Laurea Magistrale in Scienze per l'Ambiente
MArino e Costiero (SAMAC)

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Gestione delle risorse alieutiche

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Lezione 3

UNIVERSITY OF TRIESTE

OGS

Exercise 2: determining the MSY

Catches (C(t) over time) depends on B(t), assuming a fishing mortality **F** [$year^{-1}$].

$C = F \cdot B_t$ These quantities decrease the biomass (so it is a negative term)

Similarly as before the biomass over time (t+1) can be obtained from biomass at time before as:

$$B_{t+1} = B_t + B_t \cdot r \cdot (1 - B_t / \mathrm{K}) - F \cdot B_t$$

The above formulation (time-difference model) can be derived (and is thus similar) from the differential model (time continuous and infinitesimal):

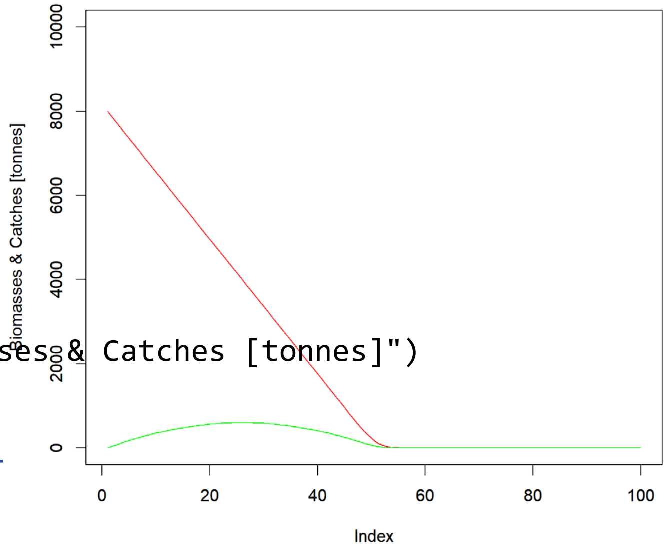
$$\frac{dB(t)}{dt} = r \cdot B(t) \cdot \left[1 - \frac{B(t)}{K}\right] - \mathrm{F} \cdot B(t)$$

This mode in fisheries is called
Surplus production model
o
Schaefer model

Let’s code this surplus production model

```
# applichiamo al modello di crescita logistica la pesca (surplus production model) e determiniamo il Massimo Rendimento Sostenibile (Maximum
Sustainable Yield)
years <- 200 #anni della simulazione
erre <- 0.3 #crescita tonnellate al anno
B0 <- 8000 #condizione iniziale in termini di biomassa all'anno zero
Kappa <- 8000 # capacitá portante del sistema in tonnellate
Bt <- as.double (1:years)# definizione del vettore che usemo per calcolare la biomassa negli anni della simulazione
Ct <- as.double (1:years) # definizione del vettore che useremo per le catture
simulations <- 100; Fmin <- 0.0; Fmax <- 0.6
deltaF <- (Fmax-Fmin)/simulations
Bss <- as.double (1:simulations)# definizione del vettore che usemo per salvare le biomasse a stato stazionario
Css <- as.double (1:simulations) # definizione del vettore che usemo per salvare le catture a stato stazionario
Cmsy <- 0.0; Bmsy <- 0.0; Fmsy <- 0.0

for (i in 1:simulations) {
Bt[1]<-B0 # condizione iniziale
FF <- deltaF*(i-1) # tasso di mortalitá da pesca (fishing mortality)
# ciclo for che serve per calcolare ripetitivamente la crescita della popolazione# ovvero ogni anno da 1 a "years" (200)
for (t in 1:years){
Bt[t+1] <- Bt[t]+Bt[t]*erre*(1-(Bt[t]/Kappa))- FF*Bt[t]
Ct[t] <- FF*Bt[t]  # l'equazione di crescita logistica con la pesca }
Css[i]<- Ct[years]  Bss[i]<- Bt[years]  # salvare i dati per definire MSY
if (Css[i]>Cmsy) {
Cmsy <- Css[i]; Bmsy <- Bss[i]; Fmsy <- FF
}
}
plot (Bss[1:simulations], type = "l", ylim = c(1,10000), col = "red", ylab = "")
par (new= TRUE)plot (Css[1:simulations], type = "l", ylim = c(1,10000), col = "green", ylab ="Biomasses & Catches [tonnes]")
plot (Css[1:simulations], type = "l",  col = "green", ylab ="Catches [tonnes]")
Cmsy <- max(Css[])
```



