clear; clc; clf;

figure(1); clf(1);

figure(2); clf(2);

figure(3); clf(3);

figure(4); clf(4);

tic

%%%% Masses in mg %%%%

W\_mass = 25000; % (mg) median of fish foraging on vertebrates from FoRAGE

F\_mass = 290; % (mg) median of fish foraging on invertebrates from FoRAGE

Z\_mass = 7.91e-1; % (mg) median of copepods and cladocerans from FoRAGE

 % Average from Houde and Roman 1987 Acartia tonsa

P\_mass = 4.857e-07; % (mg) median of algae from FoRAGE

starting\_mass = [P\_mass,Z\_mass,F\_mass,W\_mass];

% Initial densities used for visualizing model

P\_init = 8e3; % initial P density [P per mL]

Z\_init = 3E2; % initial Z density [Z per L]

F\_init = 1E2; % initial F density [F per kL]

W\_init = 5E1; % initial W density [W per ML]

y0\_4 = [850 200 200 200]; % specify vector of starting population sizes

P\_init = y0\_4(1); % identify each species start

Z\_init = y0\_4(2);

F\_init = y0\_4(3);

W\_init = y0\_4(4);

y0\_3 = y0\_4; y0\_3(4) = 0; % zero out W

y0\_2 = y0\_3; y0\_2(3) = 0; % also zero out F

% specify initial ODE parameters

k = 1000; % set carrying capacity of P

% mortality per day based on annual mortality by g of body mass (McCoy and Gilooly 2008)

d0 = 0.057;

dexp = -0.25;

d0W = d0;

d0F = d0;

d0Z = d0;

dW = d0W\*W\_mass^dexp; % prefactor is exp(1.17)/365/1000^-0.27

dF = d0F\*F\_mass^dexp;

dZ = d0Z\*Z\_mass^dexp;

r = 3; % target r

rexp = 0;

r0 = r/(P\_mass^rexp);

r = r0\*P\_mass^rexp;

% target handling in units of day

targethZonP = 1.5e-6; % units of days 1.5e-6

targethFonZ = 4e-4; % units of days

targethWonF = 1.36e-2; % units of days

% handling time scaling exponents

h1PM = 0.25;

h1ZM = -0.5;

h2ZM = 0.25;

h2FM = -0.5;

h3FM = 0.25;

h3WM = -0.5;

% calculating scaling equation intercepts to ground on targets

h0Z = targethZonP/((Z\_mass^h1ZM)\*(P\_mass^h1PM));

 hZ = h0Z\*(Z\_mass^h1ZM)\*(P\_mass^h1PM);

h0F = targethFonZ/((F\_mass^h2FM)\*(Z\_mass^h2ZM));

 hF = h0F\*(F\_mass^h2FM)\*(Z\_mass^h2ZM);

h0W = targethWonF/((W\_mass^h3WM)\*(F\_mass^h3FM));

 hW = h0W\*(W\_mass^h3WM)\*(F\_mass^h3FM);

h\_prefactors = [h0Z, h0F, h0W];

h\_scalings = [h1PM,h1ZM,h2ZM,h2FM,h3FM,h3WM];

h\_targets = [targethZonP, targethFonZ, targethWonF];

m = 0; % mutual interference

for scenario = 1:2

% choose space clearance rate scaling exponents

if scenario == 1

 a1PM = -0.25;

 a1ZM = 0.5;

 a2ZM = -0.25;

 a2FM = 0.5;

 a3FM = -0.25;

 a3WM = 0.5;

elseif scenario == 2

 a1PM = 0.25;

 a1ZM = 0.5;

 a2ZM = 0.25;

 a2FM = 0.5;

 a3FM = 0.25;

 a3WM = 0.5;

end

a\_scalings = [a1PM,a1ZM,a2ZM,a2FM,a3FM,a3WM];

