

QUOTA: From Experimental Computer Game to Fishery Management Education Tool

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**Quota**, a computer-based simulation game, originated as an experimental game for testing alternative multi-resource management regimes or systems. Highly flexible, it allows specification for a standard common-property, open-access fishery with user-specified bio-economic fishery growth model and multiple sized producers with individual harvest and cost functions. In addition to demonstrating overfishing under open-access, various forms of Property Rights Systems can be implemented, including the setting of an overall Total Allowable Catch (TAC) and further allocation of the TAC to individual producers -- Individual Quota Rights (IQR) -- that may be based on historical catch during initial periods of Open Access fishing or equal shares or shares determined by bargaining amongst the players (producers). Subsequent trading of IQRs is also implemented using a highly developed computerized trading game. Recent use of the game have been as an educational tool in university classes on resource economics and in the field at meetings of Regional Fishing Management Organizations that govern the major tuna fisheries around the world.





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QUOTA: From Experimental Computer  
Game to Fishery Management  
Education Tool

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# I. Quota: An Educational Tool



Winslow Homer: The Herring Net, 1885



# Purpose of the game - Quota : I

To make Rights Based Management (RBM) easier to understand and appreciated by demonstrating the following points.

1. *Open access leads to over-exploitation of fish stocks, even if initially there is no apparent excess capacity in the fishery,*
2. *Fish stocks can be rebuilt* to optimal and sustainable levels by limiting the total catch AND allocating the harvest to individuals (vessels or states).

# Purpose of the game - Quota : II

- 3. *Access to fishing can be guaranteed* to nations, communities, or individuals by defining appropriate RBM rules for the distribution and transfer of the rights to fish.**
- 4. *Alternative distributions fishery rents, incomes, or profits can be achieved* by different allocations of harvest rights.**

# Purpose of the game - Quota : III

- 5. *Total Value of the fishery can be maximized* by the trading of individual harvest rights.**
- 6. *Permanent access to fish by any nation, community, or individual can be ensured* by limiting the trading of harvest rights.**



# Target Audiences for Quota

1. **Fishery Managers** (e.g. RFMO governing bodies & Government officials)
2. **Industry participants** (e.g. boat owners, captains, processors, retail buyers, fishing communities, etc.)
3. **Other stake-holders** (e.g. conservation NGOs, general public)
4. **Education** (e.g. college students, others)



