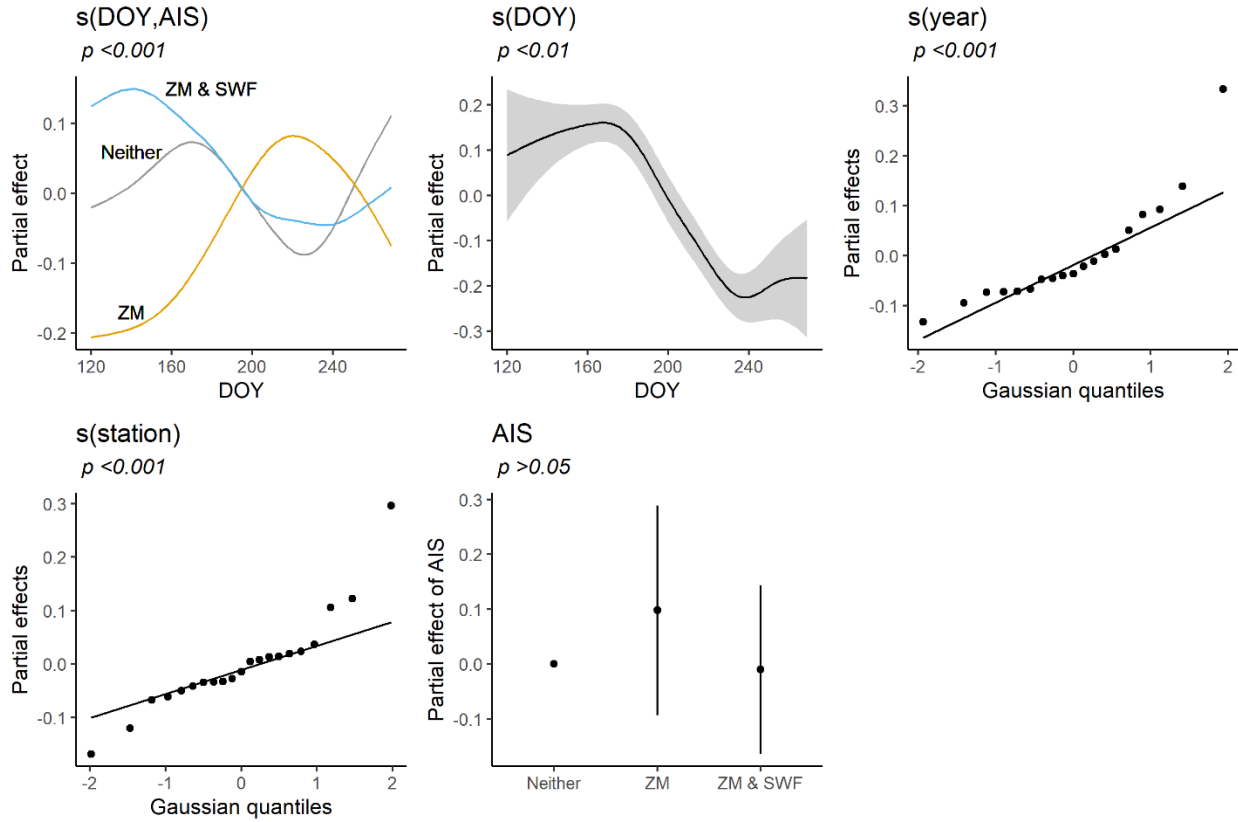


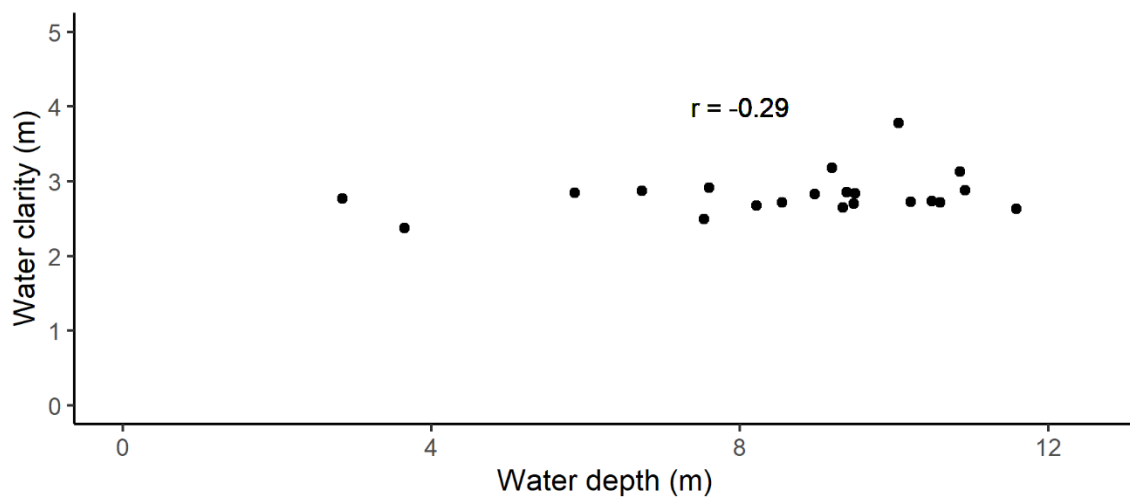
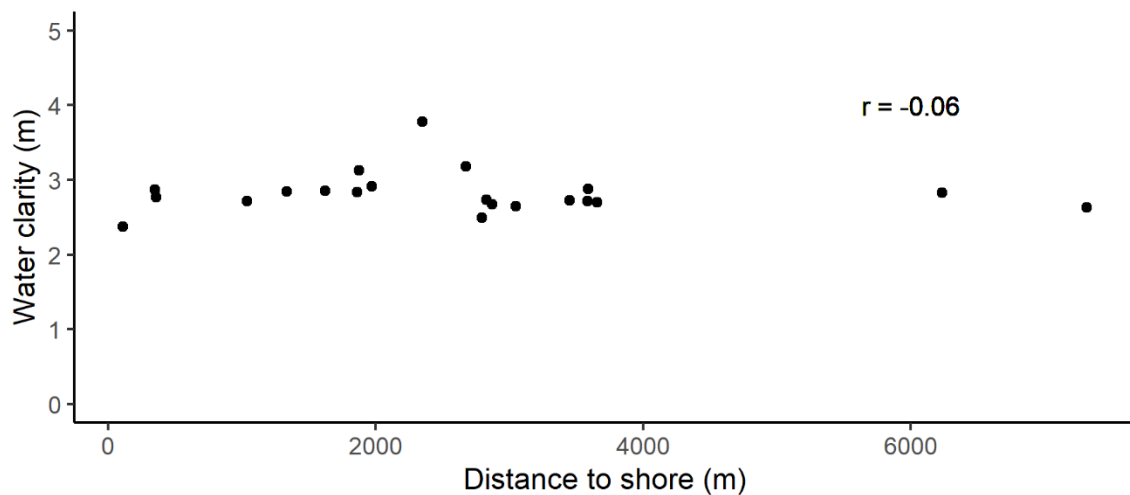
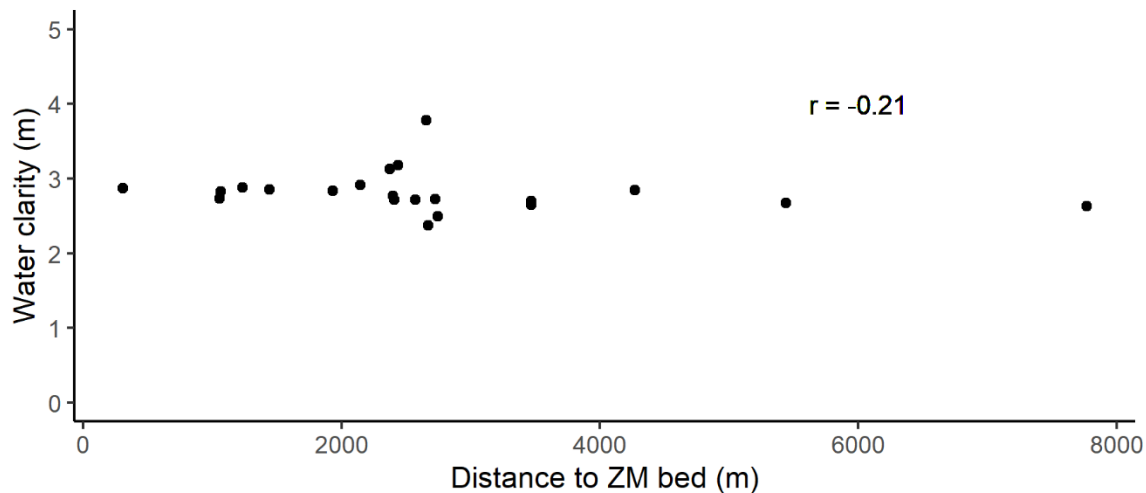
1 Supplementary Fig. 1. Partial dependence plots of individual covariates from the generalized
2 additive model of water clarity in Fig. 3. The confidence band represents the 95% C. I. The
3 invasion status categories for the AIS variable are Neither species present, ZM (*Dreissena*
4 present), and ZM & SWF (*Dreissena* and *Bythotrephes* present).



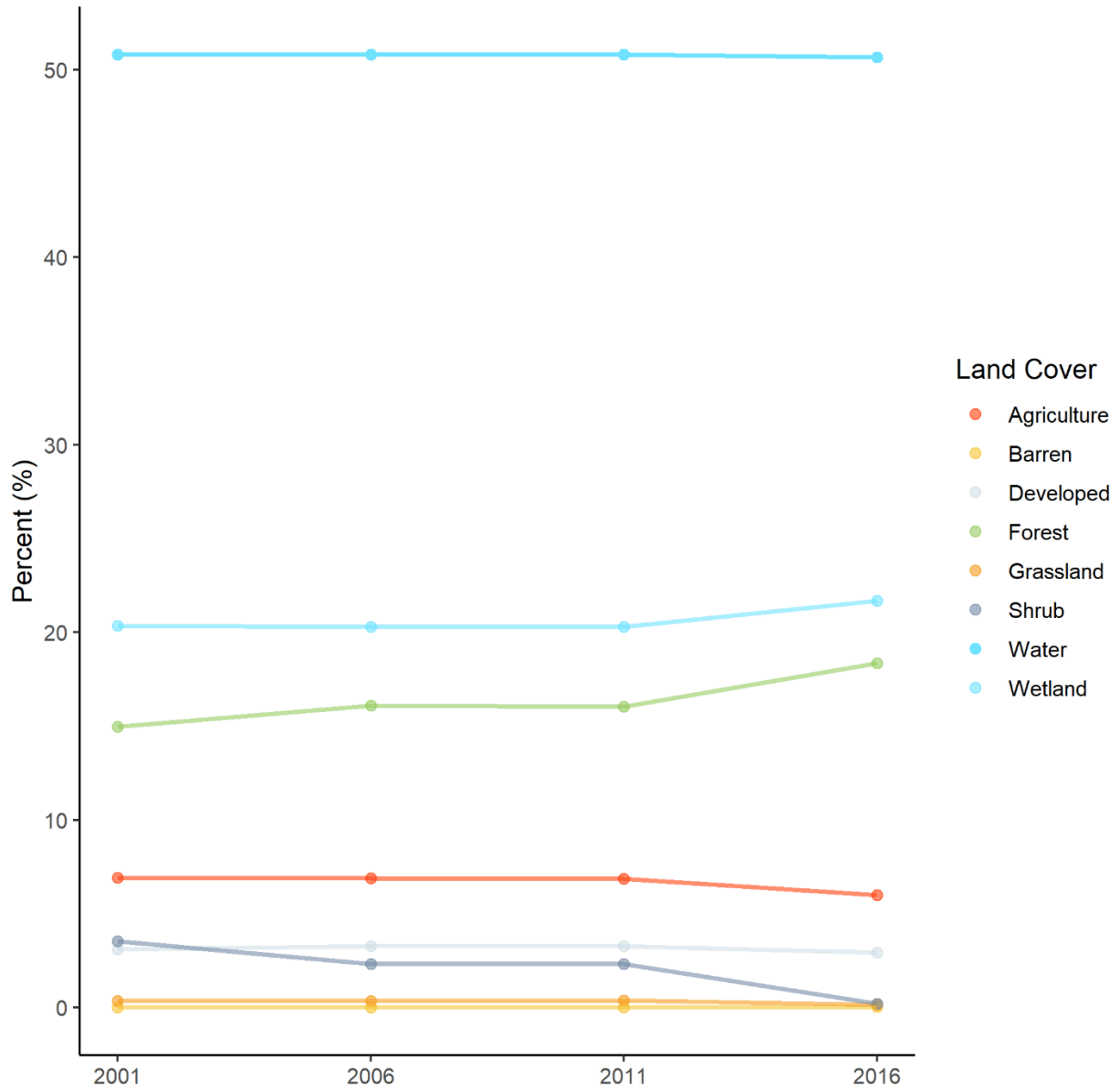
5

6

7 Supplementary Fig. 2. Plot of simulated water clarity (m) estimates at individual sampling
 8 locations versus different spatial metrics (n = 21 for each). Distance to ZM bed is the distance
 9 (m) to the nearest known *Dreissena* location based on diver surveys. Distance to shore (m) is the
 10 shortest straight-line distance between a sampling location and the shoreline.



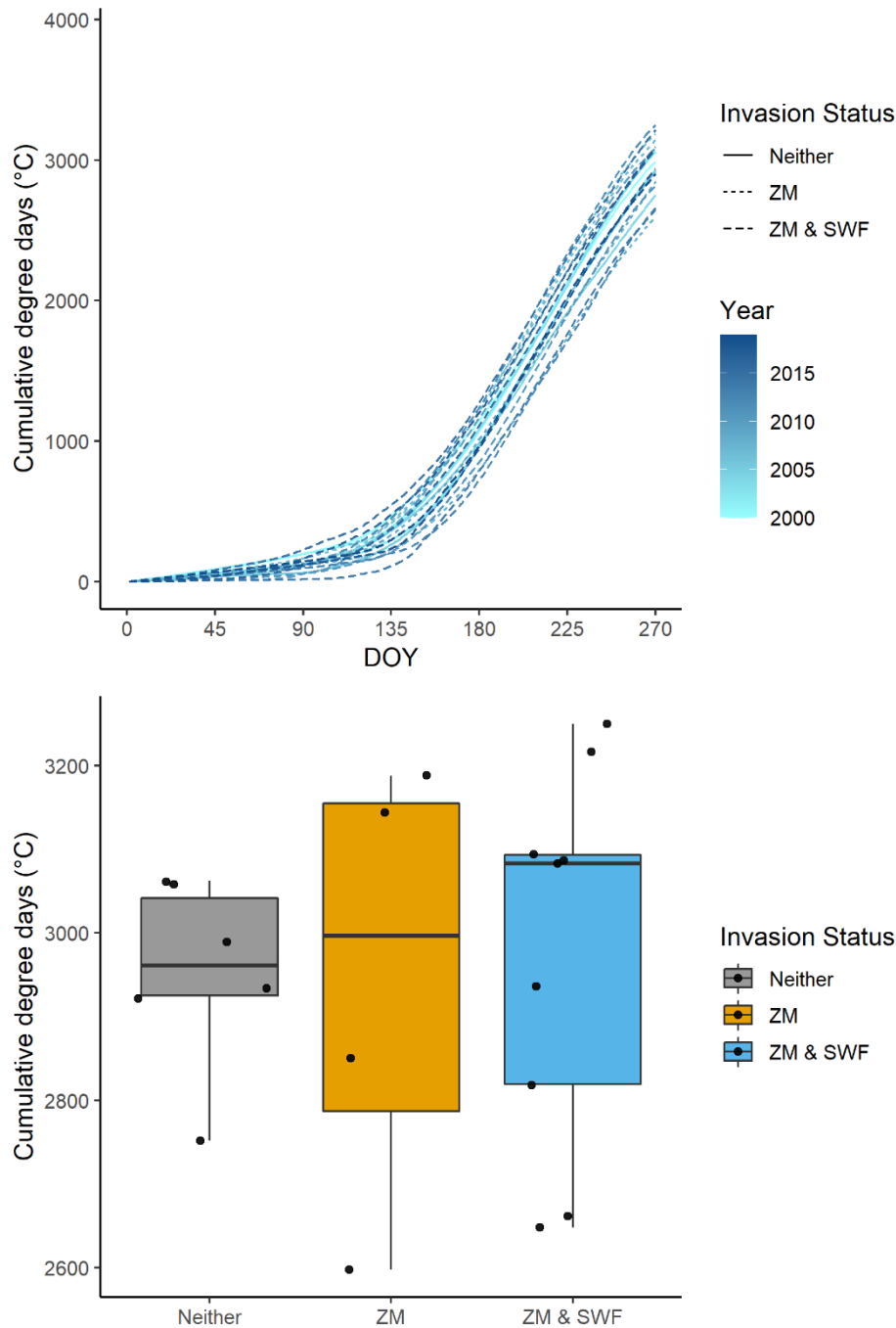
12 Supplementary Fig. 3. Land cover in the Lake Mille Lacs watershed, including the lake area, in
13 2001, 2006, 2011, and 2016, from the National Land Cover Database ⁷⁵.



14

15

16 Supplementary Fig. 4. Water temperature characteristics. Upper, plot of cumulative degree days
 17 (base 0 °C) of water temperature at 2-m depth in Lake Mille Lacs from 2000-2018. Lower, box-
 18 plot of cumulative degree days (base 0 °C) by invasion status categories. The invasion status
 19 categories are Neither species present (n = 6), ZM (*Dreissena* present, n = 4), and ZM & SWF
 20 (*Dreissena* and *Bythotrephes* present, n = 9). The center line of the box-plots are the median, the
 21 25th-75th quartile are contained within the box, whiskers are 1.5x the interquartile range, and
 22 points are cumulative degree days for individual years.



24 Supplementary Note 1

25 The following is code to reproduce the figures and supplementary figures in the manuscript using
26 the program R.

```
27 library(dplyr)
28 library(ggplot2)
29 library(wesanderson)
30 library(gridExtra)
31 library(ggpubr)
32
33 #Figure 2, heatmap
34 pal<-wes_palette("Zissou1", 25, type="continuous")
35 p2013<-ggplot(data=filter(Tmap,yr==2013), aes(Date, Depth_m, z=temp)) +
36   geom_tile(data=filter(Tmap,yr==2013), aes(fill = temp), show.legend = F, width=4)+
37   stat_contour(binwidth=2)+
38   scale_y_reverse(breaks=c(0,3,6,9))+
39   scale_fill_gradientn(colours = (pal),limits=c(4,28))+
40   scale_x_date(date_labels = "%b", date_breaks = "1 month")+
41   labs(y="Depth (m)",x="")+
42   ggtitle("2013")+
43   theme_classic()
44 p2014<-ggplot(data=filter(Tmap,yr==2014), aes(Date, Depth_m, z=temp)) +
45   geom_tile(data=filter(Tmap,yr==2014), aes(fill = temp), show.legend = F, width=4)+
46   stat_contour(binwidth=2)+
47   scale_y_reverse(breaks=c(0,3,6,9))+
48   scale_fill_gradientn(colours = (pal),limits=c(4,28))+
49   scale_x_date(date_labels = "%b", date_breaks = "1 month")+
50   labs(y="",x="")+
51   ggtitle("2014")+
52   theme_classic()
53 p2015<-ggplot(data=filter(Tmap,yr==2015), aes(Date, Depth_m, z=temp)) +
54   geom_tile(data=filter(Tmap,yr==2015), aes(fill = temp), show.legend = F, width=5)+
55   stat_contour(binwidth=2)+
56   scale_y_reverse(breaks=c(0,3,6,9))+
57   scale_fill_gradientn(colours = (pal),limits=c(4,28))+
58   scale_x_date(date_labels = "%b", date_breaks = "1 month")+
59   labs(y="",x="")+
60   ggtitle("2015")+
61   theme_classic()+
62   theme(axis.text.x=element_text(size = 9))
63 p2016<-ggplot(data=filter(Tmap,yr==2016), aes(Date, Depth_m, z=temp)) +
64   geom_tile(data=filter(Tmap,yr==2016), aes(fill = temp), show.legend = F, width=4)+
65   stat_contour(binwidth=2)+
```

```

66 scale_y_reverse(breaks=c(0,3,6,9))+
67 scale_fill_gradientn(colours = (pal),limits=c(4,28))+
68 scale_x_date(date_labels = "%b", date_breaks = "1 month")+
69 labs(y="Depth (m)",x="")+
70 ggtitle("2016")+
71 theme_classic()
72 p2017<-ggplot(data=filter(Tmap,yr==2017), aes(Date, Depth_m, z=temp)) +
73 geom_tile(data=filter(Tmap,yr==2017), aes(fill = temp), show.legend = F, width=4)+
74 stat_contour(binwidth=2)+
75 scale_y_reverse(breaks=c(0,3,6,9))+
76 scale_fill_gradientn(colours = (pal),limits=c(4,28))+
77 scale_x_date(date_labels = "%b", date_breaks = "1 month")+
78 labs(y="",x="")+
79 ggtitle("2017")+
80 theme_classic()
81 p2018<-ggplot(data=filter(Tmap,yr==2018), aes(Date, Depth_m, z=temp)) +
82 geom_tile(data=filter(Tmap,yr==2018), aes(fill = temp), show.legend = F, width=4)+
83 stat_contour(binwidth=2)+
84 scale_y_reverse()+
85 scale_fill_gradientn(colours = (pal),limits=c(4,28))+
86 scale_x_date(date_labels = "%b", date_breaks = "1 month")+
87 labs(y="",x="")+
88 ggtitle("2018")+
89 theme_classic()
90 p2019<-ggplot(data=filter(Tmap,yr==2019), aes(Date, Depth_m, z=temp)) +
91 geom_tile(data=filter(Tmap,yr==2019), aes(fill = temp), show.legend = T, width=4)+
92 stat_contour(binwidth=2)+
93 scale_y_reverse()+
94 scale_fill_gradientn(colours = (pal),limits=c(4,28), breaks=c(4,10,16,22,28))+
95 scale_x_date(date_labels = "%b", date_breaks = "1 month")+
96 labs(y="Depth (m)",x="", fill=expression("Temperature " ( degree~C)))+
97 ggtitle("2019")+
98 theme_classic()
99 legend1<-get_legend(p2019)
100 p2019<-ggplot(data=filter(Tmap,yr==2019), aes(Date, Depth_m, z=temp)) +
101 geom_tile(data=filter(Tmap,yr==2019), aes(fill = temp), show.legend = F, width=4)+
102 stat_contour(binwidth=2)+
103 scale_y_reverse()+
104 scale_fill_gradientn(colours = (pal),limits=c(4,28), breaks=c(4,10,16,22,28))+
105 scale_x_date(date_labels = "%b", date_breaks = "1 month")+
106 labs(y="Depth (m)",x="", fill=expression("Temperature " ( degree~C)))+
107 ggtitle("2019")+
108 theme_classic()

```

```

109
110 fig2<-grid.arrange(p2013, p2014,p2015, p2016, p2017,
111                   p2018,p2019,legend1,nrow=3)
112
113 #Figure 3, Generalized Additive Model
114 fig3<-ggplot(nd1, aes(DOY, exp(mod_ig_fit)))+
115   geom_line(aes(color=AIS, linetype=AIS),size=1,show.legend = FALSE)+
116   geom_ribbon(aes(ymin=exp(mod_ig_fit-se.fit),
117                 ymax=exp(mod_ig_fit+se.fit), fill=AIS), alpha=0.2, show.legend = F)+
118   theme_classic(base_size = 12)+
119   scale_color_manual(values=c("#999999", "#E69F00", "#56B4E9"))+
120   scale_fill_manual(values=c("#999999", "#E69F00", "#56B4E9"))+
121   labs(y="Clarity (m)", x="Day of Year")+
122   scale_y_continuous(limits=c(0,6), breaks =seq(0,6,by=1))+
123   scale_x_continuous(limits=c(120,270), breaks = seq(120,270,by=30))+
124   geom_text(x=133,y=4.9, label="2010-2018", size=3.5)+
125   geom_text(x=133,y=4.2, label="2000-2005", size=3.5)+
126   geom_text(x=133,y=3.0, label="2006-2009", size=3.5)
127
128 #Figure 4, multiple time series plots
129 pd <- position_dodge(width = 0.2)
130 #ZM plot
131 p1<-ggplot()+
132   geom_point(data=ZM2, aes(Year, Density), alpha=0.2, position = "jitter")+
133   geom_point(data=ZM_boot2, aes(year, median.N),size=2)+
134   theme_classic(base_size = 10)+
135   labs(title="",x="",
136        y =expression(atop(italic("D. polymorpha "),paste("(individuals " ~m^-2*"))))))+
137   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),
138                      labels=NULL)+
139   scale_y_continuous(limits=c(0,25000))+
140   geom_errorbar(data=ZM_boot2, aes(year, median.N,ymin=L.025, ymax=U.975), width=0.2)+
141   geom_line(data=ZM_boot2, aes(year, median.N), show.legend = FALSE)+
142   geom_text(data=ZM_boot2, aes(year, median.N),x=2019.5, y=15500, label="A", size=5)
143
144 #swf plot
145 p2<-ggplot(data=swf_boot)+
146   geom_point(data=swf_boot,aes(year, median.N),
147             color="black", size=2)+
148   theme_classic(base_size = 10)+
149   labs(title="",x="",
150        y =expression(atop(italic("Bythotrepes "),paste("(individuals " ~m^-3*"))))))+
151   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),

```

```

152     labels=NULL)+
153   geom_errorbar(data=swf_boot,aes(year, median.N,ymin=L.025,
154     ymax=U.975), color="black", width=0.2)+
155   geom_line(data=swf_boot,aes(year, median.N),color="black")+
156   geom_text(data=swf_boot,aes(year, median.N),x=2019.5, y=60, label="B", size=5)+
157   geom_point(data=swf, aes(Year, swf_den), alpha=0.1, position = "jitter")
158
159 #zooplankton abundance plot
160 p3<-ggplot(data=zoop_boot)+
161   geom_point(data=zoop_boot,aes(year, median.N,color=taxon,shape=taxon),
162     size=2,position = pd,show.legend = FALSE)+
163   theme_classic(base_size =10)+
164   labs(title="",x="",
165     y=expression(atop("Zooplankton", paste("(individuals ~L^-1*")))))
166   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),
167     labels=NULL)+
168   scale_y_continuous(breaks=c(0,25,50), limits=c(0,50))+
169   geom_errorbar(data=zoop_boot,aes(year, median.N,color=taxon,
170     ymin=L.025, ymax=U.975), width=0.2, position = pd,show.legend = FALSE)+
171   geom_line(data=zoop_boot,aes(year, median.N,color=taxon,linetype=taxon),
172     position = pd,show.legend = FALSE)+
173   geom_text(data=zoop_boot,aes(year, median.N),x=2013.5, y=27, label="Copepods", size=3.5,
174     color="black")+
175   geom_text(data=zoop_boot,aes(year, median.N),x=2008, y=7, label="Cladocerans", size=3.5,
176     color="black")+
177   geom_text(data=zoop_boot,aes(year, median.N),x=2019.5, y=40, label="C", size=5,
178     color="black")+
179   scale_shape_manual(values=c(16,16))+
180   scale_color_manual(values=c("#993404", "#fe9929"))+
181   scale_linetype_manual(values=c("solid", "solid"))+
182   geom_point(data=zoop1, aes(year.x, cladoN), color="#993404", alpha=0.3,
183     position="jitter")+
184   geom_point(data=zoop1, aes(year.x, copeN), color="#fe9929", alpha=0.2,
185     position="jitter")
186
187 #zoop production
188 p4<-ggplot(data=bythoP,aes(Year, X2oPdd))+
189   geom_point(size=1.5, position = pd,show.legend = FALSE)+
190   theme_classic(base_size = 10)+
191   labs(title="",x="")+
192   ylab(expression(atop("Bythotrephes P",paste("(µg ~m^-3*~dd^-1*")))))
193   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),
194     labels=NULL)+

```



```

195 scale_y_continuous(limits=c(0,55), breaks=c(0,10,20,30,40,50,60))+
196 geom_errorbar(aes(ymin=L95Cidd, ymax=U95Cidd),
197   position="dodge", width=0.1,show.legend = FALSE)+
198 geom_line(show.legend = FALSE)+
199 geom_text(x=2019.5, y=40, label="D", size=5, color="black")
200
201 p5<-ggplot(data=sum_zoopP,aes(year, Q50, color=taxon))+
202   geom_point(aes(shape=taxon),size=1.5, position = pd,show.legend = FALSE)+
203   theme_classic(base_size = 10)+
204   labs(title="",x="")+
205   ylab(expression(atop("Zooplankton P",paste("(\\u03bcg ~L^-1*~dd^-1*")))))+
206   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),
207     labels=NULL)+
208   scale_y_continuous(limits=c(0,5), breaks=c(0,1,2,3,4,5))+
209   geom_errorbar(aes(ymin=Q2.5, ymax=Q97.5, color=taxon),
210     position="dodge", width=0.25,show.legend = FALSE)+
211   geom_line(aes(color=taxon, linetype=taxon),show.legend = FALSE)+
212   scale_color_manual(values=c("#eb8055ff", "#993404", "#f9b641ff"))+
213   scale_shape_manual(values=c(16,16,16))+
214   scale_linetype_manual(values=c("solid", "solid", "solid"))+
215   geom_text(x=2009.6, y=3.75, label="Cyclopoids", size=3, color="black")+
216   geom_text(x=2005.8, y=4, label="Clado-", size=3, color="black")+
217   geom_text(x=2005.8, y=3, label="cerans", size=3, color="black")+
218   geom_text(x=2012.6, y=3, label="Calanoids", size=3, color="black")+
219   geom_text(x=2019.5, y=4, label="E", size=5, color="black")
220
221 #clarity and chlorophyll
222 p6<-ggplot(clarity)+
223   geom_point(data=clarity, aes(year, median.N,color=parameter, shape=parameter),
224     size=2, show.legend = FALSE, position=pd)+
225   theme_classic(base_size = 10)+
226   labs(title="",x="", y = (expression(atop("Chlorophyll-a",
227     paste("(\\u03bcg ~L^-1*")))))+
228   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),
229     labels=NULL)+
230   geom_errorbar(data=clarity,aes(year, median.N,ymin=(L.025),
231     ymax=(U.975),color=parameter),
232     width=0.2, show.legend = FALSE, position=pd)+
233   geom_line(data=clarity,aes(year, median.N,color=parameter),
234     show.legend = FALSE, position=pd)+
235   scale_y_continuous(limits=c(0,25),sec.axis = sec_axis(~./4, name = "Clarity (m)"))+
236   scale_color_manual(values = c("#a1dab4", "#225ea8"))+
237   scale_shape_manual(values=c(16,16,16))+

```

```

238 geom_text(data=clarity,aes(year, median.N),x=2012, y=20, label="Clarity", size=3.5)+
239 geom_text(data=clarity,aes(year, median.N),x=2015.5, y=5, label="Chl-a", size=3.5)+
240 geom_text(data=clarity,aes(year, median.N),x=2019.5, y=15, label="F",
241       size=5, color="black")+
242 geom_point(data=secchi, aes(year, 4*d_secchi), color="#225ea8", alpha=0.1,
243       position = "jitter")+
244 geom_point(data=chloro2.1.1, aes(year, result), color="#a1dab4", alpha=0.1,
245       position = "jitter")
246
247 #filter rates plot
248 p7<-ggplot(data=all.filter)+
249   geom_point(aes(year, FzooPKm),color="#a8ddb5",size=2)+
250   geom_line(aes(year, FzooPKm),color="#a8ddb5")+
251   geom_point(aes(year, ZM_KM),color="#4eb3d3", size=2)+
252   geom_line(aes(year, ZM_KM),color="#4eb3d3")+
253   geom_point(aes(year, total_KM),color="#08589e", size=2)+
254   geom_line(aes(year, total_KM), linetype="dashed",color="#08589e")+
255   geom_errorbar(aes(year,
256 FzooPKm,ymin=(FzooPKM_L95),ymax=(FzooPKM_U95)),color="#a8ddb5",
257       width=0.2, show.legend = FALSE, position=pd)+
258   geom_errorbar(aes(year, ZM_KM,ymin=(L95CI.x),ymax=(U95CI.x)),color="#4eb3d3",
259       width=0.2, show.legend = FALSE, position=pd)+
260   geom_errorbar(aes(year, total_KM,ymin=(total_L95),ymax=(total_U95)),color="#08589e",
261       width=0.2, show.legend = FALSE, position=pd)+
262   theme_classic(base_size = 10)+
263   labs(title="",x="", y = "Filtering Rate ("~km^3*~d^-1*~)")+
264   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020),labels =
265 NULL)+
266   geom_text(x=2007, y=0.5, label="Zebra Mussels", size=3.5)+
267   geom_text(x=2015.5, y=0.5, label="Zooplankton", size=3.5)+
268   geom_text(x=2015, y=2, label="Total", size=3.5)+
269   geom_text(x=2019.5, y=2, label="G", size=5, color="black")
270
271 #TP plot
272 p8<-ggplot(data=TP2,aes(year, TP_yr))+
273   geom_point(data=TP2,aes(year, TP_yr),size=1.5, position = pd)+
274   theme_classic(base_size = 10)+
275   labs(title="",x="")+
276   ylab(expression(atop("Total P (mg ~L^-1*~)")))+
277   scale_x_continuous(breaks = c(2005,2010, 2015,2020),
278       limits = c(2005, 2020), labels = NULL)+
279   scale_y_continuous(limits=c(0,0.08), breaks=c(0,.02,.04,.06,.08))+
280   geom_errorbar(data=TP2,aes(year, TP_yr,ymin=TP_yr-TP_se, ymax=TP_yr+TP_se),

```

```

281     position="dodge", width=0.1,show.legend = FALSE)+
282 geom_line(data=TP2,aes(year, TP_yr),show.legend = FALSE)+
283 geom_text(data=TP2,aes(year, TP_yr),x=2019.5, y=0.06, label="H",
284     size=5, color="black")+
285 geom_point(data=TP1, aes(year, Result), alpha=0.1,position = "jitter")
286
287
288 #fish
289 p9<-ggplot()+
290   geom_point(data=filter(fish1, species=="YEP"), aes(year, CPU,shape=location),
291     alpha=0.2,color="#edae49",show.legend = FALSE,position = "jitter")+
292   geom_point(data=filter(fish2, species=="YEP"),aes(year, cpue,
293     shape=location),size=2,
294     color="#edae49",show.legend = FALSE)+
295   geom_line(data=filter(fish2, species=="YEP"),aes(year, cpue,
296     linetype=location),color="#edae49",
297     show.legend = FALSE)+
298   theme_classic(base_size = 10)+
299   labs(title="",x="", y = "Yellow Perch (CPU)")+
300   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020),
301     limits = c(2005, 2020),labels=NULL)+
302   scale_y_continuous(limits=c(0, 100))+
303   geom_errorbar(data=filter(fish2, species=="YEP"),aes(year, cpue,
304     ymin=(cpue-se),ymax=(cpue+se)),color="#edae49",
305     width=0.2, show.legend = FALSE, position=pd)+
306   geom_text(data=filter(fish2, species=="YEP"),aes(year, cpue),x=2019.5, y=80,
307     label="I", size=5, color="black")+
308   scale_linetype_manual(values=c("solid","dashed"))
309
310 p10<-ggplot()+
311   geom_point(data=filter(fish1, species=="TLC"), aes(year, CPU,shape=location),
312     alpha=0.2,color="#00798c",show.legend = FALSE,position = "jitter")+
313   geom_point(data=filter(fish2, species=="TLC"),aes(year, cpue,shape=location),
314     size=2,color="#00798c",show.legend = FALSE)+
315   geom_line(data=filter(fish2, species=="TLC"),aes(year, cpue, linetype=location),
316     show.legend = FALSE, color="#00798c")+
317   theme_classic(base_size = 10)+
318   labs(title="",x="", y = "Cisco (CPU)")+
319   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020),
320     limits = c(2005, 2020))+
321   scale_y_continuous(limits=c(0, 125))+
322   geom_errorbar(data=filter(fish2, species=="TLC"),
323     aes(year, cpue, ymin=(cpue-se),ymax=(cpue+se)),

```

```

324         width=0.2, show.legend = FALSE, position=pd,color="#00798c")+
325 geom_text(data=filter(fish2, species=="TLC"),aes(year, cpue),
326           x=2019.5, y=100, label="J", size=5, color="black")+
327 scale_linetype_manual(values=c("solid","dashed"))
328
329 #zoop size
330 p11<-ggplot()+
331   geom_point(data=size_yr2, aes(year, length_microns),
332             alpha=0.1,shape=1,color="goldenrod", position="jitter")+
333   geom_point(data=size_yr,aes(x=year, y=year_L), color="goldenrod4")+
334   geom_line(data=size_yr,aes(x=year, y=year_L), color="goldenrod4")+
335   geom_errorbar(data=size_yr,aes(x=year, y=year_L,ymin=year_L-year_se,
336                                ymax=year_L+year_se),
337                width=0.2, position = pd,show.legend = FALSE, color="goldenrod4")+
338   theme_classic(base_size=10)+
339   labs(title="",x="",
340        y=expression(atop("Zooplankton Length", paste("(µm)"))))+
341   scale_x_continuous(breaks = c(2005, 2010, 2015, 2020), limits = c(2005, 2020))+
342   geom_text(data=size_yr, aes(x=year, y=year_L),x=2019.5, y=3000, label="K",
343            size=5, color="black")
344
345 #combine all plots
346 fig4 <-ggarrange(p1, p2,p3, p4, p6, p7,
347                 p8, p9, p10, p11,
348                 ncol=2,nrow=6,align = "v")
349
350 #Figure 5, Predator-prey plots
351 p12<-ggplot(zoop_d,aes(swf_d,clado_d))+
352   geom_point(color='#993404')+
353   theme_classic()+
354   labs(x=expression(~italic(Bythotrephes)~" (individuals " ~m^-3*")),
355        y="Cladocerans (individuals " ~L^-1*"))
356 p13<-ggplot(zoop_d,aes(swf_d,cala_d))+
357   geom_point(color="#eb8055ff")+
358   theme_classic()+
359   labs(x=expression(~italic(Bythotrephes)~" (individuals " ~m^-3*")),
360        y="Calanoids (individuals " ~L^-1*"))
361 p14<-ggplot(zoop_d,aes(swf_d,cyclo_d))+
362   geom_point(color="#f9b641ff")+
363   theme_classic()+
364   labs(x=expression(~italic(Bythotrephes)~" (individuals " ~m^-3*")),
365        y="Cyclopoids (individuals " ~L^-1*"))
366 p15<-ggplot(zoop_fish)+

```

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367 geom_point(aes(YEP_nearshore,clado_y),color='#993404',shape=16)+
368 geom_point(aes(YEP_offshore,clado_y),color='#993404',shape=1)+
369 theme_classic()+
370 labs(x="Yellow Perch (CPU)",
371       y="Cladocerans (individuals " ~L^-1*")")
372 p16<-ggplot(zoop_fish)+
373 geom_point(aes(YEP_nearshore,cala_y),color="#eb8055ff",shape=16)+
374 geom_point(aes(YEP_offshore,cala_y),color="#eb8055ff",shape=1)+
375 theme_classic()+
376 labs(x="Yellow Perch (CPU)",
377       y="Calanoids (individuals " ~L^-1*")")
378 p17<-ggplot(zoop_fish)+
379 geom_point(aes(YEP_nearshore,cyclo_y),color='#f9b641ff',shape=16)+
380 geom_point(aes(YEP_offshore,cyclo_y),color='#f9b641ff',shape=1)+
381 theme_classic()+
382 labs(x="Yellow Perch (CPU)",
383       y="Cyclopoids (individuals " ~L^-1*")")
384 p18<-ggplot(zoop_fish)+
385 geom_point(aes(TLC_nearshore,clado_y),color='#993404',shape=16)+
386 geom_point(aes(TLC_offshore,clado_y),color='#993404',shape=1)+
387 theme_classic()+
388 labs(x="Cisco (CPU)",
389       y="Cladocerans (individuals " ~L^-1*")")
390 p19<-ggplot(zoop_fish)+
391 geom_point(aes(TLC_nearshore,cala_y),color="#eb8055ff",shape=16)+
392 geom_point(aes(TLC_offshore,cala_y),color="#eb8055ff",shape=1)+
393 theme_classic()+
394 labs(x="Cisco (CPU)",
395       y="Calanoids (individuals " ~L^-1*")")
396 p20<-ggplot(zoop_fish)+
397 geom_point(aes(TLC_nearshore,cyclo_y),color='#f9b641ff',shape=16)+
398 geom_point(aes(TLC_offshore,cyclo_y),color='#f9b641ff',shape=1)+
399 theme_classic()+
400 labs(x="Cisco (CPU)",
401       y="Cyclopoids (individuals " ~L^-1*")")
402
403 fig5<-ggarrange(p12, p13,p14,p15,p16,p17,p18,p19,p20,
404                ncol=3,nrow=3,align = "v")
405
406 #Figure 6, pre- and post-invasion characteristics
407 fig6<-ggplot(change.df2,aes(taxon,median.N, fill=group1))+
408 geom_bar(stat="identity",color="black",position=position_dodge()+
409 geom_errorbar(aes(ymin=(L.025),ymax=(U.975)),

```

```

410     width=0.2, show.legend = FALSE, position=position_dodge(0.9))+
411 theme_classic(base_size = 15)+
412 labs(y="", x="", fill="")+
413 scale_x_discrete(labels=c("Clarity"="Clarity (m)",
414     "Chlorophyll-a"="Chlorophyll-a (\u03BCg ~L^-1*)",
415     "Total Filtering"=expression("Total Filtering (*km^3~d^-1*)"),
416     "Copepod"="Copepods (individuals ~L^-1*)",
417     "Cladoceran"="Cladocerans (individuals ~L^-1*)",
418     "Bythotrephes"=expression(paste(italic(Bythotrephes), " (individuals" ~m^-
419 3*"))),
420     "Dreissenax1000"=expression(paste(italic(D.~polymorpha),"
421 1000x(individuals" ~m^-2*")))))+
422 coord_flip()+
423 scale_fill_manual(values = c("#FFD662FF","#00539CFF"), labels=c("2011-2018","2006-
424 2010"))+
425 guides(fill=guide_legend(reverse=TRUE))+
426 theme(legend.position = c(.8,.2),legend.text=element_text(size=15),
427     legend.key.height =unit(1,'cm'),legend.key.width= unit(1,'cm'))+
428 annotate(geom="text", x=6, y=20, label="**", size=10)+
429 annotate(geom="text", x=7, y=20, label="**", size=10)+
430 annotate(geom="text", x=4.9, y=30, label="**", size=10)+
431 annotate(geom="text", x=3.9, y=40, label="**", size=10)
432
433 #Supplementary Figure 1, GAM individual smooths
434 p21<-ggplot(doy_ais, aes(DOY,est))+
435 geom_line(aes(color=as.factor(AIS)),show.legend = FALSE)+
436 theme_classic()+
437 theme(legend.position = "none")+
438 scale_color_manual(values=c("#999999","#E69F00","#56B4E9"))+
439 geom_text(x=180,y=0.15, label="ZM & SWF", size=3.5, color="black")+
440 geom_text(x=140,y=0.06, label="Neither", size=3.5, color="black")+
441 geom_text(x=140,y=-0.17, label="ZM", size=3.5, color="black")+
442 labs(title="s(DOY,AIS)",subtitle = ~italic("p <0.001"),
443     x="DOY", y="Partial effect")
444 p22<-ggplot(doy, aes(DOY,est))+
445 geom_ribbon(aes(ymin=est-se,ymax=est+se), fill="lightgray")+
446 geom_line(color="black")+
447 theme_classic()+
448 labs(title="s(DOY)",subtitle = ~italic("p <0.01"),
449     x="DOY", y="Partial effect")
450 p23<-ggplot(fyear, aes(sample=est))+
451 stat_qq()+
452 stat_qq_line()+

```

```

453   theme_classic()+
454   labs(title="s(year)", subtitle = ~italic("p <0.001"),
455         x="Gaussian quantiles", y="Partial effects")
456   p24<-ggplot(station, aes(sample=est))+
457     stat_qq()+
458     stat_qq_line()+
459     theme_classic()+
460     labs(title="s(station)", subtitle = ~italic("p <0.001"),
461           x="Gaussian quantiles", y="Partial effects")
462   p25<-ggplot(ais, aes(as.factor(value),partial))+
463     geom_point()+
464     geom_errorbar(aes(ymin=partial-(2*se),ymax=partial+(2*se)),width=0)+
465     theme_classic()+
466     scale_x_discrete(labels=c("Neither", "ZM", "ZM & SWF"))+
467     labs(x="", title="AIS", subtitle = ~italic("p >0.05"), y="Partial effect of AIS")
468
469   figSI1<-ggarrange(p21,p22,p23,p24,p25,ncol=3,nrow=2)
470
471   #Supplementary Figure 2, Spatial patterns in water clarity
472   p26<-ggplot(nd2, aes(dist_ZM,fit))+
473     geom_point()+
474     theme_classic()+
475     scale_y_continuous(limits=c(0,5))+
476     labs(x="Distance to ZM bed (m)", y="Water clarity (m)")+
477     geom_text(x=6000,y=4, label="r = -0.21", size=3.5, color="black")
478   p27<-ggplot(nd2, aes(dist_shore,fit))+
479     geom_point()+
480     theme_classic()+
481     scale_y_continuous(limits=c(0,5))+
482     labs(x="Distance to shore (m)", y="Water clarity (m)")+
483     geom_text(x=6000,y=4, label="r = -0.06", size=3.5, color="black")
484   p28<-ggplot(nd2, aes(-depth,fit))+
485     geom_point()+
486     theme_classic()+
487     scale_y_continuous(limits=c(0,5),)+
488     scale_x_continuous(limits=c(0,12.5))+
489     labs(x="Water depth (m)", y="Water clarity (m)")+
490     geom_text(x=8,y=4, label="r = -0.29", size=3.5, color="black")
491
492   figSI2<-ggarrange(p26, p27,p28,
493                     ncol=1,nrow=3,align = "v")
494
495   #Supplementary Figure 3, Land cover trends

```

```

496 figSI3<-ggplot(land, aes(year,per))+
497   geom_point(aes(color=landuse), size=2)+
498   geom_line(aes(color=landuse),show.legend = F,size=1)+
499   theme_classic(base_size = 12)+
500   scale_x_continuous(limits=c(2001,2016), breaks=c(2001,2006,2011,2016))+
501   labs(x="", y="Percent (%)", color="Land Cover")+
502   scale_color_manual(values=c("#FF410D99", "#F7C53099",
503     "#D0DFE699", "#95CC5E99", "#F79D1E99", "#748AA699", "#6EE2FFFF", "#6EE2FF99"))
504
505 # Supplementary Figure 4, Water temperature characteristics
506 dd1<-ggplot(temp, aes(DOY, dd.cum, group=Year))+
507   geom_line(aes(color = Year, linetype=ais))+
508   theme_classic(base_size = 12)+
509   scale_x_continuous(limits=c(0,270), breaks=c(0,45,90,135,180,225,270))+
510   labs(y="Cumulative degree days (\u00b0C)")+
511   scale_color_gradient(low = 'darkslategray1', high = 'dodgerblue4')+
512   labs(linetype="Invasion Status")
513
514 #look at cumulative dd on day 270
515 temp2<-temp%>%filter(DOY==270&Year<2019)
516 dd2<-ggplot(temp2, aes(ais, dd.cum, fill=ais))+
517   geom_boxplot()+
518   geom_jitter(color="black", size=1.5, alpha=0.9)+
519   theme_classic(base_size = 12)+
520   scale_fill_manual(values=c("#999999", "#E69F00", "#56B4E9"))+
521   labs(fill="Invasion Status", y="Cumulative degree days (\u00b0C)",x="")
522
523 FigSI4<-ggarrange(dd1,dd2,nrow = 2,ncol = 1)

```