RENEWABLE RESOURCES

LESSON OBJECTIVES

01

Analyze the basic economics of a renewable resource

02

Compare maximum sustainable yield and efficient sustainable yield

03

Analyze sources of market failure for renewable resources

QUESTION OF THE DAY

Why would people who fish be in favor of limits on how many fish they can catch?

NONRENEWABLE RESOURCE

RENEWABLE RESOURCE

Finite in quantity. Stock decreases with use and does not replenish.

Examples: oil, natural gas, minerals

Sufficient rate of generation or regeneration.

Examples: water, living species, forests

01

BASIC ECONOMICS OF RENEWABLE RESOURCES

FISHERIES

FISHERIES

What makes fisheries interesting?

Renewable resource
- Fish reproduce, replenishing stocks

Property rights
- Usually a lack of property rights for fisheries
- Other renewable resources like forest are often privately owned

Biology vs. economics
- Highlight the interaction of biological and economic systems

ECONOMIC QUESTIONS

What is the efficient rate of consumption?

- How much should I consume now? Later?
- How does it depend on the rate of growth?

What is the market rate of consumption?

- When does the market provide the efficient rate of consumption?
- When does the market not provide the efficient rate of consumption?

LET'S START WITH BIOLOGY…

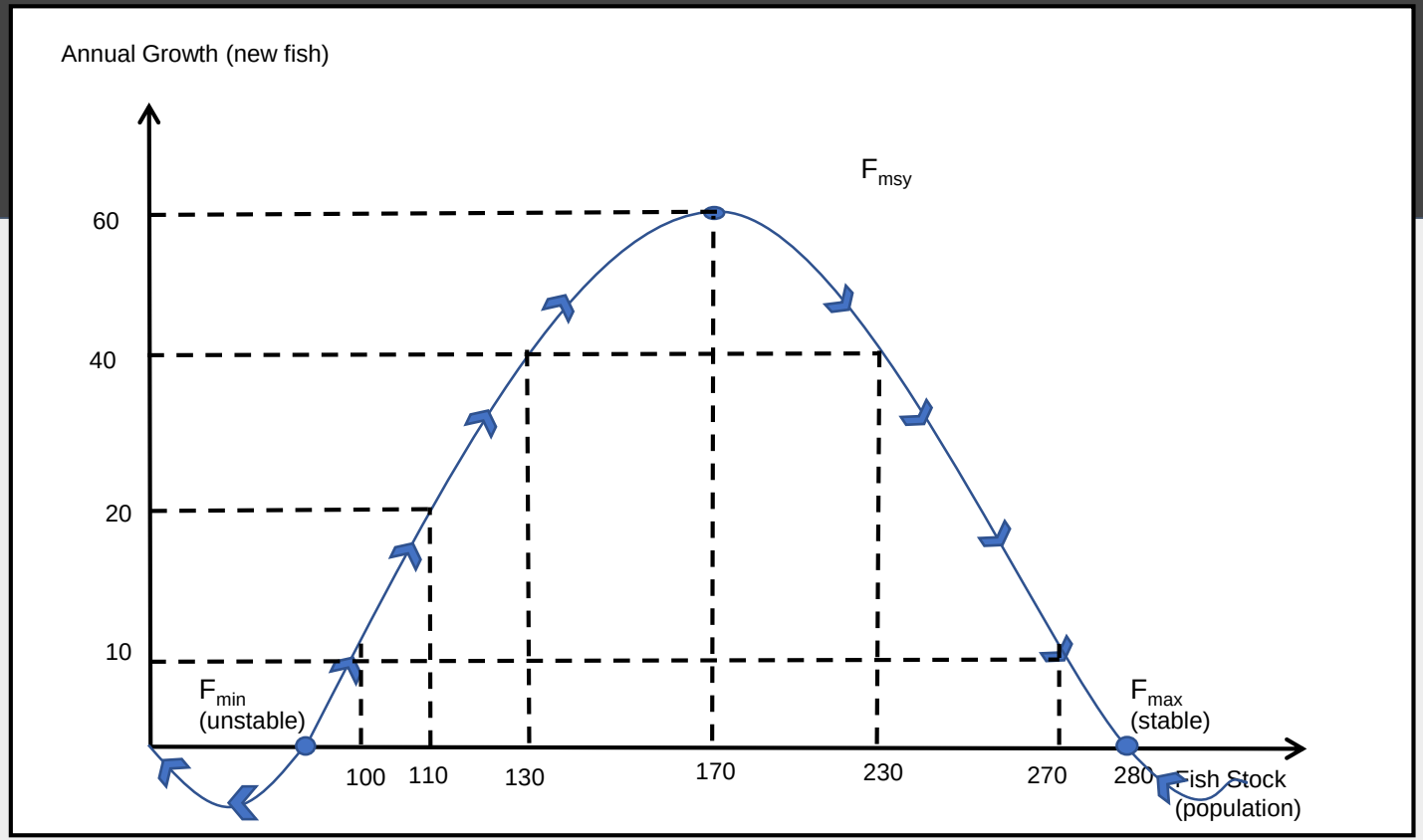
Shaeffer first proposed a biological model of fisheries

- Positive growth means births>deaths, so stocks increase.
- Negative growth means deaths>births, so stocks decrease

Three important points:

1) F_{max}
   - Carrying capacity
2) F_{min}
   - Minimum viable population
3) F_{msy}
   - Maximum sustainable yield

LET'S START WITH BIOLOGY...



