Renewable, Open-Access Resources: Basic Economics of the Fishery

Prof. Richard Sweeney
Econ 2277.01

Adapted from:
Harvard API-135/Econ 1661
Professor Robert Stavins

Renewable, Open-Access

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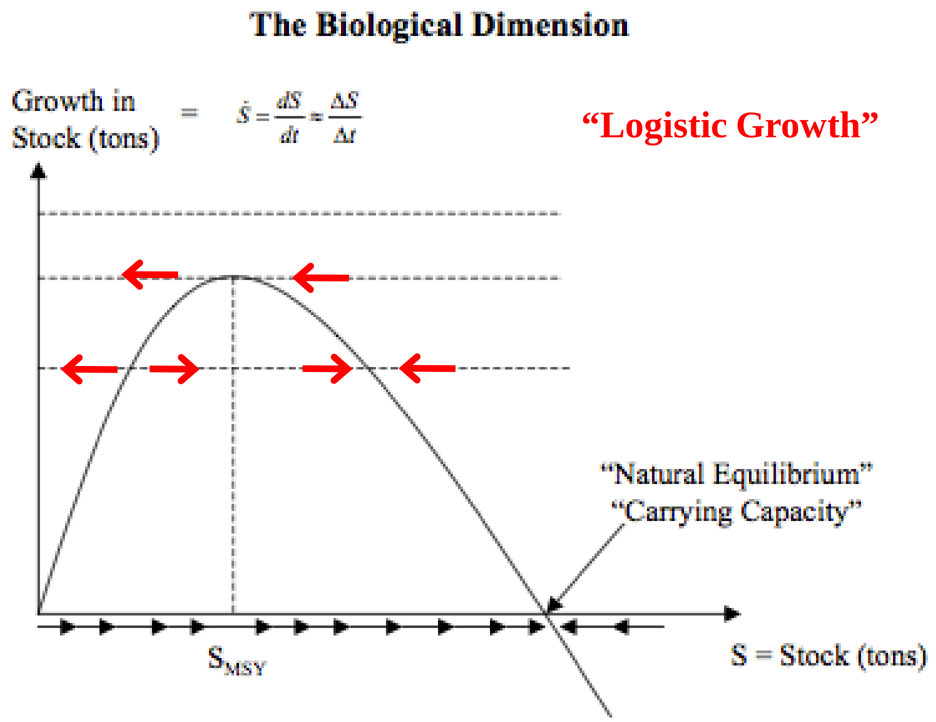
Introduction

- **Renewable Resources: Three Fundamental Questions**
  1. What's the efficient rate of use (harvest, rather than extraction) of renewable resources?
  2. Can the market be relied upon to achieve and sustain this rate?
  3. If not, what can be done about it (by government)?

- **Fisheries** are an example of biological, **open-access** resources

Basic Fishery Biology

- Gordon-Schaefer model of fishery
- Harvest level H_1 results in *extinction*
- Harvest level H_2 results in *MSY* & S_{MSY}
- Harvest level H_3 has *two* potential equilibria; only one is *efficient*, and only one is *stable* (the one on the right)
  - Species can be *saved* from extinction, e.g., if fishing ceases.
- Some species exhibit different biological growth function … *critical depensation*
  - If stock falls below MVP, cessation of harvesting will not be sufficient to save species from extinction
- Next, what level of harvest is efficient?



Efficient Sustainable Yield

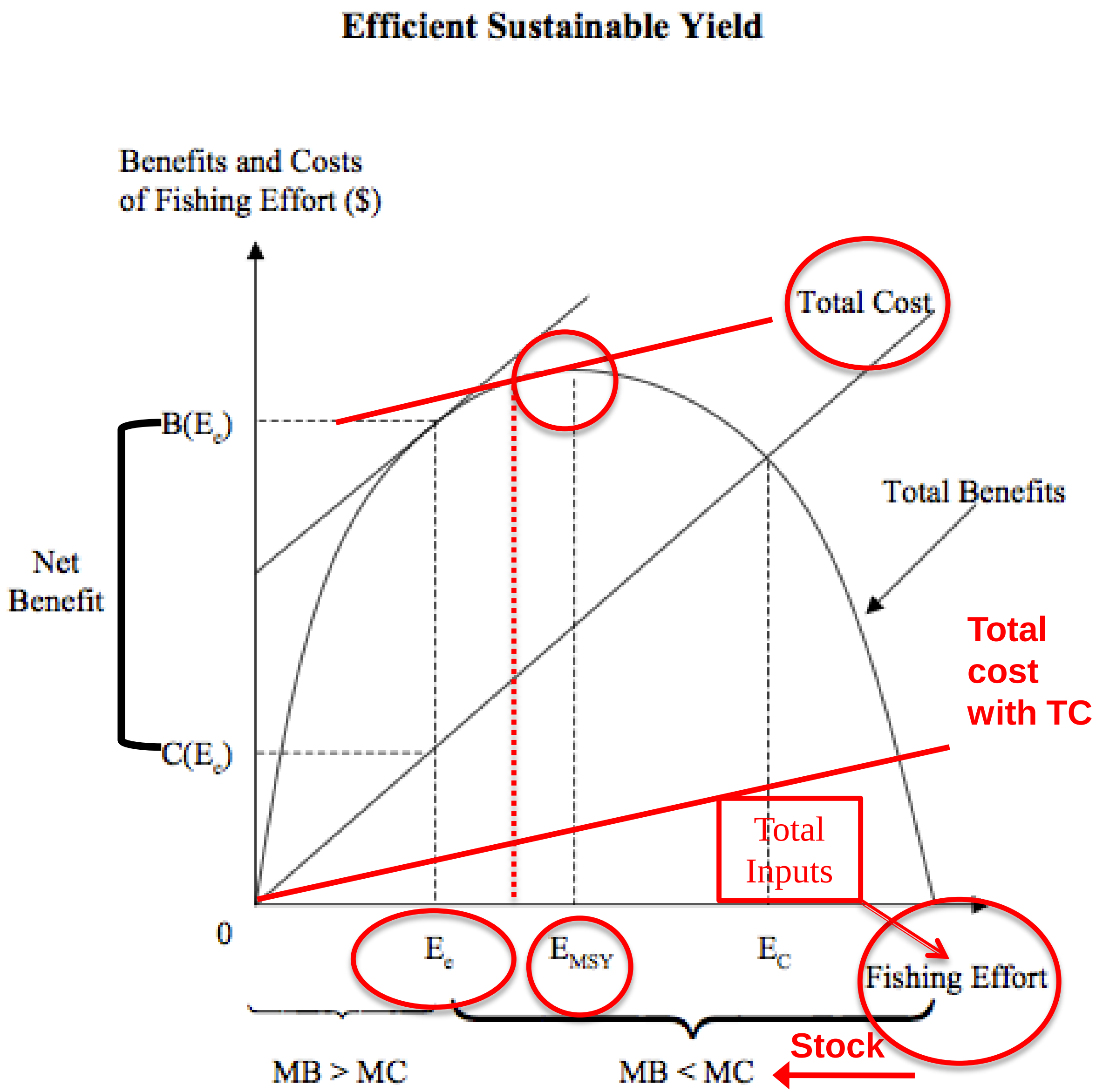
- **Simple model** to obtain fundamental insights – *put aside discounting*
  - Examine "static efficient sustainable yield," instead of "dynamically efficient sustainable yield" – *fundamental results & insights are the same*

