A brief history of Fishbanks…

Paper version invented by Dennis Meadows, former MIT Sloan Professor of System Dynamics, 1986

Online version developed by MIT Sloan and Forio, deployed through LearningEdge, 2010

Translations in beta test for Chinese, Spanish, Portuguese, with funding from Gustavo Pierini, 2014

Deployment in universities and training programs around the world, including MIT Sloan S-Lab, L-Lab, ExecEd
Fishbanks

• Intro (almost over)
• Fishbanks!
• Results and Discussion

Winslow Homer, The Herring Net

Fishbanks game by originally developed by Prof. Dennis Meadows. Web version developed by Prof. John Sterman, MIT Sloan School of Management, with help from Prof. Andrew King, Tuck School of Business, Dennis Meadows, Keith Eubanks, and Forio.com.
Your Goal
Maximize your Net Worth at the end of the game.

Net Worth = Bank Balance $ + Value of Fleet

The winner is the team with the highest Net Worth at game end.
Profit

Profit = Income – Expenses

- FISH SALES
- HARBOR & OPERATING COSTS
- NEW SHIP ORDERS
- INTEREST EARNINGS
- SHIP PURCHASES
- INTEREST CHARGES

Profit = Income – Expenses

Income includes:
- Fish sales
- New ship orders
- Interest earnings

Expenses include:
- Harbor & operating costs
- Ship purchases
- Interest charges

Profit = (Fish sales + New ship orders + Interest earnings) - (Harbor & operating costs + Ship purchases + Interest charges)
Income

Fish Sales
Catch x Price ($20 per fish)

Interest Earnings
2%/year if Minimum Bank Balance is greater than zero

Ship Sales
Price set by auction
Expenses

Harbor & Operating Costs
- Harbor: $50/year per ship
- Coastal Fishery: $150/year per ship
- Deep Sea Fishery: $250/year per ship

New Ships: $300 each. Charged at end of current year. Delivered the following year.

Ship Purchases
Buy a ship at auction. Cost: your winning bid per ship * number bought

Interest Charges
5%/yr if Minimum Bank Balance is less than zero.
You start the year with a bank balance that has accumulated through all past years. If you buy ships at auction or from other teams, the cost is subtracted. You are then charged for the operating costs of your fleet. Your fish catch is calculated and you are credited with the sales income. Finally, your account is charged for the cost of any new ships you ordered at the beginning of the year. The minimum balance is calculated and your account is adjusted by the appropriate interest.
Fishing Fleet

• Initial Fleet = 3 Ships/team

• Fleet Growth
  - Purchase from other teams via auctions
  - Order new ships

• Fleet Reduction
  - Sales to other teams via auctions
Ordering New Ships

Each year you may order the construction of new ships.

The maximum order is half of your current fleet (initial fleet + auction purchases).

If total fleet is an odd number, your maximum order is rounded up to the next whole number.
Catch

Catch influenced by:

Number of Ships, Ship Effectiveness, Weather
Ship Effectiveness

SHIP EFFECTIVENESS (FISH PER SHIP PER YEAR)

FISH DENSITY

DEEP SEA

COASTAL

MAXIMUM
Recent History of the Fisheries

YEAR

CATCH

SHIPS

PRESENT
FishBanks

- Two oceans: Atlantic, Pacific
- 5 teams in each ocean, 2-3 people per team
- The oceans are separate
- Fish do not move between oceans
- Ships do not move between oceans
- Conditions identical except for your decisions
Let’s Go Fishing

Winslow Homer, Fishing Boats, Key West (1903)
Login

• 1 Laptop per team  
  (put all others away please)

• Go to: http://bit.ly/fishbanks

• Login with the user name and password we hand out

• STOP – wait for instructions
Please Wait
Welcome to the Fishbanks Simulation

Student
- Play as individual
- Play as part of a class

Administrators
- Set up a new class
- Register as an administrator
- Administer an existing class
Fishing Areas

Deep Sea

- Maximum Population: 2000 - 4000 Fish
- Annual Operating Cost: $250 per Ship-Year
- Productivity (Max Ship Effectiveness): 25 (Fish/year)/ship

Coast

- Maximum Population: 1000 - 2000 Fish
- Annual Operating Cost: $150 per Ship-Year
- Productivity (Max Ship Effectiveness): 15 (Fish/year)/Ship
# Profit Example

## 1 Ship to Deep Sea

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Sales = 25 X $20</td>
<td>$500</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>- $250</td>
</tr>
<tr>
<td><strong>Deep Sea Subtotal</strong></td>
<td><strong>$250</strong></td>
</tr>
</tbody>
</table>

## 1 Ship to Coastal

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Sales = 15 X $20</td>
<td>$300</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>- $150</td>
</tr>
<tr>
<td><strong>Coastal Subtotal</strong></td>
<td><strong>$150</strong></td>
</tr>
</tbody>
</table>