% target space clearance rates in units of m^3 per pred per day

targetaZonP = 1e6\*4.55e-6; % m^3 per pred per day \* 1e6 cm^3 per m^3

 % From Porter et al 1982 Daphna magna

 % rounded up from 4.55e-6

targetaFonZ = 1e-3\*1e6\*1e-2; % m^3 per pred per day \* 1e6 cm^3 per m^3

 % Rounded down from Anderson et al 1978 Danio rerio eating Daphna

targetaWonF = 1e-2\*1e6\*2.73; % m^3 per pred per day \* 1e6 cm^3 per m^3

 % From Alexander et al 2015 largemouth bass eating guppies

% calculating scaling equation intercepts to ground on targets

a0Z = targetaZonP/((Z\_mass^a1ZM)\*(P\_mass^a1PM));

 aZ = a0Z\*(Z\_mass^a1ZM)\*(P\_mass^a1PM);

a0F = targetaFonZ/((F\_mass^a2FM)\*(Z\_mass^a2ZM));

 aF = a0F\*(F\_mass^a2FM)\*(Z\_mass^a2ZM);

a0W = targetaWonF/((W\_mass^a3WM)\*(F\_mass^a3FM));

 aW = a0W\*(W\_mass^a3WM)\*(F\_mass^a3FM);

a\_prefactors = [a0Z, a0F, a0W];

GGE = 0.2; % rough value

eZ = GGE\*P\_mass/Z\_mass;

eF = GGE\*Z\_mass/F\_mass;

eW = GGE\*F\_mass/W\_mass;

% run standard solver on differential Mac Ros equation

t\_max = 400; % time span

tspan = [0 t\_max]; % start end times

% call solvers for regular model solutions

ode\_4 = @(t,y) MR\_model\_four\_vol\_V5(t,y,r,k,aZ,aF,aW,hZ,hF,hW,eZ,eF,eW,dZ,dF,dW); % compile function and call

 [t4,y4] = ode23s(ode\_4, tspan, y0\_4); % return time and population density vectors

ode\_3 = @(t,y) MR\_model\_four\_vol\_V5(t,y,r,k,aZ,aF,aW,hZ,hF,hW,eZ,eF,eW,dZ,dF,dW); % compile function and call

 [t3,y3] = ode23s(ode\_3, tspan, y0\_3); % return time and population density vectors

ode\_2 = @(t,y) MR\_model\_four\_vol\_V5(t,y,r,k,aZ,aF,aW,hZ,hF,hW,eZ,eF,eW,dZ,dF,dW); % compile function and call

 [t2,y2] = ode23s(ode\_2, tspan, y0\_2); % return time and population density vectors

% plot solutions across matrix of food chain lengths

figure(5);

 subplot(4,3,1); % row 1, trophic level 4

 plot(t4,y4(:,4),'-k');

 ylim([0 400]);

 xlim([0 t\_max]);

 ylabel({['Piscivorous fish'],['(# in ML)']});

 subplot(4,3,4); % row 2, trophic level 3

 hold on; box on;

 plot(t4,y4(:,3),'-k');

 plot(t3,y3(:,3),'-.k');

 ylim([0 300]);

 ylabel({['Zooplanktivorous fish'],['(# in kL)']});

 subplot(4,3,5)

 plot(t3,y3(:,3),'-.k');

 ylim([0 300]);

 subplot(4,3,7); % row 3, trophic level 2

 hold on; box on;

 plot(t4,y4(:,2),'-k');

 plot(t3,y3(:,2),'-.k');

 plot(t2,y2(:,2),'--k');

 ylim([0 200]);

 ylabel({['Zooplankton'],['(# in L)']});

 subplot(4,3,8)

 hold on; box on;

 plot(t3,y3(:,2),'-.k');

 plot(t2,y2(:,2),'--k');

 ylim([0 200]);

 subplot(4,3,9)

 plot(t2,y2(:,2),'--k');

 ylim([0 200]);

 subplot(4,3,10); % row 4, trophic level 1

 hold on; box on;

 plot(t3,y3(:,1),'-.k');

 plot(t2,y2(:,1),'--k');

 plot(t4,y4(:,1),'-k');

 ylim([0 1000]);

 ylabel({['Phytoplankton'],['(# in mL)']});

 subplot(4,3,11)

 hold on; box on;

 plot(t3,y3(:,1),'-.k');

 plot(t2,y2(:,1),'--k');

 ylim([0 1000]);

 xlabel('Time (days)');

 subplot(4,3,12)

 plot(t2,y2(:,1),'--k');

 ylim([0 1000]);