# III. The 'Quota' Fishery Model

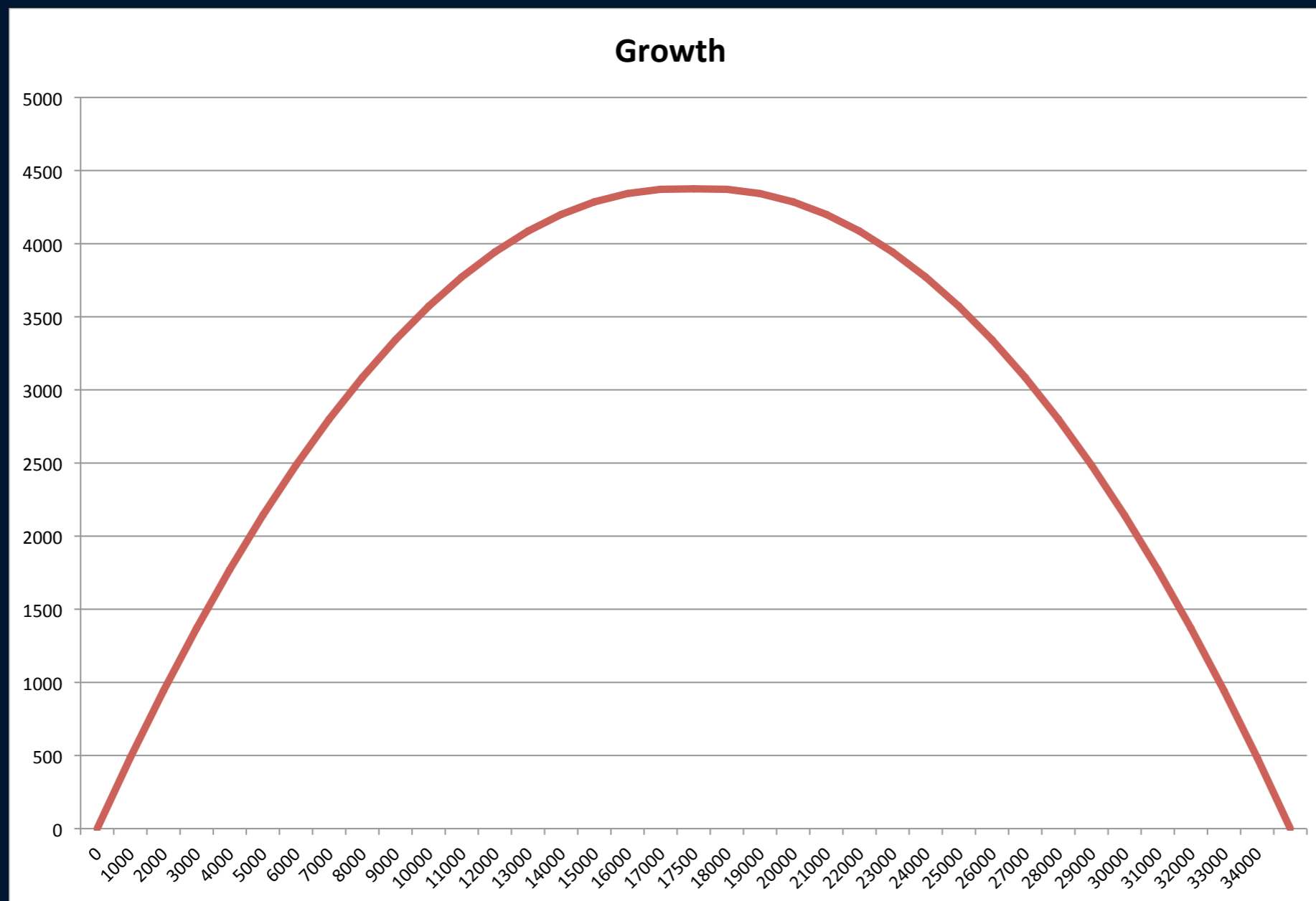


Winslow Homer: The Gulf Stream, 1899



# Maximum Sustainable Yield (MSY)

- The *Stock* of fish grows between each period.
- *Maximum Sustainable Yield (MSY)* = 4,375 at a stock level of 17,500 (for this example).





# The Fishing Technology: I

- Fishing fleet has  $N$  boats
- 3 types of boats: Large, Medium and Small
- $N/3$  boats of each type,  
where size is given by *capacity*
  - Large boats: Capacity = 400 fish units
  - Medium boats: Capacity = 250 fish units
  - Small boats: Capacity = 100 fish units



# The Fishing Technology: II

- **Profit** = (price) \*(catch) – (cost of fishing)
  - **Price** = monetary units/fish unit (e.g. 3 euros/)kilo
  - **Catch** = (boat-specific harvest rate)\*(effort)\*(stock)
  - **Cost** = (capacity specific fixed cost) + (quadratic function of effort, with boat-specific parameters)
    - ▶ i.e. it is increasingly expensive to further increase effort, including time spent fishing, gear used, fuel consumed, and other variable inputs.