## 1 Ship to Harbor

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbor Cost</td>
<td>- $50</td>
</tr>
</tbody>
</table>

**Profit** $350
Regeneration of Fish

Approximately 550 new fish per year

Deep Sea

Coastal

New Fish Per Year

0

0

Fish

Max
Develop your Strategy

1. Your goal is to end the game with the maximum possible assets.

2. Discuss within your team what strategies for boat acquisition and allocation you will follow to attain this.

3. Write your strategy down.
YEAR 1 Make decisions for current year

Buy

SOLD

NUMBER OF SHIPS

RESERVE PRICE ($/SHIP)

Sell

No. of Ships:

Reserve Price:

Make offer

CURRENT TOTAL FLEET 3

HARBOR COAST DEEP

Ship Market Value ($/Ship) 300
Number of Ships (Ships) 3
Value of Ships ($) 900
Bank Balance ($) 600
Total Assets ($) 1,500

Expected Catch per Ship (Fish/Year/Ship)

<table>
<thead>
<tr>
<th></th>
<th>Harbor</th>
<th>Coast</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>0</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

Price of Fish ($/Fish)

<table>
<thead>
<tr>
<th></th>
<th>Harbor</th>
<th>Coast</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Expected Revenue per Ship ($/Year/Ship)

<table>
<thead>
<tr>
<th></th>
<th>Harbor</th>
<th>Coast</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reven</td>
<td>0</td>
<td>300</td>
<td>500</td>
</tr>
</tbody>
</table>

Operating Cost per Ship ($/Year/Ship)

<table>
<thead>
<tr>
<th></th>
<th>Harbor</th>
<th>Coast</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>80</td>
<td>150</td>
<td>250</td>
</tr>
</tbody>
</table>

Expected Profit per Ship ($/Year/Ship)

<table>
<thead>
<tr>
<th></th>
<th>Harbor</th>
<th>Coast</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit</td>
<td>-50</td>
<td>150</td>
<td>250</td>
</tr>
</tbody>
</table>
YEAR 1
Make decisions for current year

HARBOR
COAST
DEEP

Ship Market Value ($ / Ship) 300
Number of Ships (Ships) 3
Value of Ships ($) 900
Bank Balance ($) 600
Total Assets ($) 1,500

Expected Catch per Ship (Fish / Year / Ship)
Harbor 0
Coast 15
Deep 25
Price of Fish ($ / Fish)
Harbor 20
Coast 20
Deep 20
Expected Revenue per Ship ($ / Year / Ship)
Harbor 0
Coast 300
Deep 500
Operating Cost per Ship ($ / Year / Ship)
Harbor 50
Coast 150
Deep 250
Expected Profit per Ship ($ / Year / Ship)
Harbor -50
Coast 150
Deep 250

SHIP ALLOCATION
HARBOR

Maximum Ship Orders:
No. of Ships:
Harbor 3
Coast 0
Deep 0
Total

SHIP ORDERS

Ready for next year?

• http://forio.com/simulate/mit/fishbanks
Reflection questions

• What did you do in the game?
  – How does this compare to the strategy you articulated in the beginning?

• What did you actually observe others doing through the game?
  – What did you hear them saying? What stood out for you?

• What were you thinking in the process?
  – What were your pre-existing assumptions about the situation?
  – What was your internal narrative about what was happening?

• What were you feeling through the process?
  – How did that change through different phases of the game?

• What do these actions, thoughts, and feelings remind you of?
  – Where else have you seen similar situations in your life and work?
DATA DEBRIEF – WHAT HAPPENED?
CONCEPTUAL DEBRIEF – WHAT CAN WE LEARN?
The Iceberg
A Metaphor for Systems Thinking
Event level: the Headlines

Fishing banned at Georges Bank
Local fishermen fear overcrowding

Limits may follow as cod diminishes in Gulf of Maine

Hearing casts fishery as sinking ship

Codfish depleted off Maine
Restrictions could hurt local fishermen

Loopholes found in fishing rules

Lobstermen snag record 38m pounds

N.E. lawmakers seek boat buyback ideas

Canada’s Gunboat Diplomacy
Chrétien to protect Atlantic fish stocks

Feds approve boat buyback program
Hope to thin fishing fleet with $2m in incentives
The Iceberg
A Metaphor for Systems Thinking
Typical Game Behavior - Fleet

YEAR

SHIPS

TOTAL FLEET

0 1 2 3 4 5 6 7

0 10 20 30 40 50 60 70 80
Typical Game Behavior - Catch

Fish per Year

Deep Sea Catch

Coastal Catch

YEAR
Typical Game Behavior - Fish Stocks

![Graph showing fish stocks over years for Deep Sea and Coastal areas. The graph indicates a decrease in fish stocks over time.]
Pattern #1: Overshoot and Collapse