%% call GEM function and return time series

% set up run

 h\_2 = 0.75; % define level of heritability

 EXT = [t\_max 50]; % When W go extinct

 titles = {'Population Size','Mass','Fitness gradient'}; % Column Titles

 cv = 0.3;

 num\_replicates = 200; % number of simulations

for run = 1:2

 [fitness\_gradients,stand\_times, P\_data\_out, Z\_data\_out, F\_data\_out, W\_data\_out, ...

 xP\_data\_out, xP\_var\_data\_out, xF\_data\_out, xF\_var\_data\_out, xZ\_data\_out, xZ\_var\_data\_out, xW\_data\_out, xW\_var\_data\_out,...

 t1,y1] = GEM\_4\_trophic\_level\_extinction\_final(starting\_mass,y0\_4,a\_scalings,h\_scalings,a\_prefactors,h\_prefactors,h\_targets,d0,dexp,r0,rexp,k,GGE,cv,h\_2,num\_replicates,t\_max,run,EXT(run),m);

 STI = 3; % steps to include

 if run == 1

 final\_gem\_no\_TC = [mean(P\_data\_out(1,end-STI:end)), mean(Z\_data\_out(1,end-STI:end)), mean(F\_data\_out(1,end-STI:end));...

 mean(xP\_data\_out(1,end-STI:end)), mean(xZ\_data\_out(1,end-STI:end)), mean(xF\_data\_out(1,end-STI:end));...

 mean(fitness\_gradients(1,end-STI:end)), mean(fitness\_gradients(2,end-STI:end)), mean(fitness\_gradients(3,end-STI:end))];

 final\_ode\_no\_TC = y1(end,:);

 noTC\_P = [P\_data\_out(1,:); xP\_data\_out(1,:)];

 noTC\_Z = [Z\_data\_out(1,:); xZ\_data\_out(1,:)];

 noTC\_F = [F\_data\_out(1,:); xF\_data\_out(1,:)];

 elseif run == 2

 final\_gem\_yes\_TC = [mean(P\_data\_out(1,end-STI:end)), mean(Z\_data\_out(1,end-STI:end)), mean(F\_data\_out(1,end-STI:end));...

 mean(xP\_data\_out(1,end-STI:end)), mean(xZ\_data\_out(1,end-STI:end)), mean(xF\_data\_out(1,end-STI:end));...

 mean(fitness\_gradients(1,end-STI:end)), mean(fitness\_gradients(2,end-STI:end)), mean(fitness\_gradients(3,end-STI:end))];

 final\_ode\_yes\_TC = y1(end,:);

 yesTC\_P = [P\_data\_out(1,:); xP\_data\_out(1,:)];

 yesTC\_Z = [Z\_data\_out(1,:); xZ\_data\_out(1,:)];

 yesTC\_F = [F\_data\_out(1,:); xF\_data\_out(1,:)];

 aZ\_shift = a0Z\*(final\_gem\_yes\_TC(2,2)^a1ZM)\*(final\_gem\_yes\_TC(2,1)^a1PM);

 aF\_shift = a0F\*(final\_gem\_yes\_TC(2,3)^a2FM)\*(final\_gem\_yes\_TC(2,2)^a2ZM);

 end

 % pick out a color scheme

 fill\_colors = [0.5 0.5 1; 0.9 0.75 0];

 cmap = colormap(parula); % set colormap0.3 0.8 0

 cmap2 = cmap([1,13,22,38,51,64],:); % pick colors from across colormap

 colors = [cmap2(1,:); cmap2(5,:)];

 figure(scenario); % plot medians and ci's overtop individual lines

 hold on;

 %%%%% First Column (Population Size) %%%%%

 subplot(4,3,10); box on;

 jbfill(stand\_times,P\_data\_out(2,:),P\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,P\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 if run == 1

 z3 = plot(t1,y1(:,1),'--','Color',colors(run,:),'LineWidth',2);

 elseif run == 2

 z4 = plot(t1,y1(:,1),'--','Color',colors(run,:),'LineWidth',2);

 end

 ylabel({['Phytoplankton'],['(# in mL)']});

 xlim([0 t\_max]);

 subplot(4,3,7); box on;hold on;

 jbfill(stand\_times,Z\_data\_out(2,:),Z\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,Z\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot(t1,y1(:,2),'--','Color',colors(run,:),'LineWidth',2);