How to determine mathematically MSY, given r and K

Assume steady state of the differential equantion of the surplus production model

$$0 = r \cdot B(t) \cdot \left[1 - \frac{B(t)}{K}\right] - \mathrm{F} \cdot B(t)$$

Then derivate the equilibrium equation for catches (dC/dB); remember that catches are:

$$C = F \cdot B(t)$$

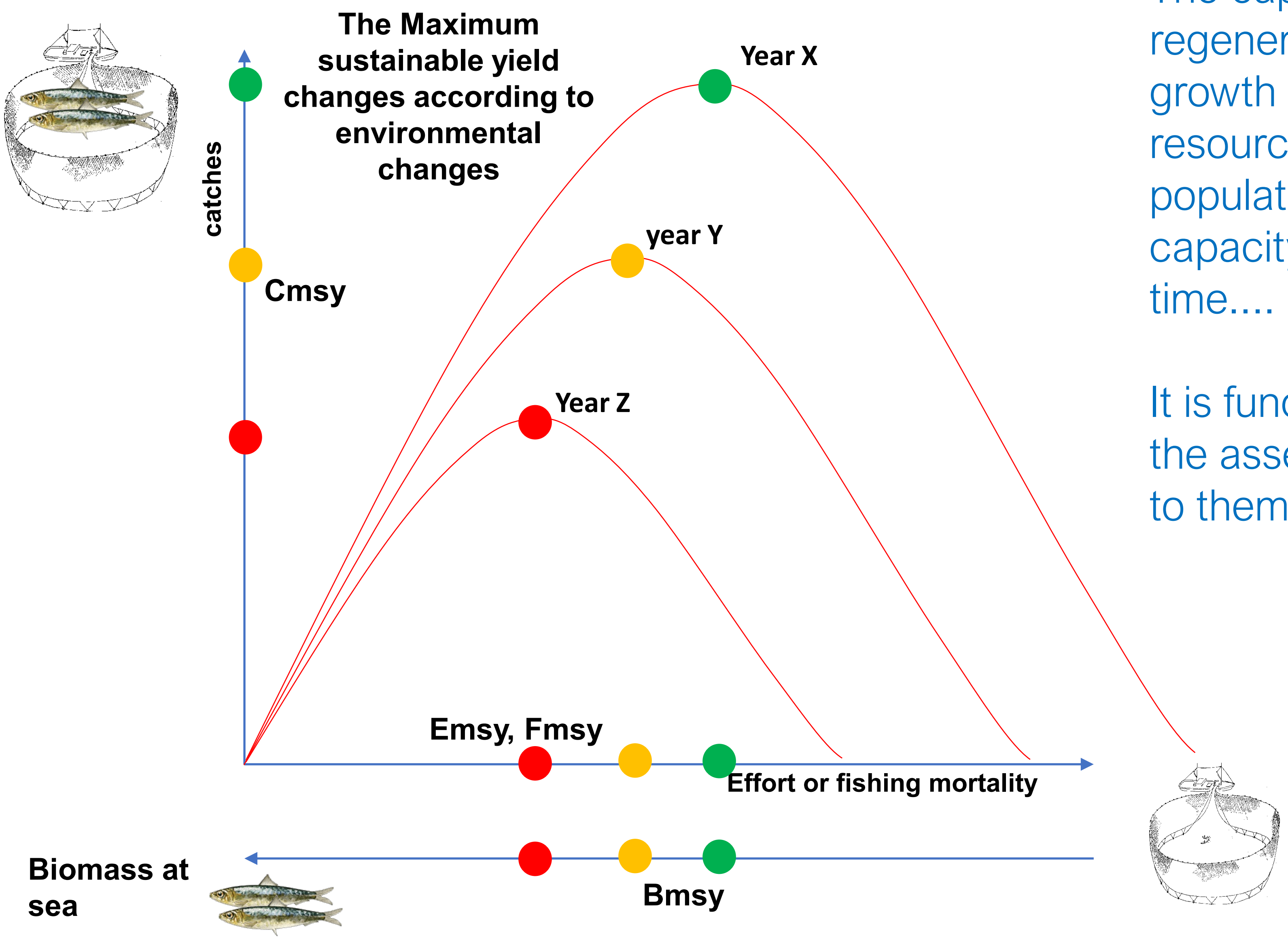
$$r \cdot B(t) - r \cdot \frac{B(t)^2}{K} = C(t)$$

$$r - 2 \cdot r \cdot \frac{B(t)}{K} = 0$$

Fundamental results for calculating MSY:

$$Bmsy = \frac{K}{2} \qquad Cmsy = \frac{\mathrm{r} \cdot K}{4} \qquad Fmsy = \frac{r}{2}$$

The dynamic nature of MSY



The capability of population to regenerate (population growth rate) and the resources on which the population is based (carrying capacity) both changes aver time....