Atlantic Swordfish Catch

Pacific Bluefin Tuna Catch
North Sea Herring Catch

Consider the Cod

• Northern or Atlantic Cod
  – Long-lived, slow to mature
  – Once immensely abundant
    • Early fishers (e.g., Basque) claimed fish so dense you could walk from Spain to the New World on their backs.
    • John Cabot, exploring Newfoundland in 1497, noted fish so thick they practically blocked his ship.
  – Harvest ≈ 250,000 metric tons/yr through 1950s
  – Vital in feeding the Old World, in the development of the New World, …and of Massachusetts:
The Sacred Cod
Massachusetts State House
Prevailing Mental Model: Unlimited Abundance

“Probably all the great fisheries are inexhaustible; that is to say that nothing we do seriously affects the number of fish.”

– Thomas Henry Huxley, 1883
US Atlantic Cod Commercial Landings
(Metric Tons/Year)

Source: US National Marine Fisheries Service

http://www.st.nmfs.gov/pls/webpls/MF_ANNUAL_LANDINGS.RESULTS
Estimated Cod Stocks, Scotian Shelf (000 Metric Tons)

Rosenberg et al., Frontiers in Ecology, 2005
Overshoot and Collapse

Why the pervasive pattern of overshoot and collapse of fisheries?

Time

Annual fish catch

Where are the leverage points for creating a sustainable fishery?

Where are they not?
The Iceberg
A Metaphor for Systems Thinking

Events
Patterns of Behavior
Systemic Structure

More Leverage
Understanding system structure

From a *system dynamics perspective*, what elements of structure did you notice?

- Stocks and flows
- Feedback loops

What did you notice about...

- Habits of thought
- Habits of action
- Artifacts
System structure

Desired Income → Gap → Meeting Needs → Individual Exploitation Effort → Desired Income

Individual Income

B
System structure

Desired Income

\[ R \]

\textit{Keeping Up With the Jones’}

\textbf{B}

\textit{Meeting Needs}

Individual Income

Individual Exploitation Effort

Neighbor and Average Income

\( + \)

\( + \)

\( - \)
System structure

- Desired Income
- Neighbor and Average Income
- Individual Income
- Resource
- Regeneration rate
- Depletion rate
- Resource Instability
- Meeting Needs
- Individual Exploitation Effort
- Keeping Up With the Jones'
- Resource Sufficiency
- Desired Income Gap
“Common Pool Resources”

- Limited Stock
- Limited Rate of Renewal
- Easily Appropriable (Low barriers to access)
- Rival (What you use, I can’t use)

EXAMPLES:
- Pastures
- Fish
- Forests
- Irrigation
- Clean Air & Water
- Climate
- Roads and Highways
- Parking Spaces
- Views
- Server Resources
- Trust among consumers
1. **Renewable resources**
can be used no faster than they regenerate.

2. **Pollution and wastes**
can be emitted no faster than natural systems can absorb them, recycle them, or render them harmless.

3. **Nonrenewable resources**
can be used no faster than renewable substitutes can be introduced.

Source: Herman Daly (e.g., H. Daly (1990) *Ecological Economics* 2, 1).
“The Tragedy of The Commons”

G. Hardin, 1915-2003

Photo: 1986
The Tragedy of the Commons

“Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest…”

“No technical solution can rescue us….”

“We may well call it ‘the tragedy of the commons,’ using the word ‘tragedy’ as the philosopher Whitehead used it: ‘The essence of dramatic tragedy is not unhappiness. It resides in the solemnity of the remorseless working of things.’
System structure

Desired Income

Keeping Up With the Jones'

Neighbor and Average Income

Individual Income

Meeting Needs

Resource Sufficiency

Resource Instability

Regeneration rate

Depletion rate

Individual Exploitation Effort

Resource

+ Desired Income

- Gap

+ Individual Income

- B

+ Meeting Needs

+ B

+ Resource Sufficiency

- Resource Instability

+ Regeneration rate

- Depletion rate
Rule-Base for Alanya

- List of eligible fishers each September
- List all usable fishing spots
- Assign spots by lottery – one per fisher
- September – January: Each day each fisher moves east to next spot
- January – May: Each day each fisher moves west to next spot
Collective Action

Elinor Ostrom: Winner, 2009 Nobel Memorial Prize in Economic Sciences
Design Principles for “Governing the Commons”

• Individuals know the boundaries and limits
  – Of the resource (“Common Pool Resource”)
  – Of the community of users (“Appropriators”)
• Rules are locally made and adapted to context
• Decisions are made together
• Active measurement and monitoring
• Effective, graduated sanctions
• Accessible mechanisms for conflict resolution
• Latitude from higher authorities to act locally

Leadership question: how do we enroll and mobilize people to create these conditions?
Where do you have agency?