# Coral reef assignment

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## Part A

### Question 1:

When we first sketched our graphs, Paulina took the approach of looking at what specifically impacts a person's opinion when considering to become a conservationist or not. Raymond looked at the entire system to explore which factors are making these decisions and impacting the socio-ecological system as a whole.

```
## Loading required package: png
```

```
## Warning: package 'png' was built under R version 4.0.2
```

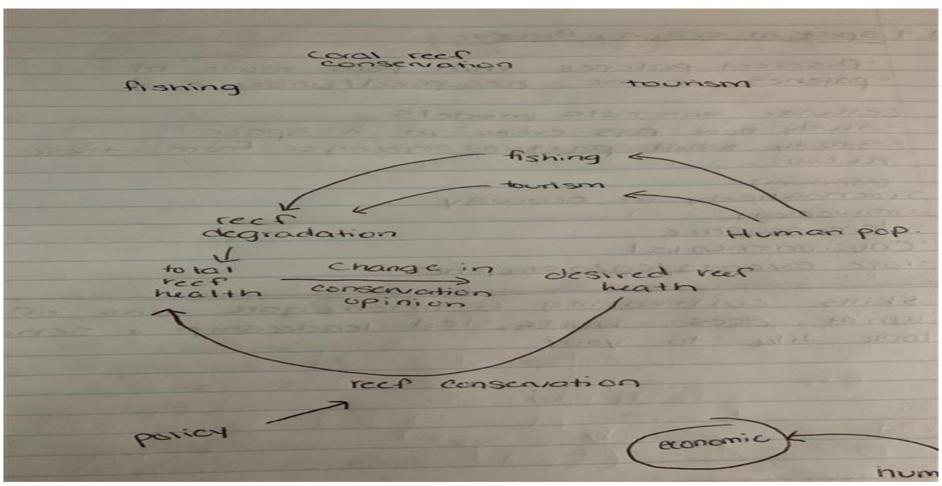



Figure 1: Paulina's diagram

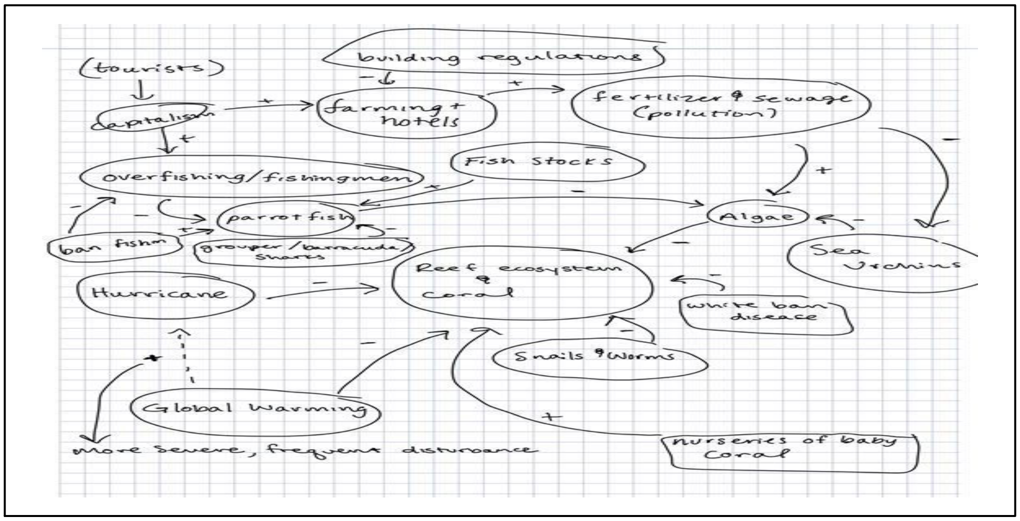



Figure 2: Raymond's diagram

## Question 2:

When we came together to talk about what we did we both felt like Paulina did a great job added structure to the model which we used to build our final diagram. Raymond added all the extra bits and pieces that influence each mechanism indiviudally. After some painstaking drawing on an online software we were able to create the following diagram using both of our ideas.