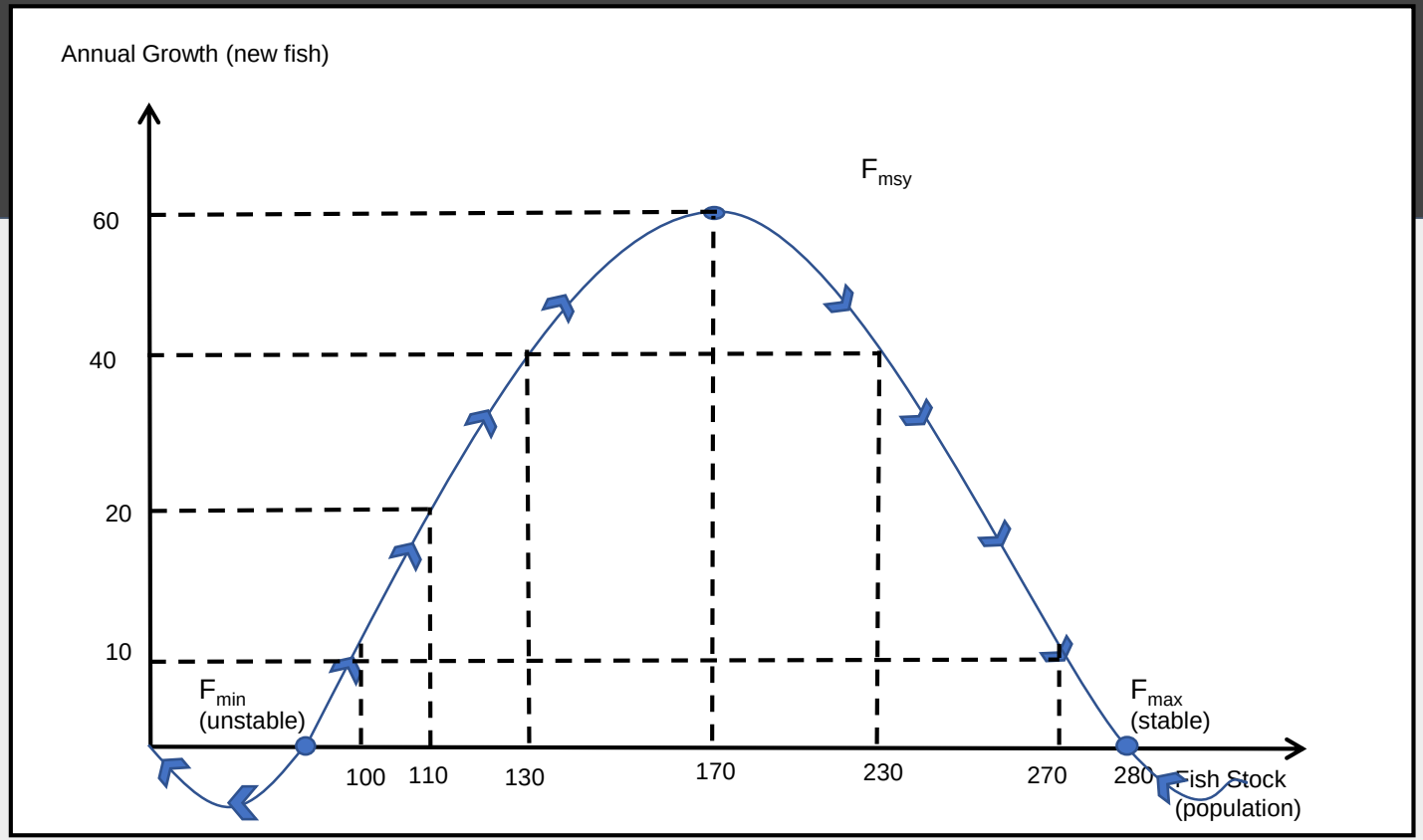
CARRYING CAPACITY

F_{max} is the carrying capacity
- Natural equilibrium
- Stable equilibrium

Consider $Q>F_{max}$
- Negative growth rate
- Q decreases to F_{max}

Consider $Q<F_{max}$
- Positive growth rate
- Q increases to F_{max}

CARRYING CAPACITY



MINIMUM VIABLE POPULATION

F_{min} is the minimum viable population

- Unstable equilibrium

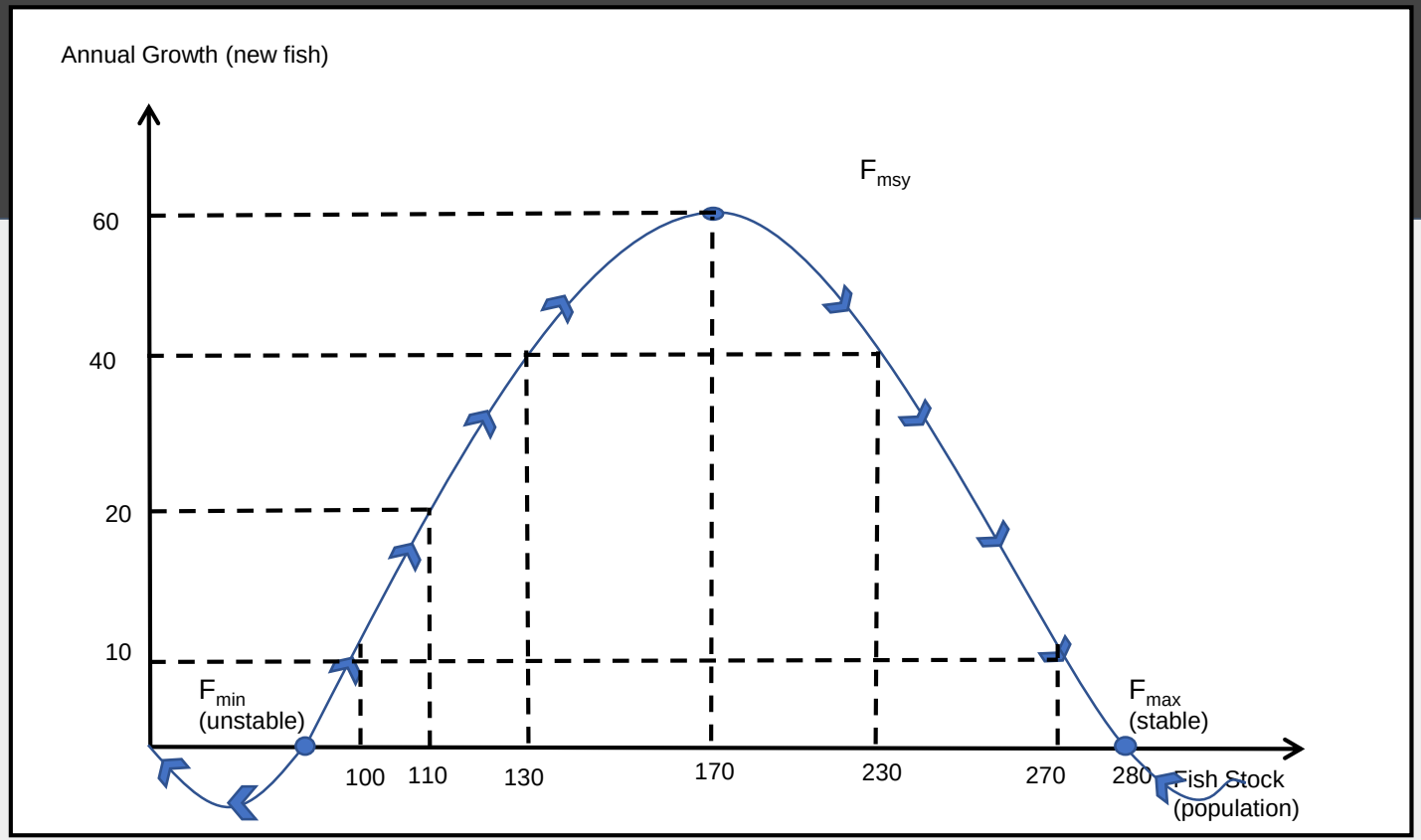
Consider $Q>F_{min}$

- Positive growth rate
- Q decreases to F_{max}

Consider $Q<F_{min}$

- Negative growth rate
- Q decreases to 0

MINIMUM VIABLE POPULATION

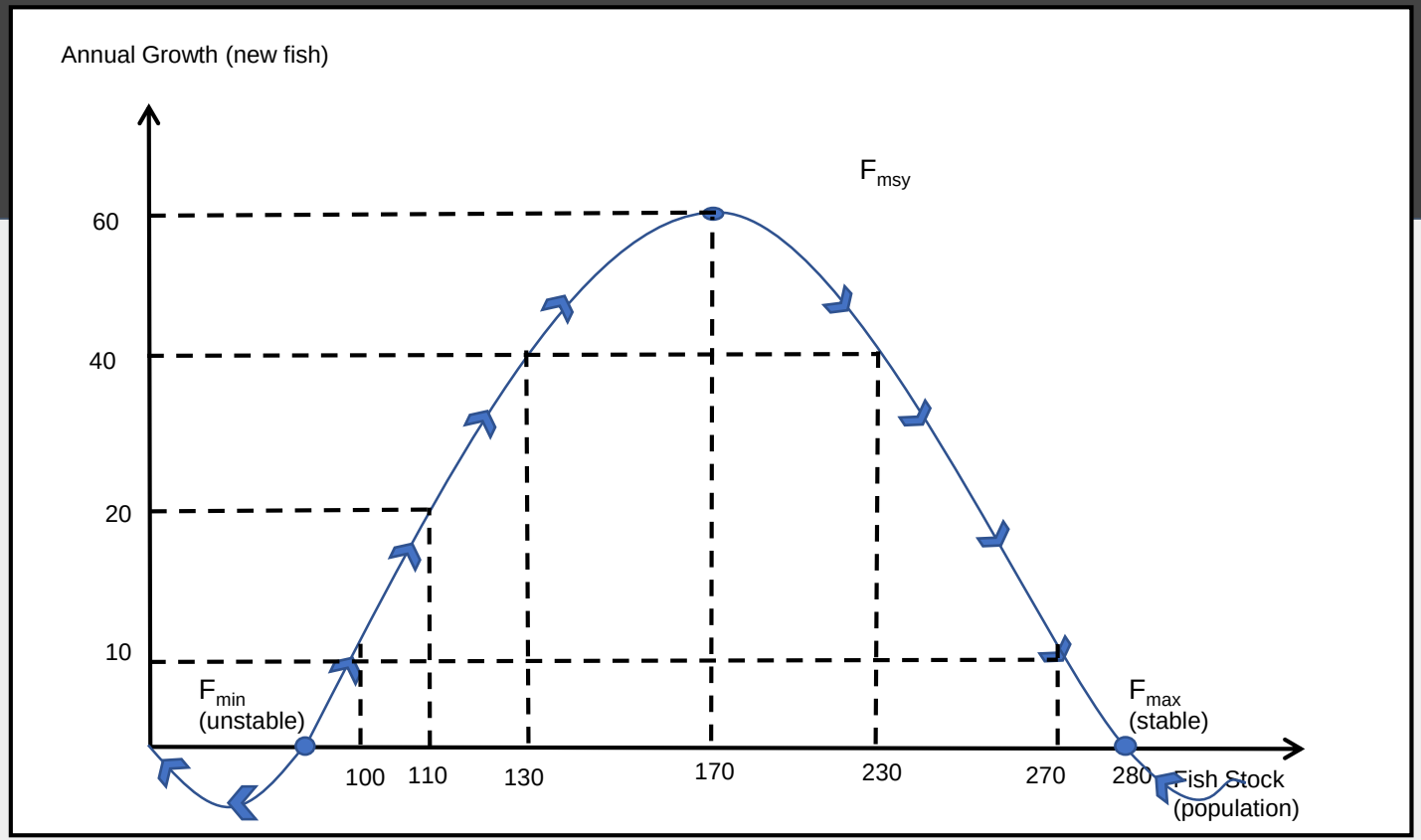


MAXIMUM SUSTAINABLE YIELD

F_{msy} is the maximum sustainable yield

- Fastest growth rate
- Largest catch that can be perpetually maintained

MAXIMUM SUSTAINABLE YIELD



A sustainable yield is an amount of fish we can harvest and keep the population constant forever.

To harvest sustainably, we must harvest such that:

the rate of harvest = the growth rate

Example from our graph above:

If there are 130 fish, then the "sustainable yield" is 40 fish.

MAXIMUM SUSTAINABLE YIELD

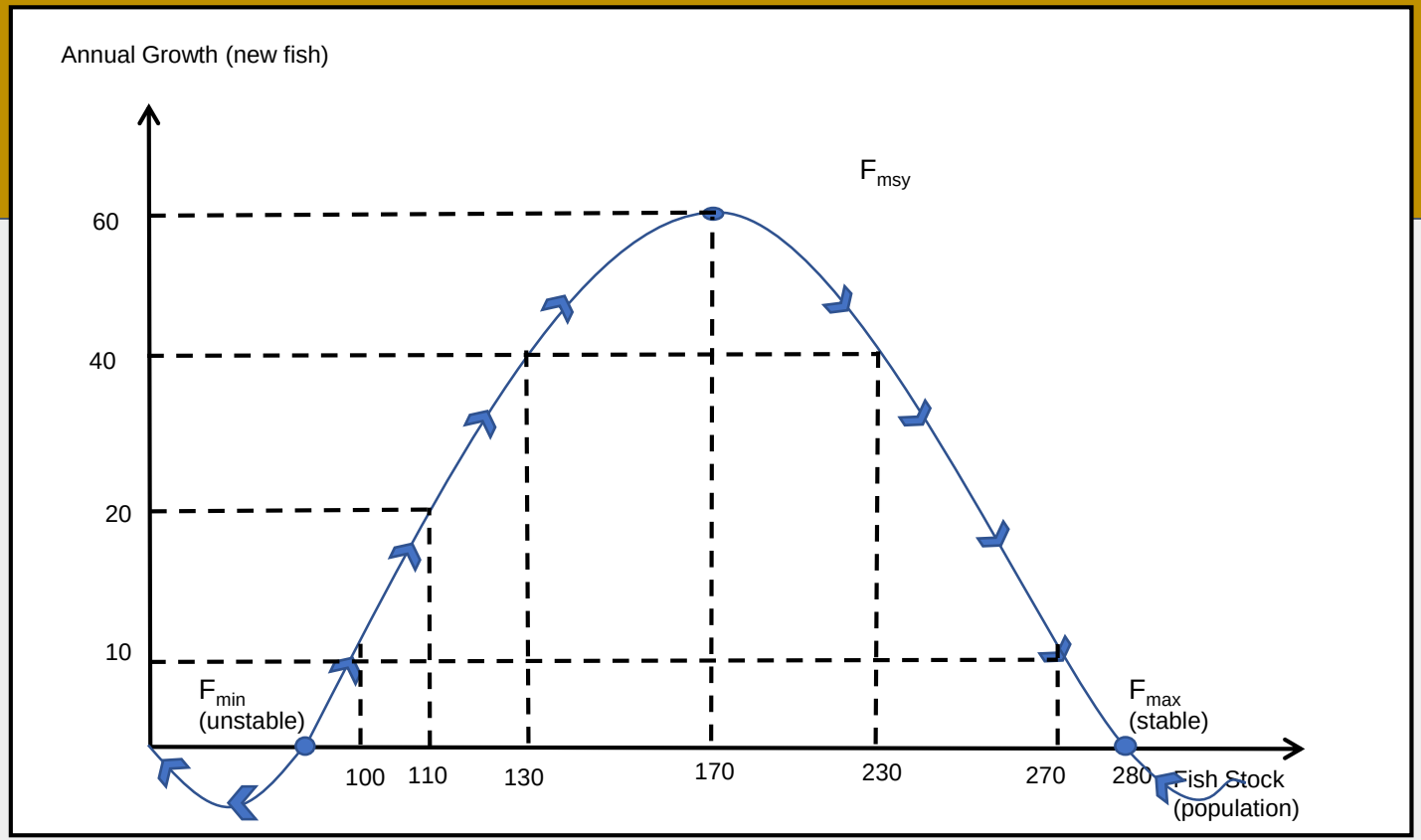
The **maximum sustainable yield (MSY)** is the rate of harvest associated with the population size that yields the **maximum growth** each year (call it F^*).