- **Definition**: (static) efficient sustainable yield is that rate of harvest that *perpetually produces the greatest annual net benefit*.

- **Three assumptions** so that *simple graphical analysis* can be used (fundamental results are robust to these assumptions):

1. Fish **price** is *constant*, not a function of the quantity sold (perfectly elastic demand)
2. **Marginal cost** of a unit of fishing effort is *constant*
3. **Marginal productivity**: Quantity of fish caught *per unit of effort* is *proportional* to the size of the *stock*, ceteris paribus

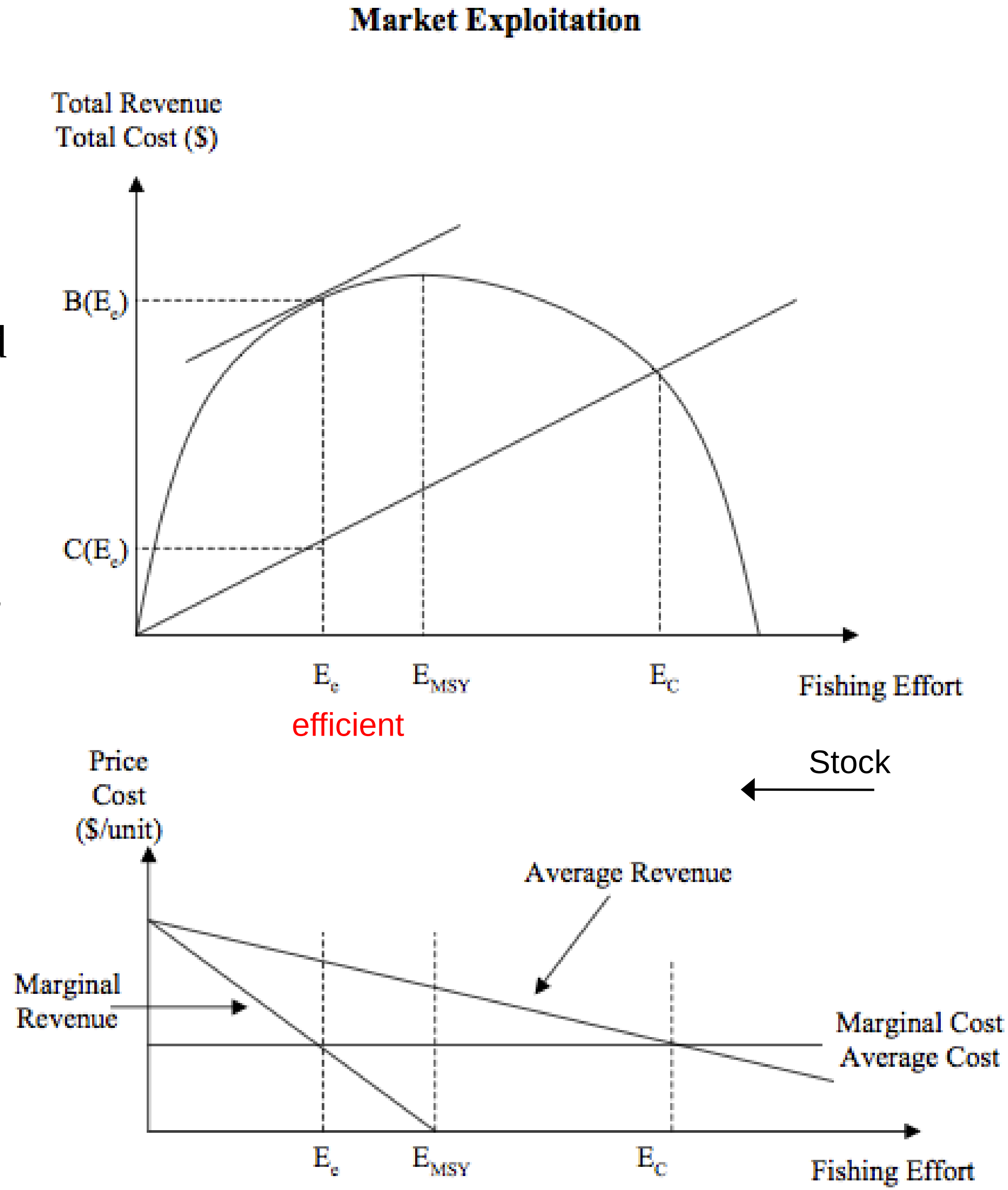
Basic Bioeconomics of the Fishery



- With prior assumptions, benefits and costs are simple functions of fishing effort
- Beyond some effort level, total catch & revenue declines