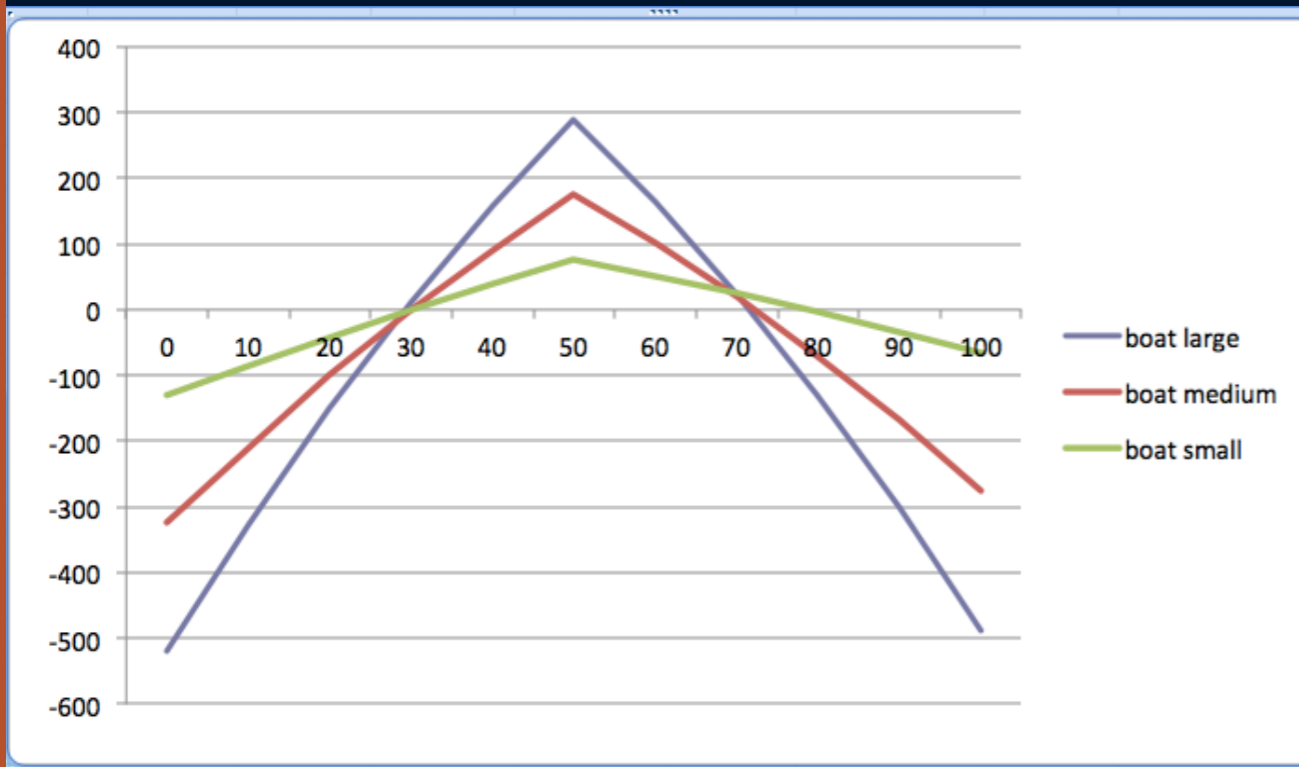


# The Fishing Technology: III

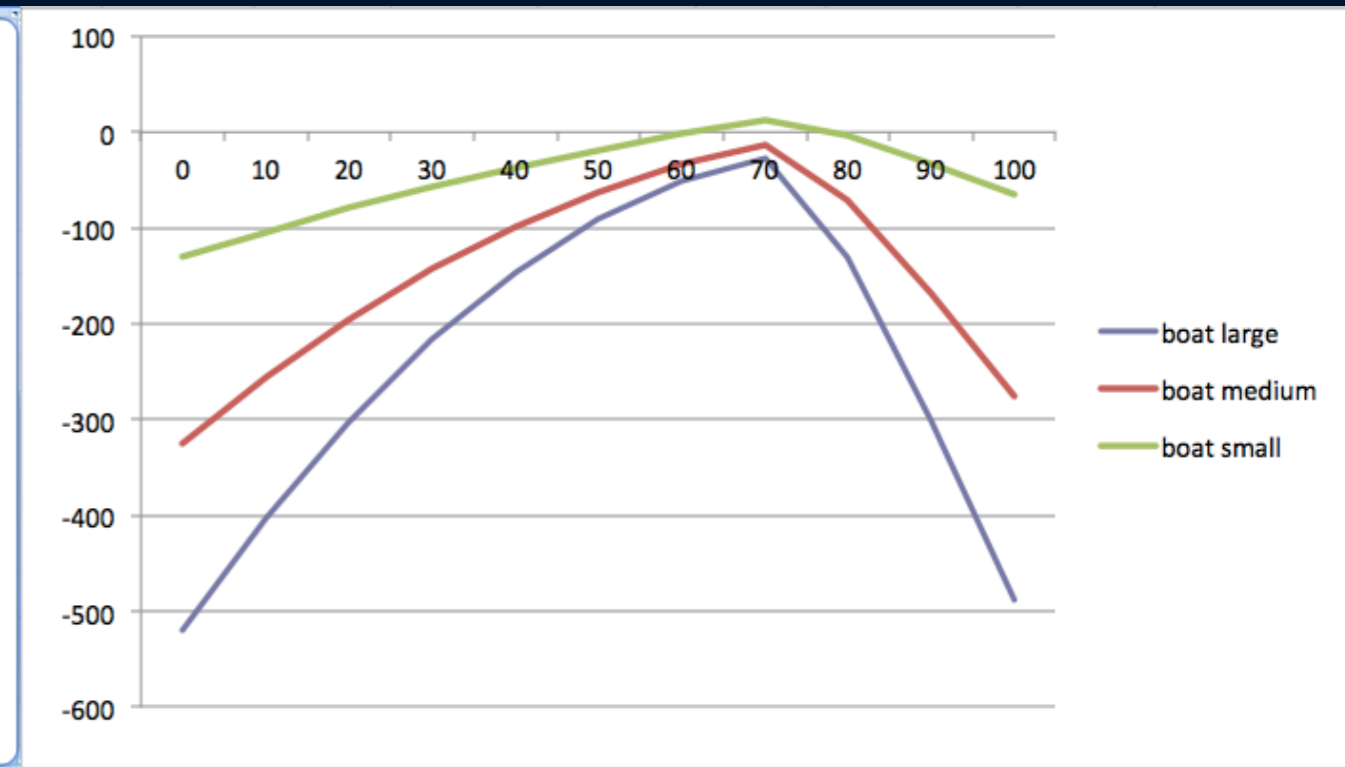
- **Effort:**
  - The percent of the *maximum fishing activity* that a boat can deploy -- a number between 0 and 100, where 50 represents a “normal” level of effort.
  - Effort may also be interpreted as *Fishing Days*, where 100 represents fishing the maximum number of days that can possibly be fished in a season.

