



Oyster Modeling Description (and Intro Demonstration)

ABSI CAB 07/16/2020

Ed Camp

Fisheries and Aquatic Sciences, University of Florida



What I want to show you :

1. Review my role & provide “mental model”
2. Review models: in general, estimation, simulation
3. This model description – current state
4. Simple demonstration
5. This model – what’s missing
6. Questions and concerns

Two images for talk:



1. Reviewing my role: broadest picture

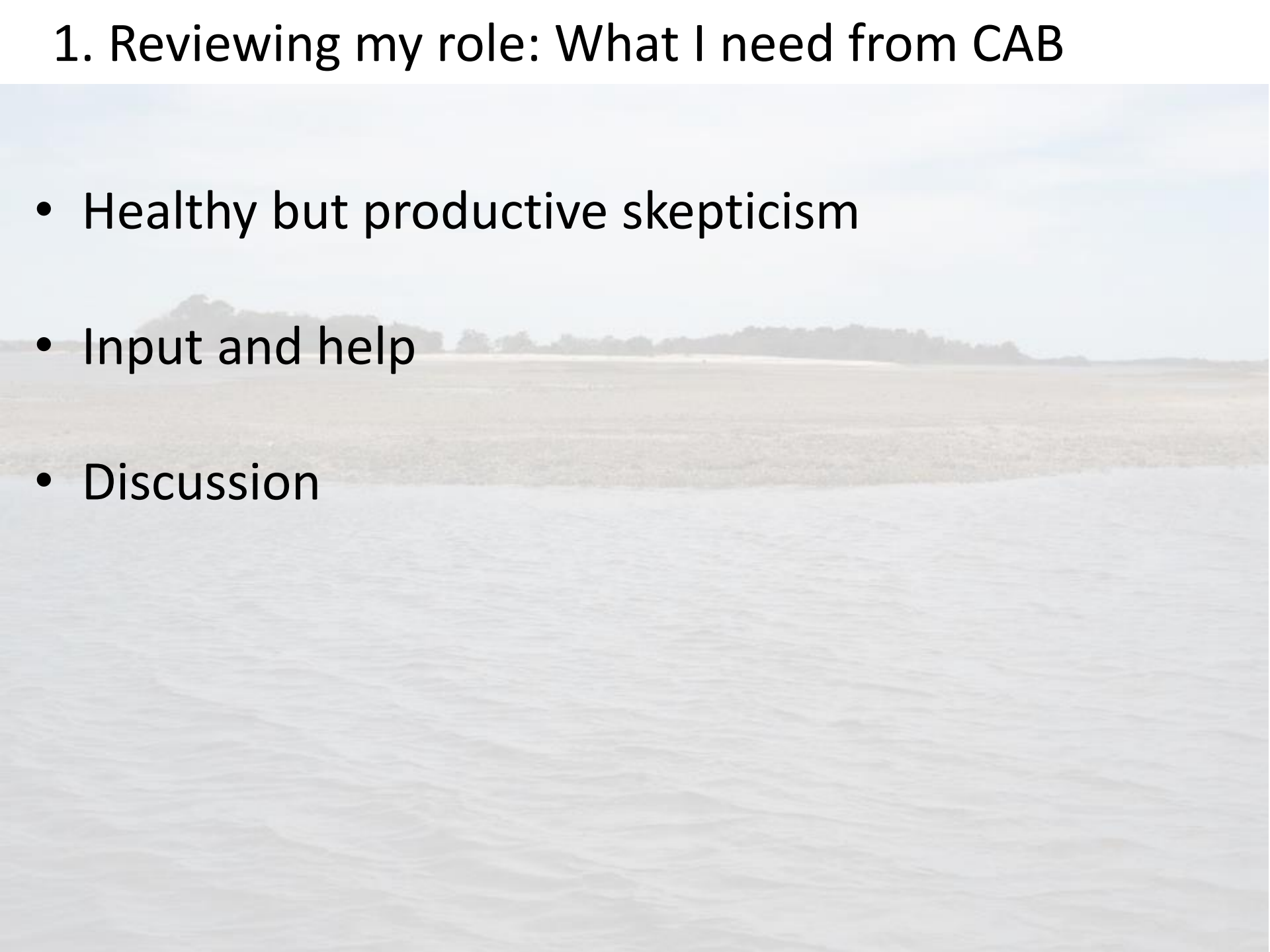
- Hydrologic model
 - Climate, water use & mgmt. → water, nutrients entering bay
- Hydrodynamic model
 - Water entering bay → water qual. throughout bay
- Oyster model
 - Fishery, mgmt. & rest., water → oyster populations and fisheries
 - Complement FWRI (Melanie Parker's) sampling and analyses
 - Inform FWC (Estes & Norberg) mgmt. actions

1. Reviewing my role: broad picture

- Guide development of oyster model
 - Oyster populations, fisheries
 - Scientifically rigorous and CAB-approved



1. Reviewing my role: What I need from CAB

- Healthy but productive skepticism
 - Input and help
 - Discussion
- 
- The background image shows a wide, flat landscape. In the foreground, there is a body of water with gentle ripples. The middle ground is a vast, flat expanse, possibly a field or a plain, leading to a distant line of trees. The sky is a pale, hazy blue, suggesting an overcast day.

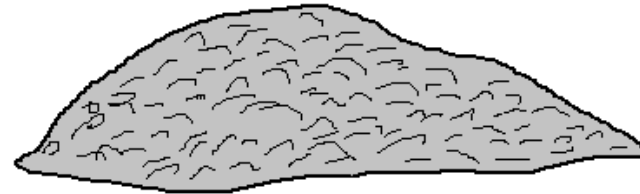
2. Review models: models as drawings of reality

```
for (i in 2:years){  
  for (k in 2:(nsites+1)) {  
    #actual effort  
    et[i,k] <- total_et * eff[k]  
    et[i,k]=0;    if(i>=fish_strt) et[i,k] = total_et * eff[k]  
    et[i,1]=et[i,2]; et[i,nsites+2]=et[i,nsites+1];  
  }  
  #open site loop back up again  
  #assuming fixed effort, so just a function of total state-wide  
  #not stocking for first 30 years, then stocking at number stock  
  #mirrors
```

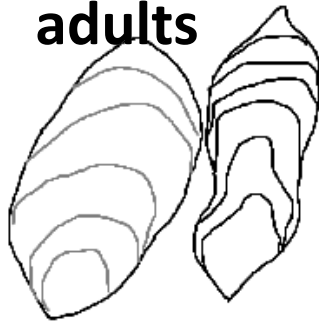
Eggs



Shell



**Harvestable
adults**



Recruits



```
nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1] #mirrors  
nage_st[i,1,k] = R_st[i,k] So.5 #note here is where you would have added post recruit st  
nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1] #mirrors
```

2. Review models: process

1. Oysters and fisheries assumptions

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #total wild and hatchery recruits, so just a function of total state-wide effort, first 30 years, then stocking at number stocked
    et[i,k] = et[i-1,k] + effort[i,k]
    hr[i,k] <- fishing * (1 - exp(-et[i,k] * qt))
    #fishing is just a flag, then harvest rate per usual
    #mirrors
    hr[i,1]=hr[i,2]; hr[i,nsites+2]=hr[i,nsites+1];

    #Set up stocking, no stocking for 30 years, then start stocking at a constant rate#
    st[i,sites]=0; if(i>=30) st[i,sites] = stock[k]*(1 -ism)
    #not stocking for first 30 years, then stocking at number stocked, #

    #recruitment unpacking
    ssb_tot[i,k] = eggs[i-1,k] + eggs_hat[i-1,k]
    #total wild and hatchery recruits
    #do I need this?
    ssb_tot[i,1]=ssb_tot[i,2]; ssb_tot[i,nsites+2]=ssb_tot[i,nsites+1];

    #dispersal
    larv[i,k] = sum(eggs[i-1,sites] * prob_mat[k,sites])
    #Use this dispersal matrix
    #Use this dispersal matrix
    larv[i,1]=larv[i,2]; larv[i,nsites+2]=larv[i,nsites+1];
    #mirrors

    larv_hat[i,k] = sum(eggs_hat[i-1,sites] * prob_mat[k,sites])
    #total wild and hatchery recruits
    #total wild and hatchery recruits
    larv_hat[i,1]=larv_hat[i,2]; larv_hat[i,nsites+2]=larv_hat[i,nsites+1]; #mirrors
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    #total wild and hatchery recruits
    #total wild and hatchery recruits
    larv_tot[i,1]=larv_tot[i,2]; larv_tot[i,nsites+2]=larv_tot[i,nsites+1]; #mirrors

    #first stage of density dependence
    N1_hat[i,k] = (larv_hat[i,k] * (1 - hert_hat)) * f[i,k] * a1_hat[k] / (1 + b1[i,k] * larv_tot[i,k])
    N1_w[i,k] = (larv[i,k] + (hert_hat * larv_hat[i,k])) * f[i,k] * a1[k] / (1 + b1[i,k] * larv_tot[i,k])