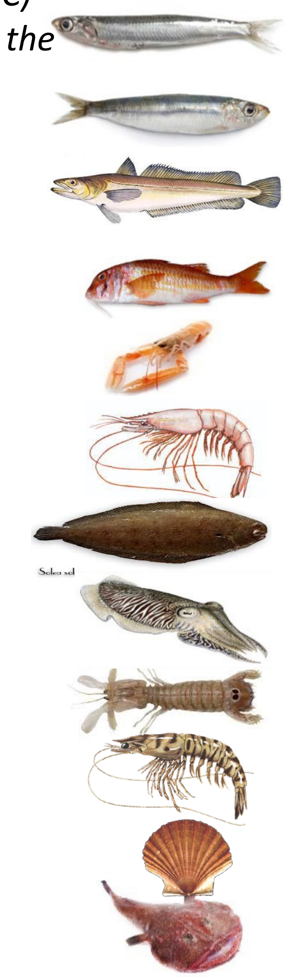
It is fundamental to update the assessments and to adapt to them

The dynamic nature of MSY

Dati da:
Scientific Advisory Committee (SAC)
General Fisheries Commission for the Mediterranean (GFCM) della FAO

Stato delle risorse ittiche soggette a sfruttamento. Valutazione delle risorse ittiche in termini di mortalitá da pesca rispetto al riferimento (MSY) .

Molte delle risorse valutate in Adriatico risultano in condizioni di pesca biologicamente non sostenibile. La situazione critica non è recente.



	2016	2017	2018	2019
Acciuga	2.23		1.69	1.51
Sardina	2.76		3.23	4.43
Nasello	1.57	1.89	2.78	3.71
Triglia di fango	2.75	1.17	1.11	2.02
Scampo			1.58	
Gambero rosa	0.48		3.34	
Sogliola			1.02 (*)	1.23 (*)
Seppia	0.81 (*)	0.84 (*)	0.89 (*)	1.23 (*)
Cannocchia	1.94 (*)	2.63 (*)	1.53 (*)	1.09 (*)
Mazzancolla		2.08		
Cappasanta				2.85
Rospo				1.38

Fcorr/Fmsy= (mortalita da pesca corrente)/(mortalitá da pesca al riferimento); valore OK = 1; * Valutazione per la sola GSA 17 («Dal Gargano in su»); altri GSA17 e 18 («fino ad Otranto»)

Fishing effort???

The catches can be described as a result of fishing mortality, which can be expressed as the result of the catchability and the effort expressed

$$C = F \cdot B(t) = q \cdot E \cdot B(t)$$

Where q is the catchability: catches obtained for a unit of effort and a unit of biomass
E is effort, i.e., the fishing effort exerted to catch the fish (in number of boats, gross tonnage of fishing vessel, days fishing, hours, surface explored, number of boats). Redo the example with q=0.01

$$\frac{dB(t)}{dt} = r \cdot B(t) \cdot \left[1 - \frac{B(t)}{K}\right] - \mathrm{q} \cdot E \cdot B(t)$$

Equation and resulting MSY

$$Bmsy = \frac{K}{2} \qquad Cmsy = \frac{\mathrm{r} \cdot K}{4} \qquad Fmsy = \frac{r}{2} \qquad Emsy = \frac{r}{2 \cdot q}$$

What about if we consider the economic part?

