*Behavior Research Methods, Instruments, & Computers*
*2000, 32(3), 417-422*

# FISH 3: A microworld for studying social dilemmas and resource management

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A Java-based microworld environment for studying resource management is described. FISH 3 may be used in research or the classroom to investigate commons dilemmas and resource dilemmas. The program uses ocean fishing as its metaphor; participants ("fishers") experience the metaphor through both graphics ("fish" may be seen in an ocean) and text (e.g., resource replenishment is translated as "spawning"). In either stand-alone or networked modes, either with all human fishers or a mixture of human and computer fishers, 15 parameters such as the number of resource units (fish), participants (fishers), and trials (seasons), payoff values, the rate and period of resource regeneration (spawning), harvesting greed by computer fishers, awareness of other harvesters' actions, uncertainty in the amount of the resource, operating costs, and whether the resource is visible to harvesters may be varied.

As environmental problems and concerns grow, social scientists must learn more about individual and small-group contributions to ecological degradation. This article describes FISH 3, a platform-independent microworld environment (DiFonzo, Hantula, & Bordia, 1998) that can be useful in these studies. In the decade since its predecessor, FISH 2 (Gifford & Wells, 1991), and its successive (2.n) versions have been made available, over 100 studies with *social dilemma*, *commons dilemma*, or *resource dilemma* in their titles have been published, as well as two important books (Komorita & Parks, 1994; Liebrand, Messick, & Wilke, 1992). A modern version of FISH should be of use to this group of researchers.

## Resource Management Problems

As a society we extract, refine, use, and dispose of many natural resources. However, society is composed of individuals, and individuals make many of these choices in their homes, at work, or during their leisure hours. The crucial aspect of individual-level resource management decisions is that they sum, across billions of individuals' actions, to societal-level management in ways that are mysterious, partly irrational, and yet all-important.

## Social Dilemmas

*Social dilemmas* are a family of situations in which individuals face choices, or dilemmas. As Dawes (1980) defined them, social dilemmas are a class of situations in which the rewards for noncooperation are greater than the rewards for cooperation no matter what others do, yet if all fail to cooperate, then all receive lower rewards. The original social dilemma was the well-known prisoner's dilemma, in which 2 participants faced the choice of whether to cooperate (refuse to turn "state's evidence" against the other prisoner) or defect (try to escape a long sentence by turning "state's evidence" against the other prisoner, without knowing the other's decision).

Among the more recently studied forms of social dilemmas are public goods problems (such as a decision about whether or not to donate to a charity or join a union when membership is voluntary), social traps, and commons or resource dilemmas. These social dilemmas can include any number of participants, rather than just two. Social traps, developed within a reinforcement theory context, involve short-term pleasure, gain, or reinforcement that, over time, leads to pain or loss (Platt, 1973). Classic social traps include smoking, overeating, and the use of pesticides such as DDT. In commons or resource dilemmas, the form of social dilemma that FISH 3 simulates, the focus is on cooperating (harvesting little, resulting in modest short-term gain but long-term protection of the resource) or defecting (harvesting much, resulting in a large short-term gain but endangering or extinguishing the resource) over a series of trials from a valuable, limited, regenerating pool of resources.

## Commons Dilemmas

Originally, "the commons" referred to a central open space in the heart of a village or small town. Undivided shares of the commons were owned by citizens in good standing, each of whom used its grass and open space to graze his/her animals. As long as there is grass enough for all the shareholders, the commons is a tranquil place. In most commons, however, the day eventually arrives when someone develops a motive to use more grass—perhaps to feed another cow or to sell the grass to another village. Or, the number of shareholders in the commons grows and, even though no one takes more than before, more individuals are using the grass. Or, grass is not as

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abundant as before because of some external force, such as drought. As demand for a limited resource increases, the issue becomes freedom in the commons (Hardin, 1968).

When the supply of a resource seems ample, people feel free to exploit the resource as much as possible, because in exploiting the resource for one's own benefit, the individual allegedly is guided, according to 18th-century economists such as Adam Smith, by an "invisible hand" to benefit the whole community. For example, a whaler who becomes rich would employ people, buy equipment; donate to social, educational, and charitable causes; and generally aid the economy.

The 19th-century economist William Lloyd (1837/1968) appears to have been the first to see a fundamental problem with this logic: He recognized that many resources are limited. In a desirable but limited commons, some individuals act in self-interest, according to Hardin, who asserted that a process called the "tragedy of the commons" then begins: "Each [person] is locked into a system that compels him [or her] to increase his [harvesting] without limit—in a world that is limited. Ruin is the destination toward which all [persons] rush, each pursuing his own best interest . . ." (p. 1244).