 ylabel({['Zooplankton'],['(# in L)']});

 xlim([0 t\_max]);

 subplot(4,3,4); box on;hold on;

 jbfill(stand\_times,F\_data\_out(2,:),F\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,F\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot(t1,y1(:,3),'--','Color',colors(run,:),'LineWidth',2);

 ylabel({['Zooplanktivorous fish'],['(# in kL)']});

 xlim([0 t\_max]);

 subplot(4,3,1); box on;hold on;

 jbfill(stand\_times,W\_data\_out(2,:),W\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,W\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot(t1,y1(:,4),'--','Color',colors(run,:),'LineWidth',2);

 xlim([0 t\_max]);

 ylabel({['Piscivorous fish'],['(# in ML)']});

 title(titles{1});

 axis([0 t\_max 0 400]);

 %%%%% Second Column (Mass) %%%%%

 subplot(4,3,11); box on; hold on;

 jbfill(stand\_times,xP\_data\_out(2,:),xP\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,xP\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[xP\_data\_out(2,1) xP\_data\_out(2,1)],'-k');

 xlim([0 t\_max]);

 xlabel('Time');

 %axis([0 t\_max P\_mass\*0.8 P\_mass\*1.2]);

 subplot(4,3,8); box on; hold on;

 jbfill(stand\_times,xZ\_data\_out(2,:),xZ\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,xZ\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[xZ\_data\_out(1,1) xZ\_data\_out(1,1)],'-k');

 xlim([0 t\_max]);

 %axis([0 t\_max Z\_mass\*0.75 Z\_mass\*1.25]);

 subplot(4,3,5); box on; hold on;

 jbfill(stand\_times,xF\_data\_out(2,:),xF\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,xF\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[xF\_data\_out(1,1) xF\_data\_out(1,1)],'-k');

 xlim([0 t\_max]);

 %axis([0 t\_max F\_mass\*0.75 F\_mass\*1.25]);

 subplot(4,3,2); box on; hold on;

 jbfill(stand\_times,xW\_data\_out(2,:),xW\_data\_out(3,:),fill\_colors(run,:),'w',1,0.2);

 hold on;

 plot(stand\_times,xW\_data\_out(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[xW\_data\_out(1,1) xW\_data\_out(1,1)],'-k');

 xlim([0 t\_max]);

 title(titles{2});

 %axis([0 t\_max W\_mass\*0.75 W\_mass\*1.25]);

 %%%%% Third Column (Fitness gradient) %%%%%

 subplot(4,3,12); box on; hold on;

 %jbfill(stand\_times,ci\_xP\_var\_up,ci\_xP\_var\_down,fill\_colors(f,:),'w',1,0.2);

 hold on;

 plot(stand\_times,fitness\_gradients(1,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[0 0],'-k');

 xlim([0 t\_max]);

 %axis([0 t\_max 0 11e4]);

 subplot(4,3,9); box on; hold on;

 %jbfill(stand\_times,ci\_xZ\_var\_up,ci\_xZ\_var\_down,fill\_colors(f,:),'w',1,0.2);

 hold on;

 plot(stand\_times,fitness\_gradients(2,:),'-','LineWidth',2,'Color',colors(run,:));

 %plot([0 t\_max],[0 0],'-k');

 xlim([0 t\_max]);

 %axis([0 t\_max 0 14e5]);

 subplot(4,3,6); box on; hold on;

 %jbfill(stand\_times,ci\_xF\_var\_up,ci\_xF\_var\_down,fill\_colors(f,:),'w',1,0.2);

 hold on;

 plot(stand\_times,fitness\_gradients(3,:),'-','LineWidth',2,'Color',colors(run,:));

 plot([0 t\_max],[0 0],'-k');

 xlim([0 t\_max]);

 %axis([0 t\_max 0 6e6]);

 subplot(4,3,3); box on; hold on;

 %jbfill(stand\_times,ci\_xPF\_var\_up,ci\_xPF\_var\_down,fill\_colors(f,:),'w',1,0.2);

 hold on;

 if run == 1

 z1 = plot(stand\_times,fitness\_gradients(4,:),'-','LineWidth',2,'Color',colors(run,:));

 elseif run == 2

 z2 = plot(stand\_times,fitness\_gradients(4,:),'-','LineWidth',2,'Color',colors(run,:));

 end

 plot([0 t\_max],[0 0],'-k');

 xlim([0 t\_max]);

 title(titles{3});

 if run == 2

 legend([z1 z2 z3 z4],'Background eco-evo','Eco-evo trophic cascade',...