At F^* (=170 fish in our example), if we harvested an amount equal to the to the growth rate (60 fish), we would get the maximum catch that can be perpetually sustained (the population is kept at F^* forever).

Note: if harvest more than MSY (or even the sustainable yield for the specific current population), then fish stocks will decline toward the minimum viable population. This is biological overfishing.

SO IS THE MAXIMUM SUSTAINABLE YIELD THE EFFICIENT OUTCOME?

MAXIMUM SUSTAINABLE YIELD



SO IS THE MAXIMUM SUSTAINABLE YIELD THE EFFICIENT OUTCOME?

WHAT'S MISSING? COSTS AND BENEFITS!

02

MAXIMUM VS. EFFICIENT SUSTAINABLE YIELD

EFFICIENT SUSTAINABLE YIELD

The economically efficient level of harvest is where net benefits from the fishery are maximized (NB = TR – TC).

Where is this? Where MR=MC.
MR = change in TR for a change in effort (slope of TR).
MC = change in TC for a change in effort (slope of TC).

EFFICIENT SUSTAINABLE YIELD

To analyze the efficient solution assume:

1) Price of fish is constant and does not depend on the amount sold
2) The marginal cost of a unit fishing effort is constant
3) The amount of fish caught per unit of effort is proportional to the size of the fish population (the fewer fish in the water, the fewer fish you catch per unit of effort).

We are going to relate fishing effort to revenues and costs. Implicitly underlying these pictures are how many fish we can catch for a specific amount of effort – which relies on the stock and growth rate of fish.