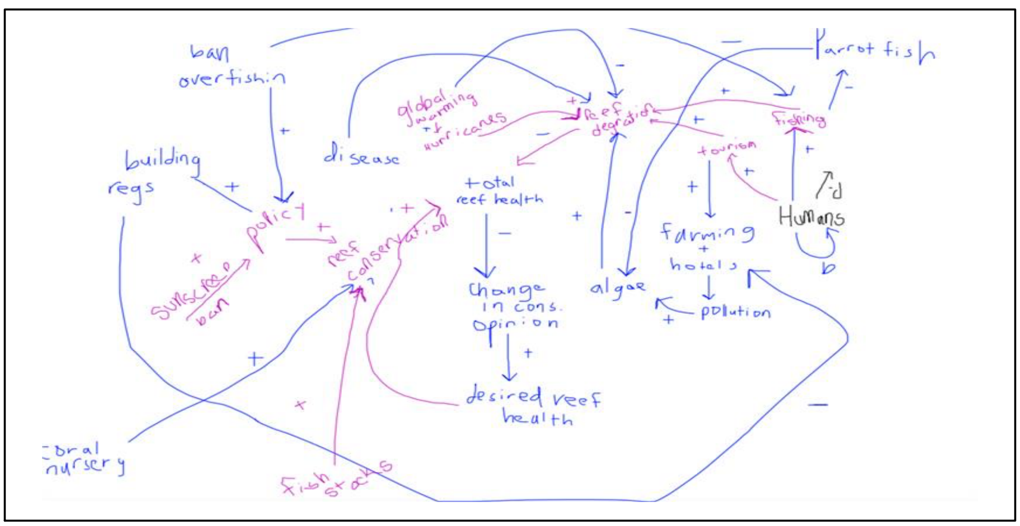



Figure 3: Diagram consisting of Raymond and Paulina's ideas.

## Question 3:

We were given the following equation:

$$\frac{dx}{dt} = kx(1-x)(-1 + j(1-C) - \sigma P(1-x) + \phi(2x-1))$$

and asked to define the variables.

- k = The number of new conservationists added to the population per time step (in this case per year)
- x = the fraction of individuals in the population willing to participate in coral conservation
- C = live coral cover on the reef
- P = number of parrotfish
- j = the rate of coral degradation (caused by algae cover, disease, natural disasters, etc.)
- $\sigma$ = Fishing rate
- $\phi$ = The sensitivity to the norms of society. (How easily influenced an individual is by others.)

| Parameter | Description | Value |
|---|---|---|
| $\kappa$ | Rate of new conservationists /year | 1.014/y |
| $j$ | Rate of coral degradation | 1.68 |
| C | Live coral cover | Try different values |
| P | Parrotfish abundance | Try different values |
| $\sigma$ | Fishing Rate | 0.5 |
| $\phi$ | Sensitivity to the norms of Society | 0.2 |

Table 1: The added in parameters of the provided differential equation.

From finding out these variables and working through the differential equation we were able to create a new diagram depicting the elements involved in the equation.

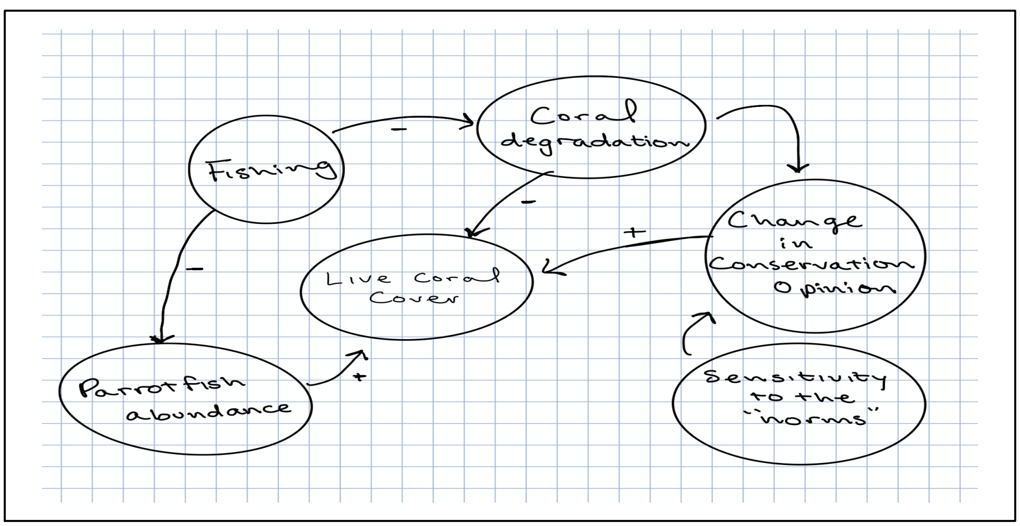



Figure 4: Diagram made using the parameters we found for the differential equation