    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    #total N1's enter hatchery recruits
    #total N1's enter hatchery recruits
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k])
    #hatchery recruits
    #hatchery recruits
    R_st[i,k] = st[i,k] * a2_st[k] / (1 + b2[i,k] * N2_tot[i,k])
    #stocked recruits
    #stocked recruits
    R[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k])
    #wild recruits
    #wild recruits

    #subjecting recruits to some mortality before they become age 1's
    nage[i,1,k] = R[i,k] * So.5
    #So.5 is set to 0.5
    #So.5 is set to 0.5
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1]
    #mirrors
    #mirrors
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    #total N1's enter hatchery recruits
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    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1]
    #mirrors
    #mirrors
    nage_st[i,1,k] = R_st[i,k] * So.5
    #note here is where you would have added post recruit mortality
    #note here is where you would have added post recruit mortality
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1]
    #mirrors
    #mirrors
```



2. Review models: process

1. Oysters and fisheries assumptions

2. Translate to math and statistical equations

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #total effort, so just a function of total state with
    #first 30 years, then stocking at number stock
    et[i,k] = effort[k]
    #fishing is just a flag, then harvest rate per usual
    hr[i,k] <- fishing * (1 - exp(-et[i,k] * qt))
    #So, up stocking, no stocking for 30 years, then start stocking at constant rates
    st[i,sites] = 0; if(i>=30) st[i,sites] = stock[k]*(1 -ism)
    #not stocking for first 30 years, then stocking at number stock,
    #total wild and hat eggs
    #recruitment unpacking
    ssb_tot[i,k] = eggs[i-1,k] + eggs_hat[i-1,k]
    ssb_tot[i,1]=ssb_tot[i,2]; ssb_tot[i,nsites+2]=ssb_tot[i,nsites+1]
    #dispersal
    larv[i,k] = sum(eggs[i-1,sites] * prob_mat[k,sites])
    larv[i,k] = eggs[i-1,k]
    larv[i,1]=larv[i,2]; larv[i,nsites+2]=larv[i,nsites+1];
    larv_hat[i,k] = sum(eggs_hat[i-1,sites] * prob_mat[k,sites])
    larv_hat[i,k] = eggs_hat[i-1,k]
    larv_hat[i,1]=larv_hat[i,2]; larv_hat[i,nsites+2]=larv_hat[i,nsites+1]
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    larv_tot[i,1]=larv_tot[i,2]; larv_tot[i,nsites+2]=larv_tot[i,nsites+1]
    #first stage of density dependence
    N1_hat[i,k] = (larv_hat[i,k] * (1 - hert_hat)) * f[i,k] * a1_hat[k] / (1 + hert_hat * larv_hat[i,k])
    N1_w[i,k] = (larv[i,k] + (hert_hat * larv_hat[i,k])) * f[i,k] * a1[k]
    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k])
    R_st[i,k] = st[i,k] * a2_st[k] / (1 + b2[i,k] * N2_tot[i,k])
    R[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k])
    #subjecting recruits to some mortality before they become age 1
    nage[i,1,k] = R[i,k] * So.5
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1]
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1]
    nage_st[i,1,k] = R_st[i,k] * So.5
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1]
  }
}
```



2. Review models: process

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #total effort, so just a function of total state with
    #first 30 years, then stocking at number stock
    hr[i,k] <- fishing * (1 - exp(-et[i,k] qt)) #fishing is just a flag, then harvest rate per usual
    #So updating things, no stocking for first 30 years, then stocking at constant rates
    st[i,nsites] = 0; if(i==0) st[i,nsites] = stock[k] * (1 -ism) #not stocking for first 30 years, then stocking at number stock,
    #do I need this?
    #total wild and hat eggs
    #do I need this?
    #dispersal
    larv[i,k] = sum(eggs[i-1,nsites] * prob_mat[k,nsites])
    # larv[i,k] = eggs[i-1,k]
    larv[i,1]=larv[i,2]; larv[i,nsites+2]=larv[i,nsites+1];
    #
    larv_hat[i,k] = sum(eggs_hat[i-1,nsites] * prob_mat[k,nsites])
    # larv_hat[i,k] = eggs_hat[i-1,k]
    larv_hat[i,1]=larv_hat[i,2]; larv_hat[i,nsites+2]=larv_hat[i,nsites+1]
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    larv_tot[i,1]=larv_tot[i,2]; larv_tot[i,nsites+2]=larv_tot[i,nsites+1]
    #first stage of density dependence
    N1_hat[i,k] = (larv_hat[i,k] * (1 - hert_hat)) * f[i,k] * a1_hat[k] / (1 + b1[i,k] * N1_hat[i,k])
    N1_w[i,k] = (larv[i,k] + (hert_hat * larv_hat[i,k])) * f[i,k] * a1[k] / (1 + b1[i,k] * (larv[i,k] + (hert_hat * larv_hat[i,k])))
    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k])
    R_st[i,k] = st[i,k] * a2_st[k] / (1 + b2[i,k] * N2_tot[i,k])
    R[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k])
    #subjecting recruits to some mortality before they become age 1's
    nage[i,1,k] = R[i,k] * So.5 #So.5 is set to 1, so this isn't operational here (used for when c
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1] #mirrors
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1] #mirros
    nage_st[i,1,k] = R_st[i,k] * So.5 #note here is where you would have added post recruit st
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1] #mirrors
```

1. Oysters and fisheries assumptions

2. Translate to math and statistical equations

3. Revise with CAB input



#wild recruits

#So.5 is set to 1, so this isn't operational here (used for when c
#mirrors

#mirros

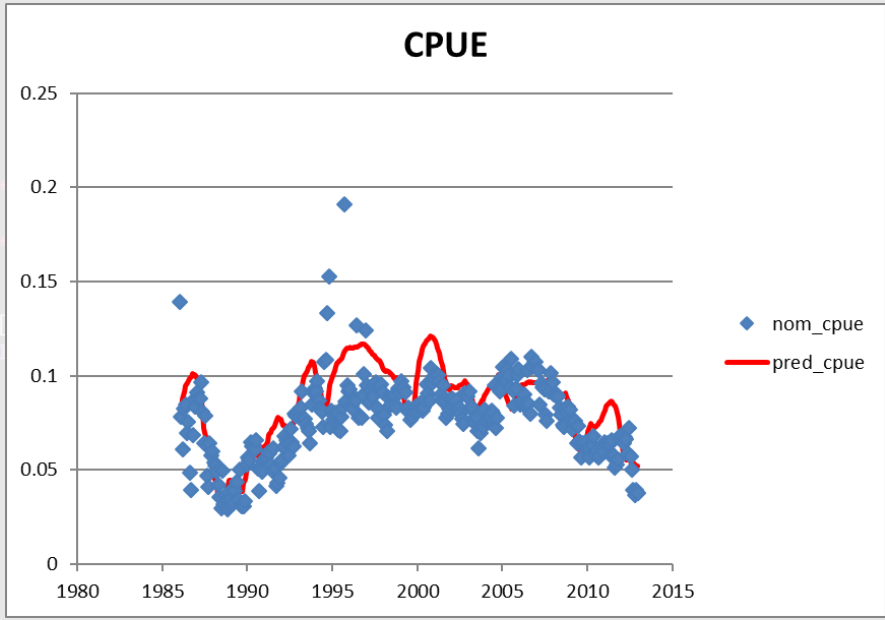
#note here is where you would have added post recruit st

#mirrors

2. Review models: process

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #total effort, so just a function of total state with
    #first 30 years, then stocking at number stock
    et[i,k] <- fishing * (1 - exp(-et[i,k] * qt))
    #fishing is just a flag, then harvest rate per usual
    hr[i,k] <- fishing * (1 - exp(-et[i,k] * qt))
    #do i need this?
    #not stocking for first 30 years, then stocking at number stock,
    st[i,nsites] = 0; if(i==0) st[i,nsites] = stock[k] * (1 - ism)
    #total wild and hat eggs
    #do i need this?
    sssb_tot[i,k] = eggs[i-1,k] + eggs_hat[i-1,k]
    sssb_tot[i,1] = sssb_tot[i,2]; sssb_tot[i,nsites+2] = sssb_tot[i,nsites+1];
    #do i need this?
    larv[i,k] = sum(eggs[i-1,nsites] * prob_mat[k,nsites])
    larv[i,k] = eggs[i-1,k]
    larv[i,1] = larv[i,2]; larv[i,nsites+2] = larv[i,nsites+1];
    larv_hat[i,k] = sum(eggs_hat[i-1,nsites] * prob_mat[k,nsites])
    larv_hat[i,k] = eggs_hat[i-1,k]
    larv_hat[i,1] = larv_hat[i,2]; larv_hat[i,nsites+2] = larv_hat[i,nsites+1];
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    larv_tot[i,1] = larv_tot[i,2]; larv_tot[i,nsites+2] = larv_tot[i,nsites+1];
    #first stage of density dependence
    N1_hat[i,k] = (larv_hat[i,k] * (1 - hert_hat)) * f[i,k] * a1_hat[k] / (1 + b1[i,k] * N1_hat[i,k])
    N1_w[i,k] = (larv[i,k] + (hert_hat * larv_hat[i,k])) * f[i,k] * a1[k] / (1 + b1[i,k] * N1_w[i,k])
    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k])
    R_st[i,k] = st[i,k] * a2_st[k] / (1 + b2[i,k] * N2_tot[i,k])
    R[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k])
    #subjecting recruits to some mortality before they become age 1's
    nage[i,1,k] = R[i,k] * So.5
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1]
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1] #mirros
    nage_st[i,1,k] = R_st[i,k] * So.5
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1] #mirros
    #note here is where you would have added post recruit st
    #mirros
  }
}
```