The catches have an economic value, the effort have an economic cost: what is the optimum from an ECONOMIC point of view? The Maximum Economic Yield

$$Revenues = C * p = F \cdot p \cdot B(t) = p \cdot q \cdot E \cdot B(t)$$

$$Fmsy = \frac{r}{2}$$

$$Costs = \alpha \cdot E$$

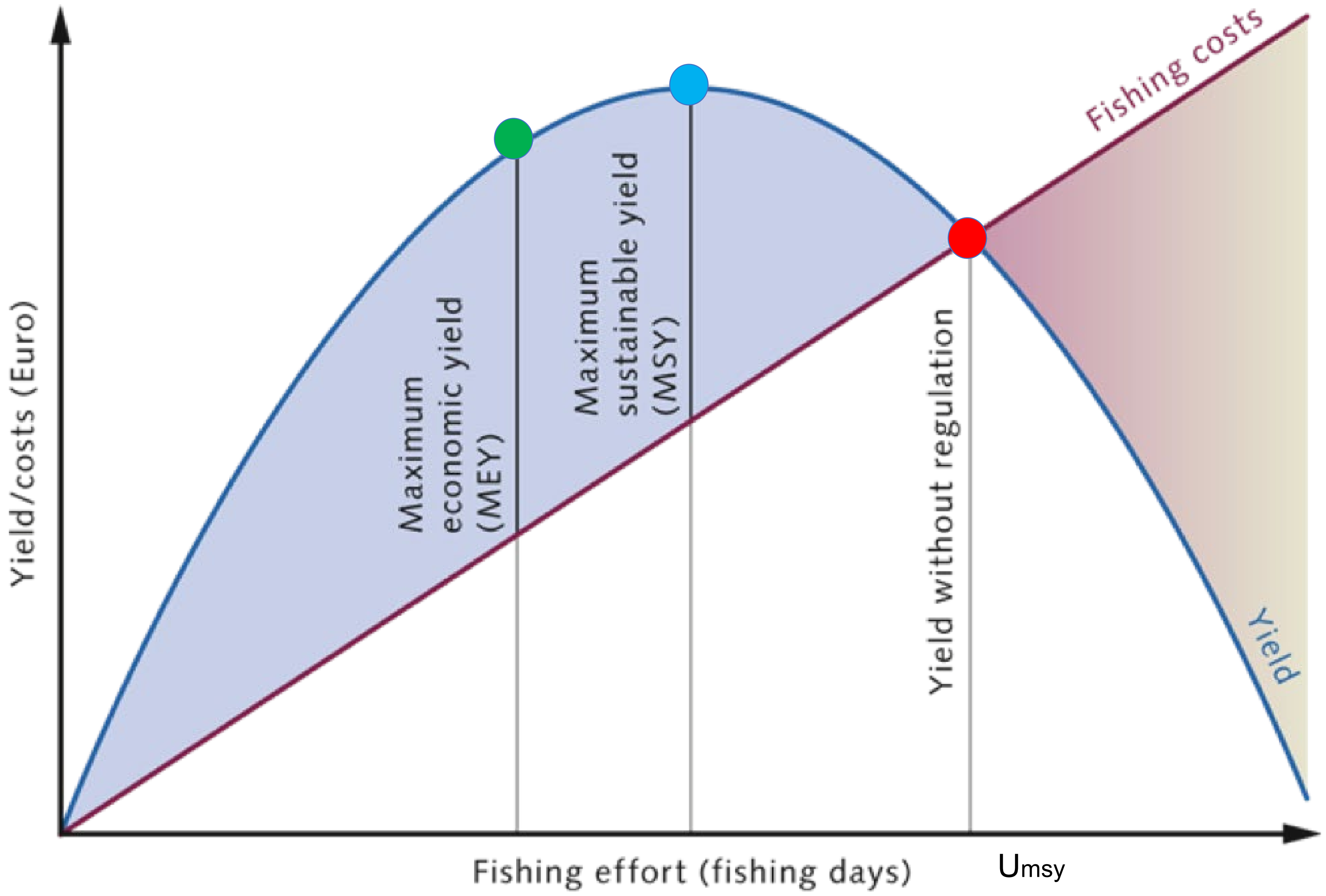
$\alpha = unit\ cost\ of\ effort$ $\qquad$ $p = price\ of\ a\ unit\ of\ landings$

The optimum effort is the one that assure maximum difference between revenues and costs (profit). Imagine a price for fish of 20 euros/tonn and a cost of effort of 300 euros/day

$$Bmey = ? \qquad Cmey = ? \qquad Fmey = ? \qquad Emey = ?$$

$$Bmsy = \frac{K}{2} + \frac{\alpha}{2pq} \qquad Cmsy = \frac{\mathrm{r} \cdot K}{4} - \frac{r\alpha^2}{4Kp^2q^2}$$

Introducing economic considerations: another indicator



The general objective is really maximizing harvest?