Many resources besides pasture lands are limited and essentially held in common: fish, forests, oil, whales, water, even fresh air. In general, a commons is any desirable resource jointly held by a group of individuals.

## The Dilemma

What is a commons *dilemma*? Some resources regenerate relatively quickly (e.g., grass for grazing, river water for electric power), and others not so quickly (e.g., fish, trees used for lumber), and some very slowly or not at all (e.g., oil, endangered species). When resources regenerate more slowly than people can harvest them, the danger of resource exhaustion arises. Users of such resources face a choice: Get ahead quickly at the expense of the commons and other harvesters, or restrain harvesting to preserve the commons and increase one's wealth slowly.

When harvesters are able (through improved technology, previous overharvesting, or sheer personpower) to harvest a resource faster than it can regenerate, the dilemma becomes actual. Harvesters must choose between rapid, resource-destructive, short-term, self-interested harvesting ("get it while you can") and restrained, long-term, public- and resource-oriented harvesting. The term *commons dilemma*, inspired by the thought of Lloyd and Hardin, was first used by Dawes (1973).

## Are Commons Dilemmas Always Fatal?

Social scientists have not unquestioningly accepted Hardin's (1968) tragedy-of-the-commons argument that individuals will always act in short-term self-interest; they consider the issue of how individuals will behave in a limited commons to be an open question that will be resolved through empirical research. Social scientists have pursued the question and created sizable bodies of work on it (e.g., Gardner, Ostrom, & Walker, 1990; Gifford, 1997, chap. 14; Komorita & Parks, 1994).

The important question is: Under *which conditions* will individuals act in self-interest, to the detriment of the others and the resource? Often it is easier or more rewarding, at least in the short run, to engage in self-serving behavior than it is to behave in the public interest. In a limited commons, the public-spirited act is often more expensive, difficult, or time-consuming, and less immediately rewarding than the self-serving act.

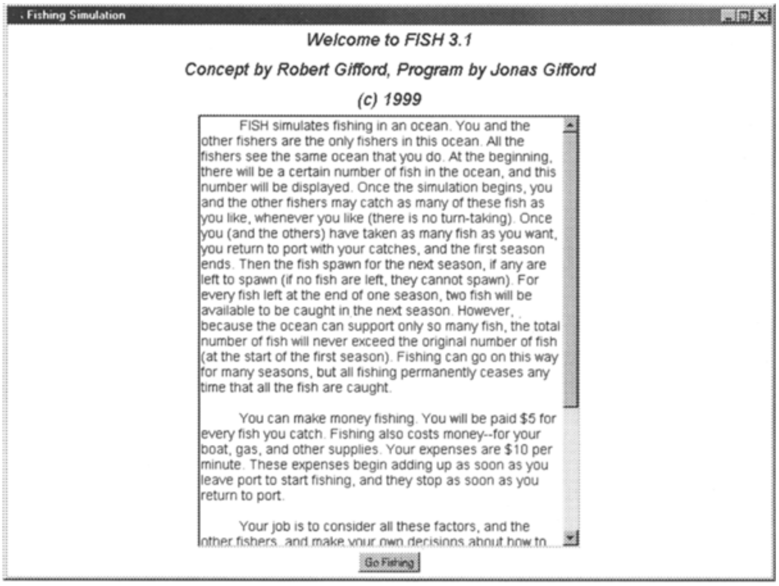
The hundred or so recent studies on this topic have examined many variables that affect choices made in the dilemma, from aspects of the resource itself (e.g., its size, or how much of it is certain versus uncertain), to the effect of varying social conditions or rules surrounding the harvesting (e.g., how the harvest is to be divided or whether a leader exists or is elected), to characteristics of the harvesters (how many there are, or how they think about or interact with other harvesters; for general reviews, see Gifford, 1997, chap. 14; Komorita & Parks, 1994). As an example, our own recent research has focused on the problem of how best to measure cooperation (Gifford & Hine, 1997b), the thinking processes of participants as the dilemma evolves (Hine & Gifford, 1997), harvesting practices as a function of attributions made about self and other harvesters (Gifford & Hine, 1997a; Hine & Gifford, 1996a), and uncertainty in the amount of the resource (Hine & Gifford, 1996b).