- TC = MC · Effort
- Efficient effort level, E_e, is where MB = MC
- E_{MSY} efficient only if MC=0
- $S_e > S_{MSY}$
- **Technological Change**
  - $E_e \uparrow$ $S_e \downarrow$
  - $Y_e \uparrow$
  - NB↑

Market Exploitation of a Fishery

- What if fishery were managed (owned) by a single competitive (price-taker) owner?
  - Incentive to maximize profit, set MB=MC, hence effort level E_e, the *efficient sustainable yield*
  - Analogous to typical property rights with nonrenewable resources
- What about real world: a coastal, ocean fishery? Sole owners are *not* the case, rather it's *open-access.*



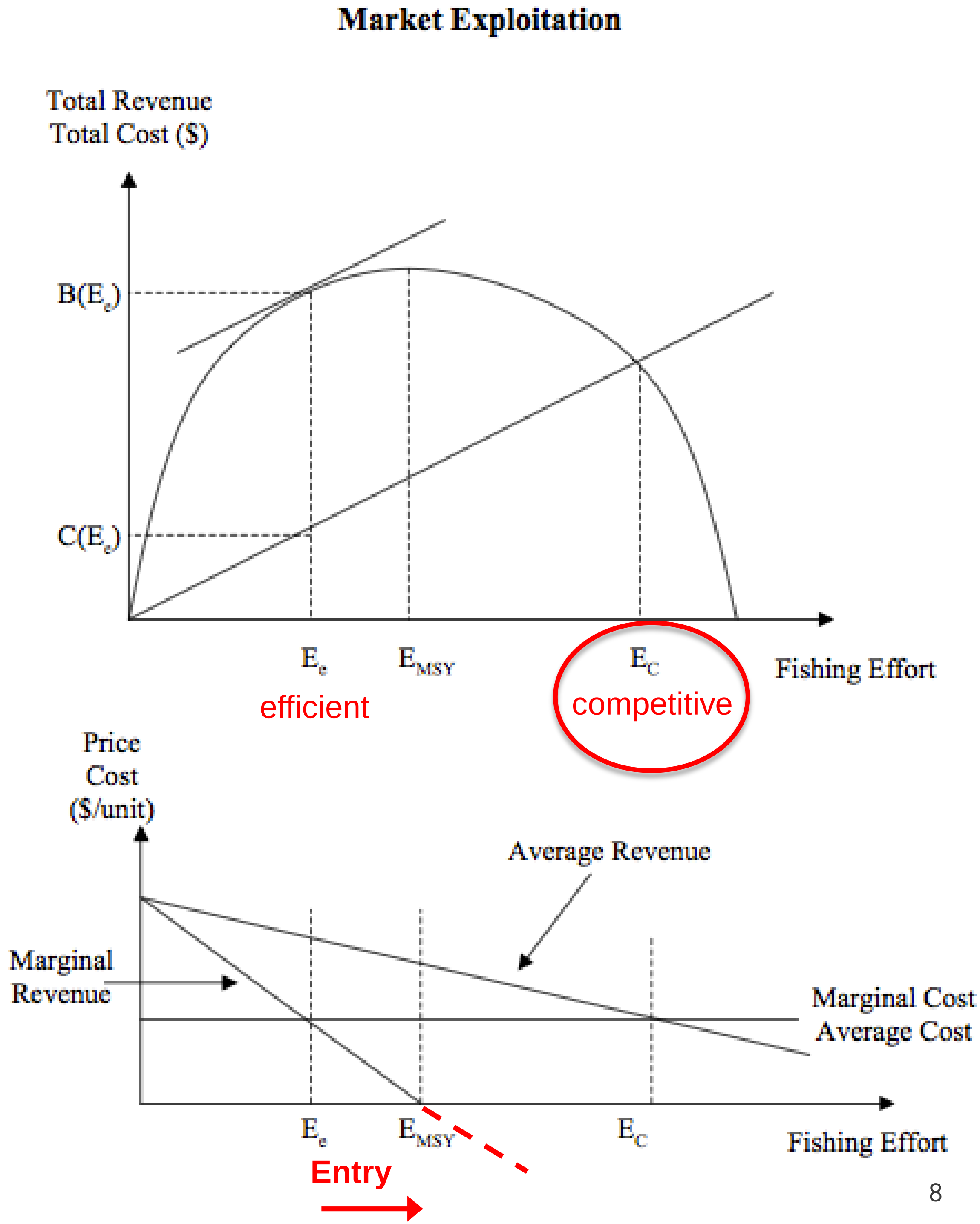
Open-Access Fisheries

- **Unrestricted access**
  - Recall *public-good* chart: rival in consumption, but not excludable
- **Two externalities**