Need to have clear objectives and to compromise together different sectors other than fisheries

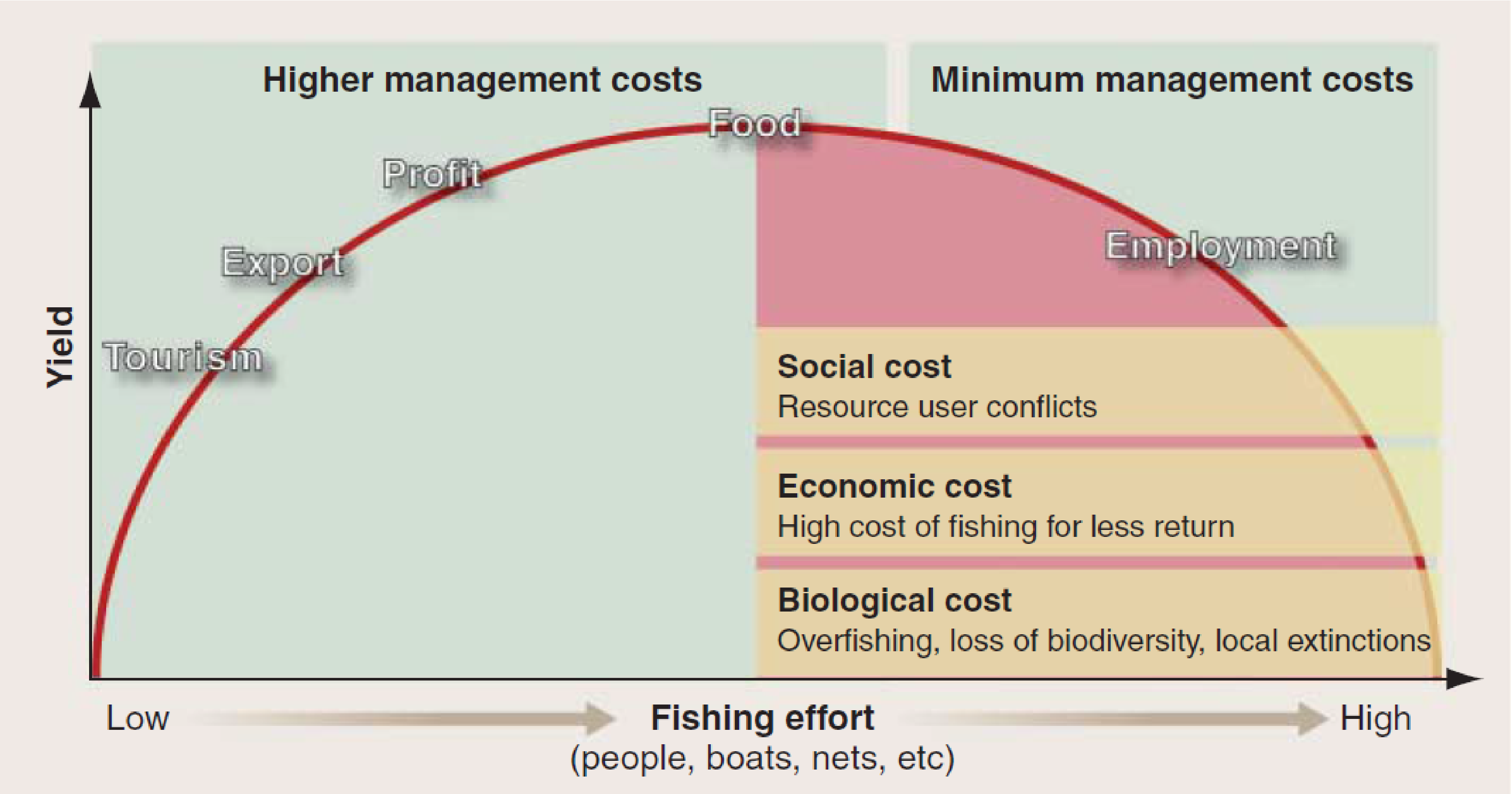


Fig. 2. The fishery management dilemma is illustrated with a simple stock production curve showing sustainable yield varying with effort. Low effort reduces biological risks and enhances economic profits at the cost of low employment and higher management costs. High effort increases employment at the cost of low economic profits and increased biological and social risks, but with low management costs (*40*).

Beddington et al (2007). Science

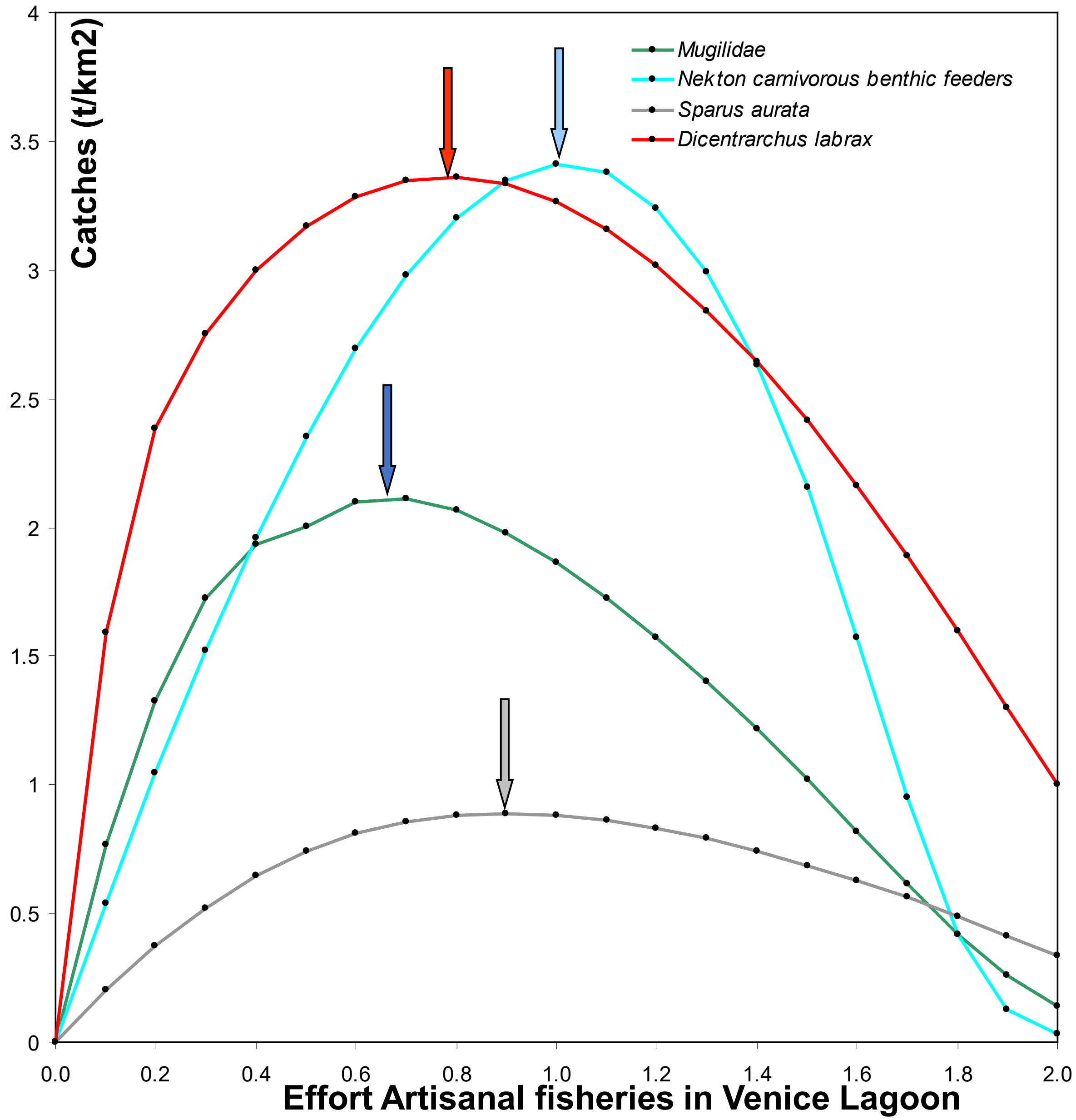
Other reference points

When several species are targeted by one fisheries the problem is that each species has its own MSY value.

The MSY set on the basis of one species might bring others to be overfished.

The species that have MSY at lower effort are called choke species because they impede harvesting if they are used to manage fisheries.

