UiT
THE ARCTIC UNIVERSITY OF NORWAY

Fisheries Economics

Yajie Liu, PhD
Associate Professor
Faculty of Biosciences, Fisheries and Economics
University of Tromsø (UiT)
Email: yajie.liu@uit.no

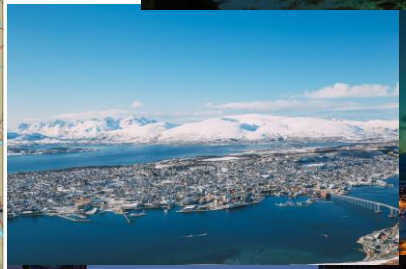
Lecture Content

1) Introduction about myself

2) Fisheries and fisheries management in Norway

3) Basic Bioeconomic Model and Fisheries Management

Tromsø, Norway



UiT the Arctic University of Norway

TROMSØ

Visiting address:
Hansine Hansens veg 18, Tromsø

ALTA

Visiting address:
Follums vei 39, Alta

KIRKENES

Visiting address:
Rådhusgata 8, 3.etg, Kirkenes

HAMMERFEST

Visiting address:
Elsa Semmelmanns vei 1, Hammerfest

HARSTAD

Visiting address:
Havnegata 5, Harstad

NARVIK

Visiting address:
Lodve Langes gt. 2, Narvik

BARDUFOSS

Visiting address:
Bardufoss lufthavn

BODØ

Visiting address:
Universitetsalléen 11, Bodø

MO I RANA

Visiting address:
Nytorget 5, Mo i Rana

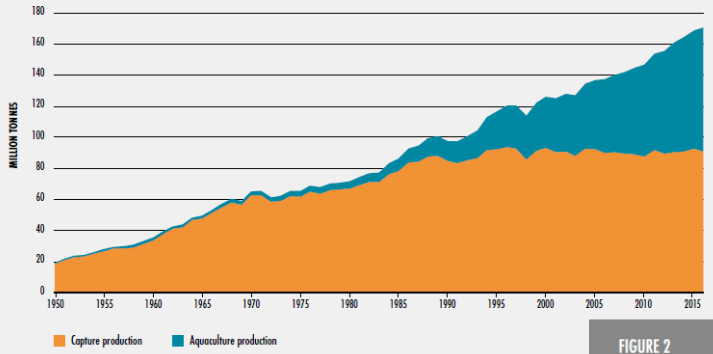
SVALBARD

› Postal addresses and opening hours
› Find buildings and rooms (Mazemap)

- In the north of Arctic circle
- 9 campus
- 3500+ staff
- 17 000 students
- 35 English courses
- https://en.uit.no/educatio

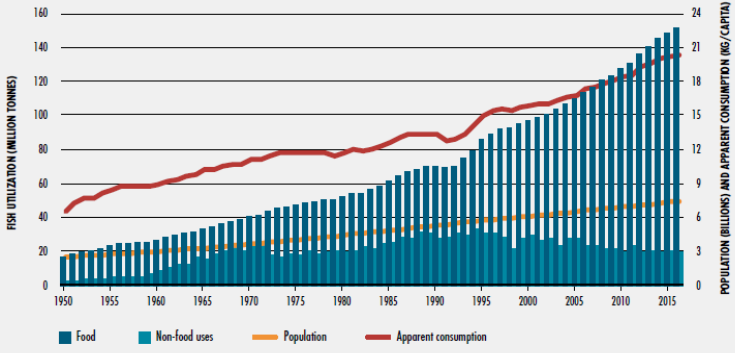
World Fisheries and Aquaculture

FIGURE 1
WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants

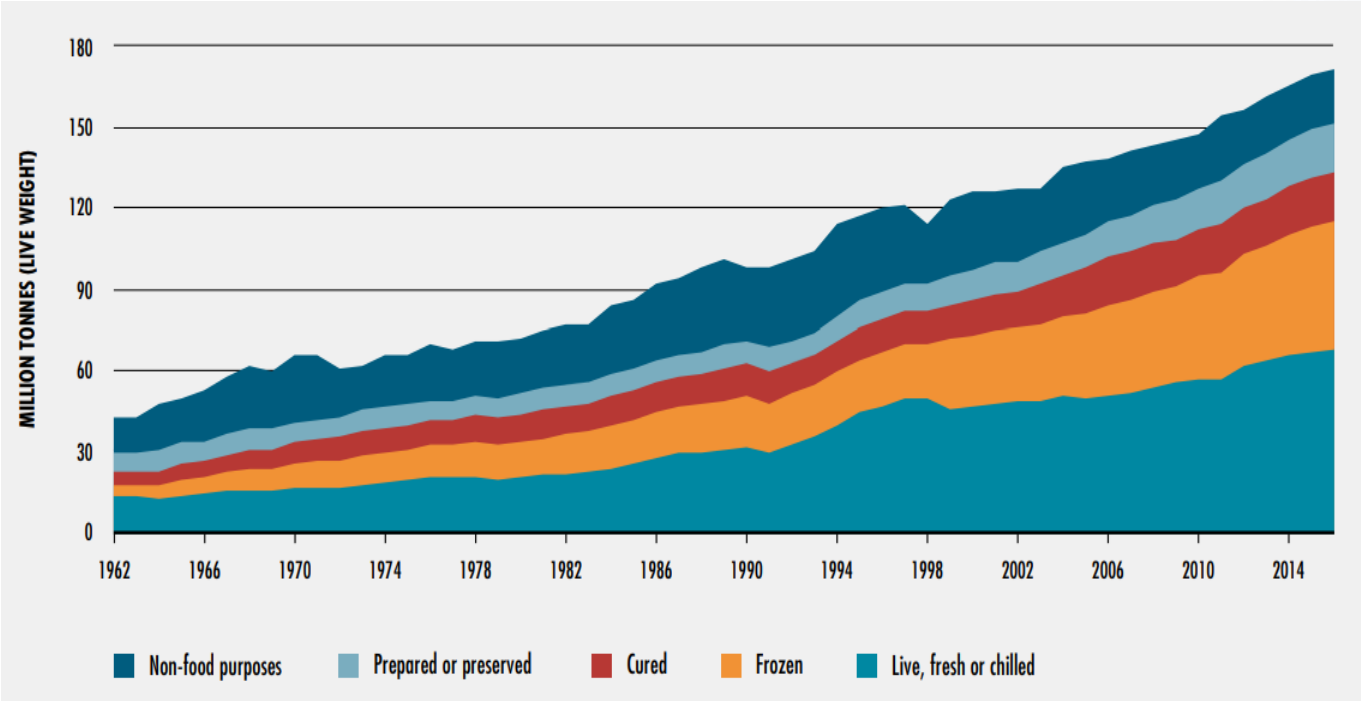
FIGURE 2
WORLD FISH UTILIZATION AND APPARENT CONSUMPTION



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants

SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

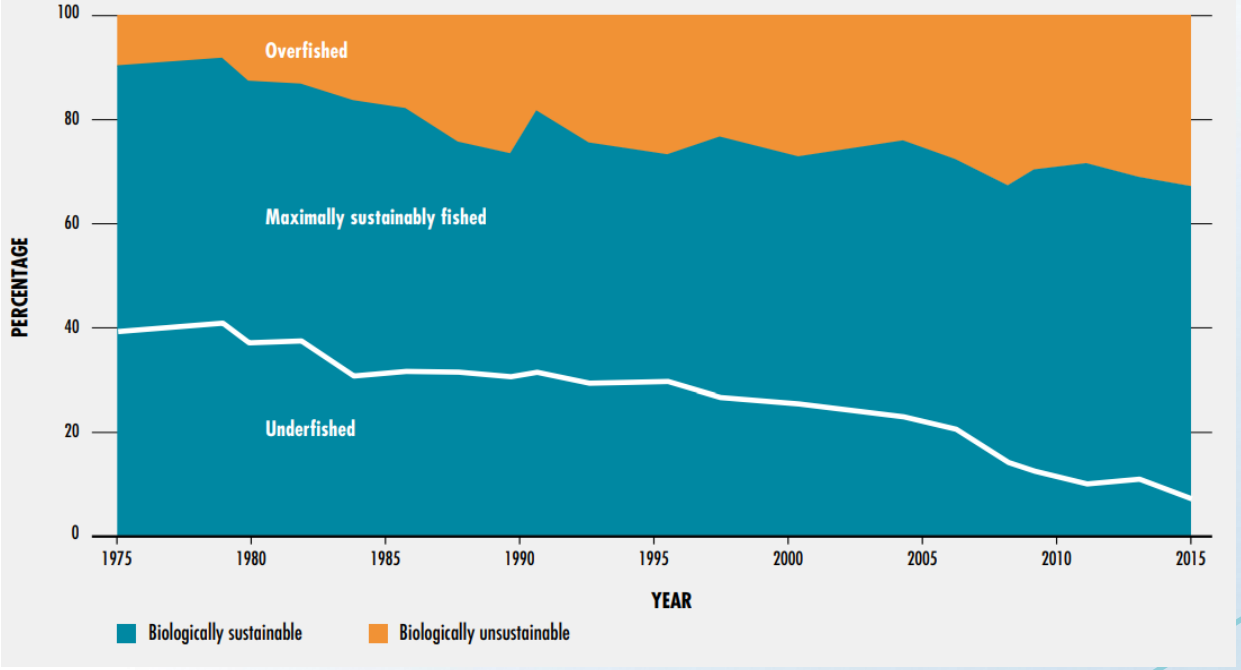
FIGURE 17
UTILIZATION OF WORLD FISHERIES PRODUCTION, 1962—2016



SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

Status of the World Fish Stocks

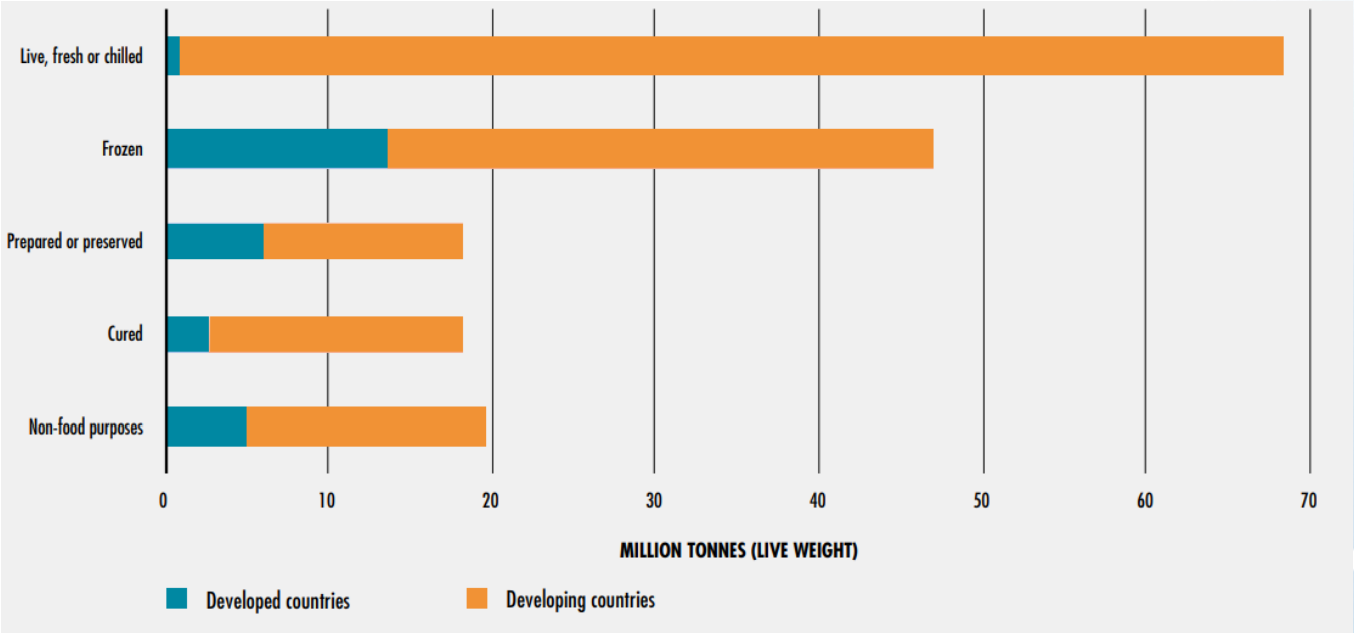
FIGURE 14
GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISH STOCKS, 1974–2015



SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

FIGURE 18

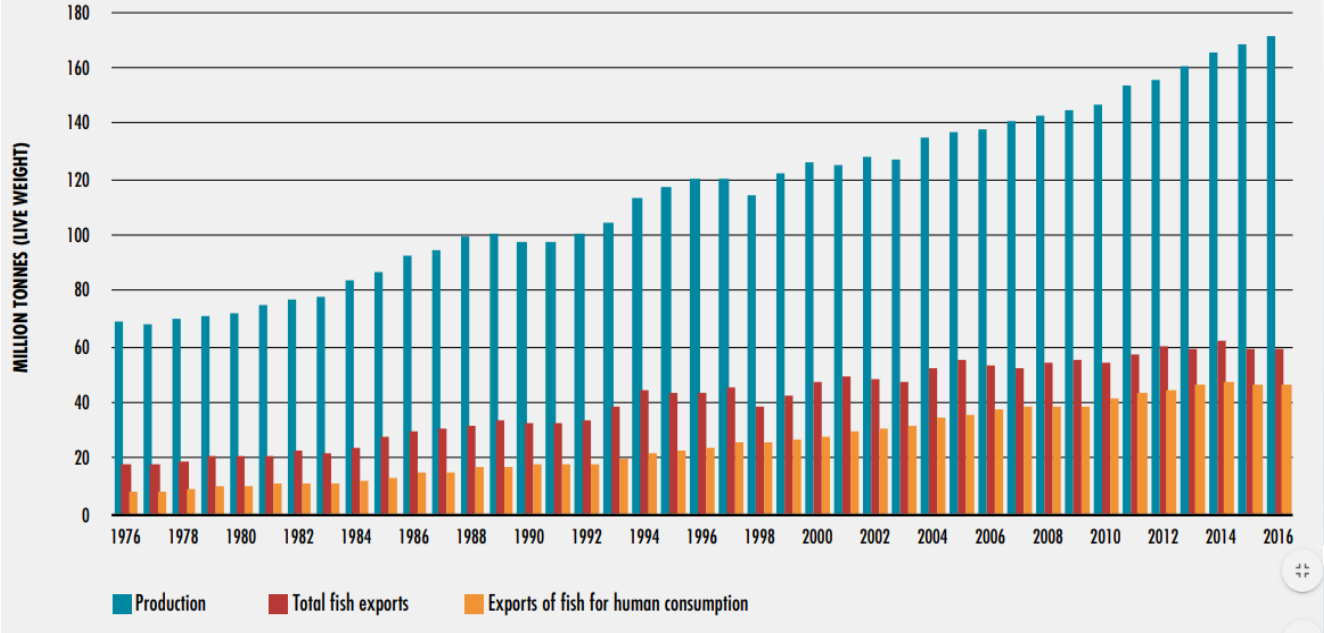
UTILIZATION OF WORLD FISHERIES PRODUCTION: DEVELOPED VERSUS DEVELOPING COUNTRIES, 2016



SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

FIGURE 19

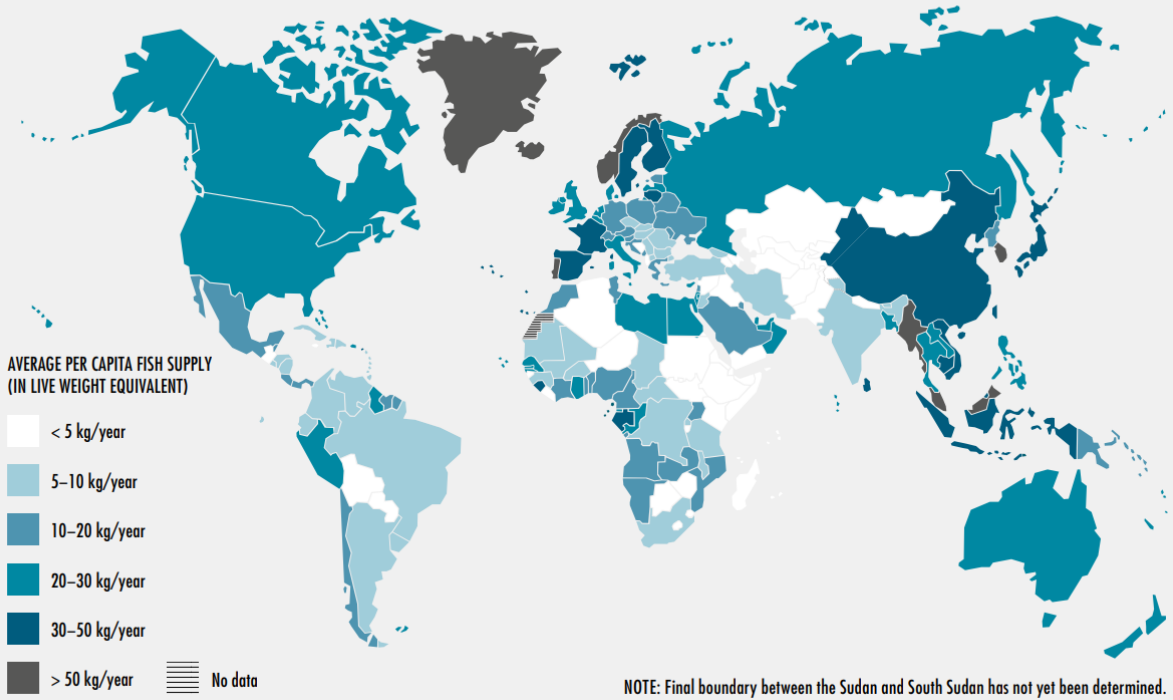
WORLD FISHERIES AND AQUACULTURE PRODUCTION AND QUANTITIES DESTINED FOR EXPORT



SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

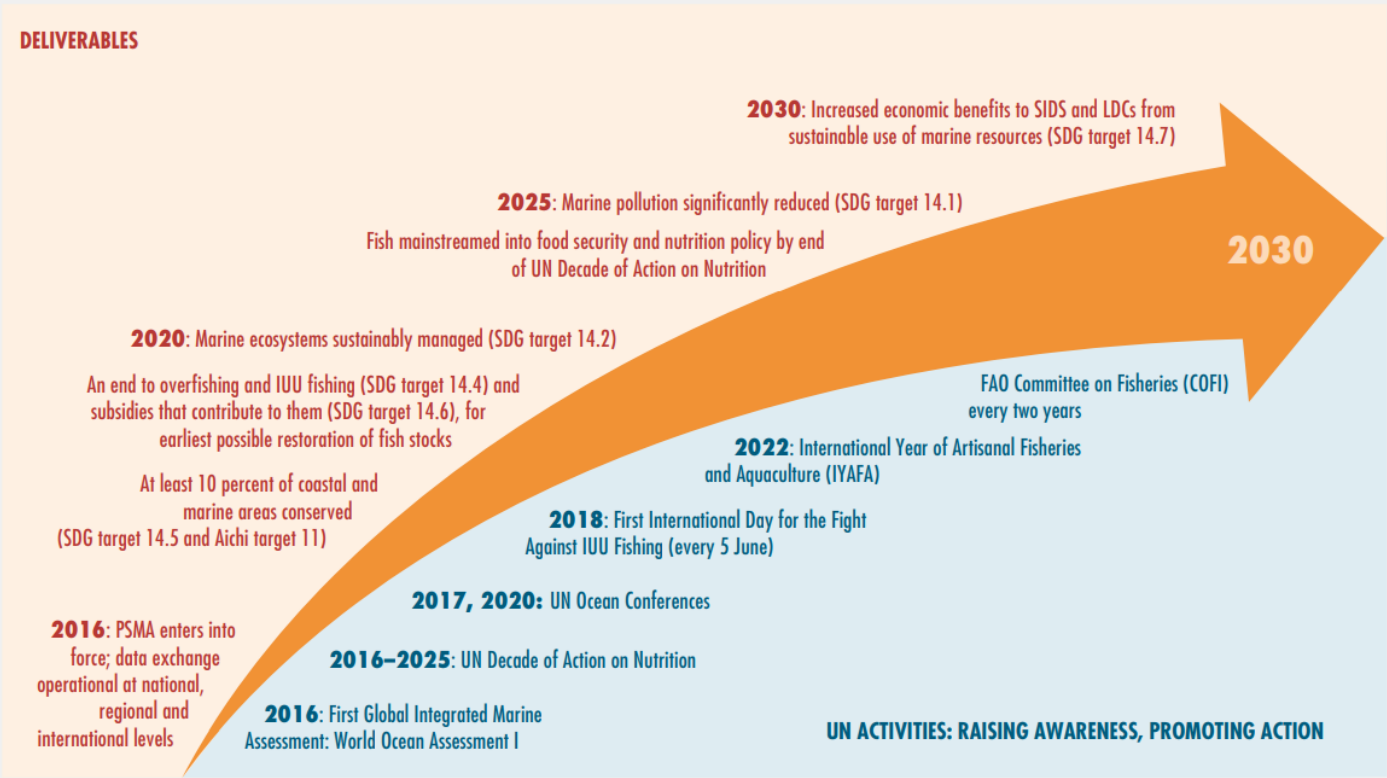
FIGURE 30

APPARENT FISH CONSUMPTION PER CAPITA, AVERAGE 2013–2015



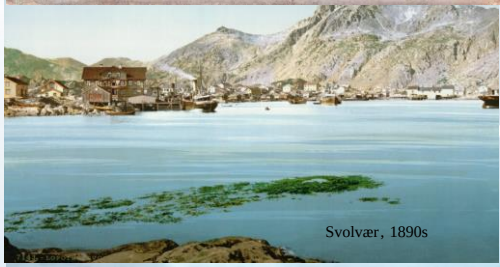
NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.