1. *Contemporaneous externality* – "If I don't catch the fish, someone else will or might!"
   - Everyone ignores scarcity – considers only MEC and MB
   - Result (we will demonstrate): over-commitment of resources (too many boats, too many fishermen, too much effort, as everyone rushes to harvest).
   - Fishermen earn a lower rate of return on their efforts, NB↓, inefficient
2. *Intergenerational externality* – over-fishing reduces available future stock
   - Lower future NB, dynamically inefficient

Market Exploitation of Open-Access Fishery

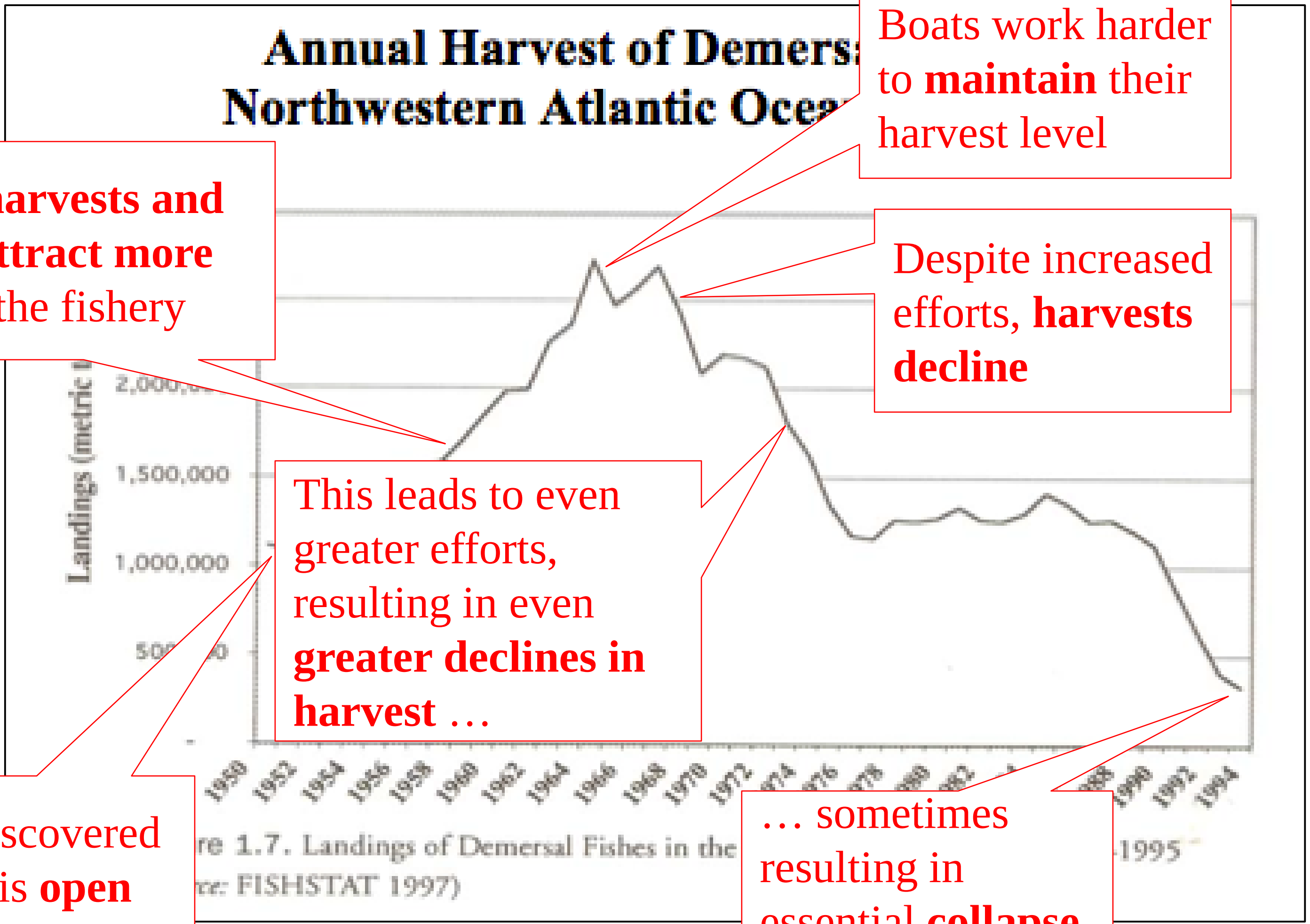
- At efficient level, E_e, each boat receives (π) share of *scarcity rent*
- But each considers MEC and (current) MR, but *not* scarcity rent
- Incentive to expand effort & entry (as long as B>C) until profits in fishery driven to **zero** at E_C
- *Excessive effort* expended to catch this quantity of fish
- So, with open access: it's *rational* for fisherman to ignore asset value (can't appropriate it)
- All scarcity rent is *dissipated*



Market Exploitation of Open-Access Fisheries: Empirical Examples & General Findings

- **Empirical Examples of Over-Capitalization & Rent Dissipation**
  - 1990 study of fishery in the Bering Sea: efficient number of ships estimated to be 9; actual number… 140
  - New England lobster fishery (1966): efficient number of traps = 450,000; actual # of traps = more than 1 million
  - North Atlantic minke whale (1995): efficient stock = 67,000 adult males; actual stock = 25,000 adult males
- **General Empirical Findings**
  - Too much effort (**over-capitalization**)
  - Stock too small, and **getting smaller**
  - And **profits** lower than otherwise (**driven to zero**)
- **Classic time-path** of open-access fisheries has been *repeated around the world*…