# Profit Functions (examples)

stock size = 12,500



stock size = 8548



Note: Different Vertical (Profit) Scales. Graphs show how profit possibilities depend on the stock.



# IV. Quota: Management Regimes



Winslow Homer: Fishing Boats, Key West, 1903



# Fishery Management Regimes

- **Open Access vs. Rights Based Management (RBM)**
  - Open Access - competitive fishery
  - RBM based on setting a Total Allowable Catch (TAC) followed by an allocation of quota to individual boats



# V. Two Quota Games



Winslow Homer: The Herring Net, 1885



# Two TAC Allocation Games: I

1. **Games of T periods:** T1 periods of *Open Access* followed by T2 periods of an *allocated TAC*.
2. Two different basic schemes for allocating the TAC are implemented in the quota games



# Two TAC Allocation Games: II

3. In one game, the TAC is allocated based on the *Historical Catch* of each boat, that is, the fraction of total catch during the periods of Open Access that each boat harvested.

Text

4. In the other game, the TAC is allocated equally to every boat, that is, each boat is given a Quota of  $1/N$  of the TAC, where  $N$  is the number of boats in the fishery.

- ▶ Note: Although not implemented in Quota yet, allocated quotas may be subsequently traded in a market for trading quota shares.

# Open Access Screen

**Quota**  
presented by the ISSF

PERIOD 1 HAS STARTED



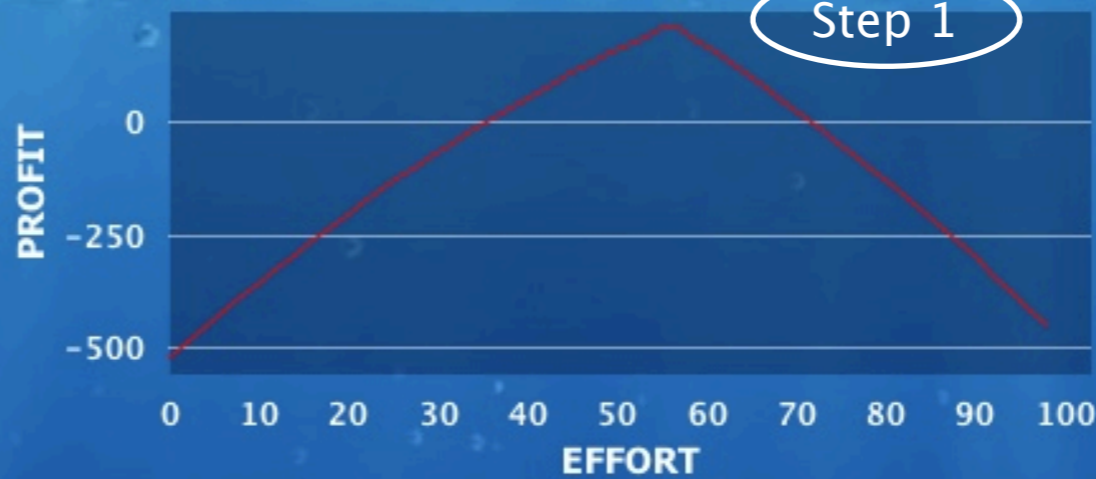
Countdown timer

OPEN ACCESS

Period	1
CATCH	
TOTAL CATCH	
QUOTA	
PROFIT	
ENDING STOCK	



<b>Producer</b>	
CAPACITY	TOTAL PROFIT
400	0 €
<b>Tuna</b>	
CURRENT STOCK	2226



**HOW MUCH EFFORT**  
WOULD YOU LIKE TO PUT IN?

Slider control with a yellow knob positioned at 63.

