The Evolution of Sustainable Use

a flash-based classroom tool for teaching population biology and sustainable resource management

Pratt

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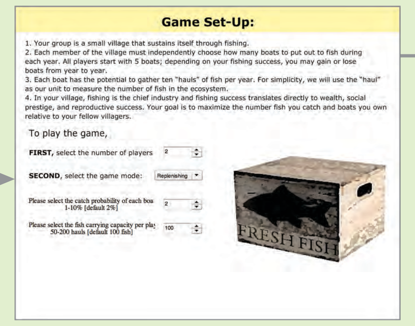
How it works

Free via Flash

The game is available for free download or direct use off of a dedicated website. It can easily be embedded into a variety of learning management systems. Students play in groups around a single computer, making implementation in a classroom or computer laboratory simple. The use of a remote number keypad facilitates competitive game play.

Set up game by specifying play parameters

Flexible set-up



Through a simple set-up screen, students can specify the number of players, the way the game incorporates the carrying capacity, the catch probability, the per-player carrying capacity, and the fecundity rate of dynamic fish populations.

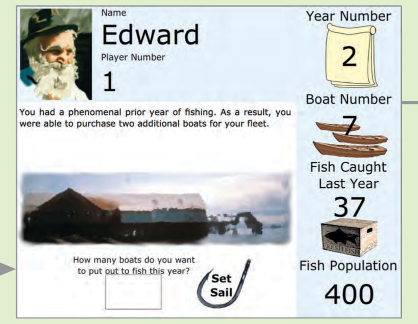
Student players assume the role of fishers in a small fishing village

Player-centered

Students enter their names and choose an avatar so that they can make their own strategy choices throughout the game.

Students play the game together for a period of 20 years of simulated fishing

Interactive play



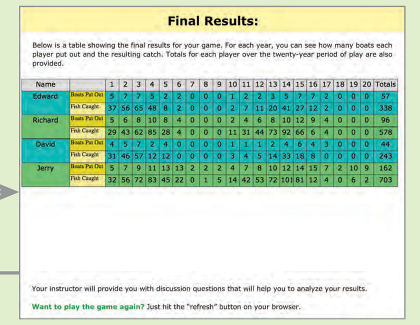
For every year of play, each student can anonymously choose how many boats to put out (one's 'fishing effort'). After each year's play, students receive an update on their most recent fishing success, the current size of their fishing fleet, and how many fish remain in the population. Based on this information and observations of other students' fishing success, each student must decide how many boats to put out in subsequent years.

After 20 years of play (or a complete collapse), students can see the results of their simulated fishery

Outcomes

Ecological collapse
Economic collapse
Social inequity
Ecological stability
Economic viability
Equitable fishing success

Complete results



At the end of each 20-year game, students receive clear tabular results that report how many boats each player put out during each year and their resulting catch. Totals for the entire game are tabulated, making it easy to see how fishing effort and fishing success correlate.

Within groups, individual students make their own choices

Students learn through play

Population growth and carrying capacity

The game incorporates simple, easy-to-understand population growth rules that allow students to observe exponential growth and decline. The presence of a simple 'ceiling' carrying capacity enables students to understand how ecological limits cap population expansion. The ability to vary growth and carrying capacity parameters in different game iterations empowers students to use an inquiry-based approach to understanding the dynamics of population growth.

Sustainable fisheries management

The game allows for fisheries collapse due to over-exploitation. In order to maintain a sustainable fishery, students must apply their knowledge of population growth to establish sustainable fishery management policy. Because the game encourages trial-and-error, students who may not initially grasp the theoretical rationale for sustainable policy can discover what works through an empirical approach. Students can be asked to not only provide the most ecologically-stable management regime but also to maximize the long-term economic benefits provided by sustainable harvesting.

The evolution of cooperation

Played competitively, the game allows students to discover the tension between competition and cooperation that defines the evolutionary process. Although the game is not explicitly genetic, students learn how the 'traits' represented by their varying exploitation strategies impact the success of both individuals within a group and the group as a whole. Students can be asked to both compete to be the most successful fisher in their group and also maximize the harvest of their group as compared to other groups. The possibility of a total 'tragedy of the commons' collapse due to the presence of 'selfish' individuals who reap short-term rewards provides students with a first glimpse of selection operating at multiple levels.