1. Oysters and fisheries assumptions
2. Translate to math and statistical equations
3. Revise with CAB input
4. Fit to data



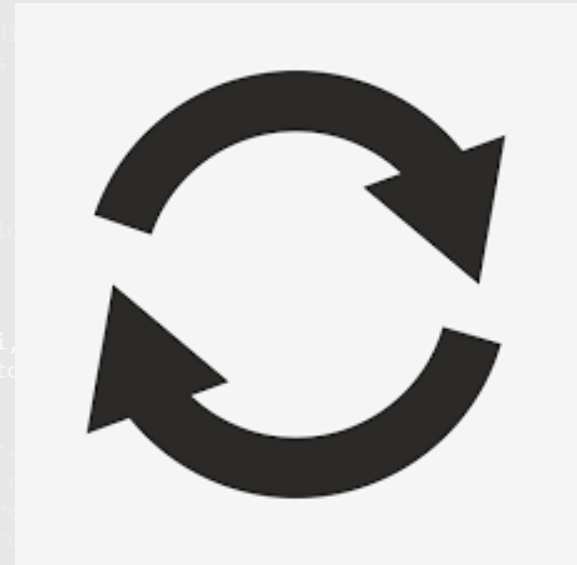
2. Review models: process

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #total effort, so just a function of total state with
    #first 30 years, then stocking at number stock
    et[i,k] = effort[i,k];
    #fishing is just a flag, then harvest rate per usual
    hr[i,k] <- fishing * (1 - exp(-et[i,k] * qt))
    #do i need this?
    #not stocking for first 30 years, then stocking at number stock,
    st[i,nsites] = 0; if(i==0) st[i,nsites] = stock[k] * (1 -ism)
    #total wild and hat eggs
    sssb_tot[i,k] = sssb_tot[i-1,k] + sssb_tot[i,nsites+2] - sssb_tot[i,nsites+1];
    #do i need this?
    #Use this density dependence to size the m
    #Use this density dependence to size that
    #mirrors
    larv[i,k] = sum(eggs[i-1,nsites] * probab_mat[k,nsites])
    larv_hat[i,k] = sum(eggs_hat[i-1,nsites] * probab_mat[k,nsites])
    larv_hat[i,1] = larv_hat[i,2]; larv_hat[i,nsites+2] = larv_hat[i,nsites+1]; #mirros
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k] #total wild
    larv_tot[i,1] = larv_tot[i,2]; larv_tot[i,nsites+2] = larv_tot[i,nsites+1]; #mirros

    #first stage of density dependence
    N1_hat[i,k] = (larv_hat[i,k] * (1 - hert_hat)) * f[i,k] * a1_hat[k] / (1 + b1[i,k] * larv_tot[i,k])
    N1_w[i,k] = (larv[i,k] + (hert_hat * larv_hat[i,k])) * f[i,k] * a1[k] / (1 + b1[i,k] * larv_tot[i,k])

    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k] #total N1's
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k]) #hatchery
    R_st[i,k] = st[i,k] * a2_st[k] / (1 + b2[i,k] * N2_tot[i,k]) #stocked re
    R[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k]) #wild recr

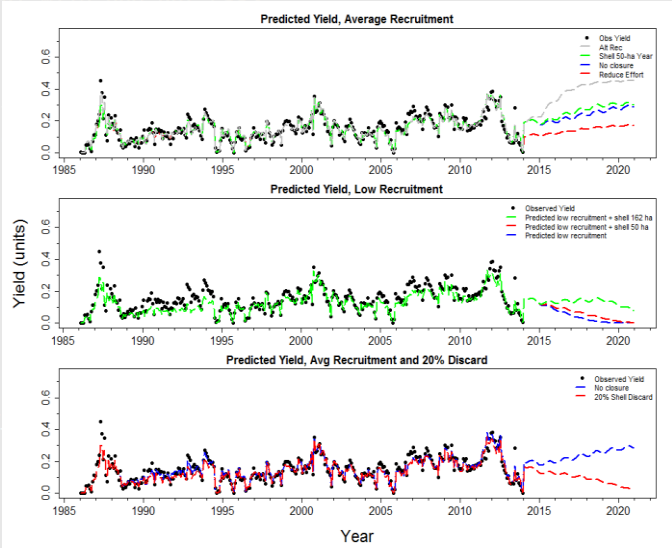
    #subjecting recruits to some mortality before they become age 1's
    #So.5 is set to 1, so this isn't operational here (used for when c
    nage[i,1,k] = R[i,k] * So.5 #mirrors
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1] #mirrors
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1] #mirros
    nage_st[i,1,k] = R_st[i,k] * So.5 #note here is where you would have added post recruit st
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1] #mirrors
  }
}
```



2. Review models: process

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    #open site loop back up again
    #fishing is just a flag, then harvest rate per usual
    hr[i,k] <- fishing * (1-exp(-et[i,k]*qt))
    #total yield per year
    st[i,nsites] = 0; if(i==0) st[i,nsites] = stock[k]*(1-ism)
    #total yield per year
    sssb_tot[i,k] = eggs[i-1,k] + eggs_hat[i-1,k]
    sssb_tot[i,1] = sssb_tot[i,2]; sssb_tot[i,nsites+2] = sssb_tot[i,nsites+1];
    #use
    larv[i,k] = sum(eggs[i-1,nsites] * probab_mat[k,nsites])
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    larv_tot[i,1] = larv_tot[i,2]; larv_tot[i,nsites+2] = larv_tot[i,nsites+1];
    #first stage of density dependence
    N1_hat[i,k] = (1-hert_hat) * f[i,k] * a1_hat[k] / (1+b1[i,k] * larv_tot[i,k])
    N1_w[i,k] = (hert_hat * larv_hat[i,k]) * f[i,k] * a1[k] / (1+b1[i,k] * larv_tot[i,k])
    #total
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    #hat
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1+b2[i,k] * N2_tot[i,k])
    #st
    R_st[i,k] = st[i,k] * a2_st[k] / (1+b2[i,k] * N2_tot[i,k])
    #wi
    R[i,k] = N1_w[i,k] * a2[k] / (1+b2[i,k] * N2_tot[i,k])
    #So
    nage[i,1,k] = R[i,k] * So.5
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1]
    #hat
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1]
    #st
    nage_st[i,1,k] = R_st[i,k] * So.5
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1]
```

1. Oysters and fisheries assumptions
2. Translate to math and statistical equations
3. Revise with CAB input
4. Fit to data
5. Repeat 3-4
6. Make predictions
 - Environment
 - Management
 - Restoration



2. Review models: purpose

1. Make discussions easier/more fruitful
2. Predict likely and unlikely outcomes of action
3. Increase understanding of oysters & fisheries
- ~~4. Be a perfect representation of reality~~

3. This model: current state

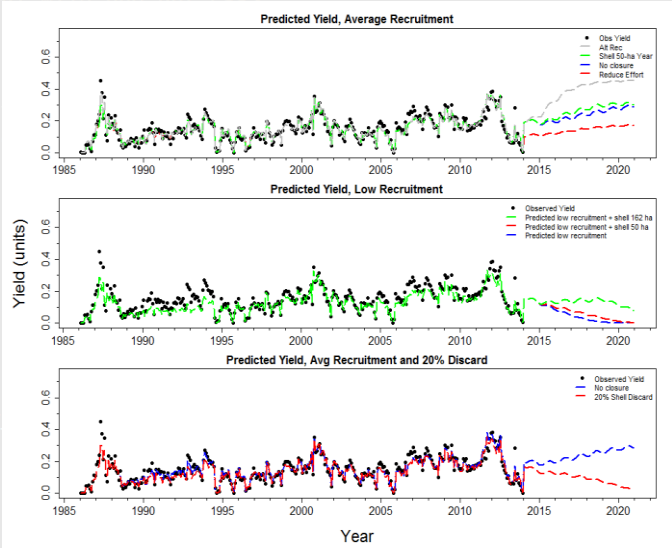
- System: simulated fished oyster population
- ***NOT fit to Apalachicola yet***
- Spatially implicit now, explicit later
- Key dynamics
 - Natural Mortality
 - Fishing mortality
 - Recruitment
 - Shell dynamics