Example: North Atlantic Demersal, 1950-1995



Boats work harder to **maintain** their harvest level

Larger harvests and profits attract more entry to the fishery

Despite increased efforts, **harvests decline**

This leads to even greater efforts, resulting in even **greater declines in harvest** …

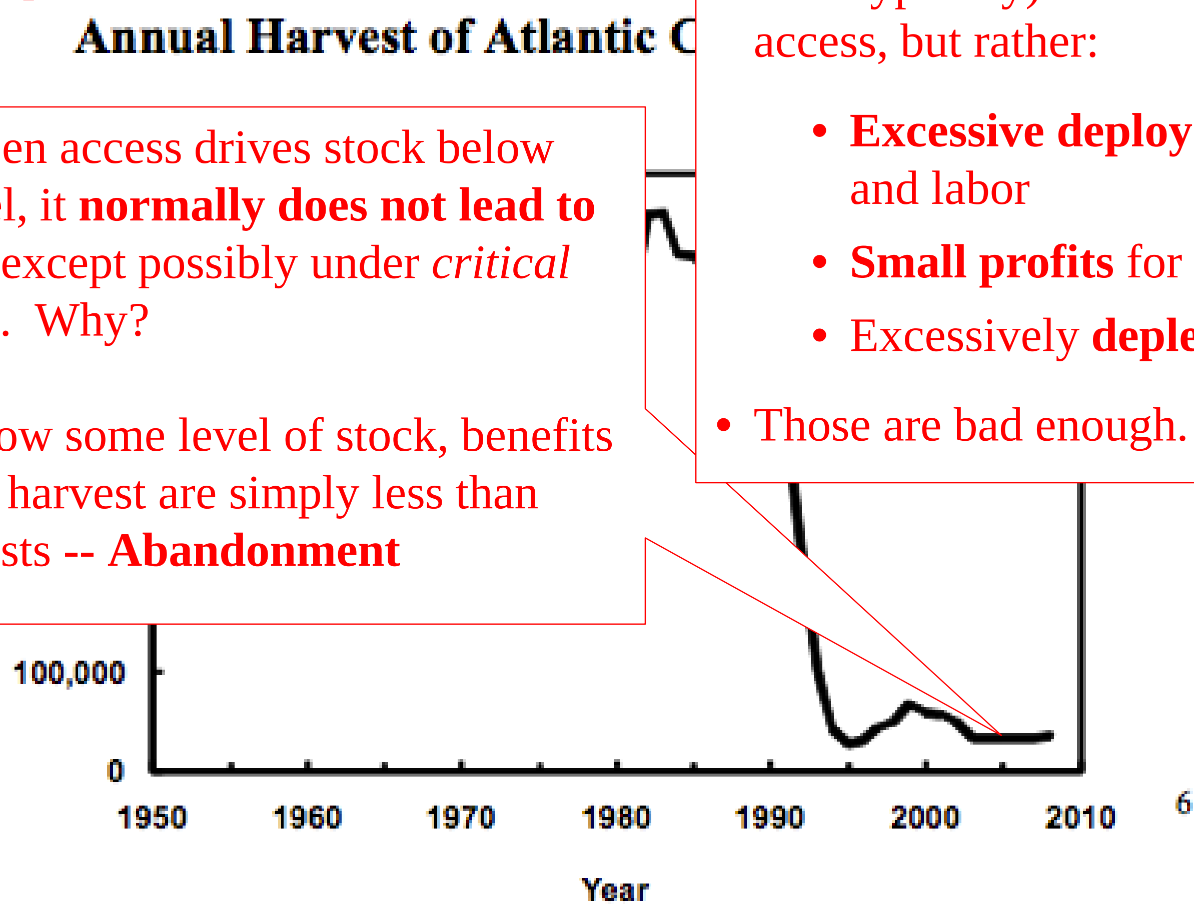
Newly discovered resource is **open to all** comers.

… sometimes resulting in essential **collapse of the fishery**

- Flounder
- Sole
- Turbot
- Halibut

Another Example: Atlantic Cod, 1950-2008

The **same pattern** has been documented for numerous species ….



- Although open access drives stock below efficient level, it **normally does not lead to exhaustion** (except possibly under *critical depensation*). Why?