63

Step 2

Submit

Step 3

Step 4



# TAC Allocation Screen

**Quota**  
presented by the ISSF

PERIOD 3 HAS STARTED



OPEN ACCESS    OPEN ACCESS

Period	1	2	3
CATCH	0	0	
TOTAL CATCH	0	0	
QUOTA	N/A	N/A	
PROFIT	0 €	0 €	
ENDING STOCK	2226	2843	



**Producer**

<b>CAPACITY</b> 400	<b>TOTAL PROFIT</b> 0 €
<b>QUOTA</b> 100 % OF TAC	<b>INCURRED PENALTY</b> 0

**Tuna**

<b>MY ALLOWABLE CATCH</b>	<b>696</b>
<b>TOTAL ALLOWABLE CATCH</b>	696
<b>TOTAL STOCK</b>	3456

**Minimum Effort Calculator**

NUMBER OF FISH TO CATCH

400

MINIMUM EFFORT REQUIRED

**36**



**HOW MUCH EFFORT WOULD YOU LIKE TO PUT IN?**

▼ **36** ▲

Step 3

**Submit**

Step 4

Step 1



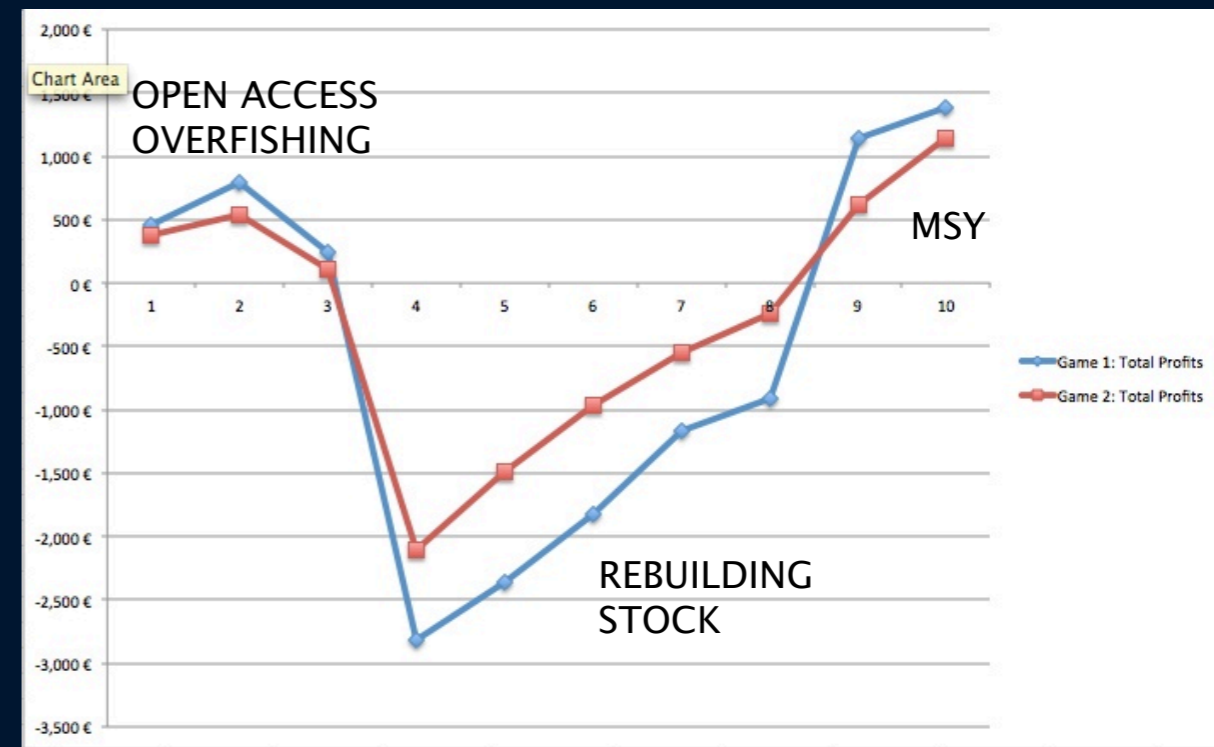
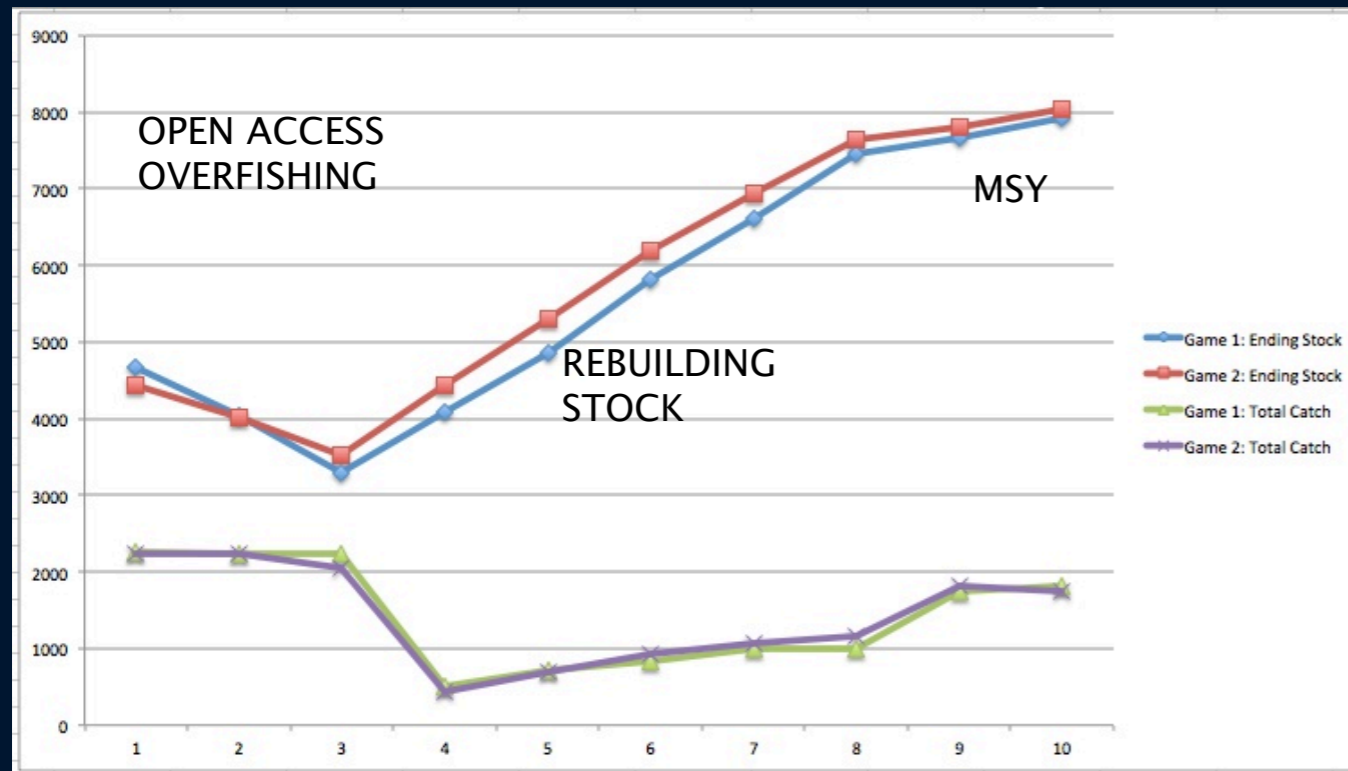
# VI. Interpreting the Results