 'Background no-evolution','No-evolution trophic cascade');

 end

end

 %plot standardized trophic cascades with and without evolution

 figure(3);

 subplot(2,4,4\*scenario-3)

 h1 = plot(0,0,'o','MarkerFaceColor',colors(1,:),'Color',colors(1,:)); hold on;

 plot(0,100\*(final\_ode\_yes\_TC(4)-final\_ode\_no\_TC(4))/final\_ode\_no\_TC(4),'o','Color',colors(2,:),'MarkerFaceColor',colors(2,:));

 h2 = plot([0 0],[100\*(final\_ode\_yes\_TC(4)-final\_ode\_no\_TC(4))/final\_ode\_no\_TC(4) 0],'--','Color',colors(2,:),'LineWidth',2);

 xlim([-1 1]);

 ylim([-100 100]);

 title('Piscivorous fish');

 ylabel('Percent change in abundance');

 subplot(2,4,4\*scenario-2)

 plot(0,0,'o','MarkerFaceColor',colors(1,:),'Color',colors(1,:)); hold on;

 plot(0,100\*(final\_ode\_yes\_TC(3)-final\_ode\_no\_TC(3))/final\_ode\_no\_TC(3),'o','Color',colors(2,:),'MarkerFaceColor',colors(2,:));

 plot([0 0],[100\*(final\_ode\_yes\_TC(3)-final\_ode\_no\_TC(3))/final\_ode\_no\_TC(3) 0],'--','Color',colors(2,:),'LineWidth',2);

 plot(100\*(final\_gem\_yes\_TC(2,3)-final\_gem\_no\_TC(2,3))/final\_gem\_no\_TC(2,3),100\*(final\_gem\_yes\_TC(1,3)-final\_gem\_no\_TC(1,3))/final\_gem\_no\_TC(1,3),'o','MarkerFaceColor',colors(2,:),'Color',colors(2,:));

 plot([100\*(final\_gem\_yes\_TC(2,3)-final\_gem\_no\_TC(2,3))/final\_gem\_no\_TC(2,3) 0],[100\*(final\_gem\_yes\_TC(1,3)-final\_gem\_no\_TC(1,3))/final\_gem\_no\_TC(1,3) 0],'-','Color',colors(2,:),'LineWidth',2);

 h3 = plot(smooth(100\*(yesTC\_F(2,:)-noTC\_F(2,:))./noTC\_F(2,:)),smooth(100\*(yesTC\_F(1,:)-noTC\_F(1,:))./noTC\_F(1,:)),'-','Color',colors(2,:),'Linewidth',2);

 xlim([-8 8]);

 ylim([-1600 1600]);

 title('Zooplanktivorous fish');

 if run == 2

 legend([h1 h2 h3],'Baseline','Without top predator, no evolution','Without top predator, evolution');

 end

 subplot(2,4,4\*scenario-1)

 plot(0,0,'o','MarkerFaceColor',colors(1,:),'Color',colors(1,:)); hold on;

 plot(0,100\*(final\_ode\_yes\_TC(2)-final\_ode\_no\_TC(2))/final\_ode\_no\_TC(2),'o','Color',colors(2,:),'MarkerFaceColor',colors(2,:));

 plot([0 0],[100\*(final\_ode\_yes\_TC(2)-final\_ode\_no\_TC(2))/final\_ode\_no\_TC(2) 0],'--','Color',colors(2,:),'LineWidth',2);

 plot(100\*(final\_gem\_yes\_TC(2,2)-final\_gem\_no\_TC(2,2))/final\_gem\_no\_TC(2,2),100\*(final\_gem\_yes\_TC(1,2)-final\_gem\_no\_TC(1,2))/final\_gem\_no\_TC(1,2),'o','MarkerFaceColor',colors(2,:),'Color',colors(2,:));

 plot([100\*(final\_gem\_yes\_TC(2,2)-final\_gem\_no\_TC(2,2))/final\_gem\_no\_TC(2,2) 0],[100\*(final\_gem\_yes\_TC(1,2)-final\_gem\_no\_TC(1,2))/final\_gem\_no\_TC(1,2) 0],'-','Color',colors(2,:),'LineWidth',2);

