

M1.3 Fisheries Management and the role of the fisheries scientist

**Assessing the status of fish stock for
management: the collection and use of basic
fisheries data and statistics**

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Background for fisheries management

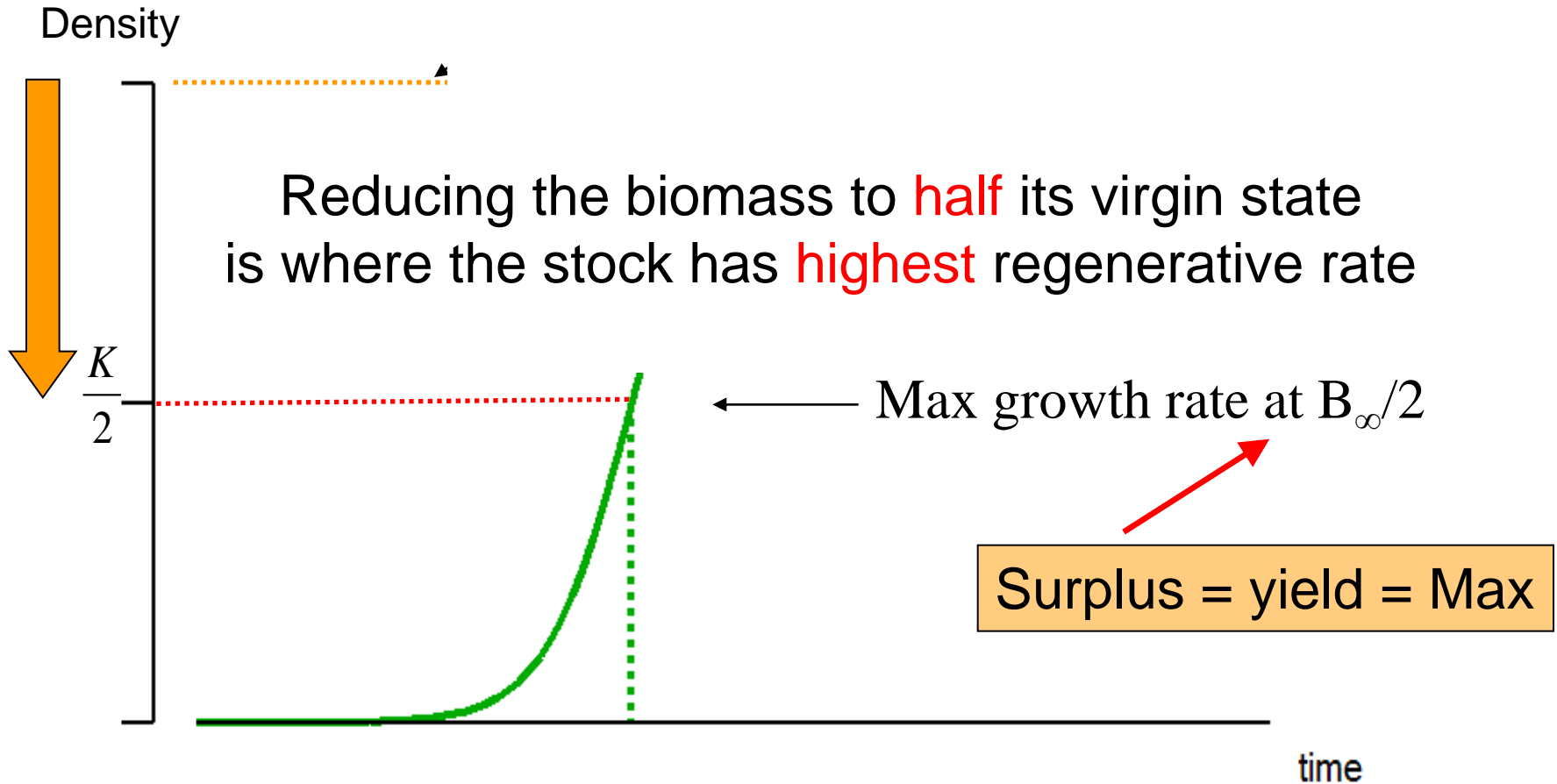
Classical or conventional fisheries management are based on two hypotheses:

- 1) The logistic Gordon-Schaefer model (Gordon 1954, Schaefer 1954)
- 2) The Common Property Theory (CPT) alias “The tragedy of the commons” (Gordon, 1954, Hardin 1961, 1968)

These are the background for concepts like carrying capacity, maximum sustainable yield (MSY), resource rent, and maximum economic yield (MEY)