EFFICIENT SUSTAINABLE YIELD

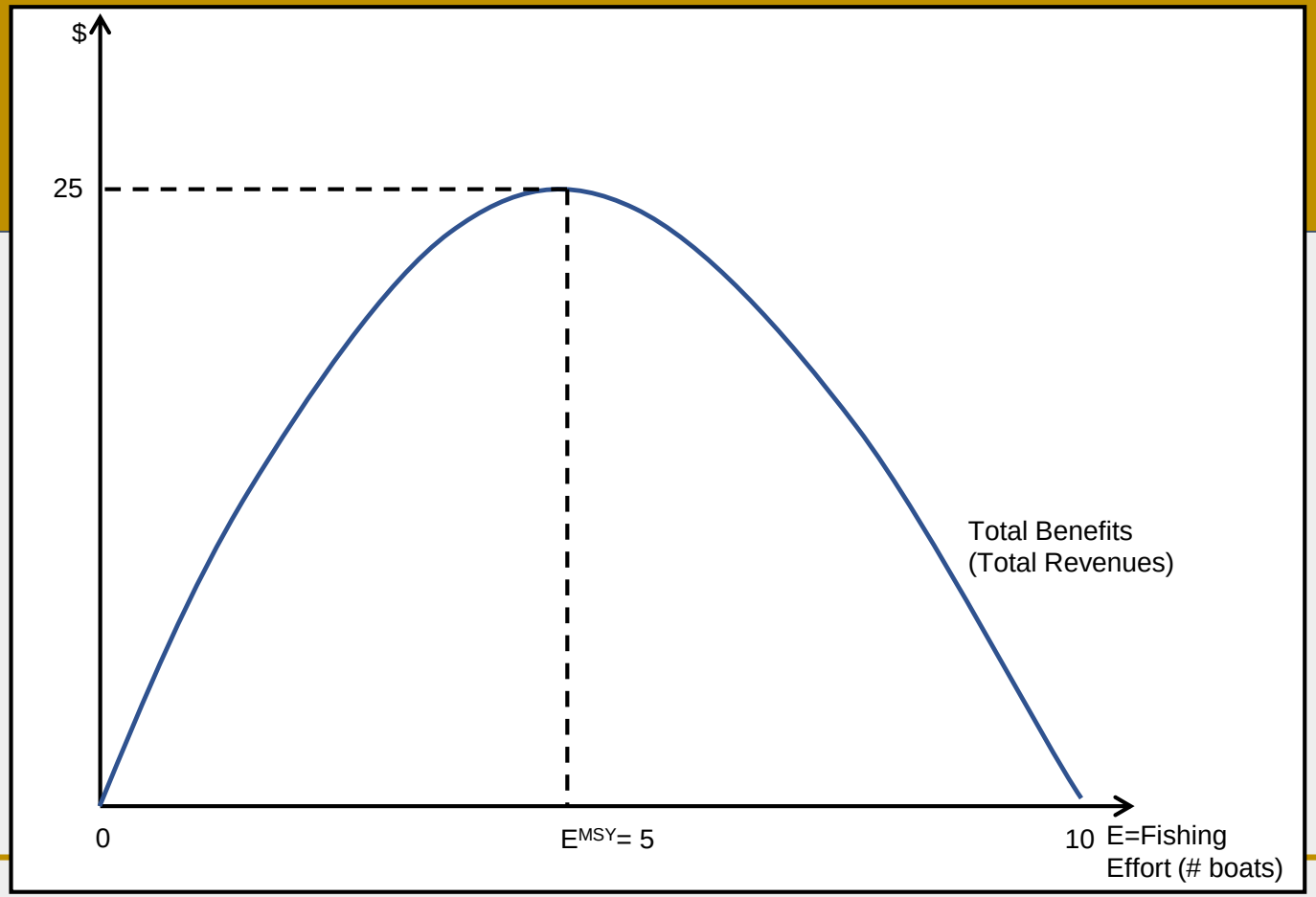
To analyze the efficient solution assume:

1) Price of fish is constant and does not depend on the amount sold
   - P=$1/ton

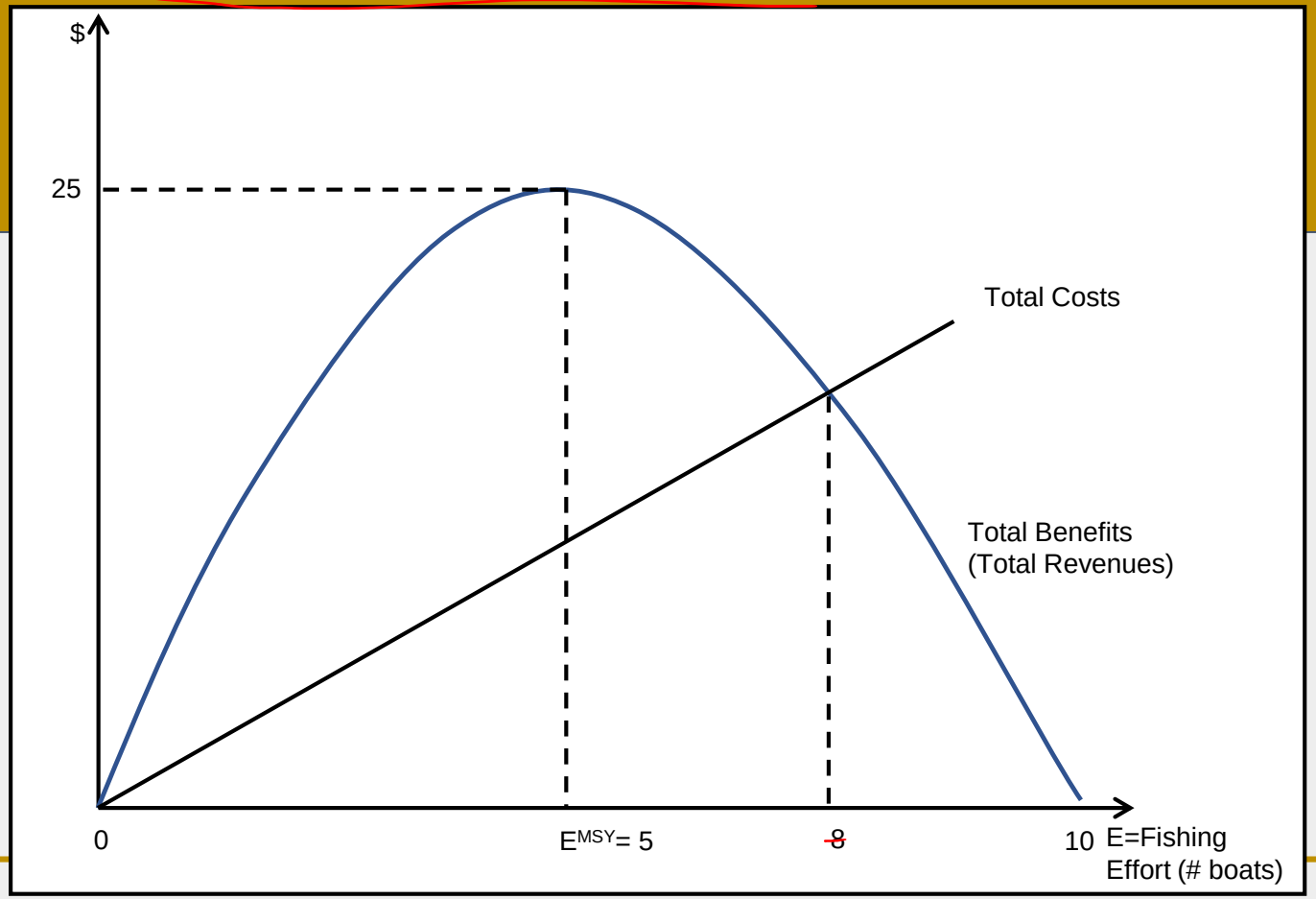
2) The marginal cost of a unit fishing effort is constant
   - MC=$3/boat

3) The amount of fish caught per unit of effort is proportional to the size of the fish population (the fewer fish in the water, the fewer fish you catch per unit of effort).
   - $Y=10E-E^2$