2. Review models: process

```
for (i in 2:years){
  for (k in 2:(nsites+1)) {
    #actual effort
    effort[i,k] = effort[i,k-1]
    #fishing is just a flag, then harvest rate per usual
    hr[i,k] <- fishing * (1 - exp(-et[i,k] qt))
    #total stock
    st[i,nsites+1] = st[i,nsites] + stock[k] * (1 - sm)
    #total stock
    sssb_tot[i,k] = eggs[i-1,k] + eggs_hat[i-1,k]
    #total stock
    sssb_tot[i,nsites+2] = sssb_tot[i,nsites+1]
    #larvae
    larv[i,k] = sum(eggs[i-1,nsites] * probab_mat[k,nsites])
    #larvae
    larv_hat[i,k] = sum(eggs_hat[i-1,nsites] * probab_mat[k,nsites])
    #larvae
    larv_tot[i,k] = larv[i,k] + larv_hat[i,k]
    #larvae
    larv_tot[i,nsites+2] = larv_tot[i,nsites+1]
    #first stage of density dependence
    N1_hat[i,k] = (1 - hert_hat) * f[i,k] * a1_hat[k] / (1 + b1[i,k] * larv_tot[i,k])
    N1_w[i,k] = (hert_hat * larv_hat[i,k]) * f[i,k] * a1[k] / (1 + b1[i,k] * larv_tot[i,k])
    #second stage of density dependence
    N2_tot[i,k] = N1_hat[i,k] + N1_w[i,k] + st[i,k]
    R_hat[i,k] = N1_hat[i,k] * a2_hat[k] / (1 + b2[i,k] * N2_tot[i,k])
    R_w[i,k] = N1_w[i,k] * a2[k] / (1 + b2[i,k] * N2_tot[i,k])
    #subjecting recruits to some mortality before they become age 1's
    nage[i,1,k] = R[i,k] * So.5
    nage[i,1,1] = nage[i,1,2]; nage[i,1,nsites+2] = nage[i,1,nsites+1]
    nage_hat[i,1,k] = R_hat[i,k] * So.5
    nage_hat[i,1,1] = nage_hat[i,1,2]; nage_hat[i,1,nsites+2] = nage_hat[i,1,nsites+1]
    nage_st[i,1,k] = R_st[i,k] * So.5
    nage_st[i,1,1] = nage_st[i,1,2]; nage_st[i,1,nsites+2] = nage_st[i,1,nsites+1]
```

- 1. Oysters and fisheries assumptions
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3. This model: current state

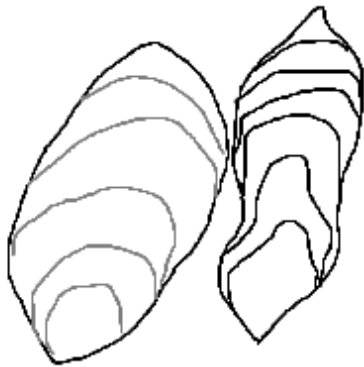
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 - Recruitment
 - Shell dynamics