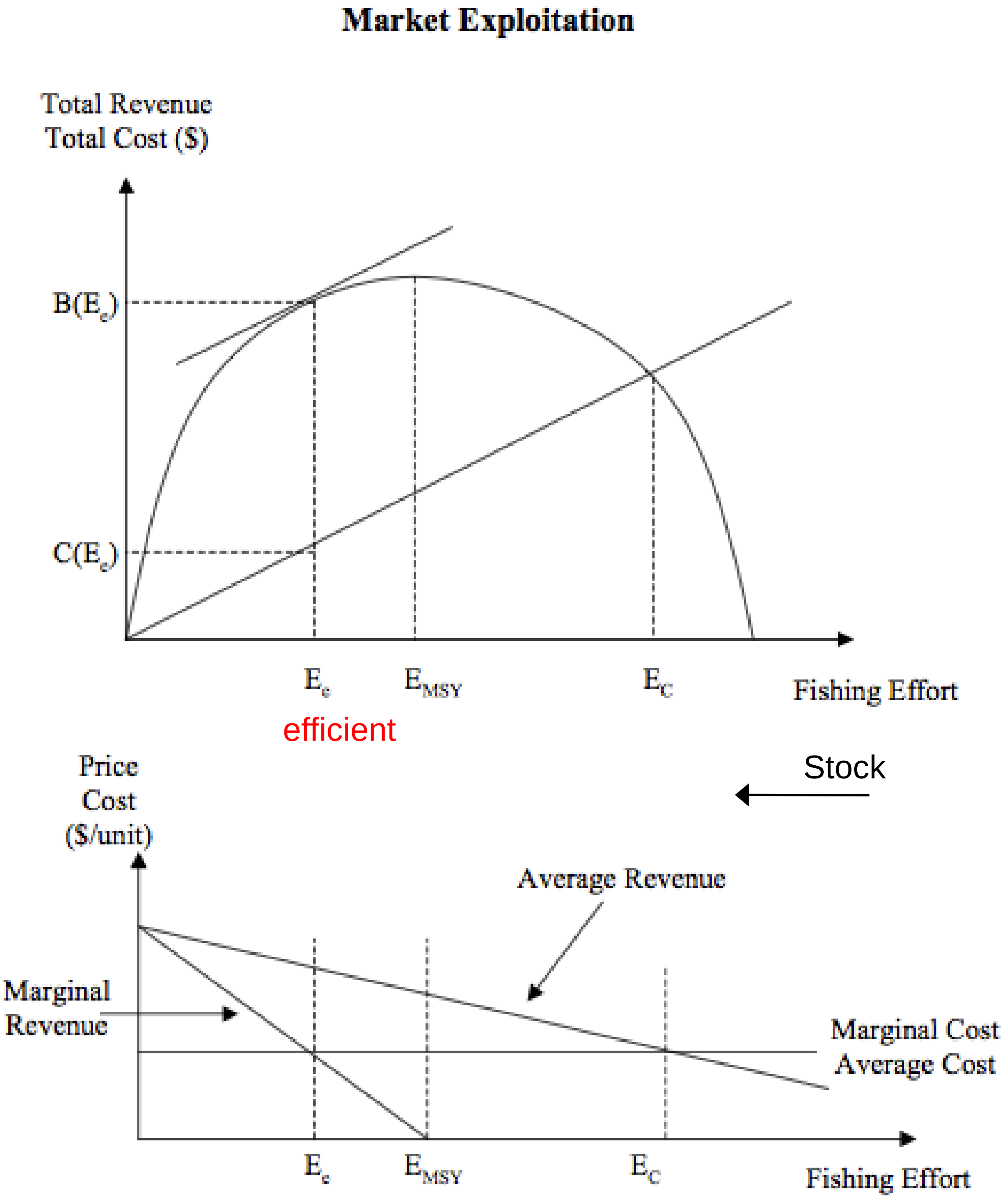
- Because below some level of stock, benefits of additional harvest are simply less than additional costs -- **Abandonment**

- So, exhaustion is **not** necessarily (or even typically) the outcome of open-access, but rather:
  - **Excessive deployment** of capital and labor
  - **Small profits** for participants
  - Excessively **depleted stock**
- Those are bad enough.

So, what can be done about this?

Alternative #1: How about Privatization?

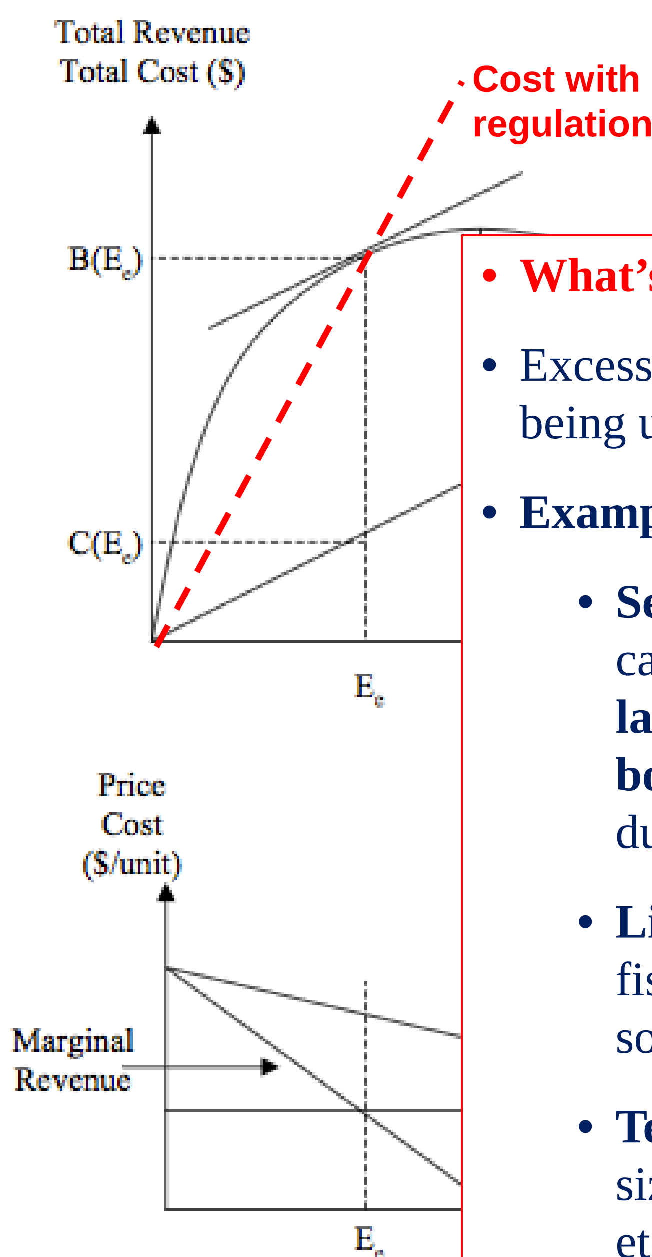
- Aquaculture can achieve efficient outcome.
- But feasible only if:
  - Species not mobile (oysters, mussels), or
  - Can be confined by barriers (catfish, trout), or
  - Instinctively return to place of birth to spawn (salmon)
- Aquaculture accounts for 47% of worldwide fish/seafood consumption (29% w/o China)
  - Not the answer for all species
  - Can create environmental problems (waste, sites used)