KEEPING MOMENTUM TO ACHIEVE THE 2030 AGENDA



SOFIA 2018: http://www.fao.org/3/i9540en/I9540EN.pdf

A Traditionally Fishing Nation - Norway


Svolvær, 1890s


Bergen, 1890 -1905

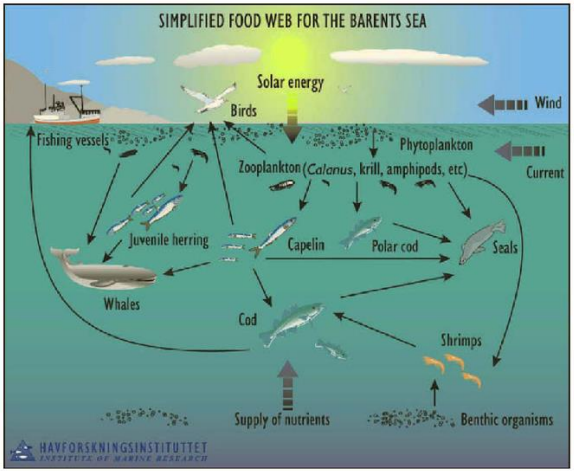
Norwegian Fisheries

Based on fish species characteristics:

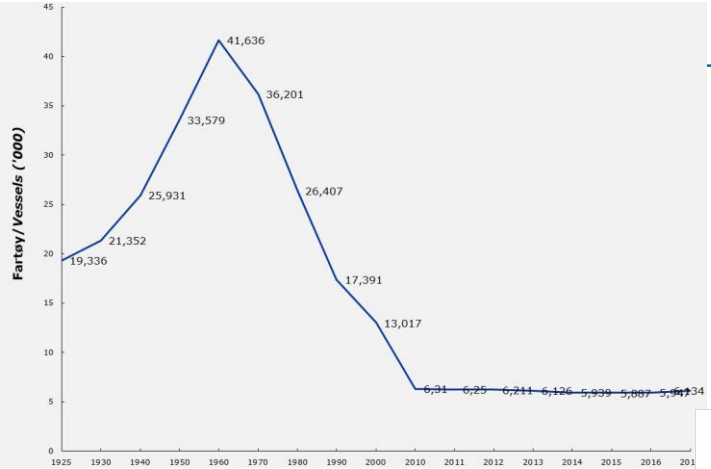
- **Pelagic species**: herring, mackerel, capelin, brisling (sprat), sandeel, Norway pout, blue whiting, etc.
- **Demersal species**: cod, saithe, haddock, pollack, ling, tusk, halibut,

Based on fishing locations and gears:

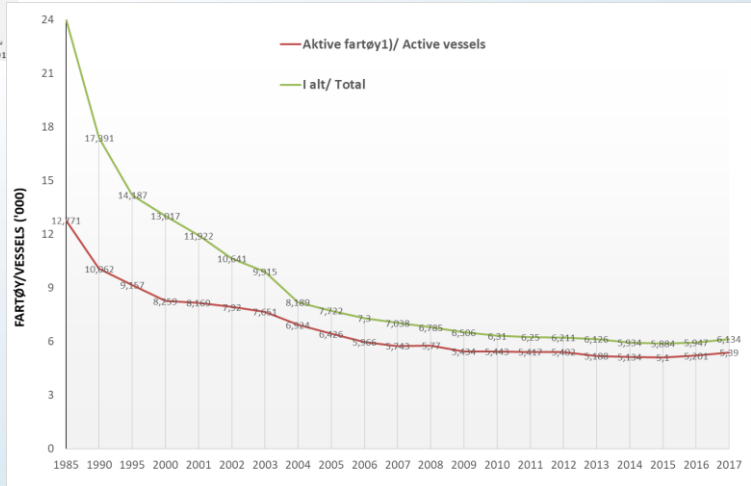
- **Coastal fisheries:** Conventional, coastal seiners, trawler.
- **Ocean fisheries:** Conventional, cod trawler, pelagic trawlers.



