Script to generate the figures for field flume results of *"Wind exposure and sediment type determine the resilience and response of seagrass meadows to climate change"*

**Loading data from textfiles:**

clear variables

close all

cd('folder with data of flume experiments');

data = load('mastertable.txt');

% col 1) site (1 - ShoCo, 2- LoFi)

% col 2) treatment (1 - full length, 2 - clipped to 8 cm, 3 - shoots removed, 4 - bare sediment)

% col 3) ucrit (m/s)

% col 4) stdev of ucrit (m/s)

% col 5)

% col 6) canopy height (m)

% col 7) shoot density (# per m^2)

load('biomassrelations.txt');

% col 1) canopy height (cm)

% col 2) shoot density (# per m^2)

% col 3) blade area per m^2

% col 4) shoot width (m)

% col 5) canopy height \* shoot density (-)

% blade lengths measured from biomass cores

load('LoFiBlades.txt');

load('ShoCoBlades.txt');

**Calculating blade area for the field flume experiments using relations derived from biomass cores**

Plotting blade length histograms for ShoCo and LoFi

bins = [0:30]./100;

[n(1,:), e(1,:)] = histcounts(ShoCoBlades./100,bins);

[n(2,:), e(2,:)] = histcounts(LoFiBlades./100,bins);

edges = e(:,2:end) - (e(:,2)-e(:,2))./2;

figure;

subplot(2,1,1)

p2 = bar(edges(2,:),n(2,:),1,'FaceColor',[0.3 0.3 0.3]);

hold on

p1 = bar(edges(1,:),n(1,:),1,'FaceColor',[0.8 0.8 0.6],'FaceAlpha',0.5);

plot([0.17 0.17],[0 40],'-','Color',[0.8 0.8 0.6],'Linewidth',1)

plot([0.24 0.24],[0 40],'-','Color',[0.3 0.3 0.3],'Linewidth',1)

xlabel('Blade length [m]')

ylabel('Counts')

legend([p1 p2],'ShoCo','LoFi')

title('A')

xtickformat('%.2f')

legend BOXOFF

Plotting corresponding canopy height x shoot density - blade area relations

subplot(2,1,2)

plot(biomassrelations(1:4,5),biomassrelations(1:4,3),'.','Color',[0.8 0.8 0.6],'MarkerSize',10)

hold on

plot(biomassrelations(5:8,5),biomassrelations(5:8,3),'.','Color',[0.3 0.3 0.3],'MarkerSize',10)

plot([40.49 96.25],0.014.\*[40.49 96.25],'-','Color',[0.3 0.3 0.3],'Linewidth',1)

plot([31.51 57.23],0.0075.\*[31.51 57.23],'-','Color',[0.8 0.8 0.6],'Linewidth',1)

text(60,0.4,{'Y = 1.31x10^{-2}X';'R^2 = 0.92'})

text(60,0.2,{'Y = 7.4x10^{-3}X';'R^2 = 0.93'})

xlabel('Canopy height x Shoot density [m^{-1}]')

ylabel('Blade area per m^2 [-]')

axis([0 110 0 1.5])

legend('ShoCo','LoFi')

title('B')

ytickformat('%.1f')

legend BOXOFF

Chart, histogram

Description automatically generated

Calculating the blade area for the flume experiments based on established relations for ShoCo and LoFi

for i = 1:length(data)

if data(i,1) == 1

BladeArea(i,:) = 0.0075\*data(i,6)\*data(i,7);

elseif data(i,1) == 2

BladeArea(i,:) = 0.014\*data(i,6)\*data(i,7);

end

end

**Calculating the increase of ucrit by the seagrass canopy, and translating this to a reduction of shear stress.**

Extracting only the ucr measurements from the full canopy to removed shoots treatments

umaxcr(:,1) = data(data(:,1) == 1,3); %sandy

umaxcr\_std(:,1) = data(data(:,1) == 1,4); %sandy

umaxcr(:,2) = data(data(:,1) == 2,3); %silty

umaxcr\_std(:,2) = data(data(:,1) == 2,4); %silty

umaxcrbare = [mean(umaxcr(7:9,1)) mean(umaxcr(7:9,2))]; %ucrit of sediment with removed shoots

Calculating relative change in ucrit for increasing blade area compared to ucrit of removed shoots

umaxchange = umaxcr./umaxcrbare;

umaxchange = umaxchange(:);

Calculating linear fit for blade area vs. reduction in ucrit

modelfun = @(b,x)(1+b(1).\*x);

xrange = 0:0.01:1.5;

beta0 = [2];