Conventional Regulatory Approaches

- Usual aim is MSY, but could be efficiency
- Possible regulations
  - Technology restrictions
  - Closure of particular areas
  - Imposition of limited season
- What do these regulations do?
  - Increase marginal costs
  - Harvest curtailed as desired
  - But net benefits to fishery (to society) are **zero.**
- So, efficient level of effort and harvest, but costs **not** minimized.
- ***So, this is not socially efficient.***

Market Exploitation



- **What's going on?**
- Excessively **costly** means are being used to catch fish
- **Examples**
  - **Seasonal limitations** cause fishermen buy **larger** boats, put out **more boats**, to **harvest more** during short season
  - **Limit on boat size** causes fishermen to buy better sonar
  - **Technology limits** (net size) leads to **more boats**, etc., etc.

Consequences of Conventional Regulation

- **Consequences** often *worse* than those of *unregulated* open-access resource
    1. *Greater* over-capitalization
    2. *Greater* welfare loss

- **Typical time-path of events**
    1. Over-fishing occurs
    2. Fishery stock is depleted
    3. Government responds by regulating the catch, thereby driving up the cost of fishing
    4. Fisherman complain that they cannot make a profit
    5. Harvests continue to fall

- **Many examples**, but here's one ………..

Open-Access Market: Excessive Harvest, Government Response, and the Ultimate Consequence

"In 1860, some 12 million oysters were sold in New York markets; by 1880, the area's oyster beds were producing 700 million a year. New Yorkers rich and poor were slurping the creatures in oyster cellars, saloons, stands, houses, cafes and restaurants... Oysters were cheap.

Everyone knew this dietary staple wouldn't last forever... **First the city restricted who could harvest** oysters**, and then when** [they could harvest]**.**

As technology made it easier to take a lot of oysters quickly, the city moved to limit the use of dredges and steam power as well.

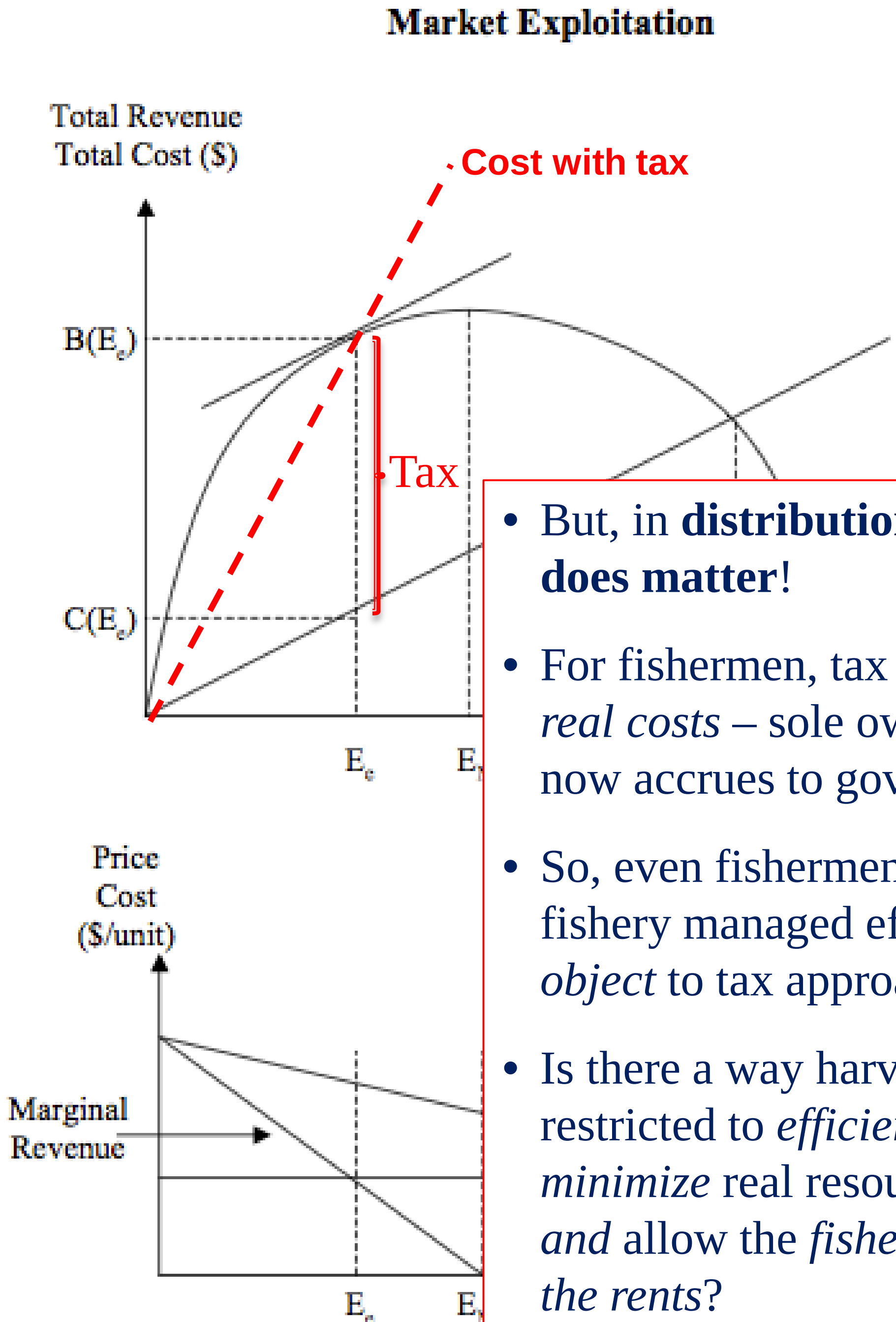
In 1927, the city's last oyster beds closed..."