4. Simple demo: A (too simple) oyster life cycle

Eggs



Harvestable adults

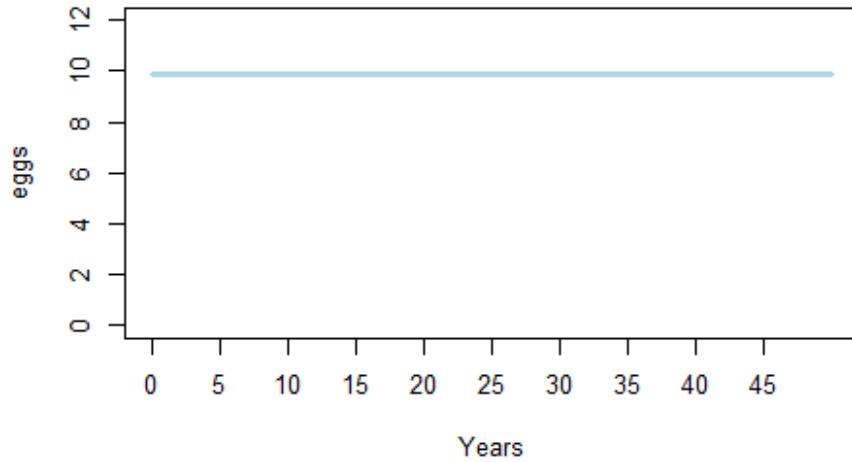


Recruits

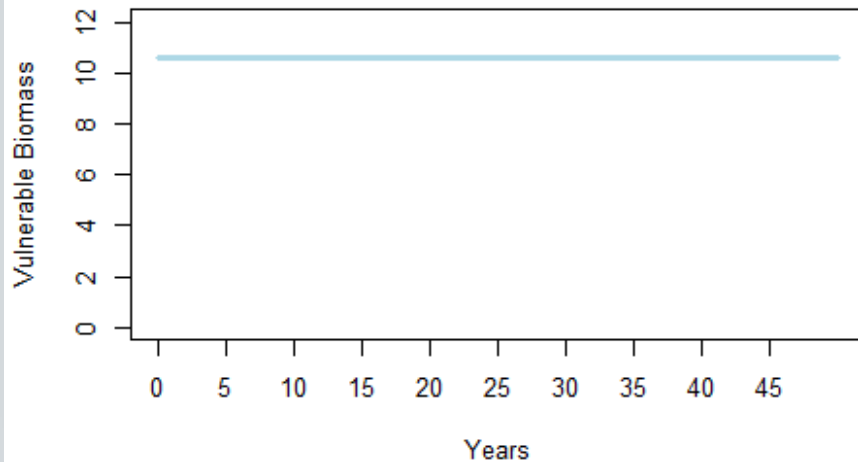


4. Equilibrium without fishing, oysters = fish

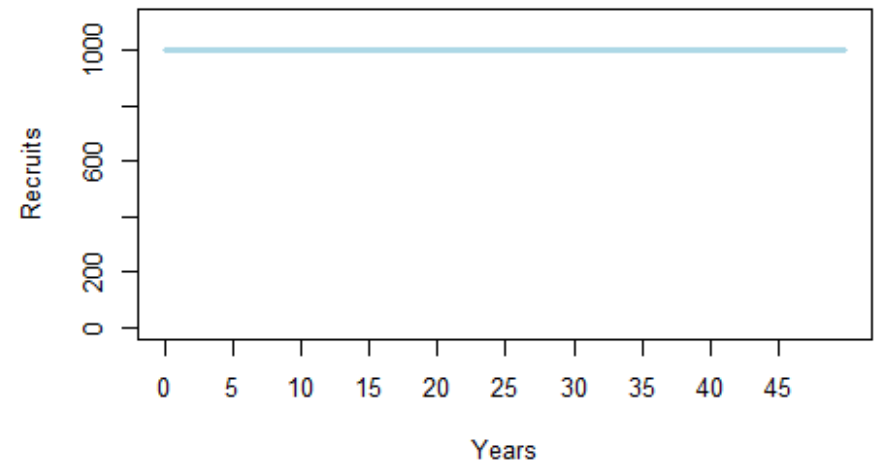
Eggs



Harvestable Adults

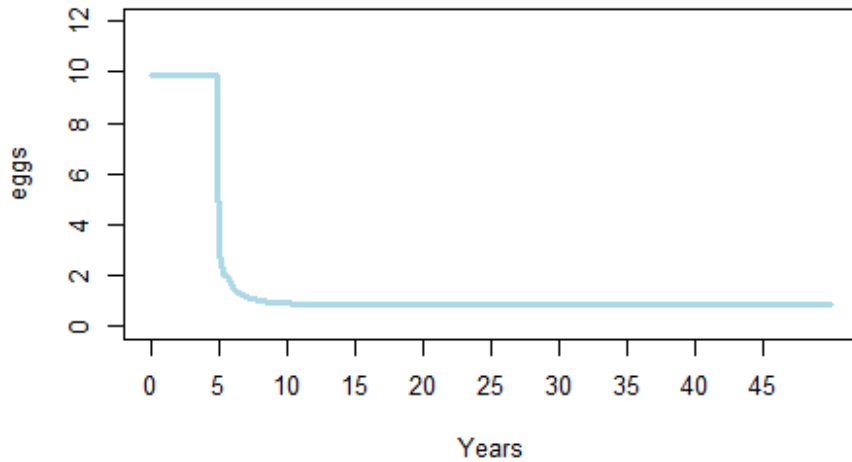


Recruits

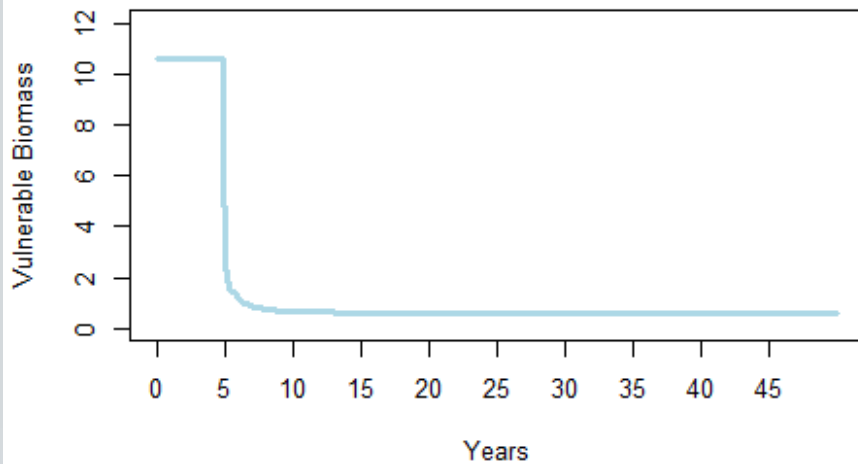


4. Equilibrium with fishing, oysters = fish

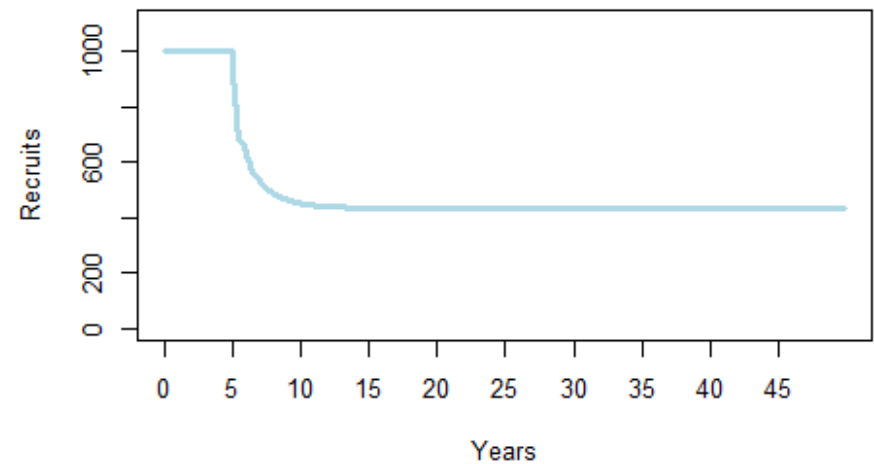
Eggs



Harvestable Adults

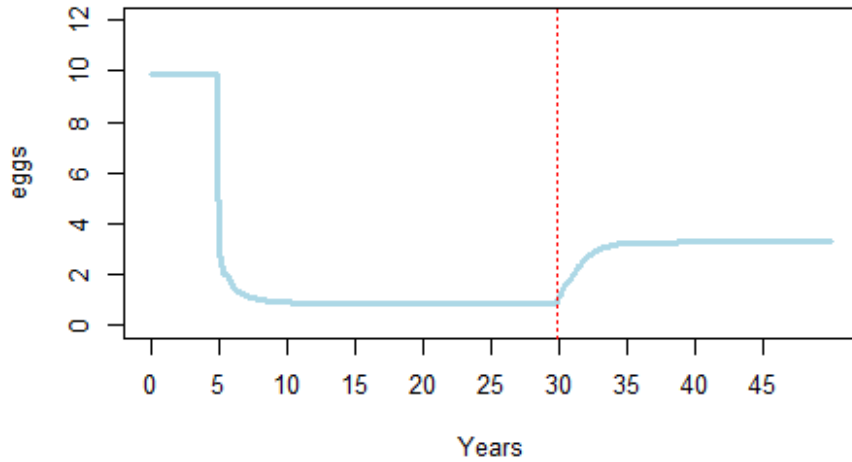


Recruits

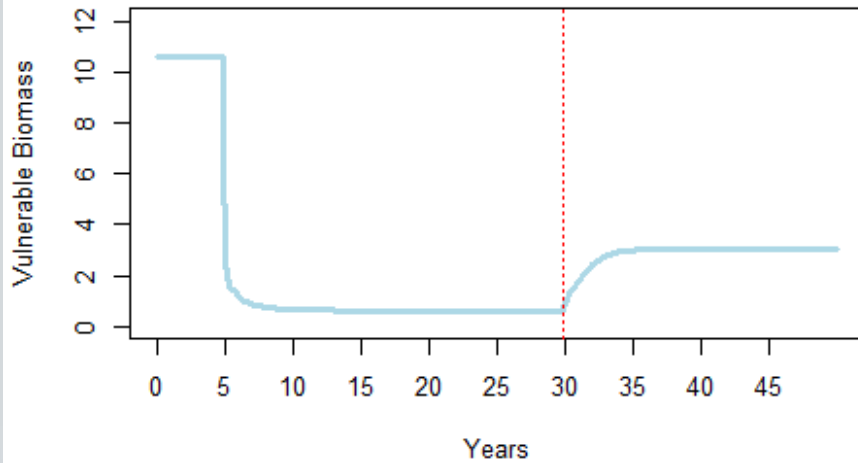


4. Equilibrium with fishing, oysters = fish

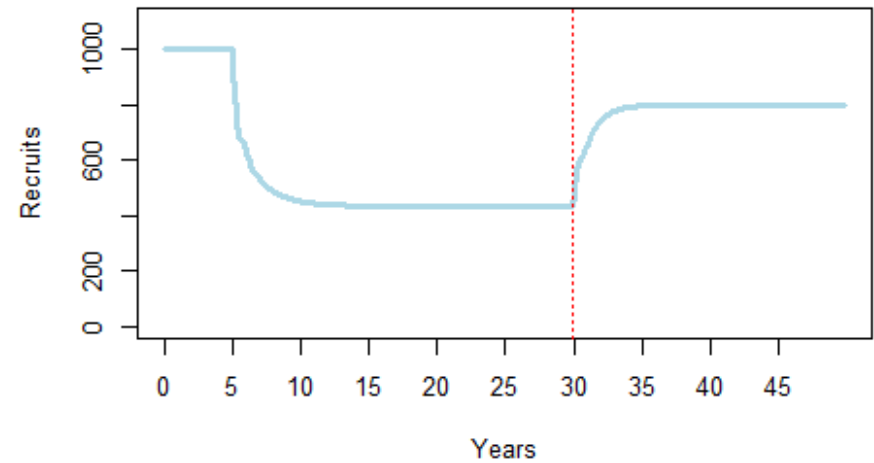
Eggs



Harvestable Adults



Recruits