In sum, we all manage a steady supply of natural resources that have been converted into products we use every day. Some of these resources come from limited sources. A commons is a pool of desirable materials that may be harvested by a number of individuals or organizations that share access to it. Commons dilemmas occur when improved technology or increased personpower enables the harvesting of resources faster than the resource can regenerate. Harvesters then must decide whether to maximize their own gain in the short term or to help maximize the gain of the whole group or public, including themselves, over the longer term.

## Simulating Commons Dilemmas

The original (noncomputerized) commons dilemma simulation was proposed by Edney (1979), who called it "the nuts game." In it, a number of participants sit around a large, shallow bowl. The bowl contains a dozen walnuts. The experimenter explains that participants may take as many walnuts out of the bowl as they wish at any time; there is no turn-taking. The walnuts may be traded at the end for something valuable, such as money, concert tickets, or food. Before the participants begin grabbing the walnuts, the experimenter adds one more piece of information: "If any walnuts remain in the bowl 10 sec after the start, I will place that many more walnuts in the bowl." The dilemma is whether to grab or to trust that others will not grab; the supply of walnuts may increase across trials if no one is too greedy.

Microworlds are dynamic, computer-based environments that exist in laboratories, but reasonably simulate



*Welcome to FISH 3.1*

*Concept by Robert Gifford, Program by Jonas Gifford*

*(c) 1999*

FISH simulates fishing in an ocean. You and the other fishers are the only fishers in this ocean. All the fishers see the same ocean that you do. At the beginning, there will be a certain number of fish in the ocean, and this number will be displayed. Once the simulation begins, you and the other fishers may catch as many of these fish as you like, whenever you like (there is no turn-taking). Once you (and the others) have taken as many fish as you want, you return to port with your catches, and the first season ends. Then the fish spawn for the next season, if any are left to spawn (if no fish are left, they cannot spawn). For every fish left at the end of one season, two fish will be available to be caught in the next season. However, because the ocean can support only so many fish, the total number of fish will never exceed the original number of fish (at the start of the first season). Fishing can go on this way for many seasons, but all fishing permanently ceases any time that all the fish are caught.

You can make money fishing. You will be paid $5 for every fish you catch. Fishing also costs money--for your boat, gas, and other supplies. Your expenses are $10 per minute. These expenses begin adding up as soon as you leave port to start fishing, and they stop as soon as you return to port.

Your job is to consider all these factors, and the other fishers, and make your own decisions about how to

**Figure 1. The introductory FISH 3 screen seen by fishers as they learn about the simulation.**

real-world conditions (DiFonzo et al., 1998). FISH 3 recreates in the laboratory the situation faced by real fishers as they choose how much of a fish stock to harvest. It is far more sophisticated than the nuts game, because about 15 parameters may be controlled or varied, yet the participants experience a dilemma that is much more realistic than a bowl of nuts.

A number of computer-based commons dilemma simulations have been described in the literature (e.g., Cass & Edney, 1978; Chapman, Hu, & Mullen, 1986; Gifford & Wells, 1991; Parker et al., 1983). Each appears to have served the experimenter's purposes well but is now technologically outdated. For example, even the most recent of these, Gifford and Wells's (1991) FISH 2.3, was based on a program library that is now obsolete, so it could not be updated. Also, the earlier programs did not allow for the manipulation of more than a few parameters. For example, the Chapman et al. program GROUP1 is written in BASIC and is limited to a single resource pool size and number of trials. The Parker et al. program seems not to include the concepts of greed or uncertainty in the resource stock.

## FISH 3

FISH 3 creates a context that includes many of the essential elements of any commons dilemma. The fishers are able, if they choose, to harvest the resource (catch fish) more quickly than the resource can regenerate itself (spawn). In fact, they are capable of harvesting all the fish at any time. Or, they may choose to restrain their harvests in the interest of conserving the stock of fish.