Logistic Gordon-Schaefer model

Density dependence



Logistic growth

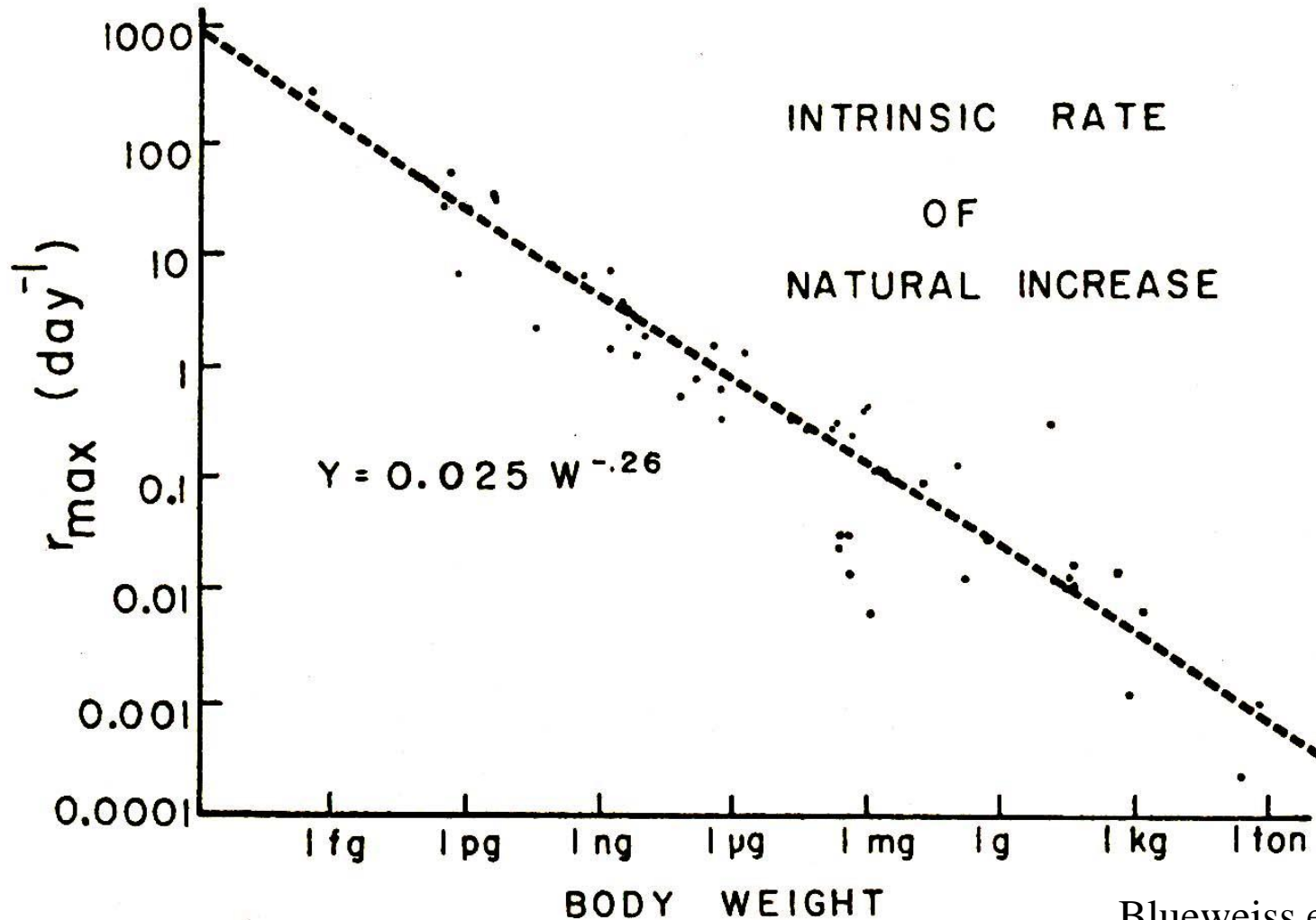
Density dependence

The speed of biological regeneration depends on:

1. The intrinsic rate of natural increase (r_m), which is a species specific constant related to life history
2. The density of the population (standing biomass) relative to the carrying capacity (K), where K is the limit (normally food).