Solutions: flexibility in management; «pretty good yield»



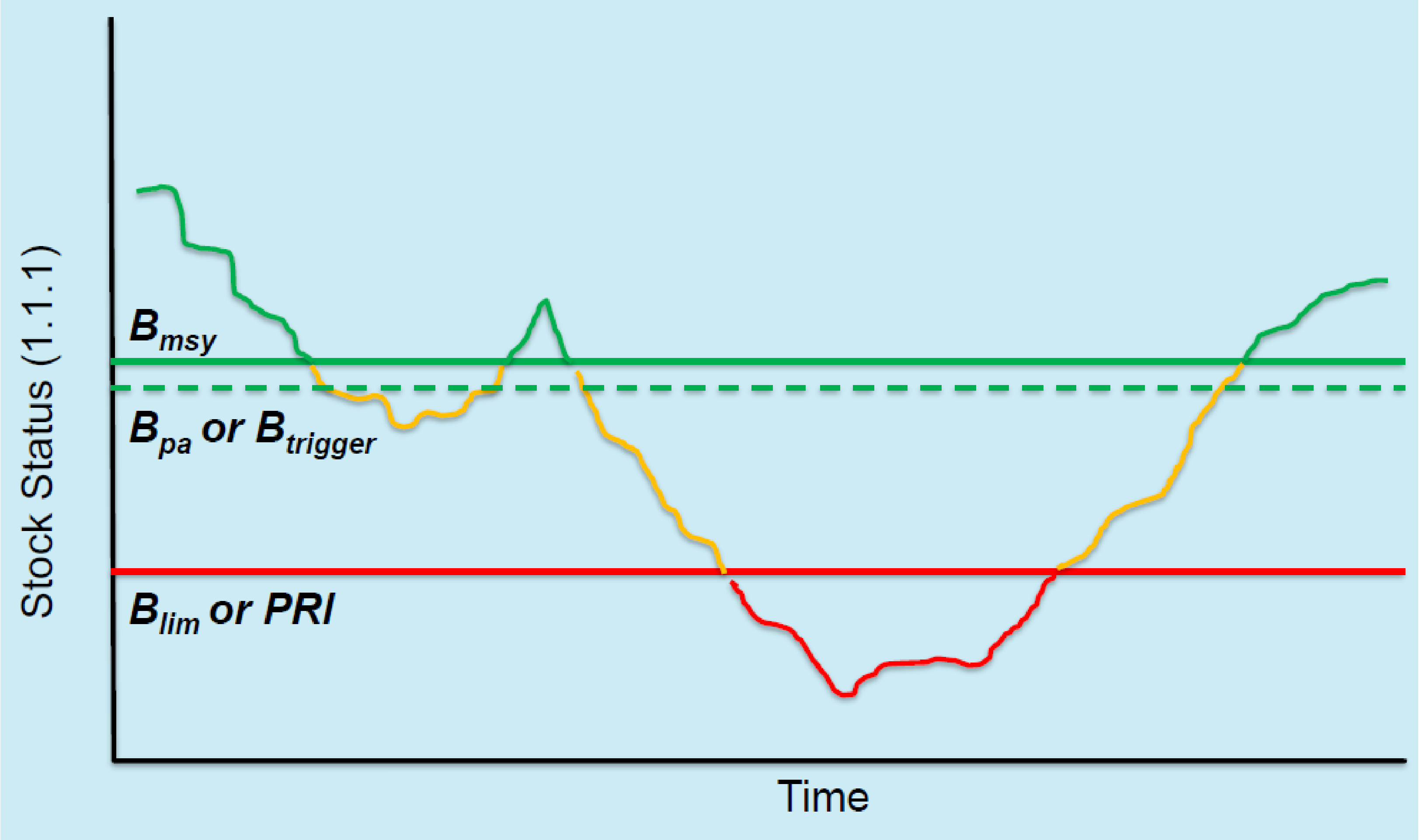
Other reference points

Fisheries science uses other references to assess the status lof the stocks:
In particular is the definition of some lower treasholds for biomass
Such as

Btrigger: Value of spawning stock biomass (SSB) that triggers a specific management action

Bpa: precautionary approach reference for biomass

Blim: a very extreme low limit of biomass usually encountered limited times in the time series of biomass



iii) Massimo rendimento sostenibile, sforzo di pesca, mortalità da pesca, costi, rendimento economico. esercizi

Dinamica di base dello sfruttamento delle risorse alieutiche

Come gestire lo sfruttamento delle risorse alieutiche

Dinamica delle risorse, sfruttamento, massimo rendimento sostenibile

iv) Le specie ittiche: crescita, riproduzione, mortalità: esercizio modelli e dati.