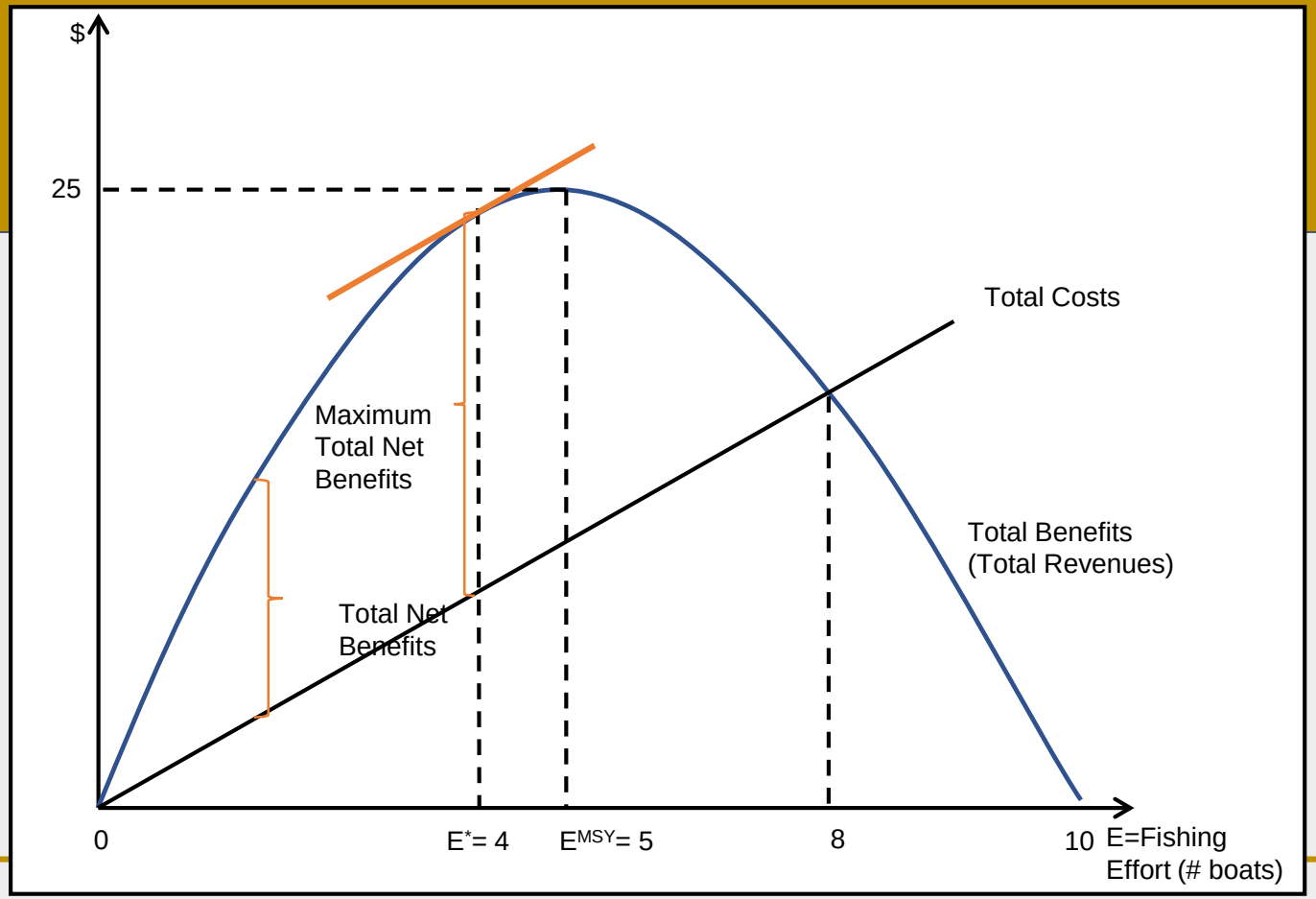
EFFICIENT SUSTAINABLE YIELD



EFFICIENT SUSTAINABLE YIELD



EFFICIENT SUSTAINABLE YIELD



EFFICIENT SUSTAINABLE YIELD

Efficient Sustainable Yield

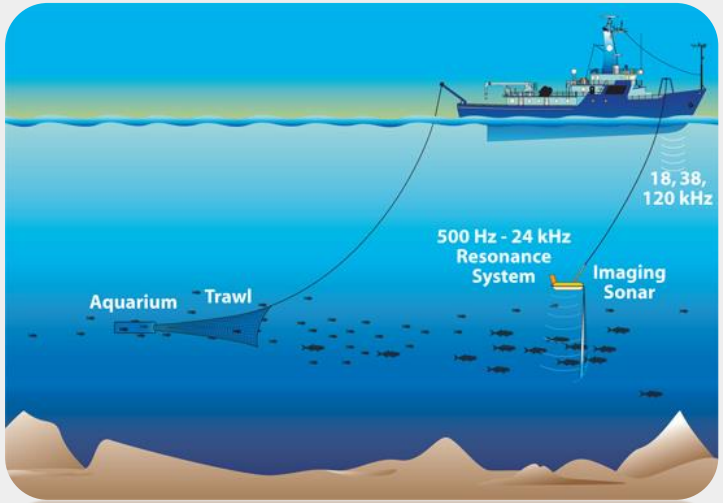
- MR=MC (profit maximization)
- Maximize rents (difference between TB and TC)

Efficient Sustainable Yield is less than Maximum Sustainable Yield

Fishing beyond this point is *economic overfishing*

- Economic overfishing occurs before biological overfishing

ATTENDANCE ACTIVITY

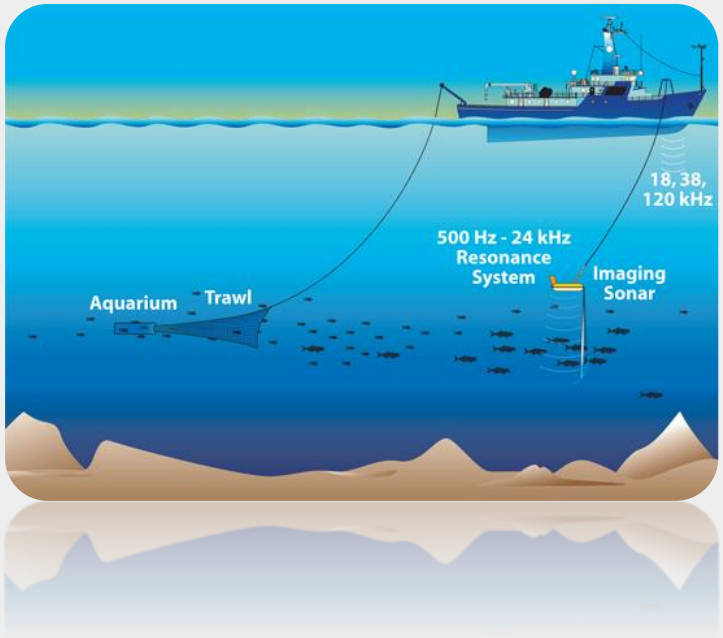


What would happen if there is an innovation in fishing?

Say sonar is invented. Now for the same unit of effort (fishing hours), **more** fish are caught.

What happens to the efficient effort level? Efficient stock of fish?

ATTENDANCE ACTIVITY



What would happen if there is an innovation in fishing?

