POLITECNICO DI MILANO

Ecosystems conservation and management

PROF. MARINO GATTO

Academic Year 2017/018 – Second test

17 January 2018

COGNOME/FAMILY NAME: ……………………………………..

NOME/FIRST NAME: ……………………………………………..

FIRMA/SIGNATURE: ....

100%	100%	100%	100%	100%	100%

RULES

DON'T use the same page to report answers to different questions;

DON'T use additional sheets (they will be trashed): instead, use the back of provided sheets and clearly indicate where to read the sequel of your answer to the question;

DON'T consult books, notes, or class mates.

DON'T use a pencil, use a pen.

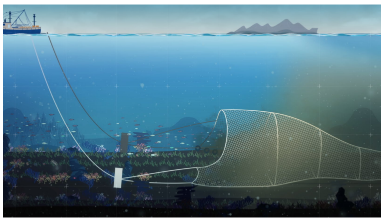
WARNINGS:

Clarity, precision e conciseness are positively evaluated.

Unjustified answers are not taken into account.

If you are not English-fluent, use Italian (or French or Spanish)

Outcomes of the test will be communicated via the official mailing system. Do not phone or e-mail the teacher before grades are published.



1. Trawling is a major disturbance to fish habitat. In particular beds of *Posidonia oceanica*, an ecologically important seagrass, are badly impacted by this kind of fishing. The effect is noxious to the fishery itself because the fish carrying capacity (and thus the fish availability to the fishermen) is of course an increasing function of the remaining habitat. Thus if seagrass is destroyed the fishery yield decreases considerably.

To analyse the problem write a model that describes the dynamics of the fish stock biomass B (kg m^{-2}) and the *Posidonia* biomass P (kg m^{-2}). The dynamics of B is logistic, however the carrying capacity is not constant but increases with *Posidonia* biomass P. Fish biomass is harvested at a rate qEB where the effort E is measured as number of operating trawlers. The dynamics of *Posidonia* biomass P is described by a constant recruitment w of new seagrass biomass (kg m^{-2} year^{-1}) and a constant mortality rate m (year^{-1}). When the trawlers are operating, part of the *Posidonia* biomass is removed at a rate zEP. The parameter values are as follows:

r = instantaneous rate of fish increase = 0.1 year^{-1}

K = fish carrying capacity (kg m^{-2}) = kP where k = 0.05

q = 0.01 (No. of trawlers)$^{-1}$ year^{-1}

w = 0.9 kg m^{-2} year^{-1}

m = 1.8 year^{-1}

z = 0.05 (No. of trawlers)$^{-1}$ year^{-1}

Find out the effort (number of trawlers) that maximizes the sustainable yield of fish biomass. Calculate the corresponding standing biomass of fish and *Posidonia* and the MSY.

Solution:

2. Differently from Pacific salmon, the Atlantic salmon *Salmo salar* can reproduce several times. In other words the survival of reproductive adults is not zero. For the small Norwegian Imsa River the relationship between the adults (measured as tonnes of biomass) returning for the first time to the river (A) in order to reproduce is approximately linked to the total biomass (tonnes) of adults (N) by the following relationship (N. Jonsson et al. *Journal of Animal Ecology*, 1998) between year k and year k+1:

$$A_{k+1} = \lambda N_k/(1+\alpha N_k)$$

with $\lambda = 2500$ $\alpha = 24$ tonne^{-1}. As some salmon survive after reproduction the total biomass of adults in year k+1 is given by the sum of A_{k+1} plus the fraction s of adults N_k that survive to the next year. Assume s=0.25.

Determine the constant escapement policy that provides the Maximum Sustainable Yield (measured as number of harvested salmon).

Solution:

3. West Nile virus (WNV) is a mosquito-borne flavivirus which has caused repeated outbreaks in humans in southern and central Europe. The main vector for WNV is the common mosquito *Culex pipiens*. Although the disease can be transmitted to humans the main virus reservoir is represented by birds.

C. B. F. Vogels et al. (*Scientific Reports*, 2017) have studied how the basic reproduction number of the disease varies with the average temperature of the country hosting mosquitoes and birds. They estimated the following parameters for countries with an average temperature of 18°C and 28°C, respectively.

- a = number of bites per mosquito per unit time = 0.14 day^{-1} at 23°C and 0.2 day^{-1} at 28°C
- m = number of female mosquitoes per bird host = 10
- b = probability of transmission of infection from infectious mosquitoes to birds per bite = 0.8
- average lifetime of mosquitoes = 33 days at 23°C and 25 days at 28°C
- bird recovery time from the disease = 5.5 days
- c = probability of transmission of infection from infectious birds to mosquitoes per bite = 0.04 at 23°C and 0.34 at 28°C

1. From the above parameters derive β, the mosquito-to-bird transmission rate and ψ, the bird-to-mosquito transmission rate for both temperatures.
2. Write down a Ross model for WNV describing the dynamics of the prevalence of infected birds (U) and that of infected mosquitoes (M).
3. Calculate the basic reproduction number and establish whether the disease can establish at the two temperatures. If it can, calculate the prevalence of both birds and mosquitoes at equilibrium.

Solution:

4. Vaccination is the most important means for preventing disease epidemics. Analyse its efficacy by considering a simple case of a city whose demography is described by a constant flow w of births and immigrations and a mortality rate μ. Consider a microparasitic disease with density-dependent transmission that provides full immunity to people that recover. The population parameters are

- w = 15000 people year^{-1}
- μ = death rate of susceptibles = 0.015 year^{-1}
- α = additional mortality rate due to the disease = 0.005 year^{-1}
- β = coefficient of disease transmission = 0.0001 (number of people)$^{-1}$ year^{-1}
- recovery time = 0.5 months .

Assume that susceptibles are vaccinated at a rate V, where V is expressed as year^{-1}. Then

- Write down the SI model that governs the epidemiological dynamics
- Calculate the basic reproduction number with no vaccination
- Calculate how big the vaccination rate V should be in order to avoid that the disease establishes in the population
- Calculate the number of susceptibles at equilibrium in the case of successful vaccination.

Solution:

5. Answer the following questions by appropriate ticking (right answer: 100% score, wrong answer: -20%)

a) Tick the unique **true** statement among the following ones

☐ Blah, blah
☐ Blah, blah
☐ Blah, blah
☐ Blah, blah

b) Tick the unique **false** statement among the following ones

☐ Blah, blah
☐ Blah, blah
☐ Blah, blah
☐ Blah, blah

6. Answer the following questions inside the frame only (penalization -20%)

Blah, blah
Blah, blah