 plot(smooth(100\*(yesTC\_Z(2,:)-noTC\_Z(2,:))./noTC\_Z(2,:)),smooth(100\*(yesTC\_Z(1,:)-noTC\_Z(1,:))./noTC\_Z(1,:)),'-','Color',colors(2,:),'Linewidth',2);

 xlim([-3 3]);

 ylim([-50 50]);

 xlabel('Percent change in body mass');

 title('Zooplankton');

 subplot(2,4,4\*scenario)

 plot(0,0,'o','MarkerFaceColor',colors(1,:),'Color',colors(1,:)); hold on;

 plot(0,100\*(final\_ode\_yes\_TC(1)-final\_ode\_no\_TC(1))/final\_ode\_no\_TC(1),'o','Color',colors(2,:),'MarkerFaceColor',colors(2,:));

 plot([0 0],[100\*(final\_ode\_yes\_TC(1)-final\_ode\_no\_TC(1))/final\_ode\_no\_TC(1) 0],'--','Color',colors(2,:),'LineWidth',2);

 plot(100\*(final\_gem\_yes\_TC(2,1)-final\_gem\_no\_TC(2,1))/final\_gem\_no\_TC(2,1),100\*(final\_gem\_yes\_TC(1,1)-final\_gem\_no\_TC(1,1))/final\_gem\_no\_TC(1,1),'o','MarkerFaceColor',colors(2,:),'Color',colors(2,:));

 plot([100\*(final\_gem\_yes\_TC(2,1)-final\_gem\_no\_TC(2,1))/final\_gem\_no\_TC(2,1) 0],[100\*(final\_gem\_yes\_TC(1,1)-final\_gem\_no\_TC(1,1))/final\_gem\_no\_TC(1,1) 0],'-','Color',colors(2,:),'LineWidth',2);

 plot(smooth(100\*(yesTC\_P(2,:)-noTC\_P(2,:))./noTC\_P(2,:)),smooth(100\*(yesTC\_P(1,:)-noTC\_P(1,:))./noTC\_P(1,:)),'-','Color',colors(2,:),'Linewidth',2);

 xlim([-50 50]);

 ylim([-15 15]);

 title('Phytoplankton');

 figure(4);

 box on; hold on;

 diff\_in\_size(1) = abs(final\_gem\_no\_TC(2,1) - final\_gem\_yes\_TC(2,1))/final\_gem\_no\_TC(2,1);

 diff\_in\_size(2) = abs(final\_gem\_no\_TC(2,2) - final\_gem\_yes\_TC(2,2))/final\_gem\_no\_TC(2,2);

 diff\_in\_size(3) = abs(final\_gem\_no\_TC(2,3) - final\_gem\_yes\_TC(2,3))/final\_gem\_no\_TC(2,3);

 diff\_in\_FG(1) = abs(final\_gem\_no\_TC(3,1) - final\_gem\_yes\_TC(3,1))/abs(final\_gem\_no\_TC(3,1));

 diff\_in\_FG(2) = abs(final\_gem\_no\_TC(3,2) - final\_gem\_yes\_TC(3,2))/abs(final\_gem\_no\_TC(3,2));

 diff\_in\_FG(3) = abs(final\_gem\_no\_TC(3,3) - final\_gem\_yes\_TC(3,3))/abs(final\_gem\_no\_TC(3,3));

 if scenario == 1

 zz1 = plot(diff\_in\_FG,diff\_in\_size,'ok','MarkerFaceColor','w');

 text(diff\_in\_FG,diff\_in\_size,{'Phytoplankton','Zooplankton','Zooplanktivorous fish'});

 elseif scenario == 2

 zz2 = plot(diff\_in\_FG,diff\_in\_size,'ok','MarkerFaceColor','k');

 text(diff\_in\_FG,diff\_in\_size,{'Phytoplankton','Zooplankton','Zooplanktivorous fish'});

 legend([zz1 zz2],'Negative scalings','Positive scalings');

 xlabel('Relative change in fitness gradient','FontSize',12);

 ylabel('Relative change in body size','FontSize',12);

 end

end

toc