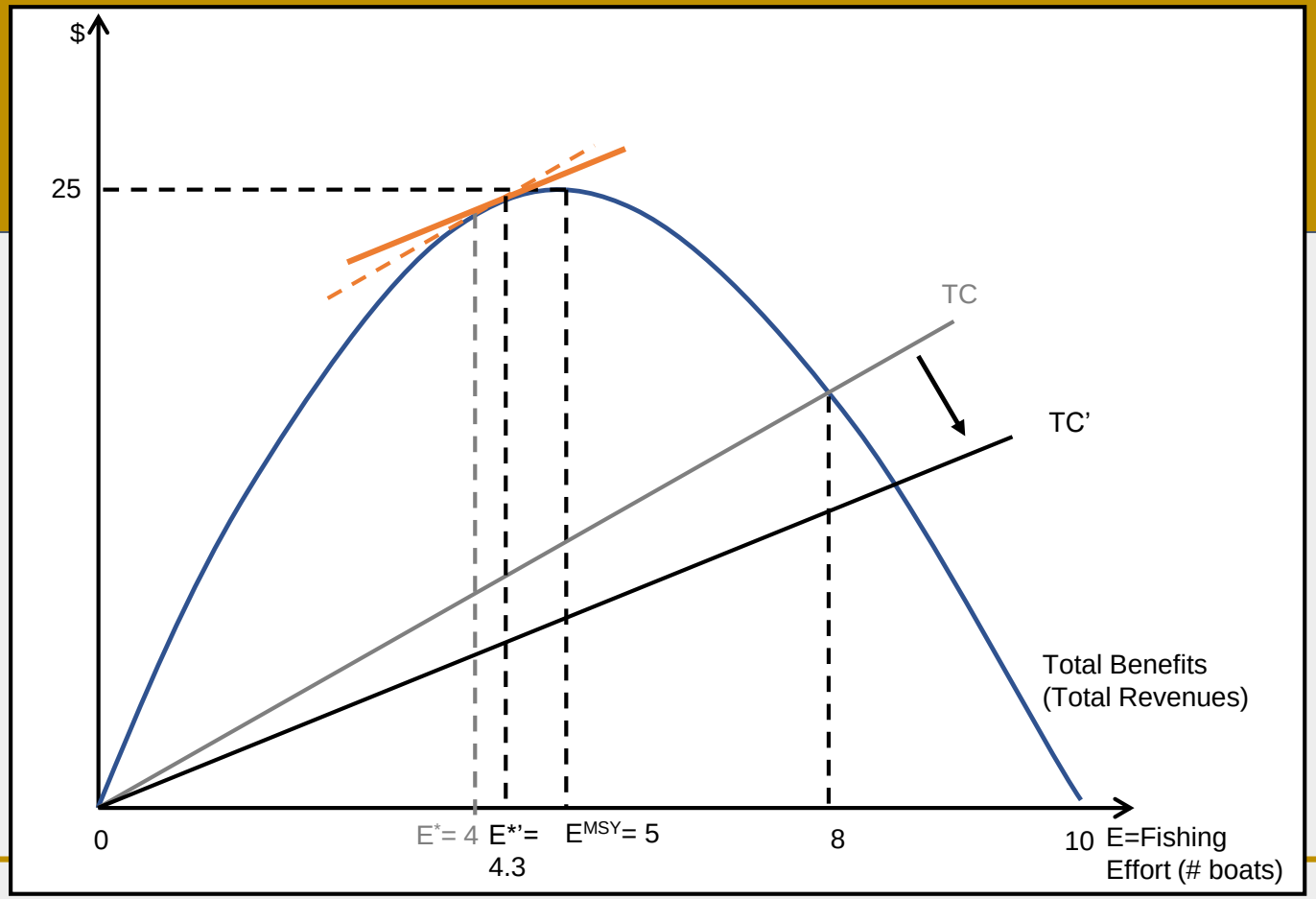
Say sonar is invented. Now for the same unit of effort (fishing hours), **more** fish are caught.

What happens to the efficient effort level? Efficient stock of fish?

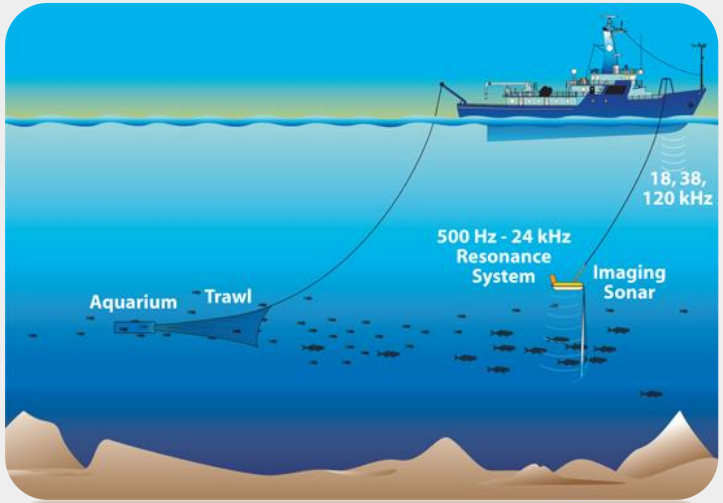
That implies marginal costs decline

The optimal effort increases while the optimal stock of fish declines

EFFICIENT SUSTAINABLE YIELD



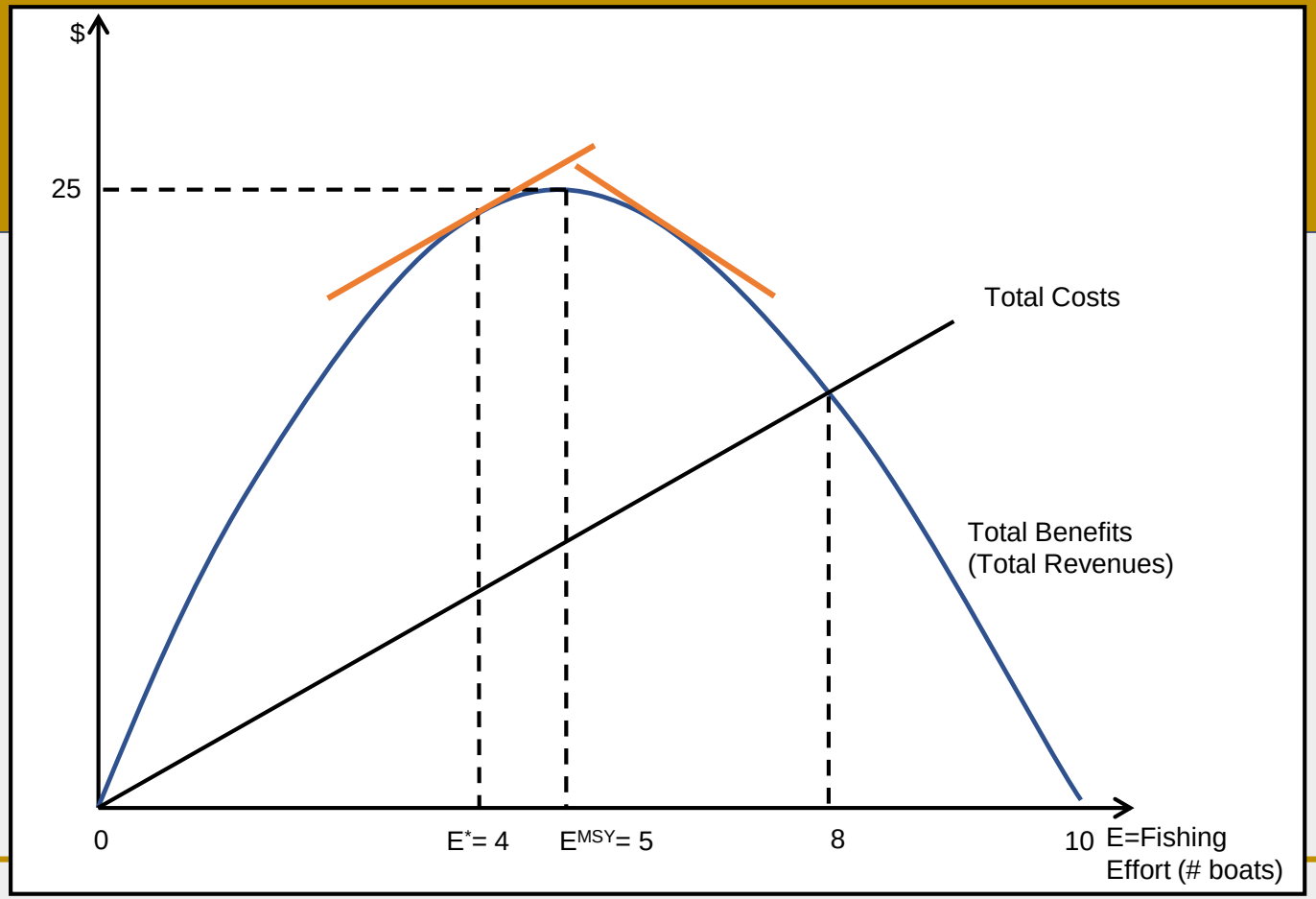
ATTENDANCE ACTIVITY



Can the economically efficient level of harvest ever be greater than the MSY?