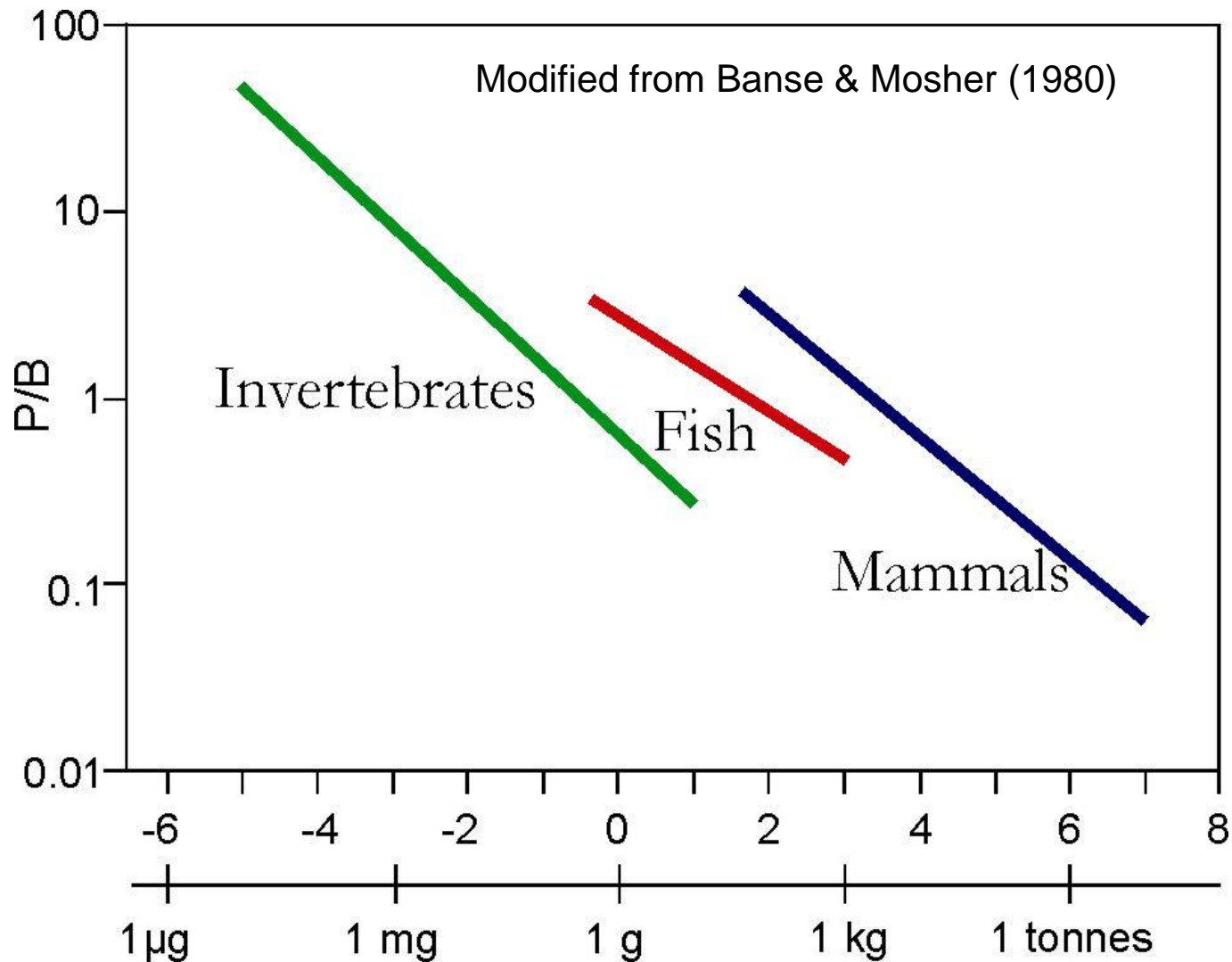
$$r \approx P/B \approx Z$$

The intrinsic rate of natural increase \approx Production to biomass ratio \approx total mortality rate



Blueweiss et al. (1978)