[beta1,R,J,CovB,MSE] = nlinfit([BladeArea(1:9);BladeArea(15:23)],[umaxchange(1:9);umaxchange(15:23)],modelfun,beta0);

[ypred1,delta1] = nlpredci(modelfun,xrange,beta1,R,'Covar',CovB,'MSE',MSE,'SimOpt','on');

Converting relative change in ucrit to a relative change in shear stress, and converting this into shear stress attenuation

taumaxchange = umaxchange .^2;

tauattenuation = 1-(1./taumaxchange);

Calculating fit for blade area vs. taucrit attenuation

modelfun = @(b,x)((b(1)./-(b(3).\*x+0.1))+b(2));

beta0 = [1 1 1];

[beta2,R,J,CovB,MSE] = nlinfit([BladeArea(1:9);BladeArea(15:23)],[tauattenuation(1:9);tauattenuation(15:23)],modelfun,beta0);

[ypred2,delta2] = nlpredci(modelfun,xrange,beta2,R,'Covar',CovB,'MSE',MSE,'SimOpt','on');

Calculating mean and std of ucrit for the treatments as reported in the manuscript text

for i = 1:4

Sa(i) = mean(data(data(:,1) == 1 & data(:,2) == i,3));

Sastd(i) = std(data(data(:,1) == 1 & data(:,2) == i,3));

Si(i) = mean(data(data(:,1) == 2 & data(:,2) == i,3));

Sistd(i) = std(data(data(:,1) == 2 & data(:,2) == i,3));

end

Extracting individual treatments for plotting figure 4A

SaPrist = data(data(:,1) == 1 & data(:,2) == 1,3);

SaClip = data(data(:,1) == 1 & data(:,2) == 2,3);

SaGone = data(data(:,1) == 1 & data(:,2) == 3,3);

SaBare = data(data(:,1) == 1 & data(:,2) == 4,3);

SiPrist = data(data(:,1) == 2 & data(:,2) == 1,3);

SiClip = data(data(:,1) == 2 & data(:,2) == 2,3);

SiGone = data(data(:,1) == 2 & data(:,2) == 3,3);

SiBare = data(data(:,1) == 2 & data(:,2) == 4,3);

Theil-Sen fits for figure 4A

[fitsand(1), fitsand(2)] = TheilSen\_regression(BladeArea(1:9),data(1:9,3));

[fitsilt(1), fitsilt(2)] = TheilSen\_regression(BladeArea(15:23),data(15:23,3));

R^2 values for figure 4A and 4B

r\_sand = corrcoef(fitsand(1).\*BladeArea(1:9)+fitsand(2),data(1:9,3));

r\_silt = corrcoef(fitsilt(1).\*BladeArea(15:23)+fitsilt(2),data(15:23,3));

r\_all1 = corrcoef(1+beta1.\*BladeArea([1:9,15:23]),umaxchange([1:9,15:23]));

r\_all2 = corrcoef(beta2(1)./-(beta2(3).\*BladeArea([1:9,15:23])+0.1)+beta2(2),tauattenuation([1:9,15:23]));

**Generating Figure 4**

Generating figure 4A

figure;

subplot(2,2,1)

hold on

p1 = bar(NaN,NaN,'Facecolor',[0.8 0.8 0.6]);

p2 = bar(NaN,NaN,'FaceColor',[0.3 0.3 0.3]);

p3 = plot(NaN,NaN,'.k','MarkerSize',25);

p4 = plot(NaN,NaN,'s','MarkerSize',6,'MarkerFaceColor','k','MarkerEdgeColor','none');

p5 = plot(NaN,NaN,'d','MarkerSize',6,'MarkerFaceColor','k','MarkerEdgeColor','none');

p6 = plot(NaN,NaN,'ok','MarkerSize',6);

plot(BladeArea(1:3),data(1:3,3),'.','Color',[0.8 0.8 0.6],'MarkerSize',18)

plot(BladeArea(4:6),data(4:6,3),'s','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(7:9),data(7:9,3),'d','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(10:14)-0.1,data(10:14,3),'o','Color',[0.8 0.8 0.6],'MarkerSize',6)

plot(BladeArea(15:17),data(15:17,3),'.','Color',[0.3 0.3 0.3],'MarkerSize',18)

plot(BladeArea(18:20),data(18:20,3),'s','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(21:23),data(21:23,3),'d','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(24:28)-0.1,data(24:28,3),'o','Color',[0.3 0.3 0.3],'MarkerSize',6)