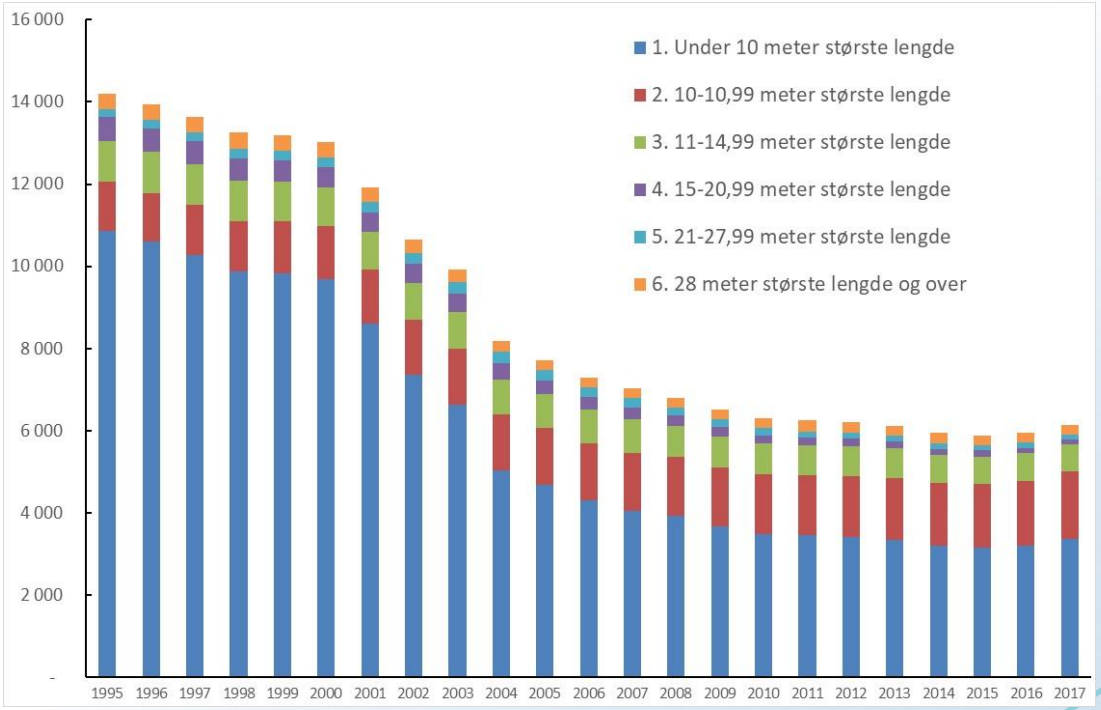
Norwegian Fishing Vessels



Source: www.ssb.no

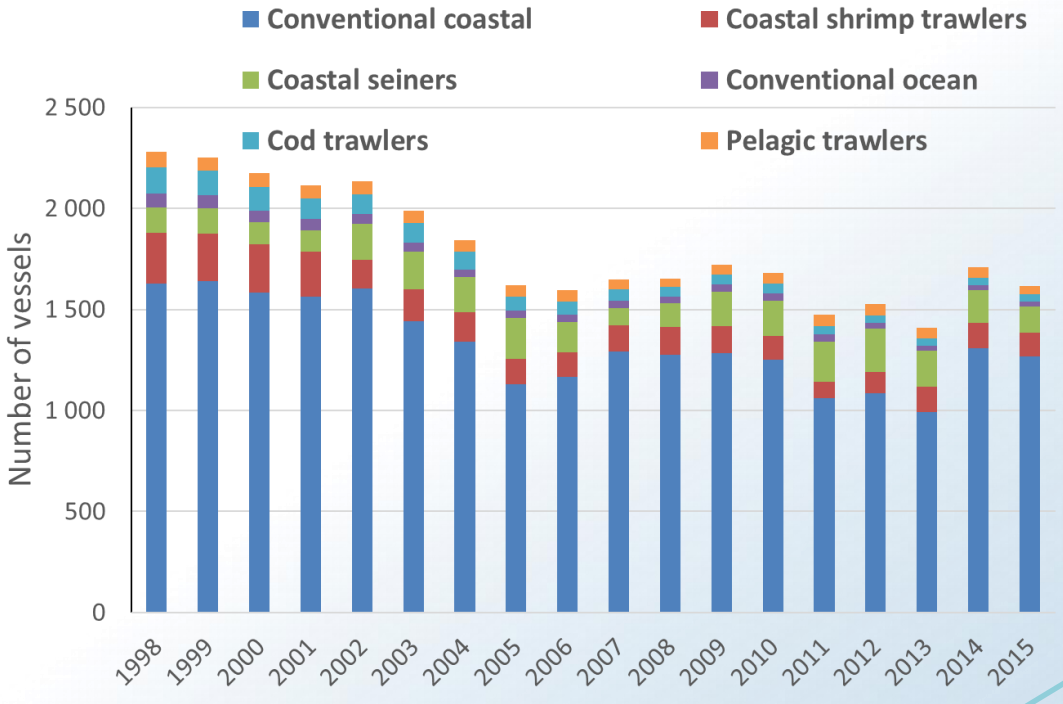


Norwegian Fishing Vessels



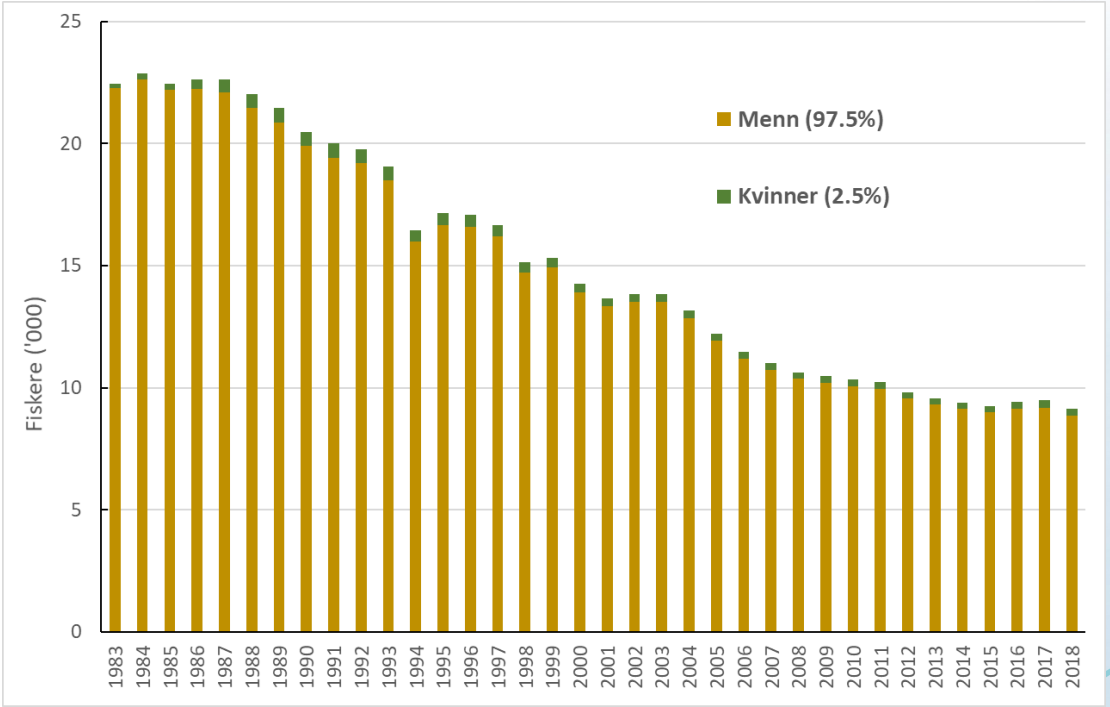
Source: www.ssb.no

Norwegian Fishing Vessels



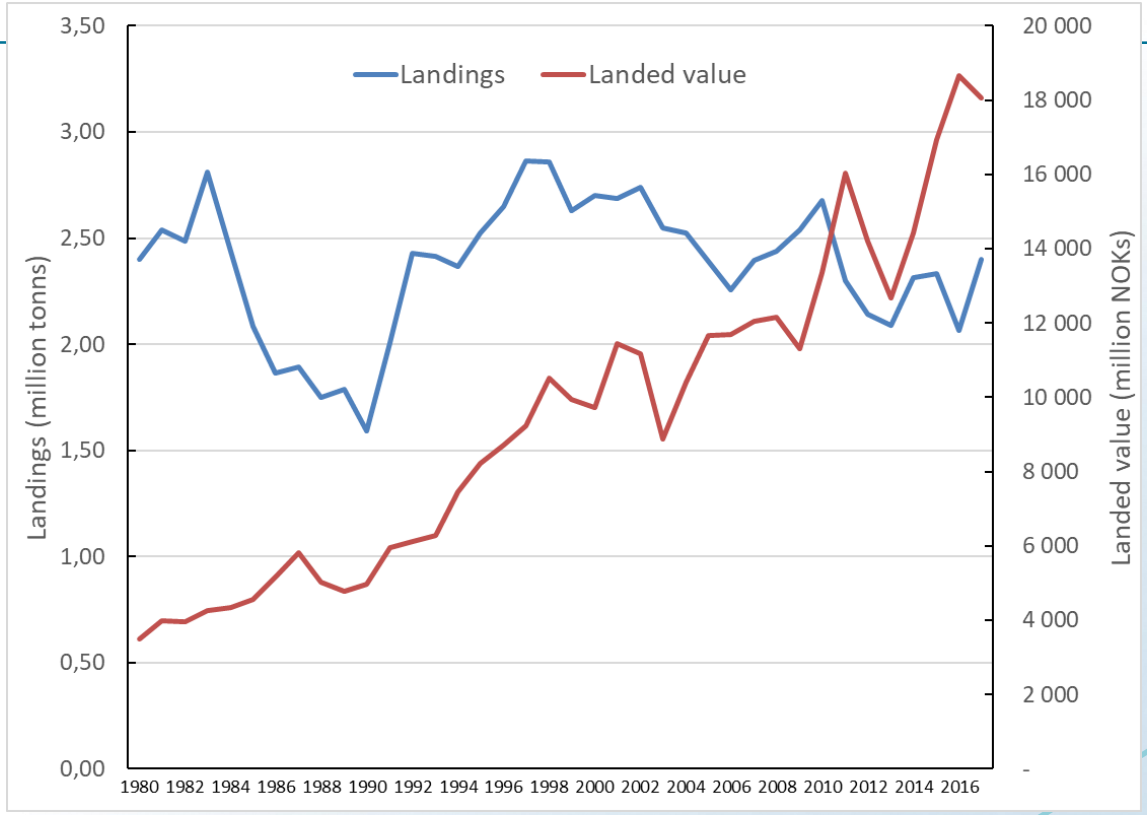
Source: www.ssb.no

Fishers



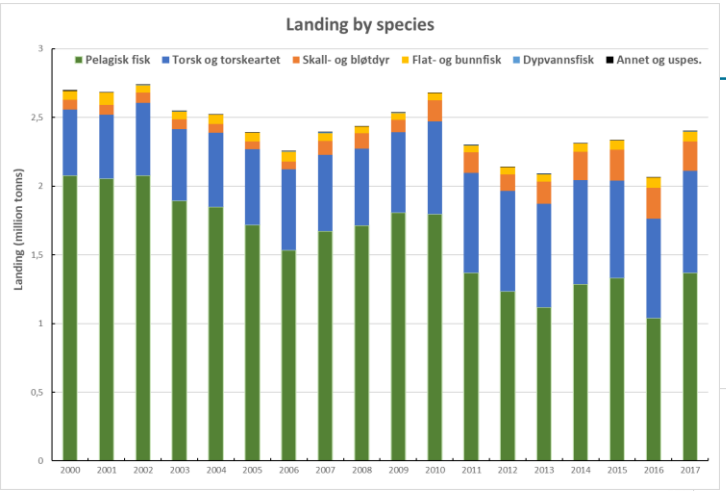
Source: www.ssb.no

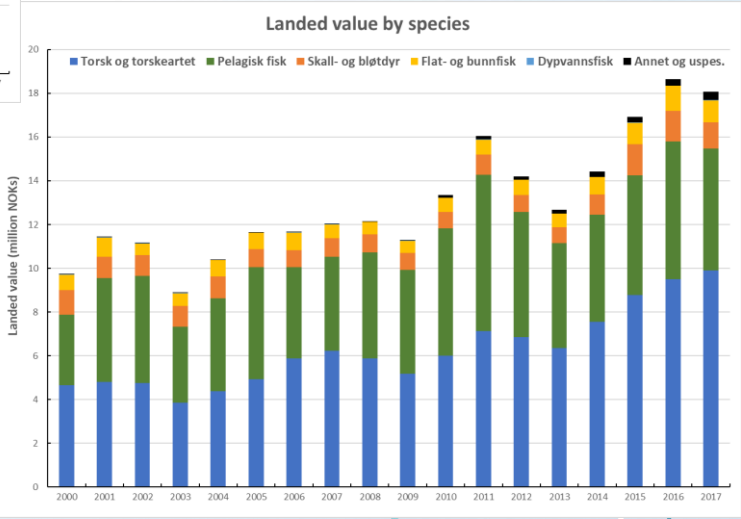
Fish Landings and landed Value



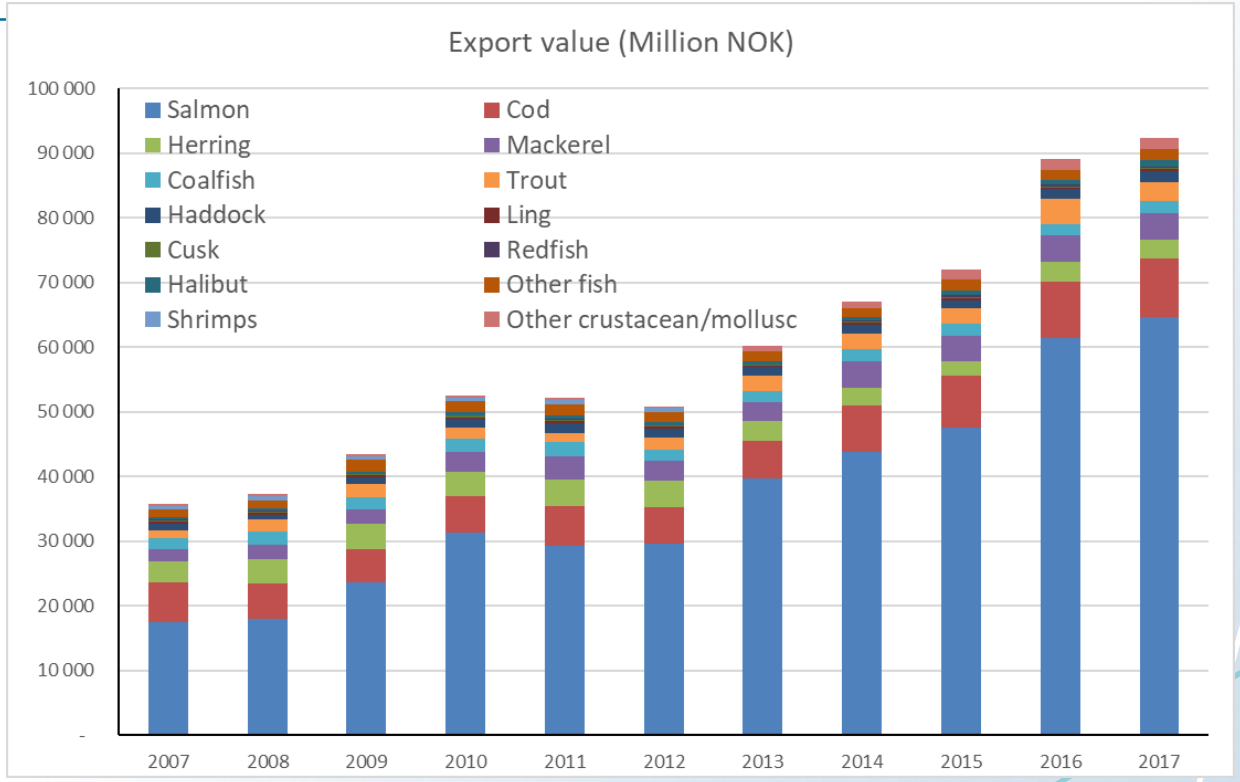
Source: www.ssb.no

Landings by Species



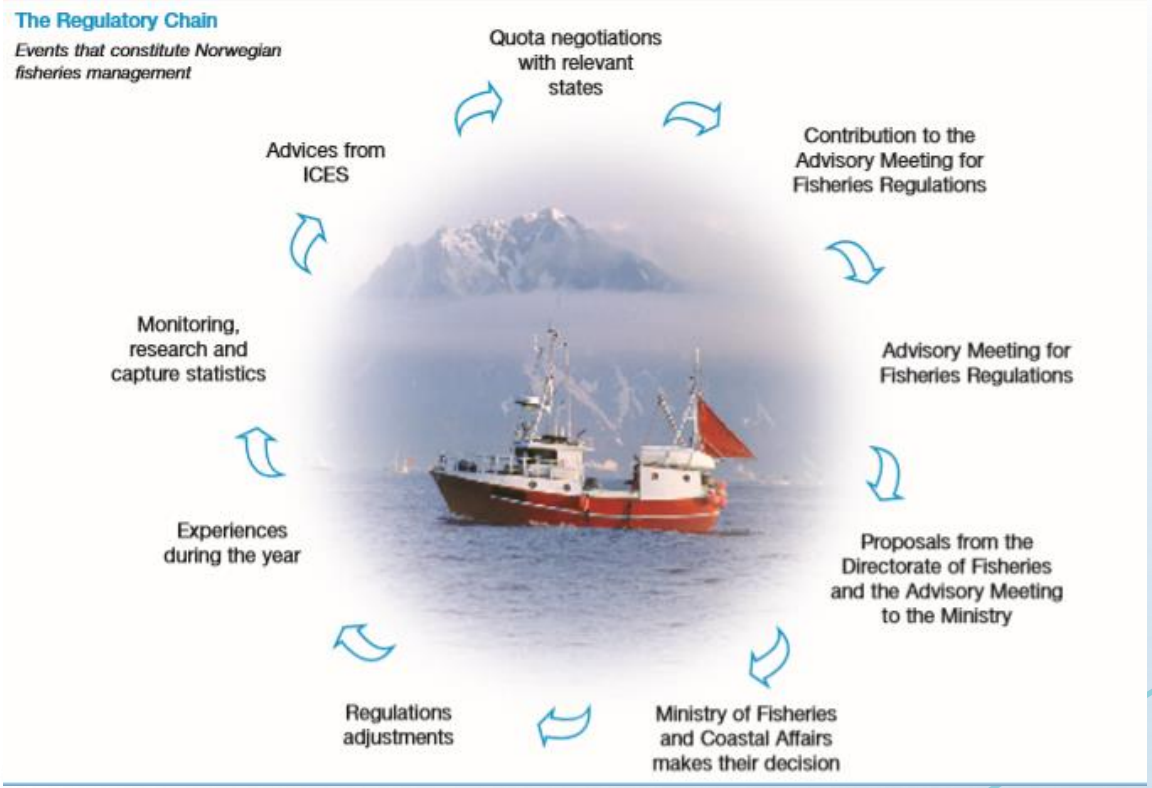


Seafood Export



Source: www.ssb.no

Norwegian Fisheries Regulation Chain



Main Fisheries Regulations in Norway

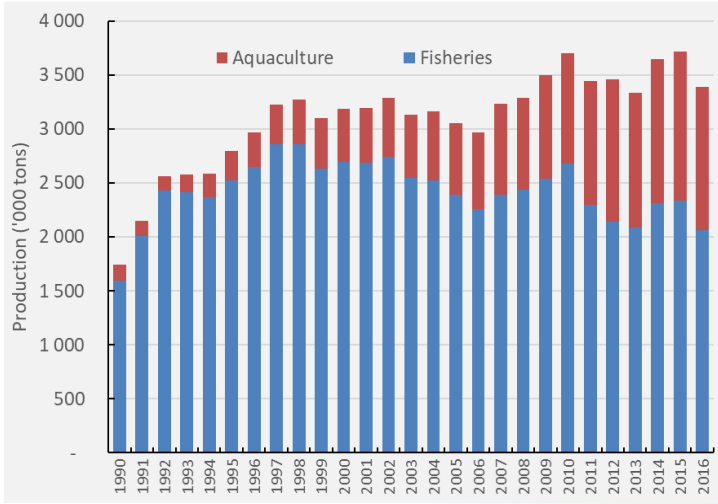
Input Regulations

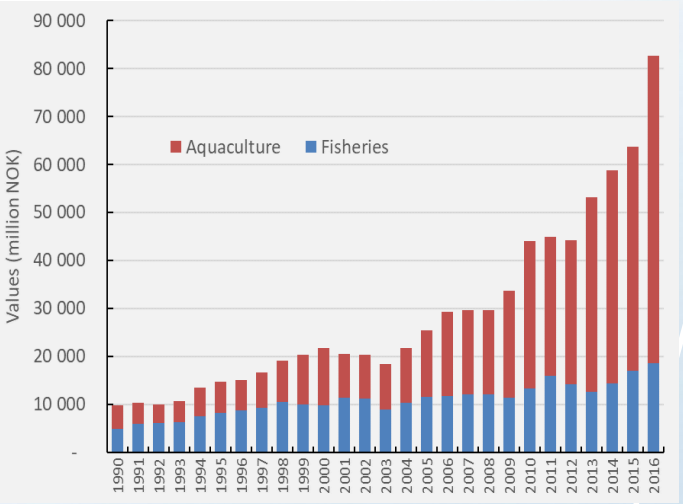
- Vessels: Concessions, annual license
- Gear restrictions and Seasonal closure

Output Regulations

- Quotas (TAC, IVQ)
- Harvest control rules
- By-catch and discard
- Toward ecosystem-based management

A Modern Farming Country?





Source: www.ssb.no

Resource Economics
– Some Concepts

- **Economics** – study of allocation of limited resources for human wants and desires;
- **Resource scarcity** – limited resource for unlimited needs (its use costly)
- **Use of Resources** incurs an opportunity cost – make choices
- **Economic rent** – profit earned exceeds the opportunity costs of all input factors.
- **Resource rent** – super normal profit from exploiting or extracting resources (may vary?)

Fish and Fisheries

Fish:

- A renewable resource (self reproduction);
- Characterized with natural growth and carrying capacity;
- Subject to harvest for food and nutritional needs;

Fisheries:

- Involve Fishers who Employ fishing vessels and gears;
- Harvested for personal and commercial uses;