No, it would imply the costs of fishing decrease as effort increases
This defies production ‘laws’

EFFICIENT SUSTAINABLE YIELD



03

MARKET FAILURE FOR RENEWABLE RESOURCES

WHEN DO MARKETS PROVIDE THE EFFICIENT OUTCOME?

DO MARKETS PROVIDE THE EFFICIENT OUTCOME?

It depends!

Critically, whether markets provide the efficient outcome for renewable resources depends on property rights.

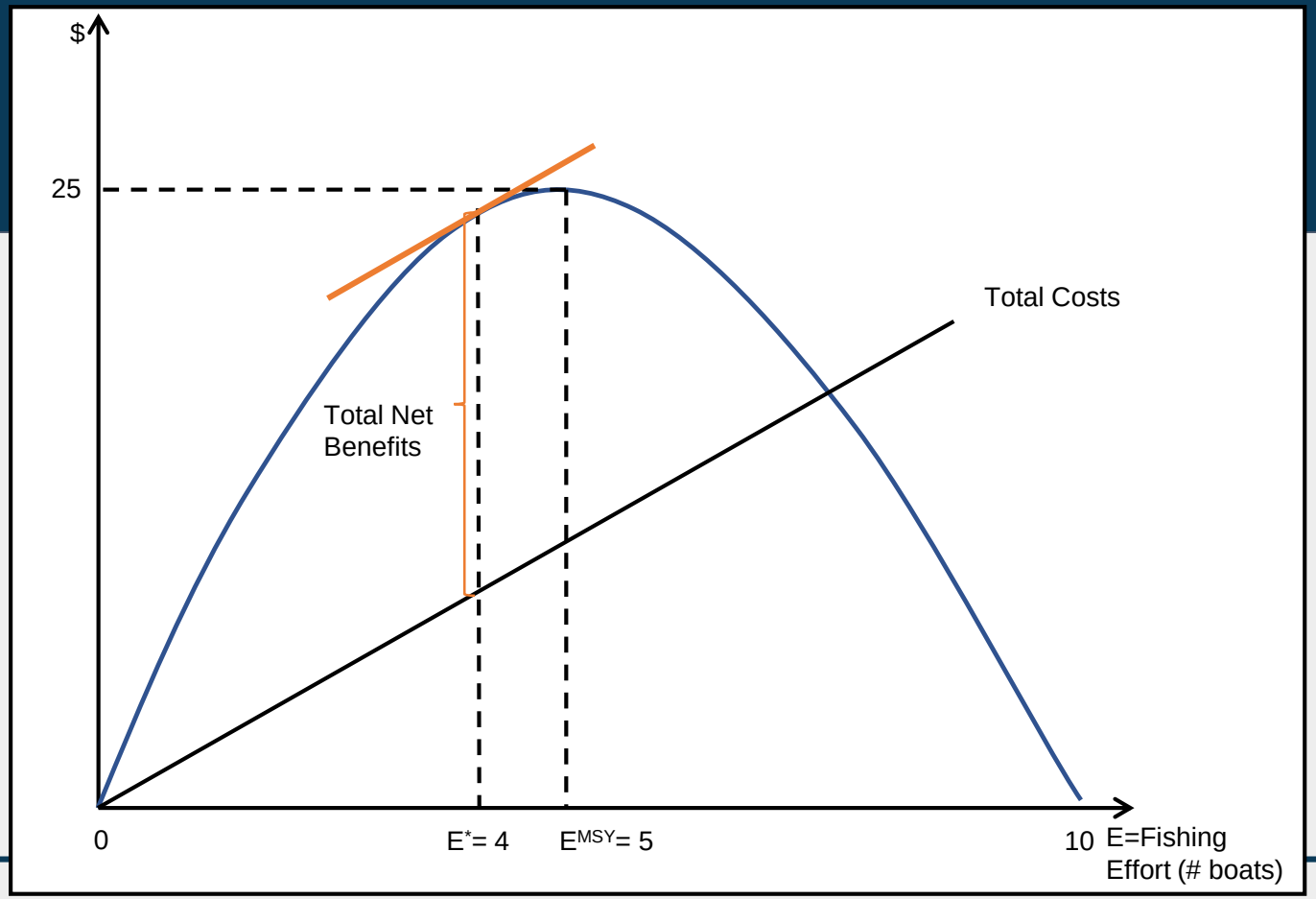
PRIVATELY OWNED FISHERY

Assume a fishery is privately owned (sole owner has full property rights).

What will be the profit maximizing yield?

The efficient point maximizes profits!

MARKET YIELD (PRIVATELY OWNED)



PROBLEM

Most fisheries are not privately owned. Instead most are open access, meaning they lack any restriction on who can use the resource or how much they can extract.

SO WHAT HAPPENS IN A REAL FISHERY?

OPEN ACCESS FISHERY

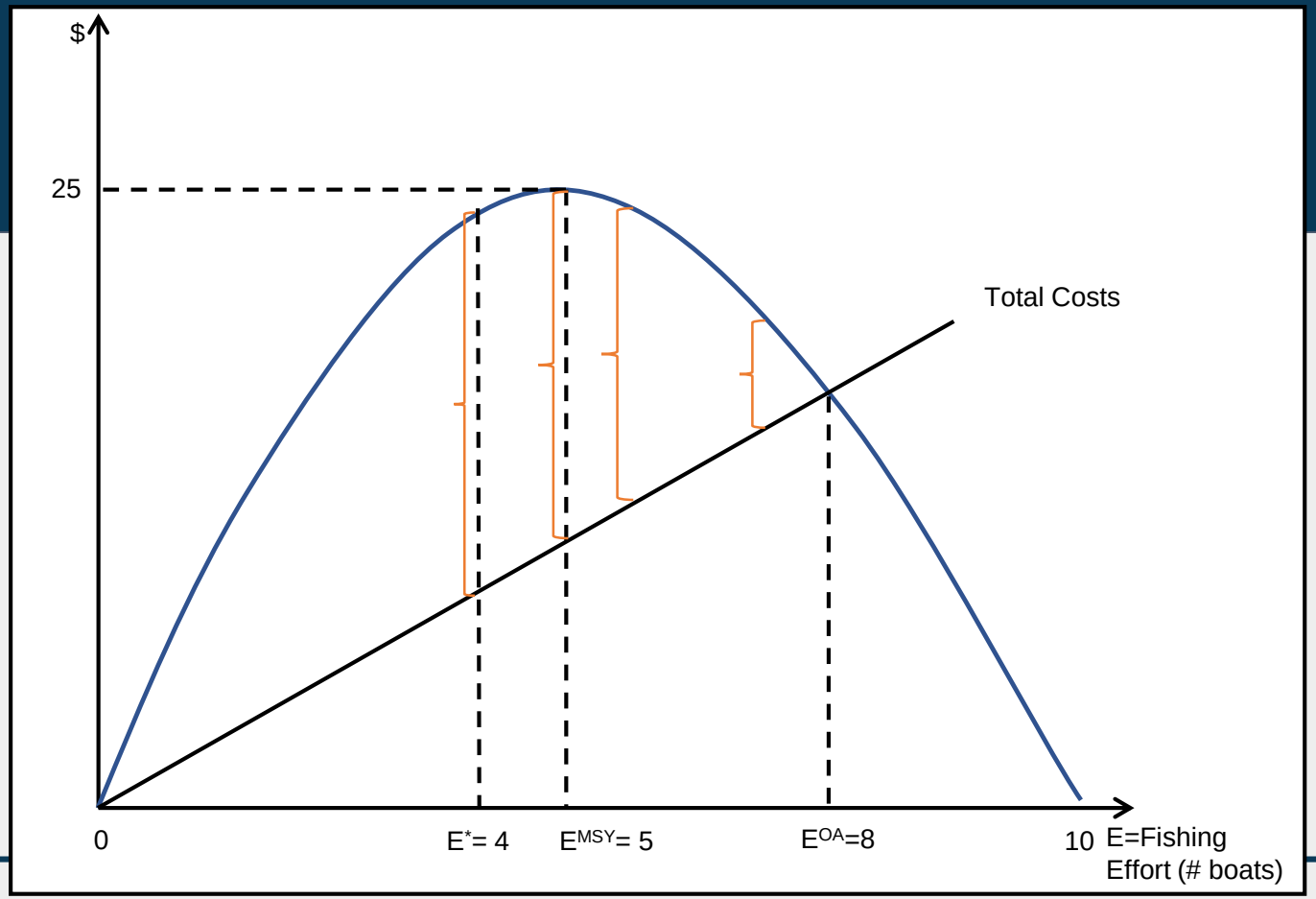
Assume a fishery is not privately owned.