plot([0 0.4546],fitsand(1).\*[0 0.4546]+fitsand(2),'Color',[0.8 0.8 0.6],'Linewidth',1);

plot([0 max(BladeArea)],fitsilt(1).\*[0 max(BladeArea)]+fitsilt(2),'Color',[0.3 0.3 0.3],'Linewidth',1);

xlabel('Blade area per m^2 seabed surface (-)')

text(0.25,0.30,['y = 0.17x + 0.19\newlineR^2 = ',num2str(r\_sand(1,2)^2,'%.2f')])

text(0.85,0.22,['y = 0.12x + 0.15\newlineR^2 = ',num2str(r\_silt(1,2)^2,'%.2f')])

ylabel('u\_{cr} (m s^{-1})')

axis([-0.1 1.5 0.1 0.3])

xticks([0 0.5 1.0 1.5])

yticks([0.1 0.2 0.3])

legend([p1 p2 p3 p4 p5 p6],'ShoCo','LoFi','full length shoots','Shoots clipped','Shoots removed','Bare','Location','southoutside')

legend BOXOFF

xtickformat('%.1f')

ytickformat('%.1f')

title('A')

Text, letter

Description automatically generated

Generating figure 4B

subplot(2,2,2)

plot(xrange,ypred1,'-k','Linewidth',1)

hold on

plot(xrange,[ypred1-delta1;ypred1+delta1],'--k','Linewidth',1)

plot(BladeArea(1:3),umaxchange(1:3),'.','Color',[0.8 0.8 0.6],'MarkerSize',18)

plot(BladeArea(4:6),umaxchange(4:6),'s','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(7:9),umaxchange(7:9),'d','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(15:17),umaxchange(15:17),'.','Color',[0.3 0.3 0.3],'MarkerSize',18)

plot(BladeArea(18:20),umaxchange(18:20),'s','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(21:23),umaxchange(21:23),'d','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

xlabel('Blade area per m^{2} seabed surface (-)')

ylabel('u\_{cr} normalized to u\_{cr,0} (-)')

axis([0 1.5 0.9 2])

text(0.25,1.85,['y = 0.81x\newlineR^2 = ',num2str(r\_all1(1,2)^2,'%.2f')])

set(gca,'box','off');

xtickformat('%.1f')

title('B')

Chart, scatter chart

Description automatically generated

Generating Figure 4C

subplot(2,2,3)

plot(xrange,ypred2,'-k','Linewidth',1)

hold on

plot(xrange,[ypred2-delta2;ypred2+delta2],'--k','Linewidth',1)

plot(BladeArea(1:3),tauattenuation(1:3),'.','Color',[0.8 0.8 0.6],'MarkerSize',18)

plot(BladeArea(4:6),tauattenuation(4:6),'s','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(7:9),tauattenuation(7:9),'d','MarkerFaceColor',[0.8 0.8 0.6],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(15:17),tauattenuation(15:17),'.','Color',[0.3 0.3 0.3],'MarkerSize',18)

plot(BladeArea(18:20),tauattenuation(18:20),'s','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

plot(BladeArea(21:23),tauattenuation(21:23),'d','MarkerFaceColor',[0.3 0.3 0.3],'MarkerEdgeColor','none','MarkerSize',6)

xlabel('Blade area per m^{2} seabed surface (-)')

ylabel('Shear stress attenuation (-)')

axis([0 1.5 -0.2 1])

text(0.25,0.85,['R^2 = ',num2str(r\_all2(1,2)^2,'%.2f')])

set(gca,'box','off');

xtickformat('%.1f')

title('C')

Chart, diagram, scatter chart

Description automatically generated

Statistical analyses reported in the manuscript text

anovatrix = [SaClip SiClip;SaGone SiGone];

[~,stats(1,1)] = ttest(SaPrist, SaClip);

[~,stats(2,1)] = ttest(SaClip, SaGone);

[~,stats(3,1)] = ttest(SaPrist, SaGone);

[~,stats(4,1)] = ttest2(SaPrist, SaBare);

[~,stats(5,1)] = ttest2(SaGone, SaBare);

[~,stats(1,2)] = ttest(SiPrist, SiClip);

[~,stats(2,2)] = ttest(SiClip, SiGone);

[~,stats(3,2)] = ttest(SiPrist, SiGone);

[~,stats(4,2)] = ttest2(SiPrist, SiBare);

[~,stats(5,2)] = ttest2(SiGone, SiBare);