- Subject to management control;

Fishing Effort: type and amount of technologies (tools) used,

Type of fisheries:

- Inshore fishing *vs.* Ocean-going fishing
- Small-scale *vs*. Industrial (large-scale) fisheries
- Commercial, recreational, subsistence, artisanal fisheries

Issues Related to Fish Resource and Fisheries

- Fish stock declining;
- Too many fishing vessels;
- Advanced fishing technology;
- Falling catch and low income;
- Waste and loss;
- Habitat destruction/pollution;
- Climate change;
- ……

- **Open Access – Tragedy of the commons**;
- Over capacity;
- Over fishing;
- Globalization;
- IUU fishing and bycatch;
- Conflicts between fishing;
- Not right management;
- ……

Fisheries Economics

The study of how society (or fishers) decides:

- What type of fish(es) (or fisheries) to harvest (***Production***)
- How to harvest (***technology***)
- Harvest for whom (***consumption and distribution***)
- For what purpose (***economics, social***, etc)

Goals of allocation of scare resources are**:**

- **Producers (fishers)**: Maximize profit
- **Consumers**: maximize satisfaction (utility)
- **Society**: maximize social welfare

Important Reference Points

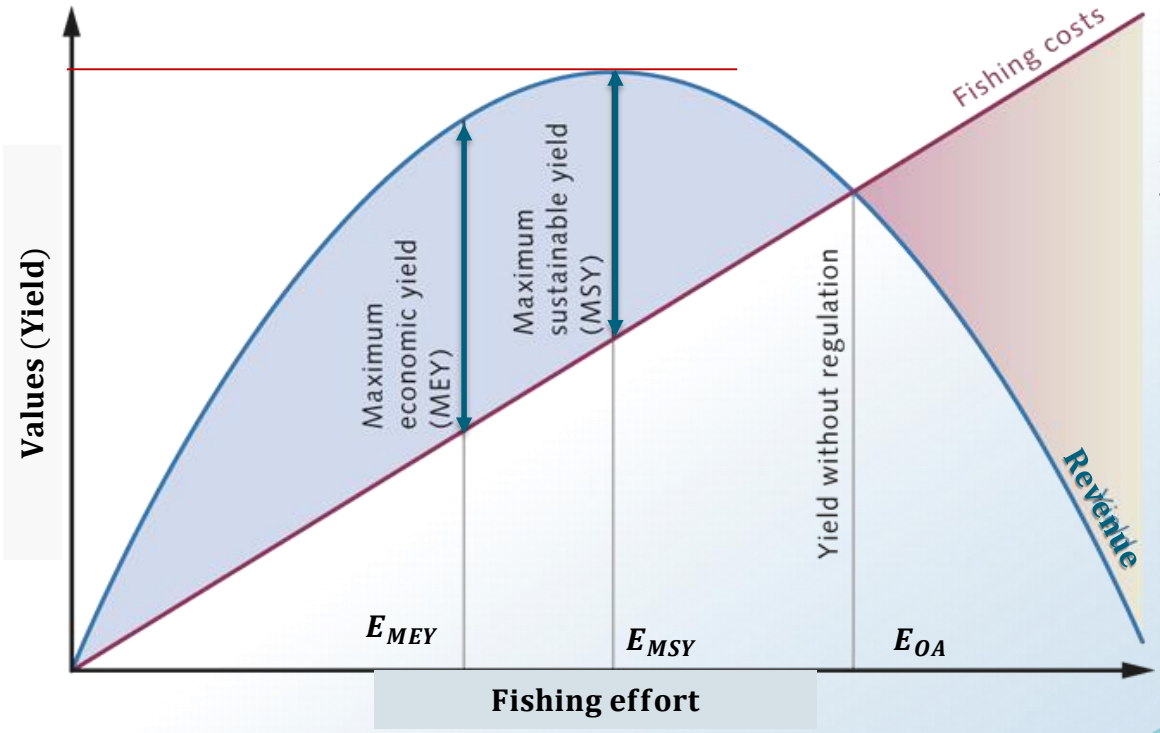
1) **Sustainable Yield** (**harvest**)

2) **MSY** (**M**aximum **S**ustainable **Y**ield)

3) **Open Access (OA)**

4) **MEY (M**aximum **E**conomic **Y**ield**);**

Important Reference Points



What are E, X and Y for three cases?

Fish Population

Stock Change = Growth + Birth – Death + immigration – emmigration - harvest

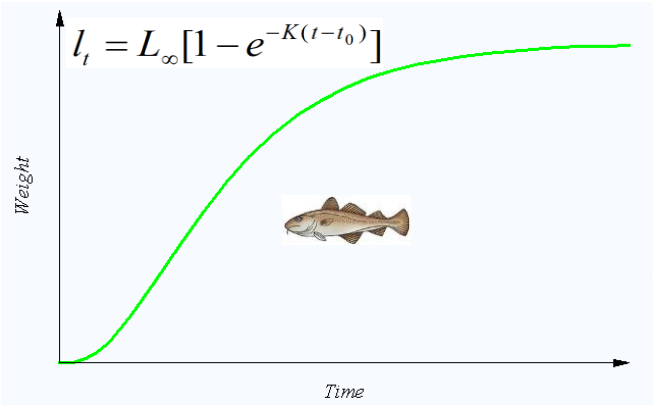
Stock Change = Growth + Recruitment – Harvest

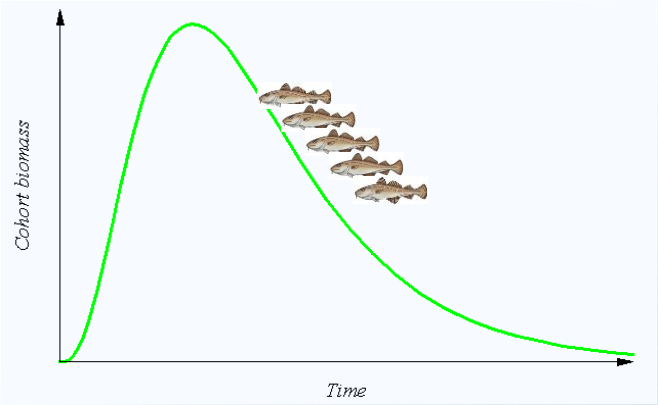
Stock Change = Growth – Harvest

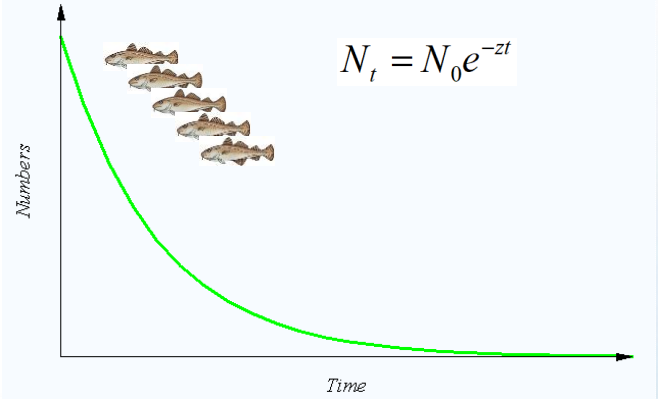
Without Fishing: $\dot{X} = X_{t+1} - X_t = F(X)$

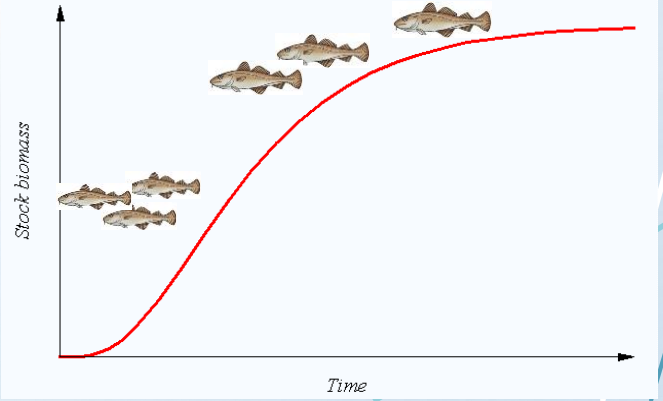
With Fishing: $\dot{X} = X_{t+1} - X_t - H_t = F(x) - H_t$

Biological Model - Fish Growth

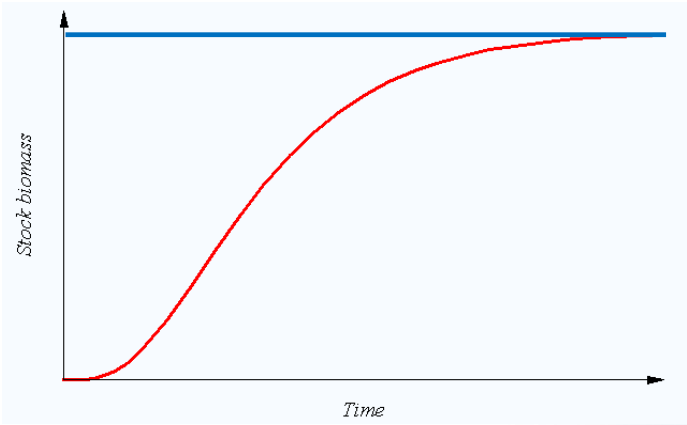


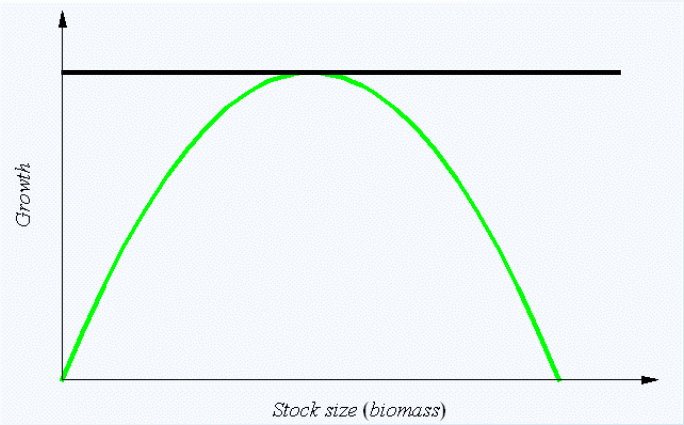






Biological Model - Fish Growth



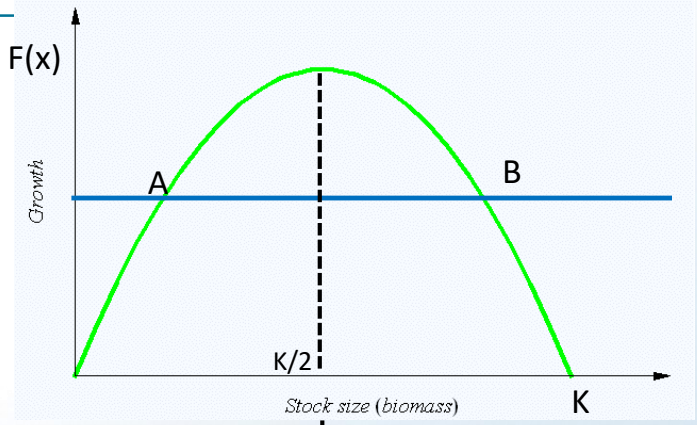


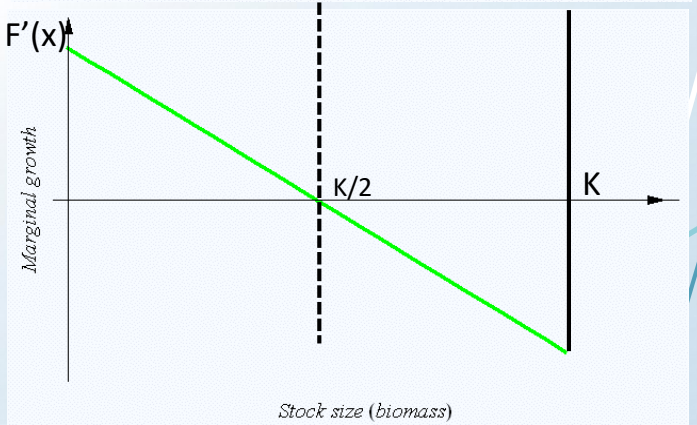
Biological Model –
Population Dynamics

Logistic Growth Function:

$$F(X) = rX(1 - \frac{X}{K})$$

$$F'(X) = \frac{dF(X)}{dX} = r(1 - {}^{2X}/_{K})$$





Biological Equilibrium

Q: What is biological Equilibrium?

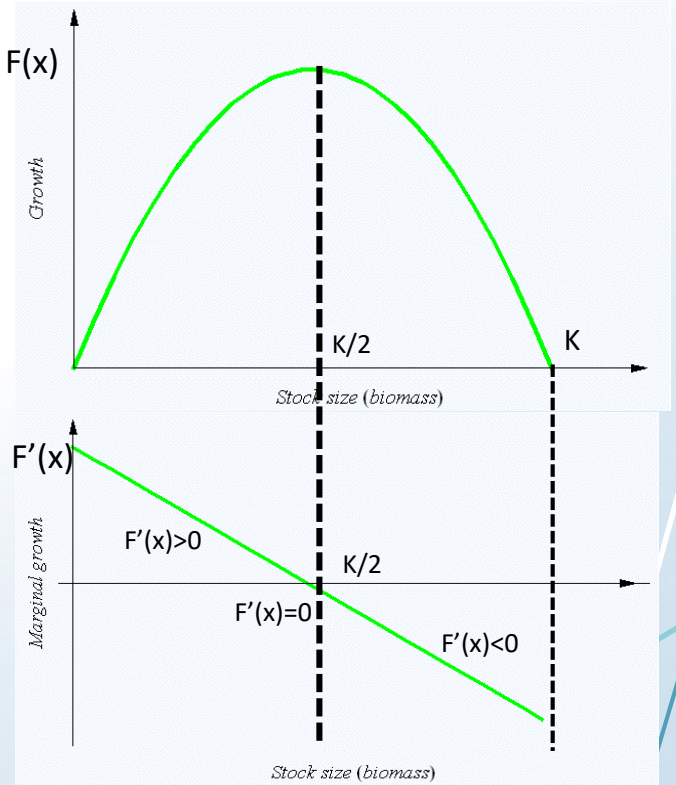
$$\dot{X} = F(X) = rX(1 - {}^{X}/_{K})$$

Q: What is maximum biological Equilibrium?

$$F'(X) = \frac{\partial F(X)}{\partial X} = r\left(1 - {}^{2x}/_{K}\right) = 0$$

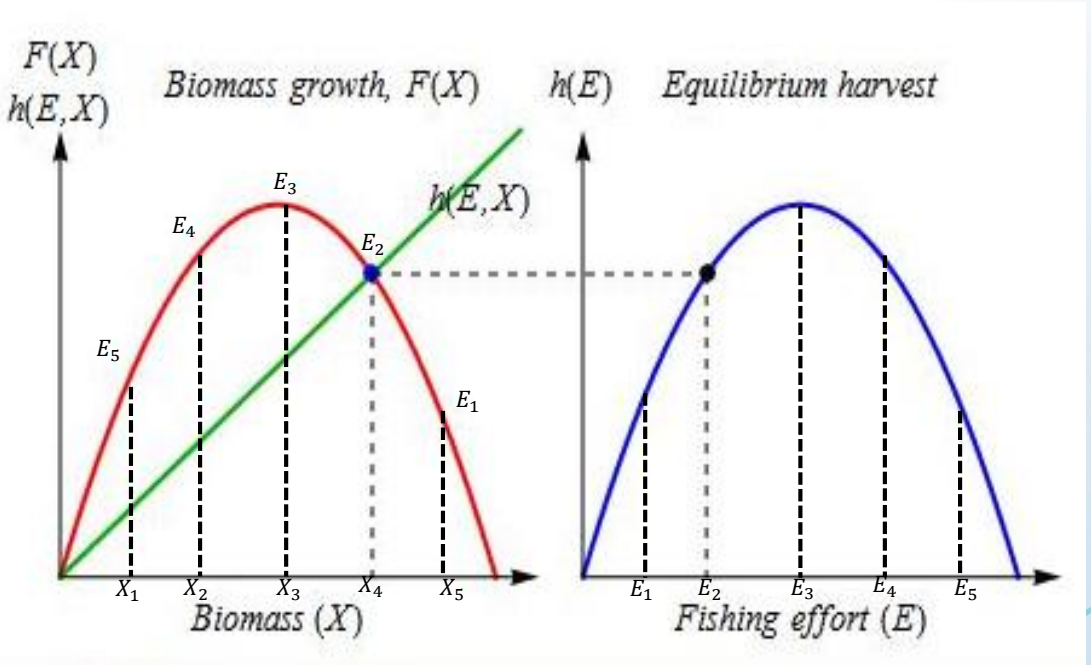
$$X_{MSY} = {}^{K}/_{2}$$

$$F(X_{MSY}) = {}^{rK}/_{4}$$



Harvest – Production Function

$$H = H(X, E) = qEX$$

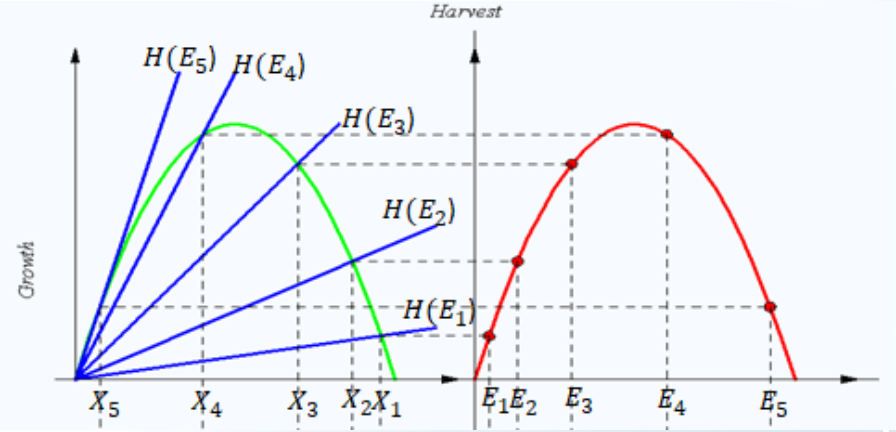


Equilibrium harvest

$$H = H(X, E) = qEX$$

$$F(X) = rX(1 - {}^{X}/_{K})$$

$$F(X) = H(X, E)$$



Q: What is maximum equilibrium harvest (yield) - **MSY**?

Equilibrium Harvest

$$rX(1 - {}^{X}/_{K}) = qEX$$

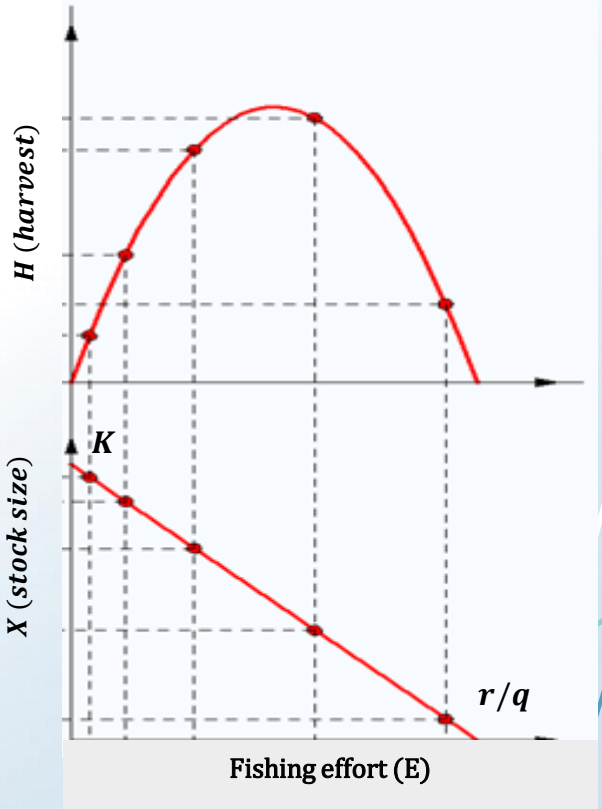
$$\mathrm{X} = K(1 - {}^{qE}/_{r})$$

$$H(E) = qKE\ (1 - {}^{qE}/_{r})$$

$$X_{MSY} = K/2$$

$$H_{MSY} = rK/4$$

$$E_{MSY} = r/2q$$



Economics

i) Total Revenue from Fishing (TR):

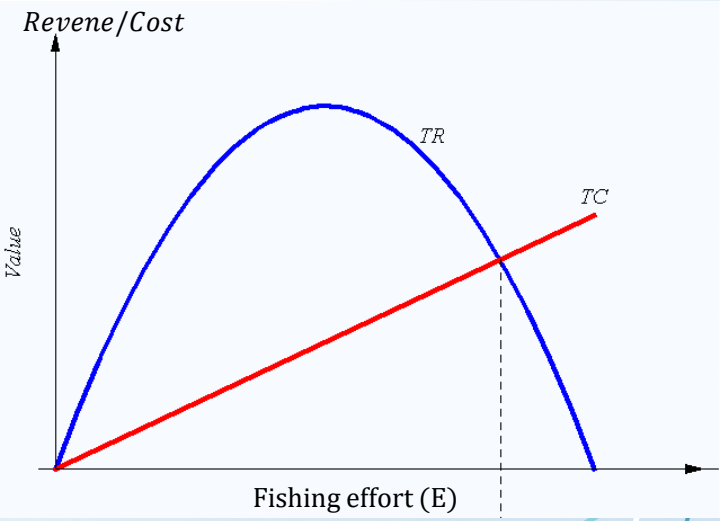
$$TR = p \cdot H(E) = TR(E)$$

ii) Total Cost of Fishing (TC):

$$TC = c \cdot E = TC(E)$$

iii) Resource Rent:

$$\pi = TR - TC$$



Economics

Total Revenue from Fishing (TR):

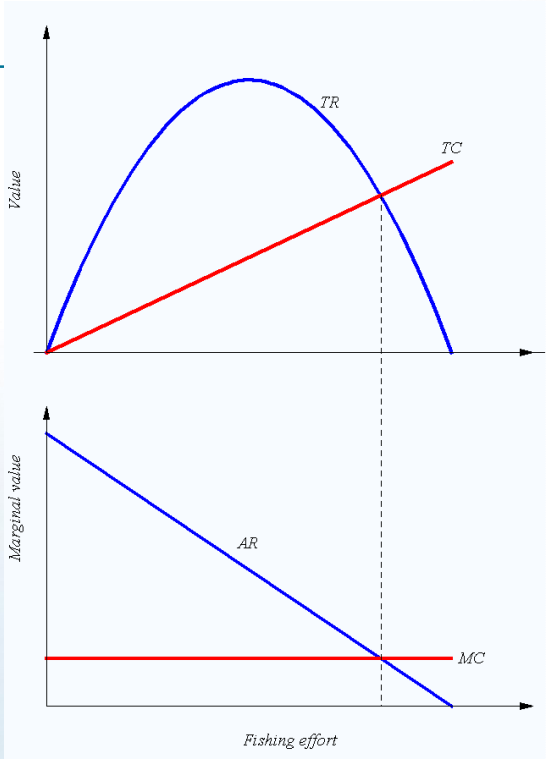
$$TR = p \cdot H(E) = TR(E)$$

a) **Average revenue:**

$$AR = \frac{TR}{E} = \frac{TR(E)}{E} = AR(E)$$

b) **Marginal revenue**:

$$MR = \frac{dTR(E)}{dE} = MR(E)$$



Economics - Revenue

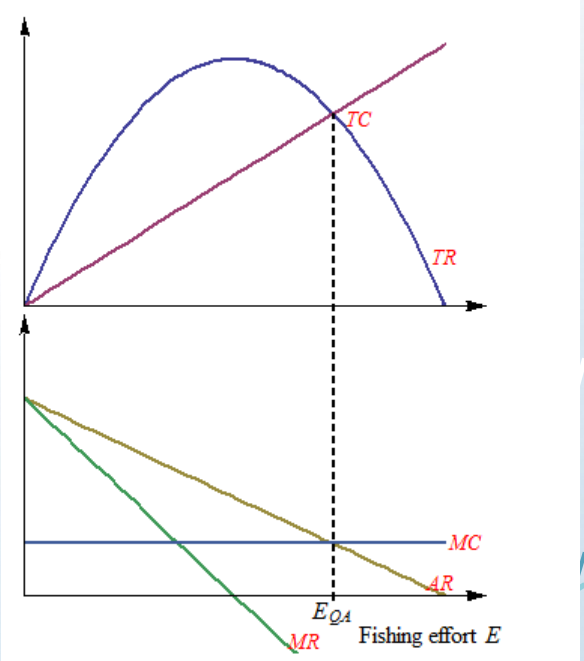
$$TR = p \cdot H(E) = TR(E)$$

$$H = qKE\,(1 - {}^{qE}/_{r})$$

$$TR = p \cdot H(E)$$
$$= p \cdot qKE\,(1 - {}^{qE}/_{r})$$

$$AR(E) = \frac{TR(E)}{E}$$
$$= p \cdot qK\,(1 - {}^{qE}/_{r})$$

$$MR(E) = \frac{dTR(E)}{dE} = p \cdot qK\,(1 - {}^{2qE}/_{r})$$



Economics - Costs

Total Cost of Fishing (TC):

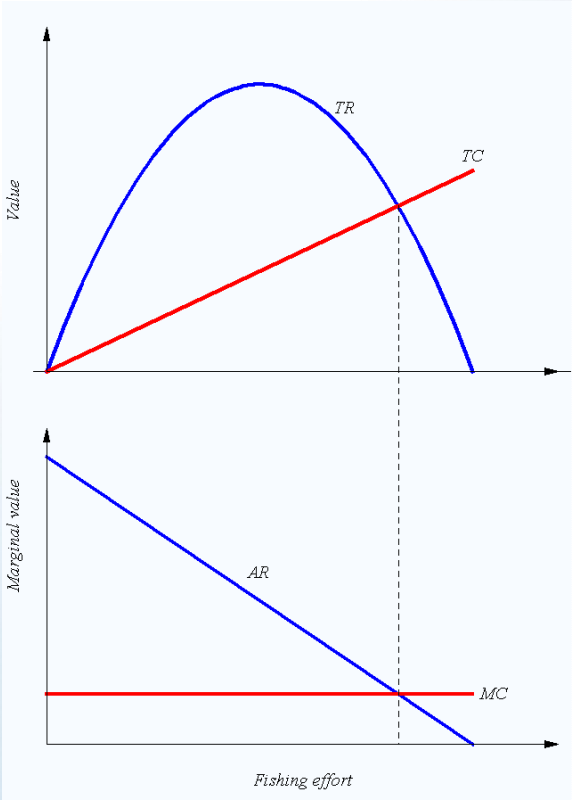
$$\boldsymbol{TC = c \cdot E = TC(E)}$$

a) Average cost:

$$AC = \frac{TC(E)}{E} = c$$

b) Marginal cost:

$$MC = \frac{dTC(E)}{dE} = MC(E) = c$$



Open Access

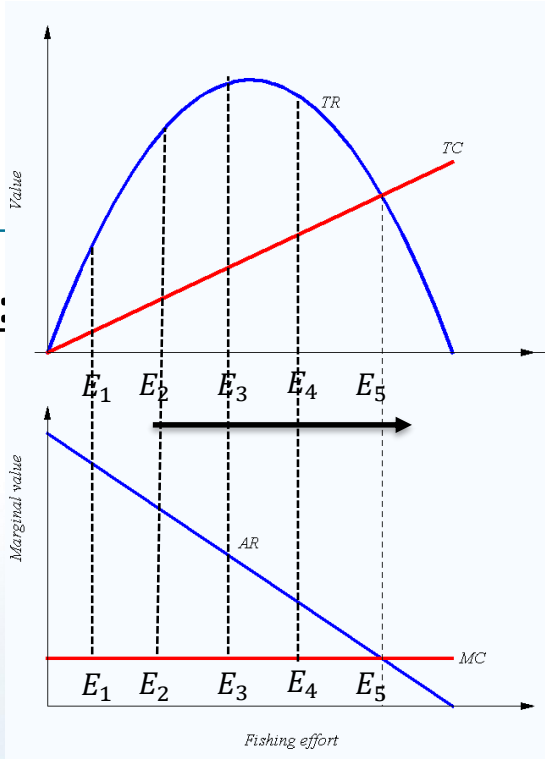
When fisher is making a nominal profit:

$$\pi = TR - TC = 0$$

$$AR = MC$$

$if\ \ AR > MC$, then
more fishers enter the fishery

$if\ \ AR < MC$, then fishers exit the fishery



What is the open access bioeconomic equilibrium?

Open Access

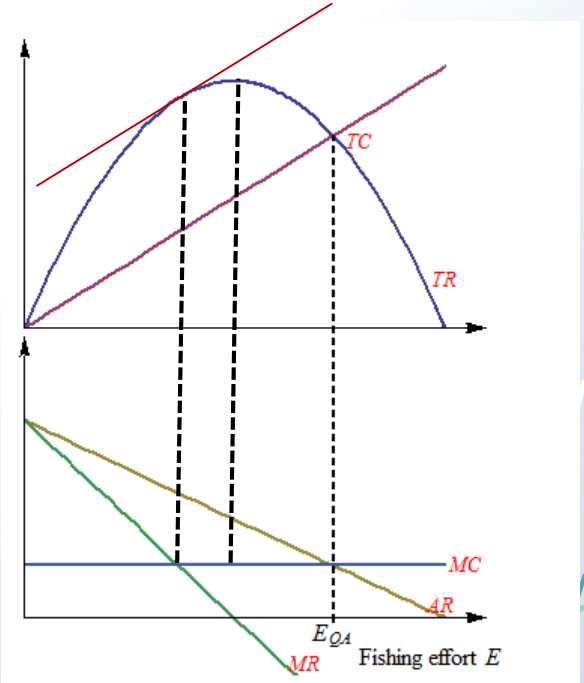
$$TR - TC = 0$$

$$TR = pH(E) = pqKE\,(1 - {}^{qE}/_{r})$$

$$TC = c \cdot E$$

$$\boldsymbol{E_{OA} = r/q\,(1 - {}^{c}/_{pqk})}$$

$$\boldsymbol{X_{OA} = c/pq}$$



Maximum Economic Yield (MEY)
(Maximum resource rent)

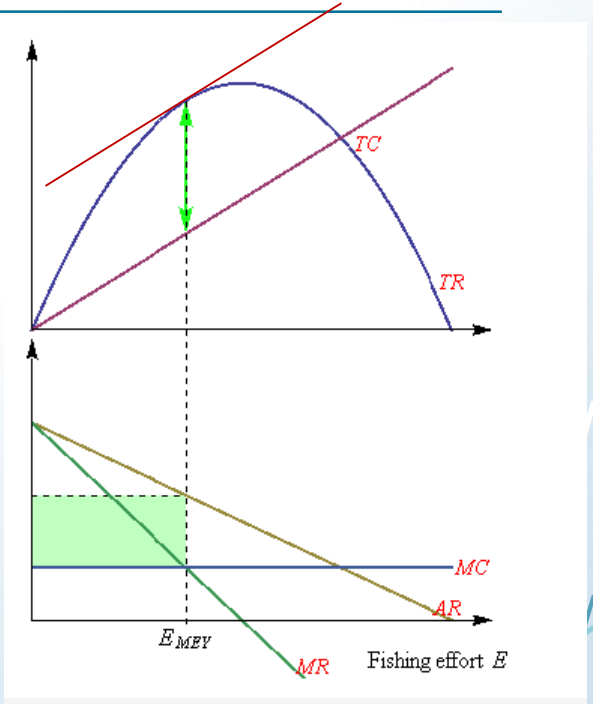
Resource rent (π) is Maximized when $\mathbf{MR}(E) = MC(E)$

$$MR(E) = \frac{dTR(E)}{dE} = p \cdot qK\,(1 - {}^{2qE}/_{r})$$

$$MC = \frac{dTC(E)}{dE} = MC(E) = c$$

$$E_{MEY} = r/2q\,(1 - {}^{c}/_{pqk}) = 1/2E_{OA}$$

$$X_{MEY} = \frac{K}{2} + {}^{c}/_{2pq} = X_{MSY} + 1/2X_{OA}$$



Important Reference Points

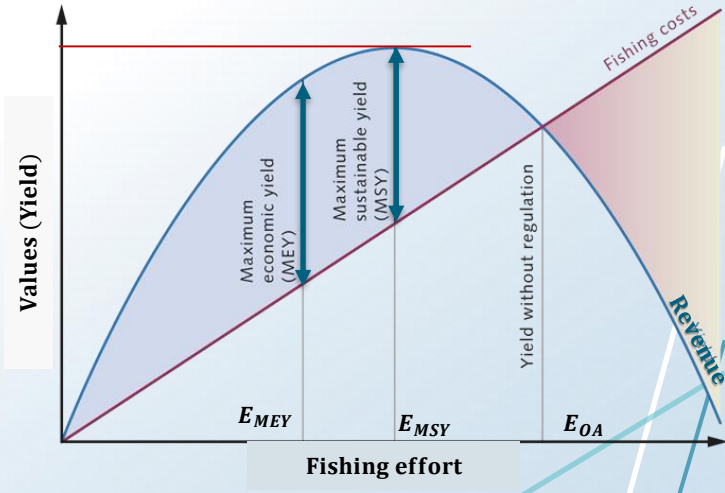
1) **Sustainable Yield (harvest)**

2) **MSY (Maximum Sustainable Yield)**

3) **Open Access (OA)**

4) **MEY (Maximum Economic Yield);**

Q: What are fishing effort, stock size and harvest levels for these points?



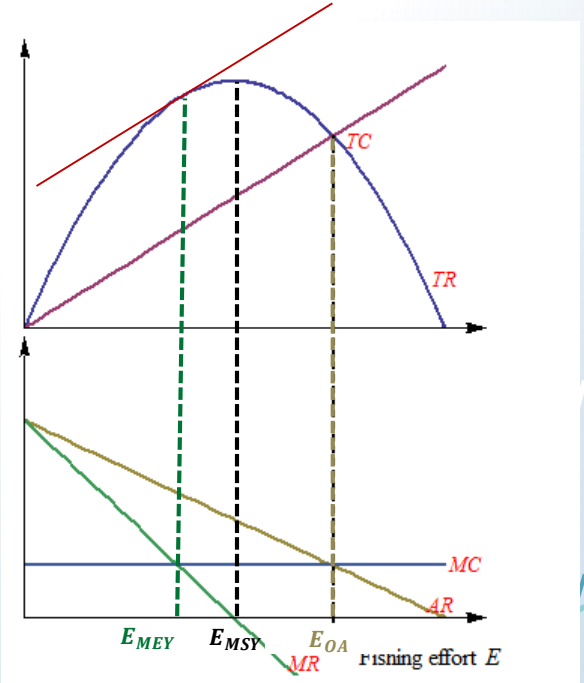
Important Reference Points

Difference in fishing effort, stock size and profit for the cases of MSY, OA and MEY.

$$E_{OA} > E_{MSY} > E_{MEY}$$

$$X_{OA} < X_{MSY} < X_{MEY}$$

$$\pi_{MEY} > \pi_{MSY} > \pi_{OA}$$



Fisheries Management

	INPUT CONTROL	OUTPUT CONTROL
Direct control	• Fishing licences • Capacity restriction (e.g., engine power) • Limited entry (# of vessels, fishing days, season, areas, etc) • Technical measures (e.g., gears used, mesh size, etc) • Marine protected areas (e.g., salmon fjord)	• Quota system (TAC; IFV; ITQ)) • Minimum fish size Minimum price
Indirect control	• Tax on fishing effort • Tax/Subsides on fuel • Buyback program	• Tax on harvest/landing fee • Transferable quota (ITQ)

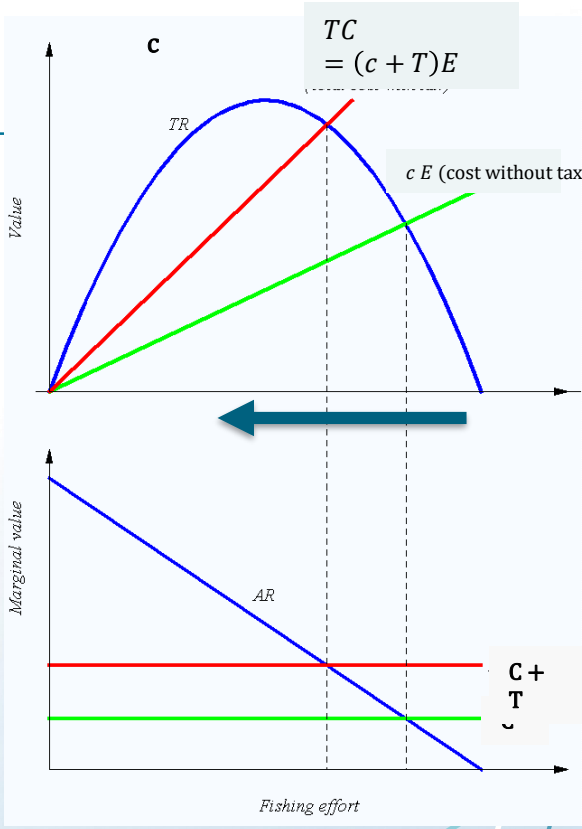
Fisheries Management

- Economic instrument

I) *Tax* on fishing effort, E

$$TC = (c + T) \cdot E$$

- **Effort is reduced,**
- **Renevue for government;**

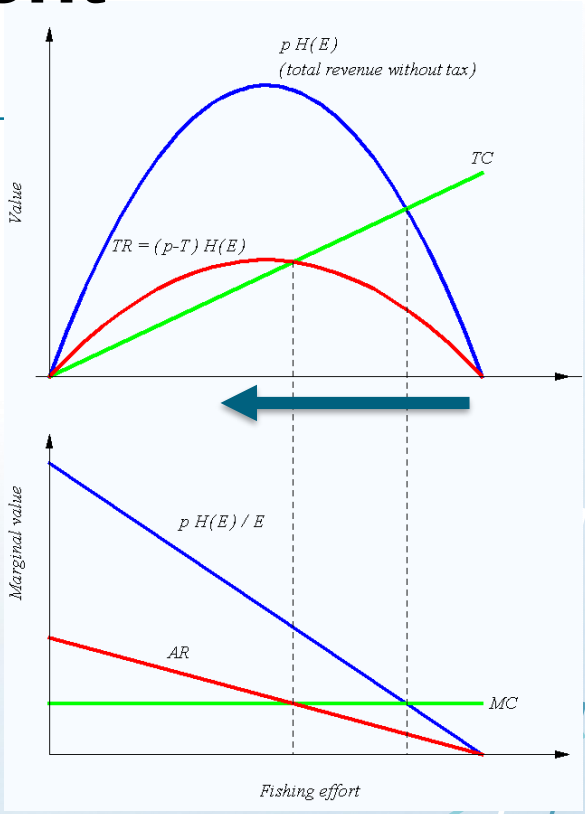


Fisheries Management

- Economic instrument

I) *Tax* on harvest

$$TR(E) = (p - T) \cdot H(E)$$



Questions

What would you do:

- If you are working as a government officer
- If you are an industrial (large-scale) fisher
- If you are an small-scale fisher
- If you are working for a NGO
- ……