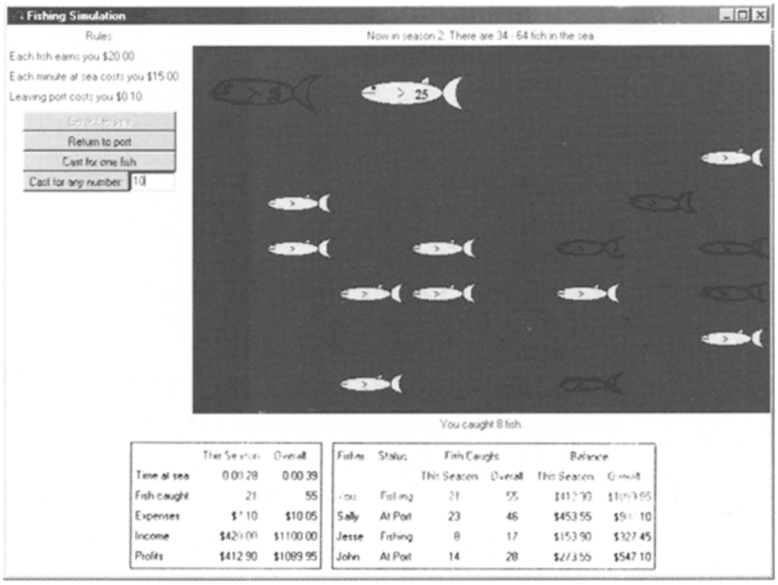
Each fisher has equal and full access to the resource. Their harvests and identities may (or may not) be displayed to other harvesters. Payoffs can be arranged so that a relatively large, quick profit may be made (which tends to exhaust the resource) or a larger, albeit slower growing profit may be made (when harvesters use restraint and allow the resource to regenerate).

In FISH 3, both text and graphics support the metaphor of ocean fishing. An introductory window (Figure 1) describes the simulation so that it is possible for participants to use it without experimenter instruction.

The fishers individually set out to fish, cast for fish (one, or any number), and return to port. Resource regeneration occurs through the periodic spawning of any fish that remain after a season of fishing. Any number of seasons can be run. Fishers are paid for each fish they catch and charged for the time they spend fishing, as an analogue to operating costs.

FISH 3 can be run with all human fishers (1, for demonstration or teaching purposes, or any number), or with 1 human fisher and any number of computer fishers. It is written in Java 1.1 and is portable to any Java-enabled platform. FISH 3 supports a fully networked and interactive environment. It connects any mixture of Java-enabled computers with Internet access, using the Internet for communication between computers. Any number of oceans can be managed by one server program, and any number of participants on computers with Internet access can share these oceans, either with other human fishers or with computer fishers, and fish in real time. The FISH 3 manual (http://web.uvic.ca/~rgifford/fish/) explains how to specify these options in the configuration files.

A typical setup template file in which the experimenter chooses options for each of FISH 3's parameters is shown in Appendix A. Figure 2 shows a screen shot that depicts a typical scene during a FISH 3 session. The dark



Rules:

Each fish earns you $20 00

Each minute at sea costs you $15 00

Leaving port costs you $0 10

Now in season 2 There are 34 - 64 fish in the sea

You caught 8 fish

| | This Season | Overall |
|---|---|---|
| Time at sea | 0 00 28 | 0 00 39 |
| Fish caught | 21 | 55 |
| Expenses | $7 10 | $10 05 |
| Income | $420 00 | $1100 00 |
| Profits | $412 90 | $1089 95 |

| Fisher | Status | Fish Caught | | Balance | |
|---|---|---|---|---|---|
| | | This Season | Overall | This Season | Overall |
| You | Fishing | 21 | 55 | $412 90 | $1089 95 |
| Sally | At Port | 23 | 46 | $453 55 | [illegible] |
| Jesse | Fishing | 8 | 17 | $153 90 | $327 45 |
| John | At Port | 14 | 28 | $273 55 | $547 10 |

**Figure 2. A screen shot from the middle of a simulation. The simulation itself is in color. The "uncertain" fish are shown as outlines of fish that are of the same color as the background's. The larger fish with numbers on them (e.g., 25 or 50) represent that many fish. They are used to avoid clutter on the screen when a large number of fish are used, and they "make change" into individual fish when necessary.**

fish are known (to the fishers) to exist; the outlined fish (an optional parameter) represent uncertainty in the fish stock: From the fishers' perspective, they may or may not actually be in the ocean.

Each fishing season ends when all fishers choose to return to port (i.e., have caught as many fish as they wish). Fishers, therefore, are able to exhaust the resource within one season if they so choose. If that happens, the simulation ends. If all the fishers return to port without harvesting all the fish, spawning will occur (at any rate set by the experimenter) and they may return to fish for another season.

FISH 3 is economically realistic. For example, fishers may vary in their initial wealth. They may pay a fee to leave port (if the experimenter chooses). They may be paying on a loan for their boat. They may pay operating costs (e.g., for labor and fuel). They receive payment for each fish caught, at any rate the experimenter chooses. The number of fishers in a fleet, the original size of the fish stock, and the degree of knowledge about other fishers and their harvesting behavior can be varied.

## FISH 3 Variables

The greed of the programmed (computer) fishers can range from 0 to 1, where 0 causes them to take no fish, .5 causes them to take fish at an exactly sustainable rate, and 1 causes them to take every fish possible. Of course, other parameters that are not part of the program itself may also be varied, such as whether communication is permitted, whether persuasive attempts are made, and which personal and group characteristics of fishers are examined.