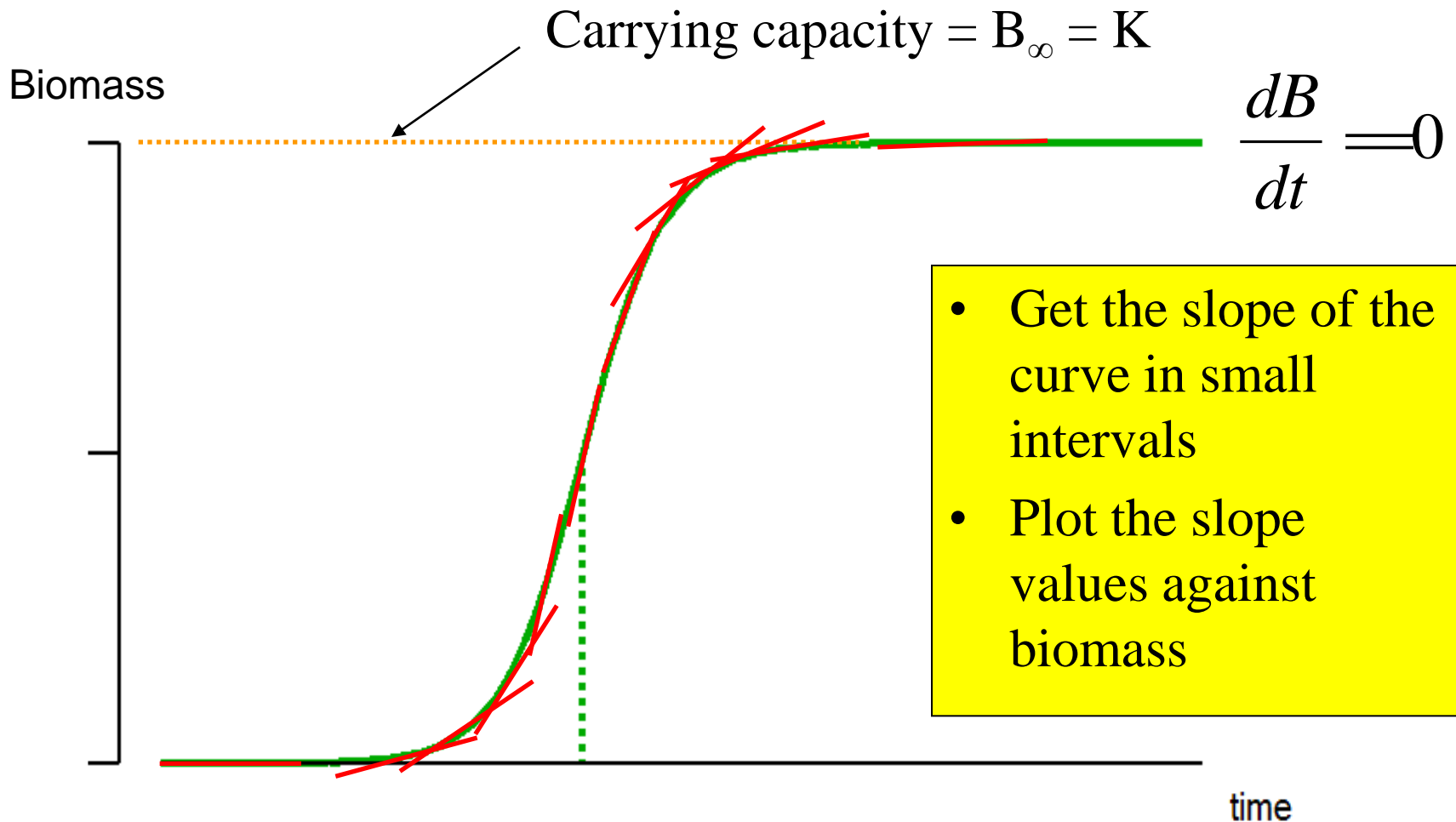
$$r \approx P/B \approx Z$$



Log P/B ratio is a linear function of log body size

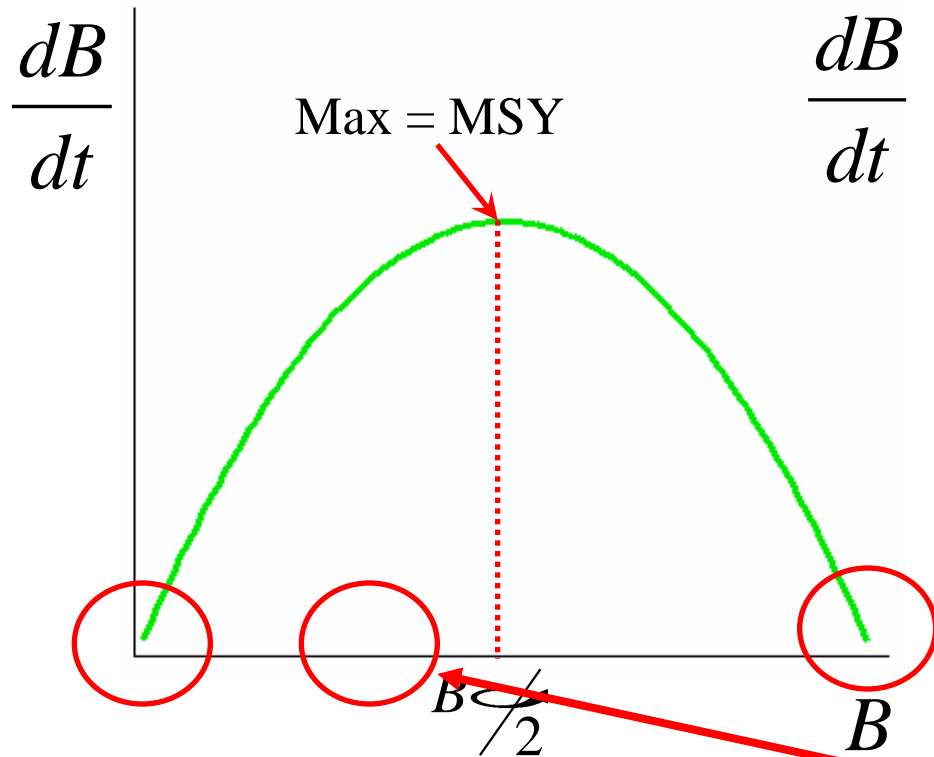
Surplus production - MSY

finding the *growth rate* as a function of the biomass



Logistic growth – Surplus production

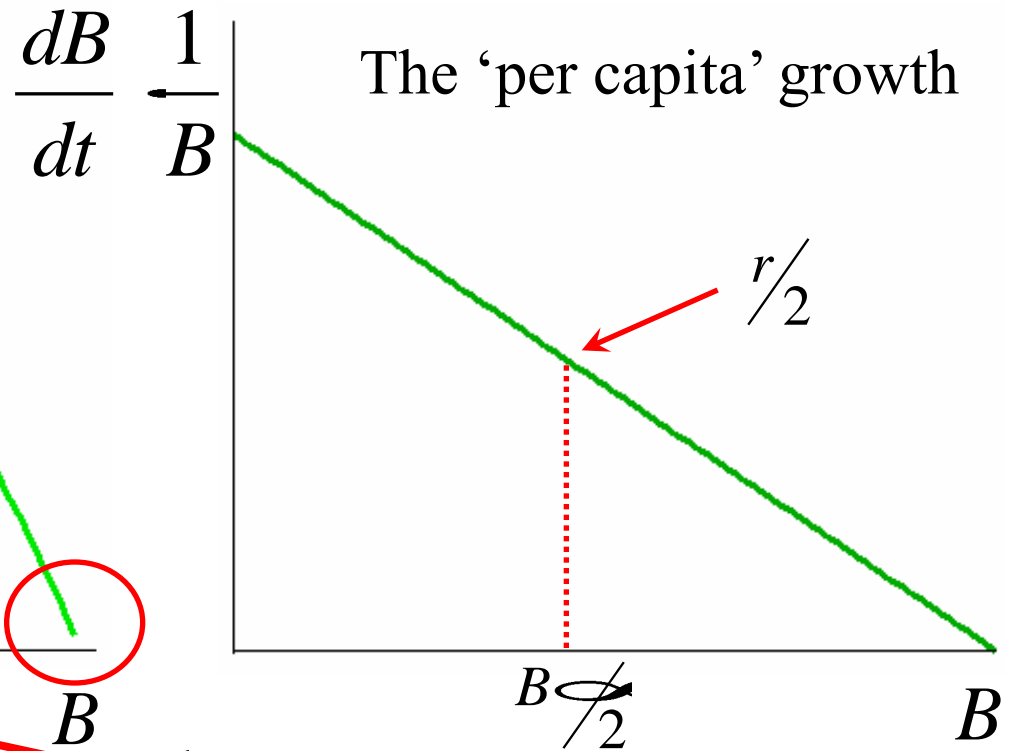
The rate of change in biomass production as a function of the biomass



No growth
No surplus
No stock

No growth
No surplus

The change of specific growth rate as a function of the biomass



For most fish stocks
MSY is at $\approx 30\%$ of B_{∞}

Fishing

Catch = Fishing mortality · Biomass

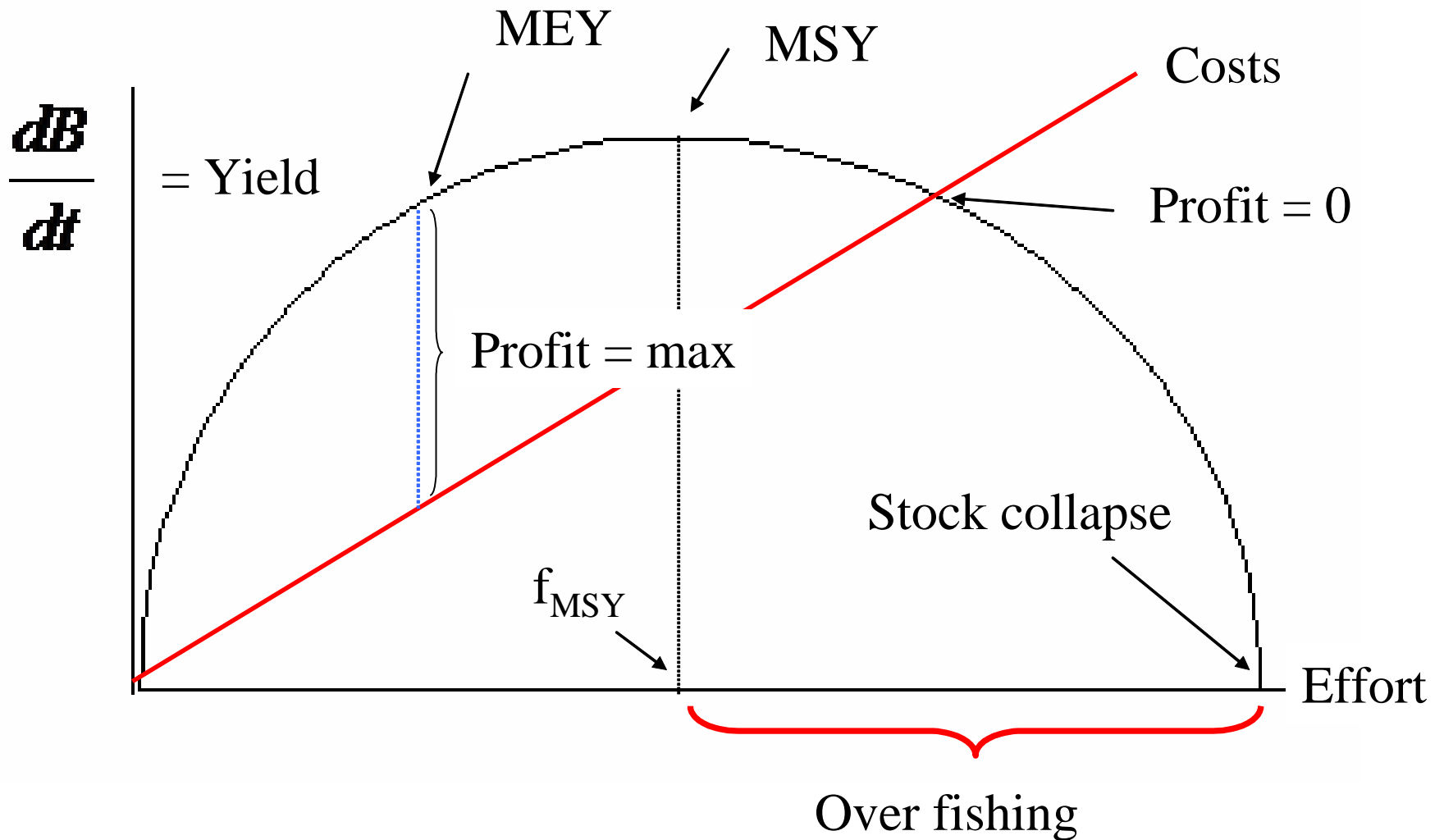
$$C = F \cdot B = q \cdot f \cdot B$$

- q = catchability coefficient
- f = fishing effort

If q = constant then catch \approx biomass · effort

→ The yield curve as a function of effort has same shape as the production curve as a function of biomass

Common property theory (CPT) (open access)



Common property theory

- Much debate whether CPT is “true” or “False”
- However, it is an analytical model, not an empirical model
- It can only be “true” if the underlying assumptions are true – are they?
 - Single species model (no switching)
 - Man is the only predator
 - Nature stable and in balance
 - Fishing continues even profit is low or 0
- Why does CPT not apply to natural predators?
 - They are also harvesting a common?

2 types of over fishing:

- **Growth over fishing**

When catching the fish before they have utilized the growth potential (from Y/R models → **mesh size** regulations)

- **Recruitment over fishing**

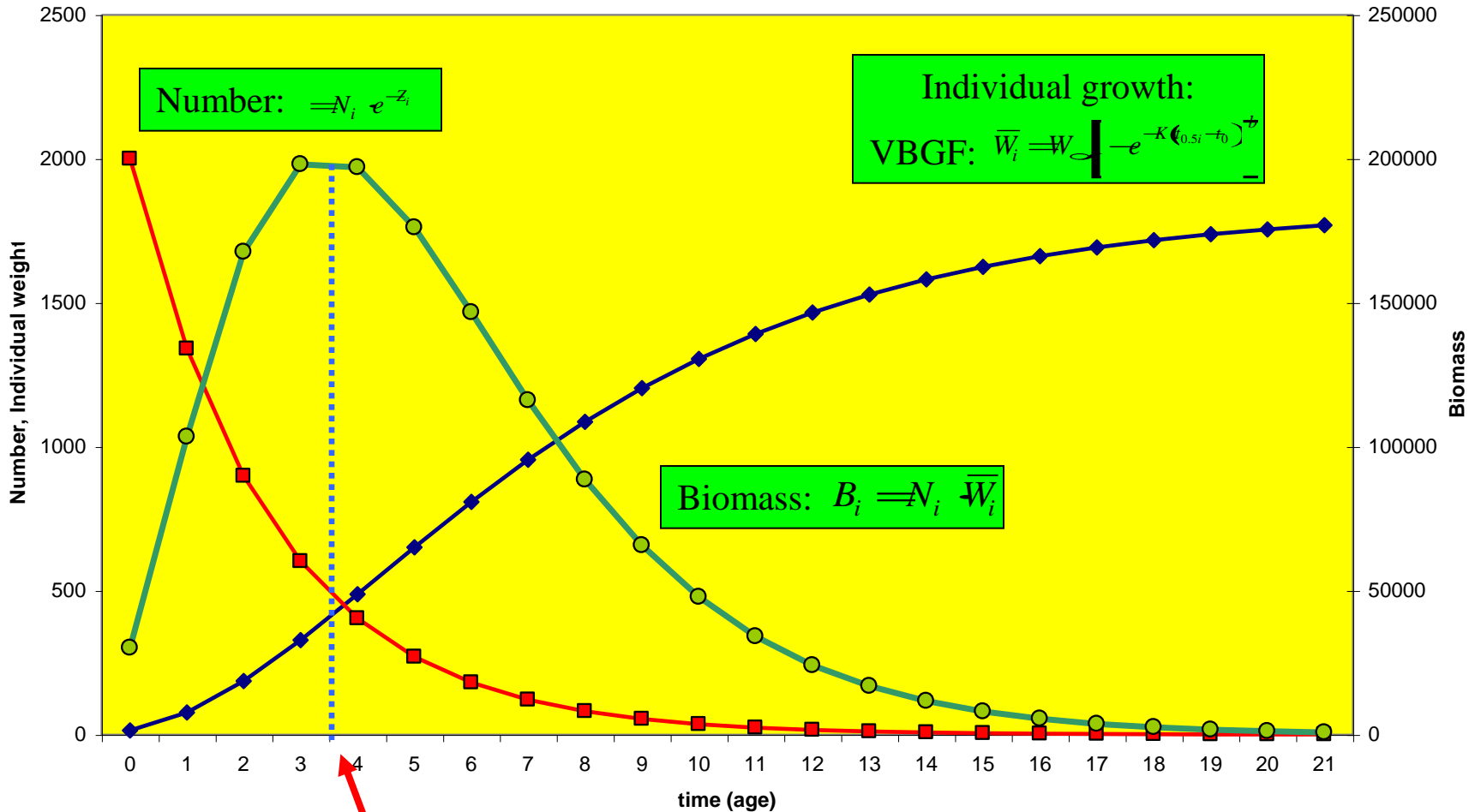
When stock is so low that recruitment is impeded (e.g. Schaefer model → **effort** regulations)

Both are difficult to define in a fluctuating ecosystem with multi-species interactions.

Y/R models – biomass of a cohort

$$Y = \sum_{tc}^{t \max} F_t \cdot N_t \cdot \bar{W}_t = F \cdot \bar{B}$$

Biomass of a cohort



Age of capture regulated by mesh size

Yield and fish production

- Biological production (P) is the total amount of tissue generated in a population (or community) in a particular space during a given period of time, regardless of its fate.
- It is of central interest in the exploitation of renewable resources, as the yield (Catch) is a fraction F (Fishing mortality) of the mean biomass (B), and is a fraction (x) of biological production P

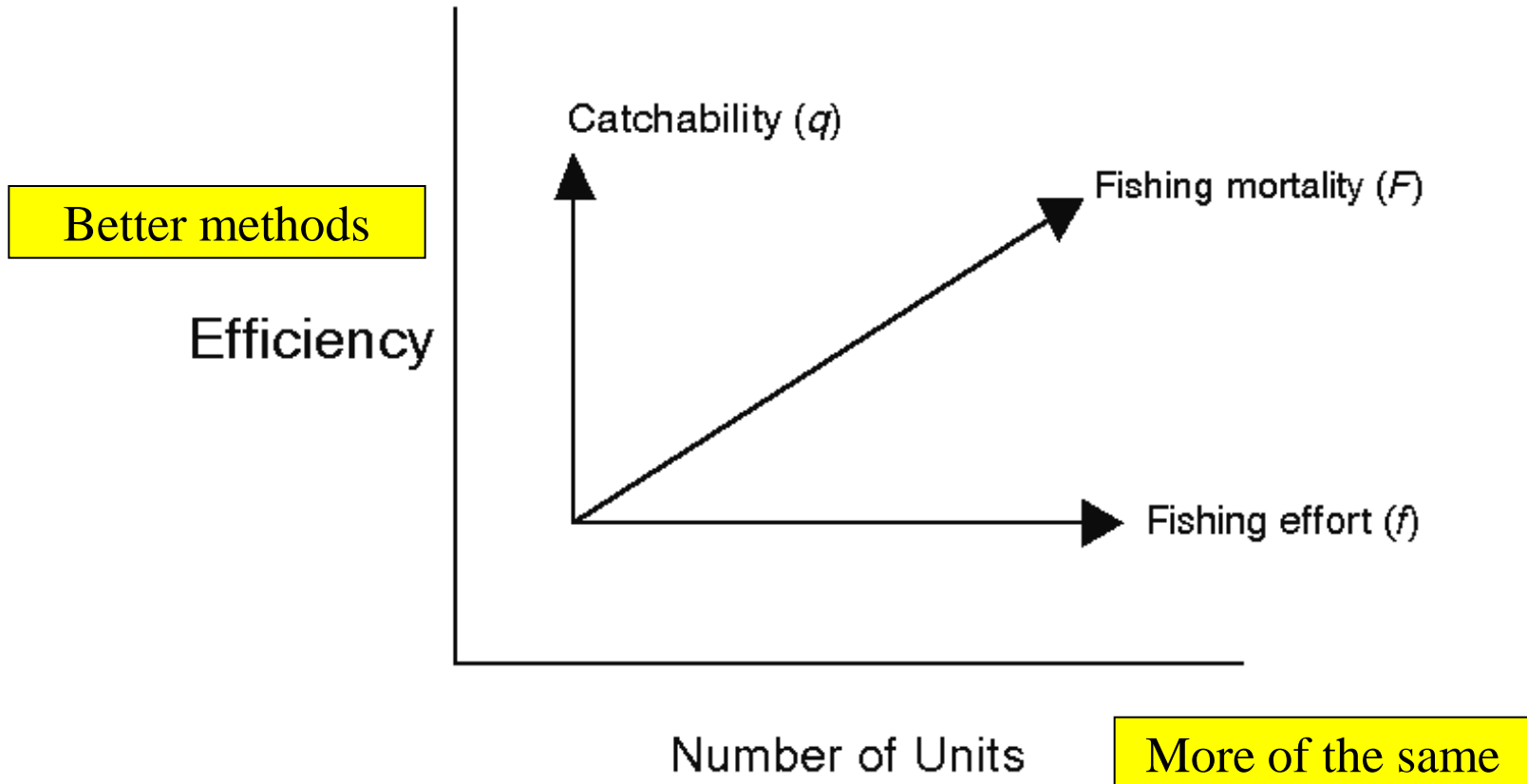
$$P = r \cdot \bar{B} = Z \cdot \bar{B}$$