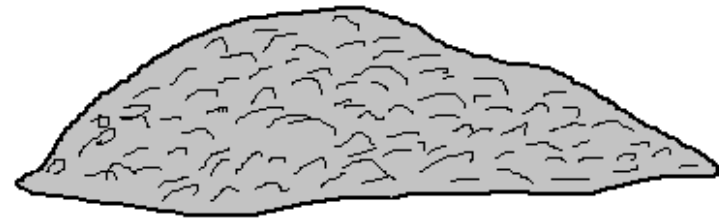


4. Simple demo: A oyster life cycle

Eggs



Shell



Harvestable adults

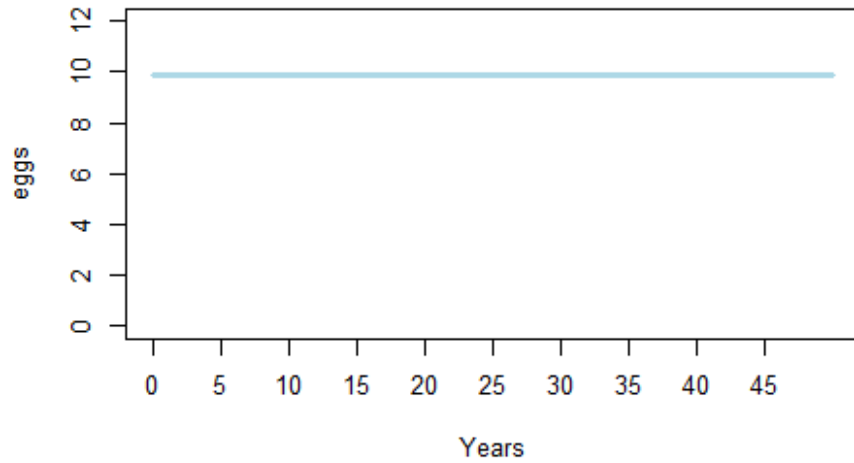


Recruits

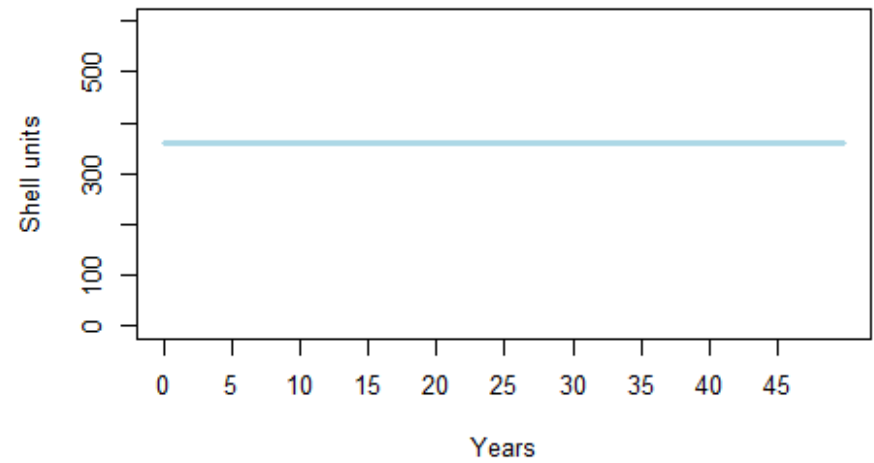


4. Shell model without fishing

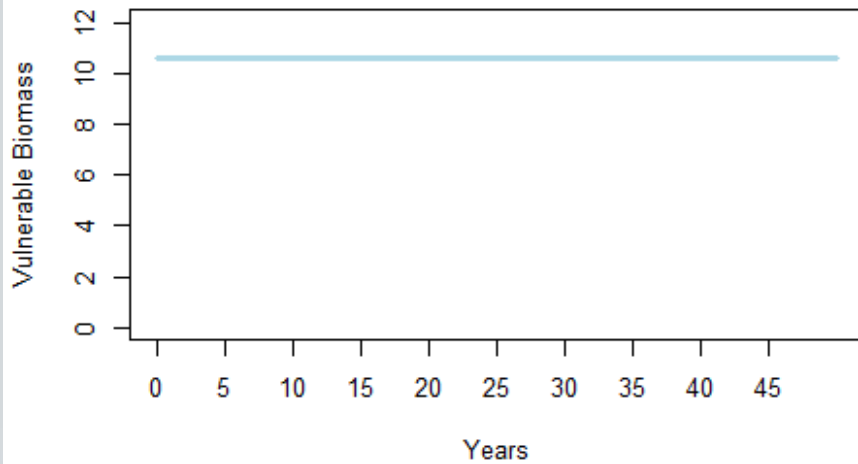
Eggs



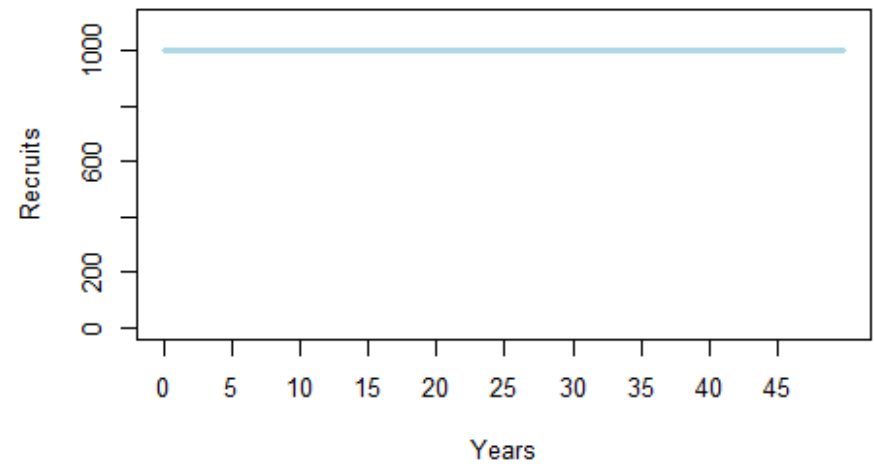
Shell



Harvestable Adults

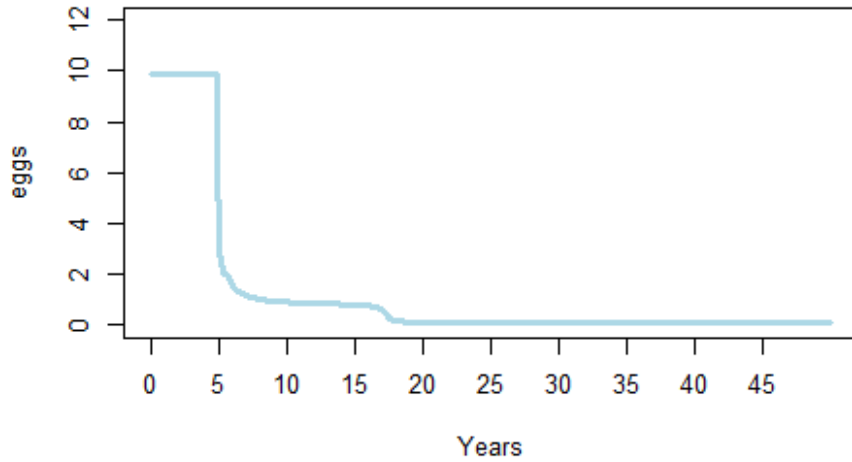


Recruits

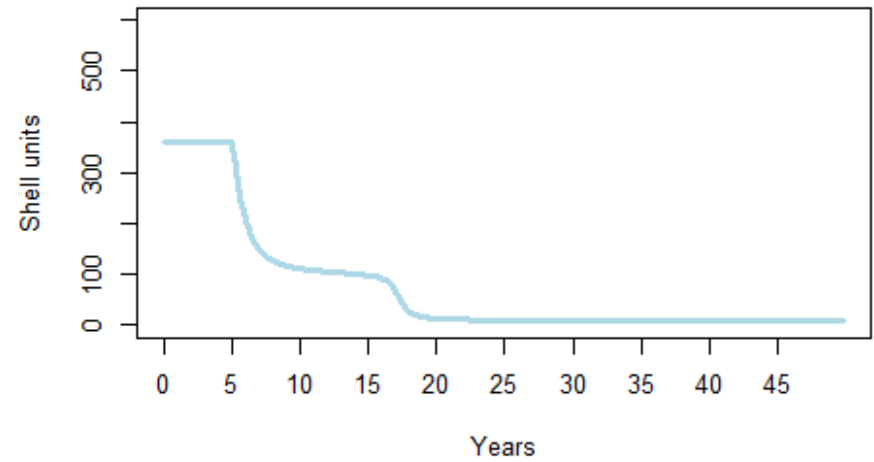


4. Shell model with fishing

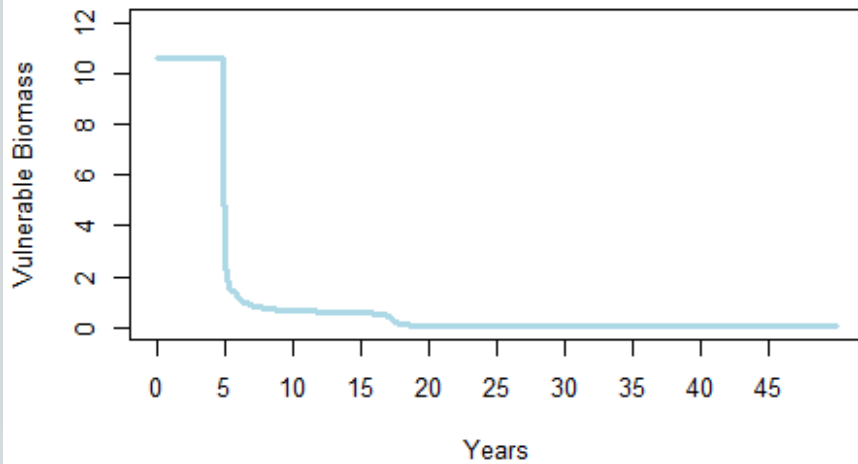
Eggs



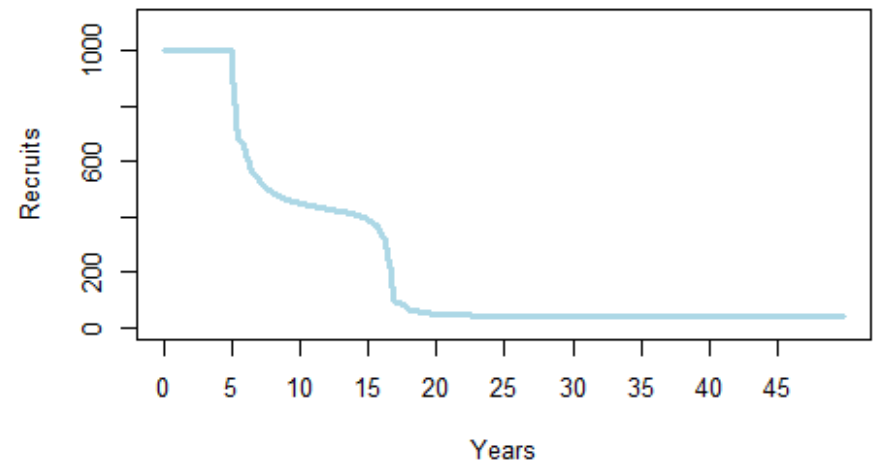
Shell



Harvestable Adults

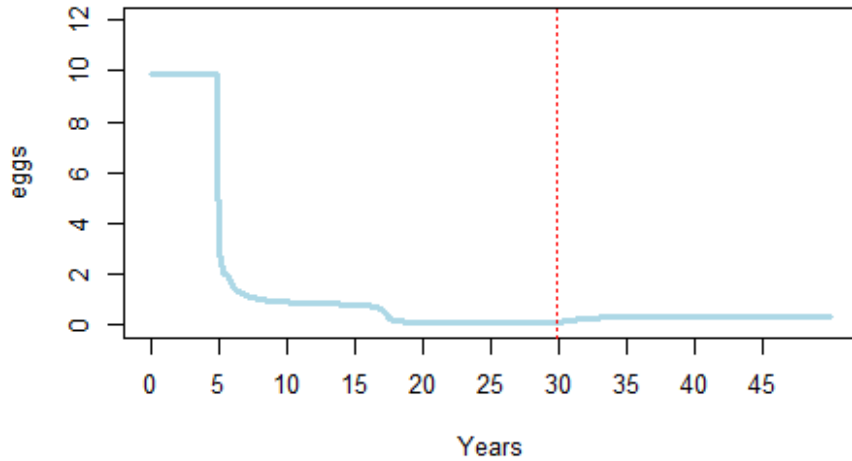


Recruits

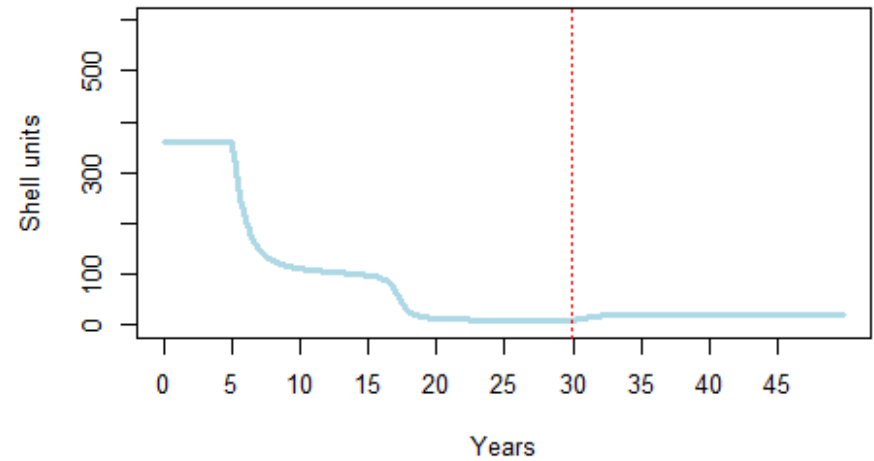


4. Add mgmt. responses like effort reductions...

