of congestion or overuse, because they are subtractable.

Open Access Resource - A limited resource that appears to each individual to be limitless. Individuals use the resource without taking into account the effect that their use has on others.

Overexploitation - Refers to harvesting a renewable resource to the point of diminishing returns.

Tragedy of the Commons – A phrased coined by Garret Hardin (1968) used to describe how self-interested, individuals, acting independently and rationally behave contrary to a group's long-term best interests by depleting some common resource.

Carrying Capacity - The maximum number of individuals of a given species that an area's resources can sustain without significantly depleting or degrading those resources.

Cooperation - The process of groups of organisms working or acting together for their common/mutual benefit.

Regulation - A rule or law designed to control or govern behavior.

# Science Education Standards Addressed

***Next Generation Science Standards (NGSS)***

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity **(HS-LS2-7)**

Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce **(HS-LS2-8)**

Crosscutting Concepts

**Stability and Change**

Much of science deals with constructing explanations of how things change and how they remain stable. (HS- LS2-7)

Science and Engineering Practices

### Constructing Explanations and Designing Solutions

* Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.
* Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations
* Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past.

# Guide to supplemental materials

**Handouts**

Each group will receive a worksheet to guide them through the activities and to assist in organizing and structuring their data.

File names: Fiack\_Tragedy\_grouphandout1.docx and Fiack\_Tragedy\_grouphandout2.docx

**Videos**

The following videos should be used to introduce the concept of the Tragedy of the Commons (video 1) and policy tools that are commonly implemented to solve the issue (video 2). The videos are essential and useful for facilitating classroom discussion.

 Video 1: Chalk Talk: Tragedy of the Commons, Part 1, NSF

* + <https://www.youtube.com/watch?v=KZDjPnzoge0>

 Video 2: Chalk Talk: Tragedy of the Commons, Part 2, NSF

* + <https://www.youtube.com/watch?v=IVwk6VIxBXg>