### Question 5:

```r
require(deSolve)
```

```
## Loading required package: deSolve
```

```
## Warning: package 'deSolve' was built under R version 4.0.2
```

```r
# Initial values
state <- c(X = 0.5) #proportion of total population that are conservationists
times <- seq(0, 100, by = 0.1)

# Parameters
parameters <- c(k = 1.014,j = 1.68, s = 0.5, phi = 0.2, C = 0.3, P = 0.5)

# Model
consv <- function(t,state,parameters){
  with(as.list(c(state,parameters)),{
       dX <- k*X*(1-X)*(-1+j*(1-C)-s*P*(1-X)+phi*(2*X-1))
      list(c(dX))
  })}

# Solve model and plot results
out <- ode(y = state,times=times,func=consv,parms=parameters)
par(mfrow=c(1,1))

plot(out[,1],out[,2],ylab='X',xlab='time',las=1)
```

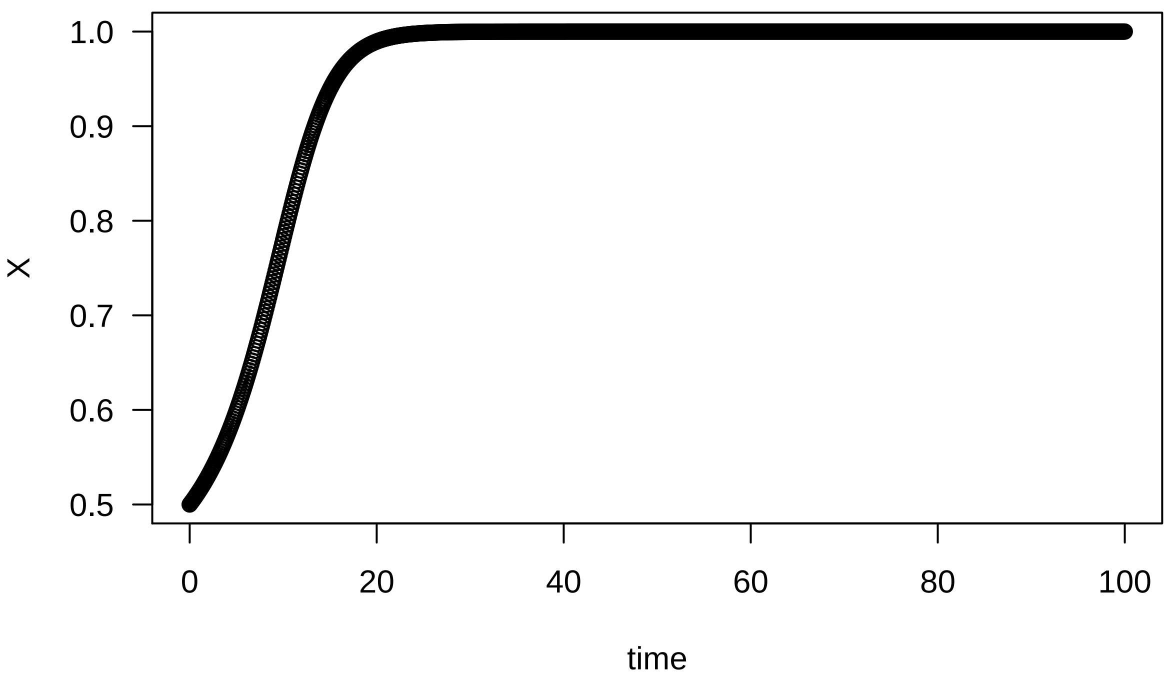



Figure 5. Fraction of individuals in the population willing to participate in coral conservation.

(a) What are the long-term dynamics of the system with the default parameters given below?