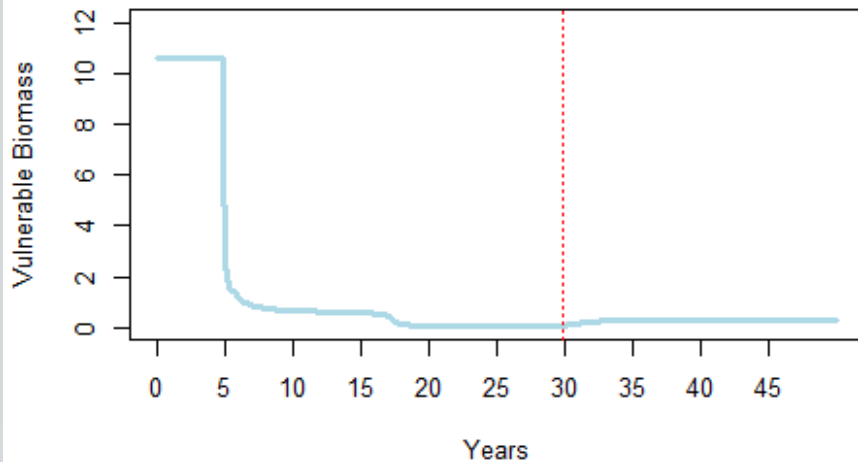
Eggs



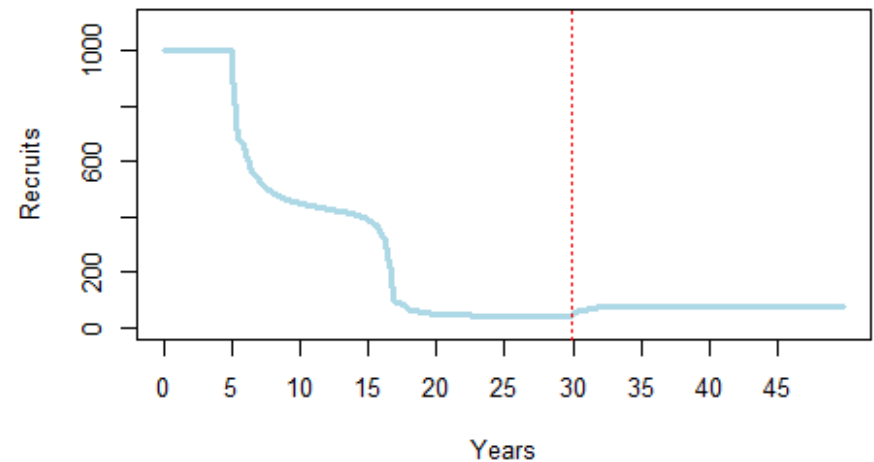
Shell



Harvestable Adults

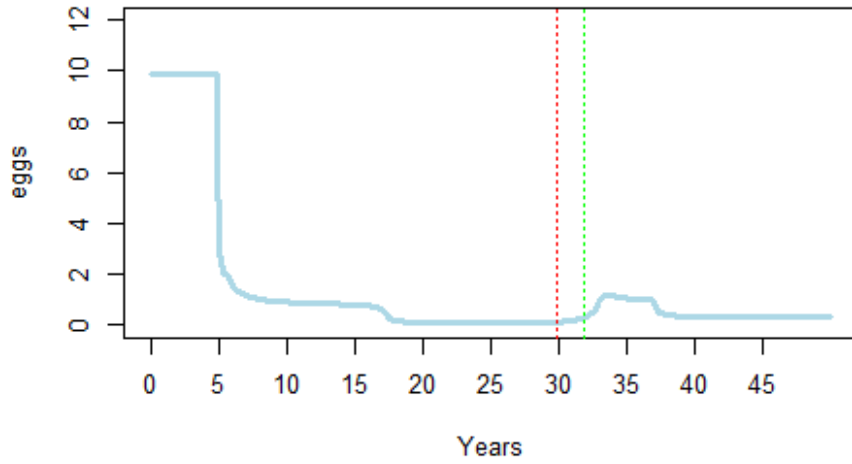


Recruits

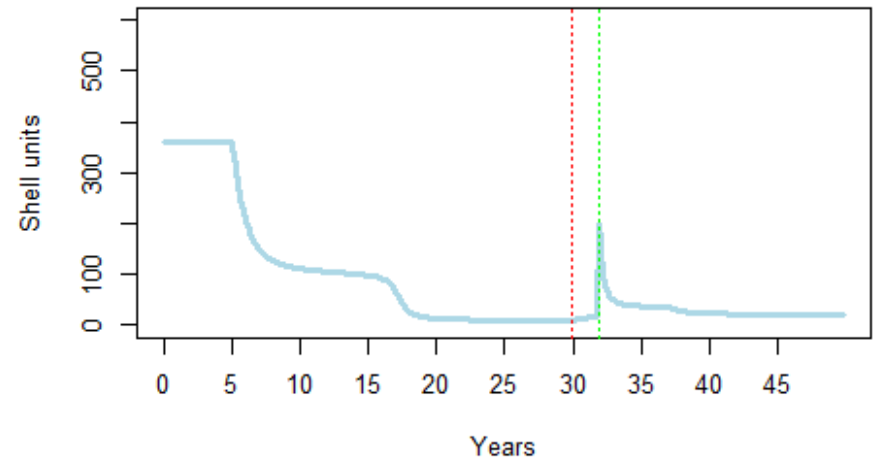


4. ...and add restoration

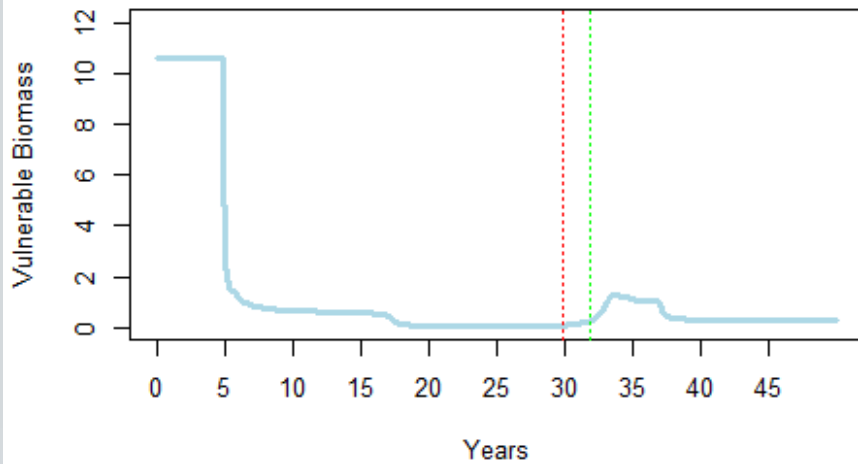
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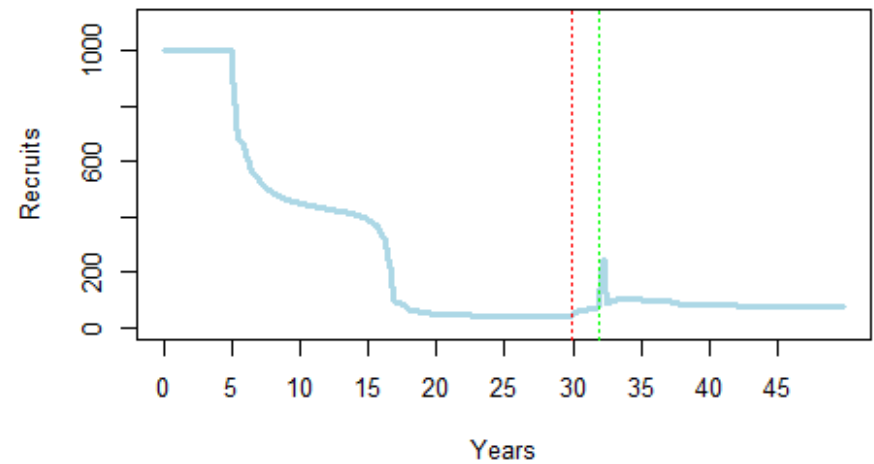
Shell



Harvestable Adults

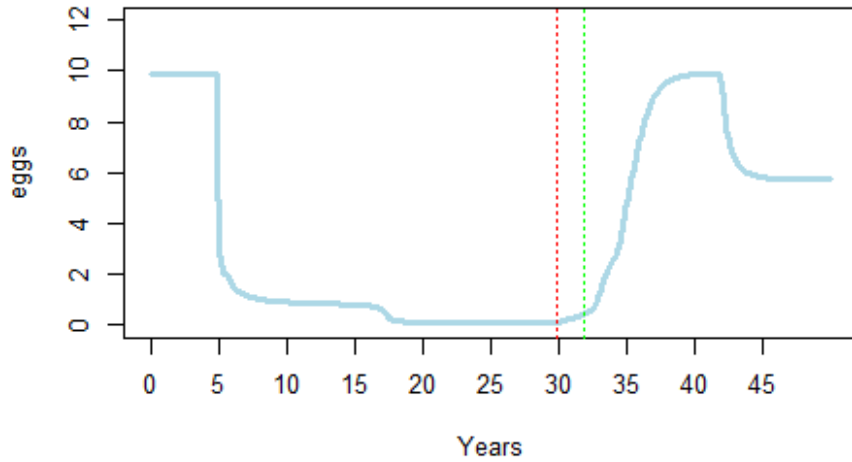


Recruits

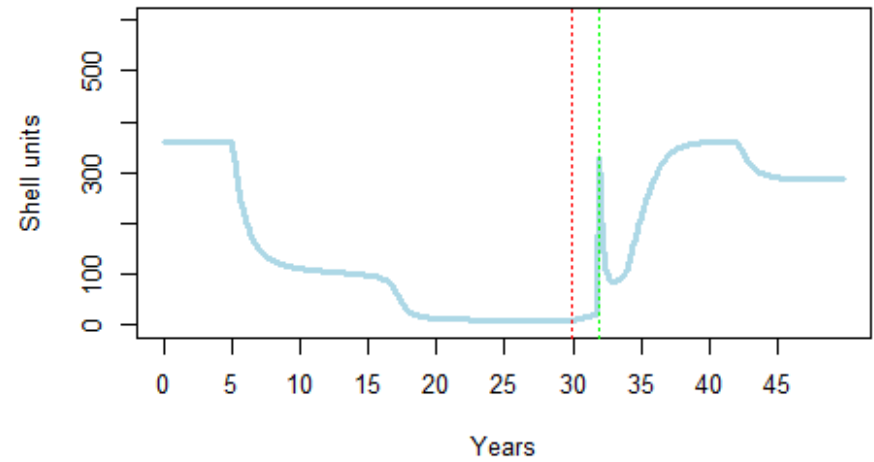


4. More extreme closures and restoration

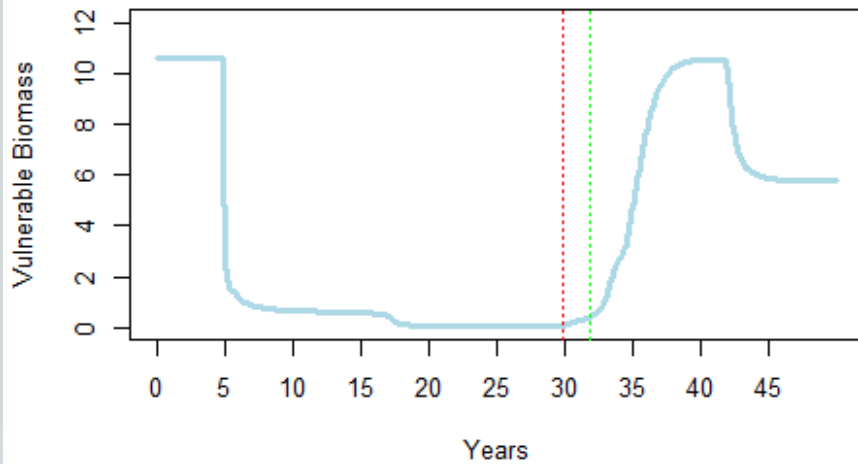
Eggs



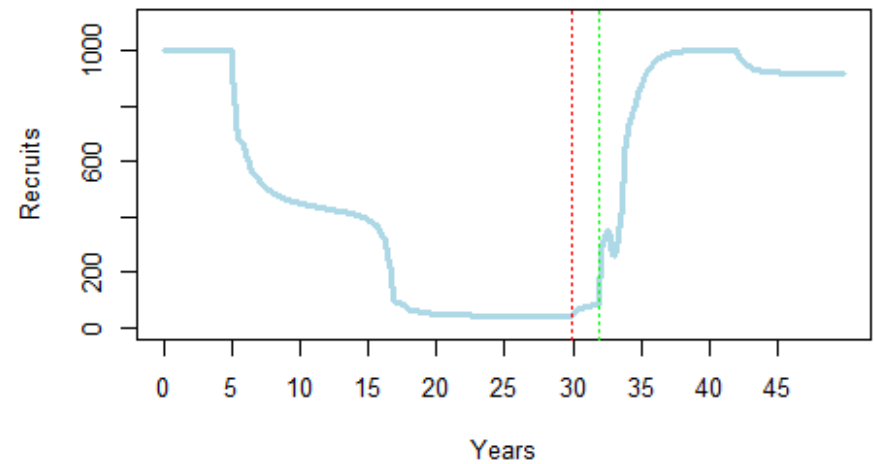
Shell



Harvestable Adults



Recruits



4. Demonstration, if time and if screen shared



4. Simple demo: summary

- Let's us look at what would happen if
 - “we took these mgmt. actions”
 - “the system works like this”
- Reminder: results aren't prescriptive/predictive until base model is fit to data.

5. What's missing from this model

- Fit model to data
 - Fisheries dependent (oyster harvest)
 - Fisheries independent (FWRI data)
- Make spatially explicit
 - Represent specific bars?
- Fine tune potential mgmt. actions
- Adding in economic components

6. Questions and Concerns

- How to keep people updated about model?
- Timing
 - Takes time and people to build model
 - Need fisheries independent data
 - Ideally everything would be done now



Questions and concerns

edvcamp@ufl.edu