$$\text{Catch} = F \cdot \bar{B} = x \cdot P$$

$$\text{where } x = \frac{F}{Z}$$

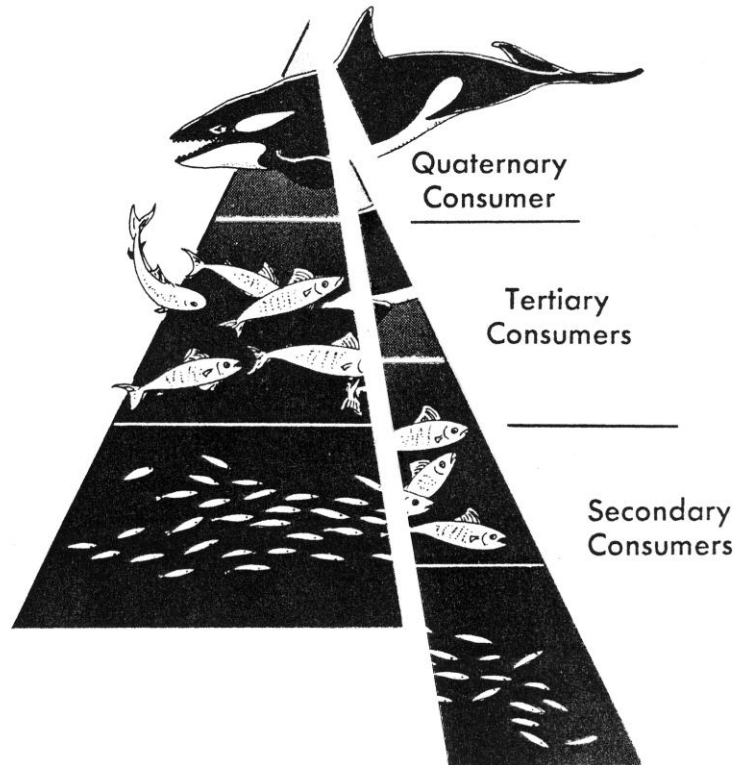
Fishing mortality (F)

$$F \equiv \frac{\text{Catch}}{\text{Biomass}} = q \cdot f = \text{catchability} \cdot \text{effort}$$



Management questions are:

- 1) How much of the production can be harvested (the exploitation *rate*)
- 2) What is a rational harvesting strategy (the exploitation *pattern*), that is which rates should be applied to each stock and individual sizes.



How ?

$$Catch = F \bar{B}$$



How much ?

Management regulations what are the options?

Catch ~~=~~ *Fishing mortality* ~~-~~ *Biomass*

$$Y \neq F \cdot B \neq q \cdot f \cdot B$$

- Man is a predator
- We can regulate directly or indirectly on:
 - Yield (Y), Fishing mortality (F) or Biomass (B)
- That is all. Any management regulation can be reduced to one of the three

Management regulations what are the options?

Minimum SSB, MBAL, B_{pa}

B

$$Y = \bar{B} \cdot F$$

Y

F

Catch control: MSY, TAC

Size of capture: tc
Mortality index: $Z = F + M$
Exploitation rate: $E = F/Z$
Effort control: $f = F/q$
F control: $F_{0.1}$, F_{med} etc.
Closed area
Closed season

Management regulations

- The choice of management regulations depends on:
 - Knowledge of the stock (research)
 - Control of the fishery (compliance)
 - Management level (distribution, quotas)
- Hierarchy of regulations in terms of required stock knowledge (= research costs):

$$B > Y > F, \text{ where for the latter } f > q$$

Management regulations

- This means that for fisheries where little or nothing is known, management regulations are always based on regulating q :
 - Mesh size
 - Size of capture
 - Gear types
 - Closed area or season (e.g. MPAs)
- When nothing is known these regulations are based on assumptions.
- Next step is effort (f) control, then TAC etc.
- Each new step requires exponential increase in research and monitoring.

The role of the fisheries scientist

- **Fisheries science** is the academic discipline of **managing** and **understanding** fisheries. It draws on the disciplines of
 - biology,
 - ecology,
 - oceanography,
 - statistics,
 - economics and
 - management
- It is a **quantitative** science based to a large extent on statistical inference and analyses (fish are invisible and moving around)

The role of the fisheries scientist

- To ‘understand’ fisheries means a.o:
 - To understand how a population responds to increased mortality, and how a selective mortality influences genetic changes.
 - To understand the limitations and underlying assumptions in the models we use.
 - To understand the limitations and uncertainty for drawing conclusions based on the available data.
 - To understand the relative impact of environment versus human exploitation on a population, i.e. what are the natural fluctuations?

The role of the fisheries scientist

- To ‘manage’ fisheries means a.o:
 - To be able to translate and explain all the ‘understanding’ (based on all the previous points), to the community and the authorities.
 - To realize that man is not the only regulator in a natural system.
 - To understand the implications of management regulations, not only for the fish community but also the fishing community.

The role of the fisheries scientist

- The ‘ideal’ fisheries scientist does not exist.
- It is impossible to be an expert in all the fields the ‘science’ builds on.
- Adding more complexity to an already complex situation does not always produce better results.
- Most of what we know we have learned from our failures and past history.
- How many more failures must we do, and how much longer must we wait, before we understand?
- Therefore never blindly accept the current theories, particularly if they are based on assumptions.

Conclusion

"The improver of natural knowledge absolutely refuses to acknowledge authority, as such. For him, scepticism is the highest of duties; blind faith the one unpardonable sin."

Thomas H. Huxley