- Without government intervention, no one entity typically exercises complete control over a fishery (aquaculture being a major counter-example!)

What will be the profit maximizing yield?

They will enter the fishery until economic profits are zero

MARKET YIELD (OPEN ACCESS)



SO WHAT HAPPENS IN A REAL FISHERY?

Under open access increase effort until economic profits are zero

- Increase in effort relative to efficient equilibrium

In other words, there will be too much capital devoted to fishing. This is the **"tragedy of the commons."**

- Social trap - free access to a finite good will ultimately result in destruction of the resource through over exploitation

Fisheries can be thought of an environmental **asset**

- A sole owner would balance the benefits of using the asset with **the costs of using it.**

In an open access resources, participants only consider the **benefits of using today**

- The individual can never capture the asset value (value of having bigger stocks throughout time)
- This leads to overexploitation

EXAMPLE: BERING SEA AND ALEUTIAN ISLANDS FISHERIES (ALASKA)

Huppert (1990)

Efficient number of motherships

- Boats that take on and process fish so cat-boats don't have to return to shore so often
- Estimated to be 9
- Actual number of boats is 140

The estimated lost net benefits (profits) are $124 million a year.

OPEN ACCESS VS. COMMON PROPERTY

It is important to note a difference between open access and common property.

- Open access – means no property rights or restrictions
- Common property – means shared property rights

Though open access creates inefficiencies through the *tragedy of the commons* problem, this does not mean the same will occur under common property.

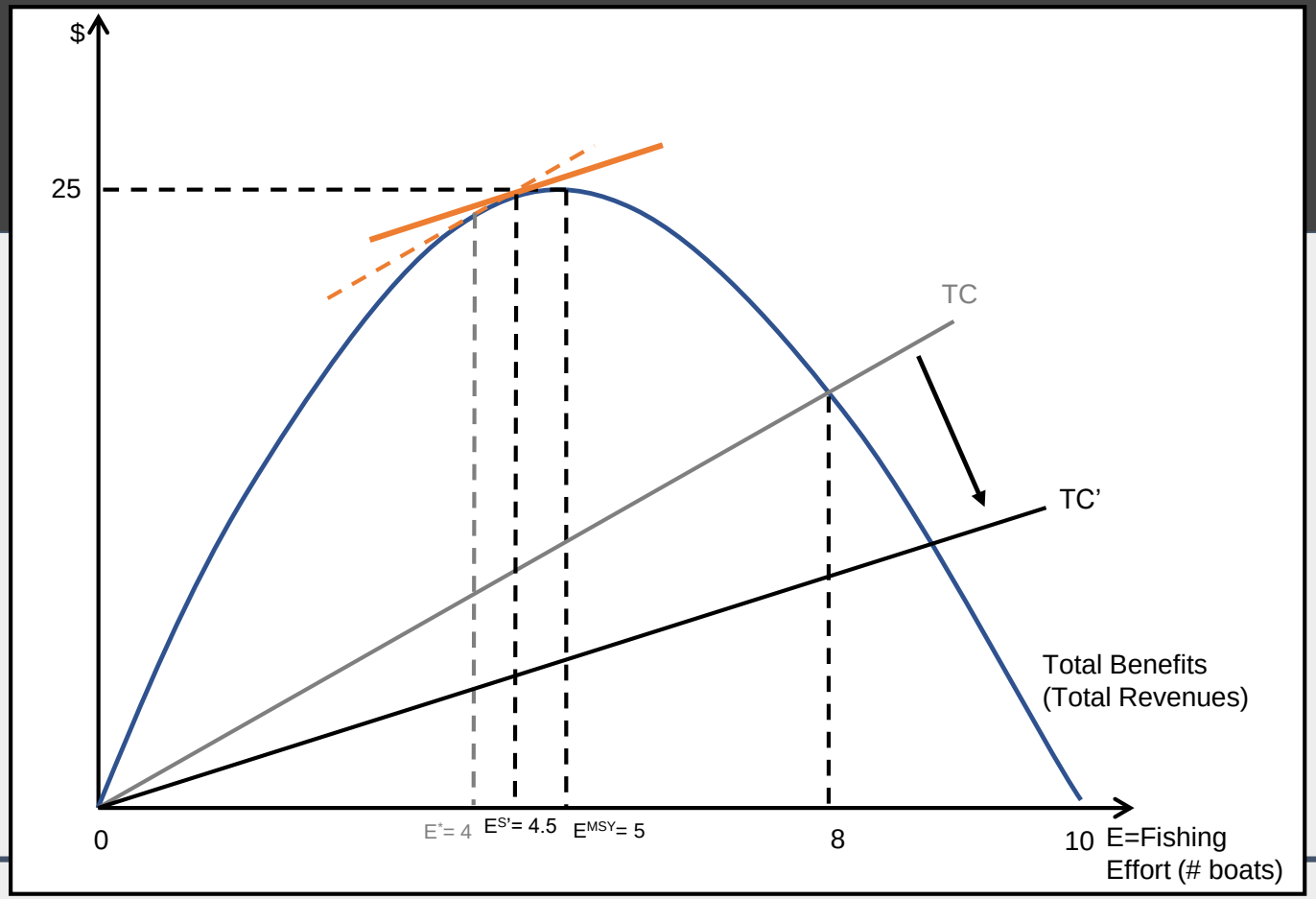
WHAT ARE SOME OTHER SOURCES OF MARKET FAILURE?

SUBISDIES

Sumaila and Pauly (2006)
Estimates that global governments spend $30 to $34 billion per year subsidizing their fishing industries

What happens to market outcomes with subsidies?

EFFICIENT SUSTAINABLE YIELD



DEPLETION EXTERNALITY

Current fishing processes often result in bycatch
- The unintended capture of nontarget fish and marine mammals
- Shrimp trawling captures 20lbs bycatch per 1lb shrimp

Bycatch introduces a "depletion externality"
- Cost to society from reducing stock of bycatch

What happens to market outcomes?
- Market effort is too high

Akin to externality in open-access fishing

EXAMPLE:
DOLPHIN-TUNA BYCATCH

Between 1960 and 1972 average of 100,000 dolphins were killed as bycatch of US tuna fishing.

Marine Mammal Protection Act required U.S. fishers to take measures to decrease dolphin mortality in 1975

By 2000, mortality levels were around 5,000 per year.

WHAT CAN WE DO?

PUBLIC POLICY AND FISHERIES

How to achieve efficient harvest?

Could turn commons into private property… not possible for many transitory/migratory animals, but possible for more stagnant ones & or containable species: **aquaculture**.

WHAT OTHER POLICIES CAN ACHIEVE OPTIMAL HARVEST?

We will briefly look at three alternatives:

1) Command and control
2) Taxes
3) Quotas

LESSON OBJECTIVES

01

Analyze the basic economics of a renewable resource

02

Compare maximum sustainable yield and efficient sustainable yield

03

Analyze sources of market failure for renewable resources