The New York Times Book Review
March 5, 2006
The Big Oyster: History on the Half Shell, by Mark Kurlansky

Is there a better way? ……

Taxes

- Is there a way of reducing harvest to *efficient level* while providing *incentives for cost reductions*?
- **Tax** on effort (fish landed); *increases MC*. Question: Isn't this inefficient, just like conventional regulation?
  - Tax is a *transfer*, not a real resource cost; except to degree that revenues used less productively by public sector
  - *Net benefits* subtract costs, not transfers, from gross benefits
- So, net benefits with tax approach are *identical* to net benefits with efficient outcome.
  - In other words, ***tax policy is efficient instrument.***



- But, in **distributional terms**, it **does matter**!
- For fishermen, tax payments are *real costs* – sole owner's rent now accrues to government
- So, even fishermen who want fishery managed efficiently *object* to tax approach
- Is there a way harvest can be restricted to *efficient level*, *minimize* real resource costs, *and* allow the *fishermen to keep the rents*?

Individual Transferable Quotas (ITQs)

- **The Basics**
  - *Quota* entitles holder to catch specified quantity of fish (*not* boat quotas)
  - *Total* of all quotas set equal to efficient catch for fishery
  - Quotas are freely *transferable*, i.e. can be bought and sold
- **We will later model generic policy instrument** (tradable rights) & performance in very different context (pollution control), but for now ….
- **Anticipated Aggregate Outcome of ITQ System**
  - *Achieve targeted* (possibly efficient) level of total harvest
  - Incentives – quotas flow to those with lower costs: *static cost-effectiveness*
  - Encourages cost-reducing technological change (like tax): *dynamic cost-effectiveness*

Individual Transferable Quotas (ITQs)

- **Distributional Considerations**
  - If government *auctions* the quotas, it looks just like a *tax*
  - But government can *freely allocate* the quotas to fishermen
    - (in proportion to historical catch, for example)
    - Some buy, some sell allowances – *rents remain in private sector within the regulated fishery*
- **Moving Target**
  - If conditions *change*, and *efficient (target) catch* is even lower, government would have to *buy* back quotas for the fishermen
  - Possible, but …
  - Instead, *quotas are set in terms of share (%) of total catch*
  - It's *easy* for government to *change the total allowable catch*

Experience with ITQ Systems

- **ITQ systems have been used successfully** worldwide for:
  - *150 major fisheries* for 170 species
  - in *17 countries*
  - some with *very significant fishing industries*, such as Australia, Canada, Iceland, and New Zealand
- **New Zealand uses ITQs to regulate its entire commercial fishery**
  - Since 1986, system has been *very effective*
  - Has *eliminated* over-fishing
  - Has *restored sto*cks to sustainable levels, and *increased fishermen's profits*
- **Several ITQ systems are in operation in the United States**
  - Virginia's striped-bass fishery
  - Alaska's pacific halibut fishery

U.S. Pacific Halibut Fishery

- **Open access led to a gradually diminishing stock throughout 1970s**
- **Regulatory response: in effort to reduce harvest, season reduced** to *125 days* in 1975, then *25 days* in 1980, and then just *2 days* in 1994. **Result:**
  - More effort expended in a shorter time – *rampant over-capitalization*
  - By 1994, crews remained out for entire 48 hours of the season → *high rates of injury and mortality*
  - Due to rushed fishing, *by-catch* (of other species) exceedingly high, as was *ghost fishing* from abandoned nets
  - *Fresh* halibut became a *rarity*, because nearly all of the catch had to be frozen; and much of it decayed on docks due to insufficient processing capacity
  - *The regulatory approach failed even to limit the catch*, with targeted total allowable (targeted) catch exceeded in two out of three years (1975-1994)

U.S. Pacific Halibut Fishery (continued)

- **ITQ system was established in 1995**
  - *Season length increased* from 2 days to more than 200 days
  - *Safety problems* were *diminished*
  - *By-catch reduced* by 80%
  - *Ghost finishing losses fell* by 77%
  - *Quality* of fish in market *increased*
  - *Number of fishing vessels decreased*
  - *Value* of harvest *increased*
  - *Total allowable catch* has **never** been exceeded since inception of program

From the National to the International Domain

- **National and Sub-National Use of ITQs**
  - ITQ systems can be (and have been) used *effectively*
    - In *inland bodies of water* (lakes)
    - *Within countries' jurisdictions* (200 miles from coastline, where *richest fisheries* are located

- **International Domain**
  - What about the *open oceans*?
    - International *negotiation* – and possibly *treaties* – required
    - *Governance* is much more difficult
      - *Free-rider* problems
      - *Institutional* issues
    - Example is *whaling*
    - Analogous to *global climate policy* challenges (later in the course)

Renewable Open-Access Resources Highlights

- Basic biology: Schaefer model, MSY, stable and unstable equilibria
- Basic bioeconomics: efficient sustainable yield, role of costs, relationship between efficient level of effort and MSY level of effort
- Market with single competitive owner
- Typical open-access market: contemporaneous and intertemporal externalities
- Alternative public policies: privatization; conventional regulations; taxes; and individual transferable quotas
- International challenges