Ecological concepts

Understanding growth and harvest dynamics

Students can be asked to discover the basic growth properties of this simplified system and describe the effects of harvesting on population growth. By playing games with varying carrying capacity, catch probability, and student fishing effort, students uncover how these parameters affect population growth. Game play allows students to develop an intuitive sense of how ecological conditions impact the sustainability of a fishery.

Discovering the tragedy of the commons

In the ecologically-unrealistic "replenishing" mode, students learn that increased fishing effort increases the probability of overall fishing success. But in the ecologically-realistic "dynamic" mode, individual students pursuing fishing success have the potential to lead to crash or even total collapse of the system. Through their individual choices and the choices of their fellow group members, students learn how and when the tragedy of the commons can emerge. Game play allows students to develop an intuitive sense of how social conditions impact the sustainability of a fishery.

Implementing sustainable policy

Once students have discovered the social and ecological conditions that can lead to fisheries collapse, they can be challenged to implement 'policy' that allows for sustainable harvest. Students learn through trial-and-error that successful policies must address all three pillars of sustainability: social equity, ecological stability, and economic viability.

Engaging activities

Ecologically-based game rules

Carrying capacity

Carrying capacity can be set from 50-200 hauls of fish per player, allowing students to explore how ecosystems of varying abundance affect their fishing success. Carrying capacity functions in two modes: 1) in "replenishing" mode, the yearly supply of available fish is equal to the carrying capacity; and 2) in "dynamic" mode, the carrying capacity represents a ceiling on growth (i.e. growth is depicted as exponential, not logistic). Carrying capacity is scaled to the number of players, allowing student groups of differing sizes to more easily compare their results.

Exponential growth

In "dynamic" mode, fish grow exponentially each year based on a fecundity rate between 0-200%, allowing students to explore how the overall population growth rate affects the sustainability of their fishery. Students will discover that allowing their fish population to fall to a low abundance dramatically increases the time required for recovery to the carrying capacity. In "replenishing" mode, the fish population does not grow or shrink: each year, it replenishes to the carrying capacity regardless of how heavily the population was fished in the previous year.

Fishing success is probabilistic based on effort

The catch probability of each boat can be set between 1-10%, allowing students to explore how fishing technologies of varying efficacy affect the sustainability of their fishery. Boats harvest fish in units of "hauls", and each haul of fish is more susceptible to being caught when there are more boats in the water. Students who put out more boats are more likely to catch more fish, but because the harvesting algorithm incorporates stochasticity, it is possible for players exerting equal fishing effort to realize differing harvests.

Increase and decrease of fishing fleet

While each student starts out with five boats, it is possible for students to gain or lose boats based on their fishing success each year. This feature adds economic realism to the game and makes over-exploitation due to competition more likely. Players who harvest more than 6 hauls per boat receive an additional boat in the following year; those who harvest more than 8 hauls per boat receive two additional boats in the following year. Failure to catch at least 5 hauls per boat results in the loss of one boat, failure to catch at least 3 hauls per boat results in the loss of two boats, and failure to catch any fish results in total loss of a player's fleet. Students who lose all of their boats are eliminated from the game; only ecological limits prevent students from amassing larger and larger fleets.

Population crashes and collapses

In "dynamic" mode, the population can crash or collapse due to over-exploitation. The fecundity rate, the catch probability, and the overall fishing effort of the student group all influence the probability of crash or collapse. Student groups who collectively place too many boats in the water each year will discover that their fishery can rapidly decline. Such declines can be reversed if students choose to reduce their fishing effort, but such reductions in fishing effort lead to an overall decline in the fishing fleet of the group. Student groups who continue to over-exploit their fishery will discover that total collapse is possible (the fish population can decline to zero). It is also possible to sustain total economic loss in conjunction with a crash, as students may lose all their boats while the fish population is very low.

Underlying algorithms

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