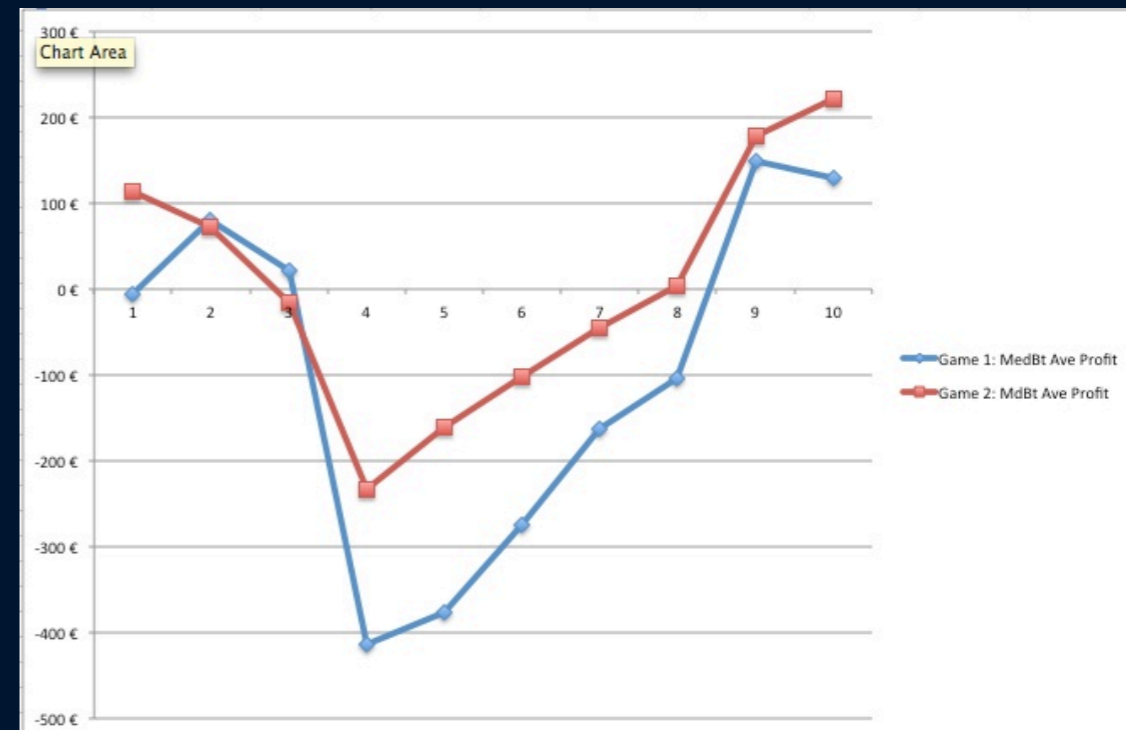
Winslow Homer: Lost on the Grand Banks



# Examples of Game Outcomes: I



# Game Examples: III





# Interpretation: I

- During *Open Access* periods the total stock of fish declined and so did profits. Continued open access fishing causes a collapse of the fishery and the loss of all income from fishing.
- Introducing a TAC and a rule for adjusting the TAC to re-build stocks to the desired level was *successful* when the TAC was enforced. Total fishery income increased to close to the maximum.

# Interpretation: II

- Enforcement of the TAC was accomplished by granting an *Individual Allowable Catch* (or, a *Quota*) to each boat and assessing a *penalty* for fishing beyond one's allowed catch.



# Interpretation: III

- In Game 2, (under equal allocation), the small boats could not profitably fish all their quotas, even as stocks were rebuilt, thus some of the TAC was left unharvested.

# Interpretation: IV

- Because not all the TAC was harvested in later periods in Game 2, total industry profits could (potentially) be increased.
- However, if the small boats could *sell* or *lease* their *unfished* quota to large boats, both sized boats would benefit and total industry profits would be higher than in Game 2.  
(This point will be demonstrated in a future version of the Quota Game in which the opportunity to trade quota rights is added to the game.)



# Future Development Plans

- Trading of Quota (currently under development)
- Bargaining over Management Regime
  - when to begin limiting catch (imposing TAC)
  - what level to set TAC and how fast to rebuild stocks
  - what distribution of TAC to implement, including the rules for trading of quota shares
- Multiple species fisheries and by-catch
- Spatial Management (time & area closures)
- Capacity management (entry/exit; buyback of existing capacity - an auction game)



# Thank you!

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**All Game Participants**

Winslow Homer: Inside the Bar, 1883