Specifically, FISH 3 allows the study's investigator to define

- the size of the fish stock (the maximum is several hundred),
- the number of seasons (replenishment trials) for the simulation (no maximum),
- the regeneration rate of the fish stock,
- the greediness of computer fishers,
- the uncertainty in the fish stock,
- the probability that a cast will be successful (from 0–1),
- which information is displayed about the other fishers,
- the profits and expenses of fishing,
- the initial balances of all fishers (i.e., wealth at the start of the simulation), and
- the messages that appear as instructions before the simulation begins and the messages that are shown after the simulation ends.

## Output

FISH 3 automatically collects, aggregates, and stores information about each fisher's harvests each season in ASCII format. These data include time spent fishing, number of casts, fish caught, costs, and profits for each fisher and fleet (group).

FISH 3 also computes four different cooperation formulae that measure both harvest restraint and harvest efficiency at both the individual and group levels for each season and over all seasons. The restraint measures are simple indices of the proportion of the fish population taken by individuals or groups. The efficiency measures consider regeneration rates, and are more like measures of sustainable harvesting practices (for details, see Gifford & Hine, 1997b). Data can be translated from the ASCII file into SPSS and most other statistical packages.

Appendix B shows typical results from a FISH 3 session in which there was 1 human fisher and 3 computer fishers; the harvest data for the computer fishers are not displayed because the fishers harvested at a known (programmed) rate, which is called their "greed level."

### Hardware and Software

FISH 3 was written in Java 1.1. It is available in two distribution formats, one for the Sun-Java environment and one for the Microsoft environment.

The program can run on any stand-alone machine, with other fishers simulated by the program. To study groups, each fisher requires his/her own computer, typically running Microsoft's Windows or the Apple operating system. Most current research programs on resource management that focus on the responses of small-to-medium groups to simulated social dilemmas and that vary any of the parameters mentioned earlier could use FISH 3. The program is very flexible in terms of allowing many combinations of conditions to be examined.

### Availability

FISH 3 may be viewed in more detail, including a quick manual, a full manual, and screen shots, at http://web.uvic.ca/~rgifford/fish/. A zipped copy of FISH 3 may be obtained at no charge by writing or e-mailing R.G. at rgifford@uvic.ca.

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*(Continued on next page)*

## APPENDIX A
## A Sample Setup File for FISH 3

```
fishValue=2000
costPerSecond=25
costPerDeparture=0
maxRealFish=300
maxMysteryFish=30
maxNumberOfSeasons=5
chanceOfCatch=1.0
allowMultipleCasts=y
spawnFactor=2.
showEachFisher=y
showNames=y
showStatus=y
showNCaught=y
showBalance=y
name1=Eva
initialBalance1=500
name2=Sally
greediness2=.3
initialBalance2=3000
name3=Jesse
greediness3=.5
initialBalance3=0
name4=John
greediness4=.4
initialBalance4=4000
```

## APPENDIX B
## Output for a Sample Session

**Table B1**
**FISH 3 Simulation Summary: Mon May 31 22:00:08 PDT 1999**

| Fisher | Group | Season | NFInit | FTaken | Profit | IR | GR | IE | GE |
|---|---|---|---|---|---|---|---|---|---|
| Eva | | | | | | | | | |
| | 1 | 1 | 300 | 30 | $590.75 | 0.6 | 0.6 | 0.909 | 0.833 |
| | | 2 | 300 | 60 | $1,195.50 | 0.2 | 0.5 | 0.7 | 1. |
| | | 3 | 300 | 80 | $1,596.00 | −0.067 | 0.433 | 0.433 | 0.867 |
| | | 4 | 260 | 30 | $598.75 | 0.538 | 0.585 | 0.967 | 0.987 |
| | | 5 | 300 | 100 | $1998.50 | −0.333 | 0.367 | 0.167 | 0.733 |

Note—Eva was the sole human fisher in a simulation that included 3 computer fishers programmed to fish with defined levels of greed. NFInit, total number of fish available at the start of the season. FTaken, number Eva took during the season. Profit is based the value of the fish taken minus capital and operating costs. IR, GR, IE, and GE are the four cooperation indices: individual restraint, group restraint, individual efficiency, and group efficiency (see text for some details, and Gifford & Hine, 1997b, for full computational details).

(Manuscript received June 9, 1999;
revision accepted for publication May 28, 2000.)