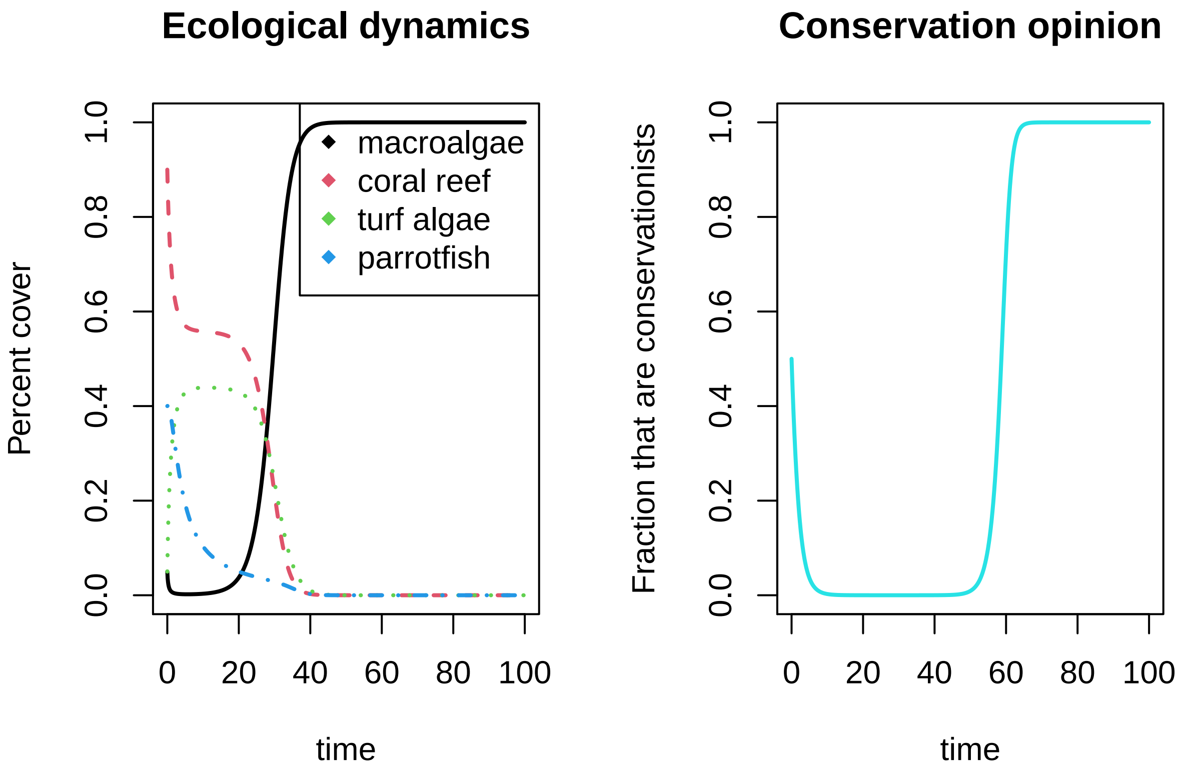
When half the population are already conservationists and live coral cover and Parrotfish abundance are both at 50%, the long-term dynamics of the system go to zero, meaning that when coral and Parrotfish are fairly healthy, fewer people will have an opinion on coral conservation. However, once live coral cover decreases to 30%, the proportion of people who become conservationists begins to increase.

(b) What are the most important parameters in determining long-term dynamics?

The most important parameters in determining long-term dynamics in this system are live coral cover. As Parrotfish abundance decreases, the proportion of people willing to participate in coral conservation continues to decrease, therefore, it is not an important parameter.

## PART B:

```
# Coupled socio-environmental coral reef model
# Created by Easton R. White
# Edited on 7-Aug-2019
# From Thampi et al. 2018 paper https://www.nature.com/articles/s41598-018-20341-0#Sec6

require(deSolve)
coupled_model <- function(Time, State, Pars) {
  with(as.list(c(State, Pars)), {
    dM <-  a*M*C - (P*M)/(M+T) + gamma*M*T
    dC <-  r*T*C - d*C - a*M*C
    dT <- (P*M)/(M+T) - gamma*M*T - r*T*C + d*C
    dP <- s*P*(1 - P/C) - sigma*P*(1 - X)
    dX <- kappa*X*(1 - X)*(-1 + j*(1 - C) - sigma*P*(1 - X) + phi*(2*X - 1))
    return(list(c(dM,dC,dT,dP,dX)))
  })
}

pars <- c(a = 0.1, gamma = 0.8, r = 1.0, d = 0.44, s = 0.49, sigma = 0.5, kappa= 1.014, j=1.68, phi = 0


yini  <- c(M = 0.05, C = 0.9, T = 0.05, P = 0.4, X = 0.5)
times <- seq(0, 100, by = 0.1)
out   <- ode(yini, times, coupled_model, pars)

par(mfrow=c(1,2))
matplot(out[ , 1], out[ , 2:5], type = "l", xlab = "time", ylab = "Percent cover",main = "Ecological dy
legend('topright',legend = c('macroalgae','coral reef','turf algae','parrotfish'),col = c(1,2,3,4),pch =

matplot(out[ , 1], out[ , 6], type = "l", xlab = "time", ylab = "Fraction that are conservationists",ma
```


Ecological dynamics
Conservation opinion
macroalgae
coral reef
turf algae
parrotfish
Percent cover
Fraction that are conservationists
time
time
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

#PART C: