Examples for 'A framework for styding cyclones'

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Overview

Here, we use data for three examples that illustrate the implementation of the reserach framework.

1. We compare response of stream biogeochemistry (NO3 and K) from two tropical headwater streams that differ in cyclone frequency. The watershed in Fushan experiences a damaging cyclone (cat. 4 or greater) very frequenly (approximately annualy), and the watershed in Luquillo experiences them occasionally (approximately decadaly)
2. We compare the GPP responses of three coastal marshes (Texas, New Jersey and Lousiana), where cyclone timing was a major infleuncing factor.
3. We look at fish abundance data from four estuaries in Texas that expereinced differing storm strenght (rainfall total and windspeeds) during Hurricane Harvey in 2017.

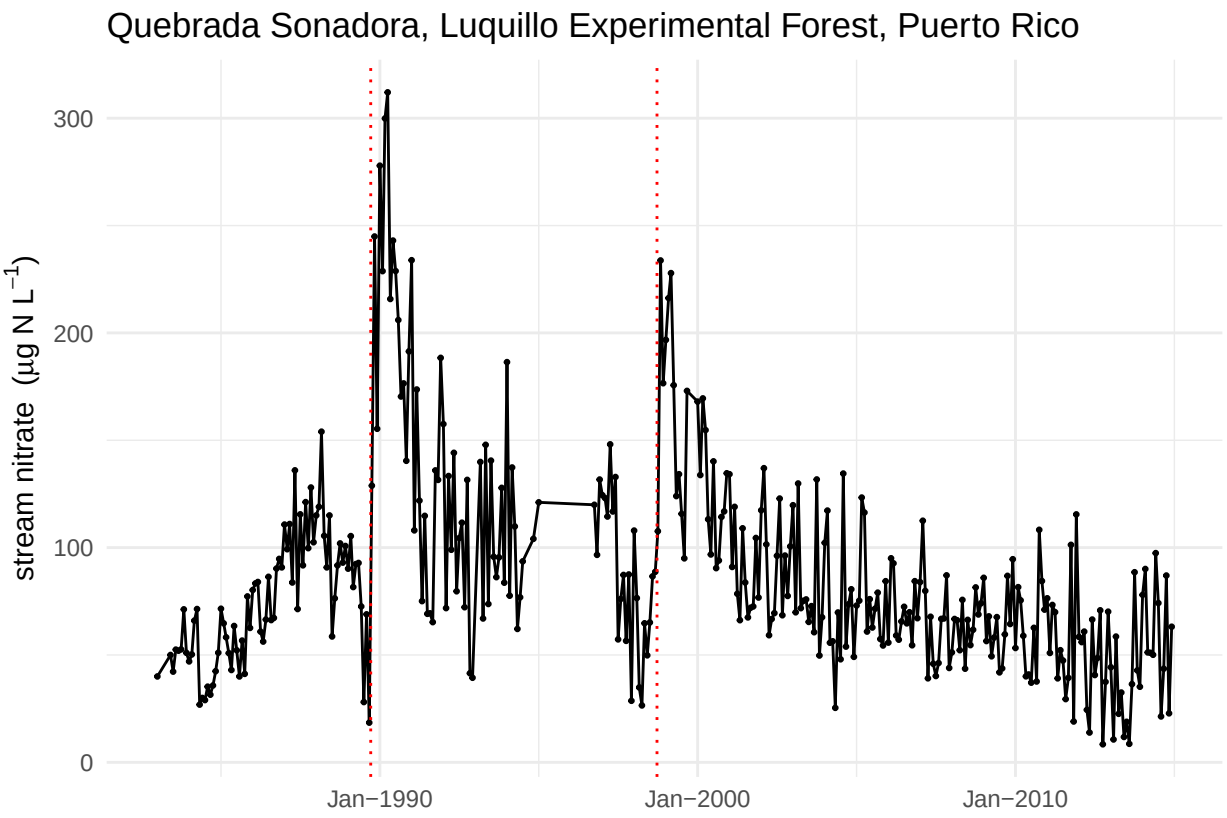
```
### read in the data
library(readr)

########## LUQUILLO
LUQ_K <- read_csv("C:/Users/hogie/Dropbox (Personal)/LUQ LITTERFALL for Hurricane Workshop 4.2019/CONCE
col_types = cols(Month_Yr = col_date(format = "%b-%y")))

LUQ_NO3 <- read_csv("C:/Users/hogie/Dropbox (Personal)/LUQ LITTERFALL for Hurricane Workshop 4.2019/CON
col_types = cols(Month_Yr = col_date(format = "%b-%y")))

########## FUSHAN
FUS_K <- read_csv("C:/Users/hogie/Dropbox (Personal)/LUQ LITTERFALL for Hurricane Workshop 4.2019/CONCE

FUS_NO3 <- read_csv("C:/Users/hogie/Dropbox (Personal)/LUQ LITTERFALL for Hurricane Workshop 4.2019/CON
```

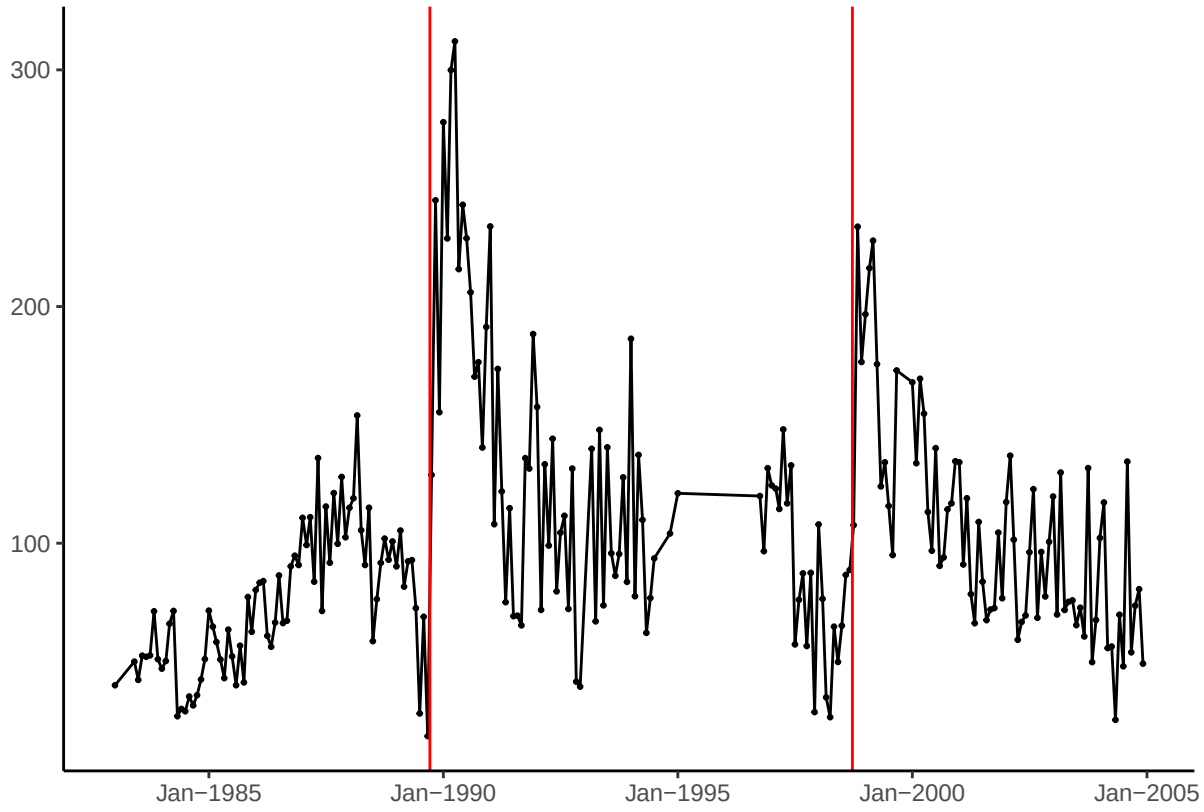
Stream Nitrate

LUQ

NO3 - N

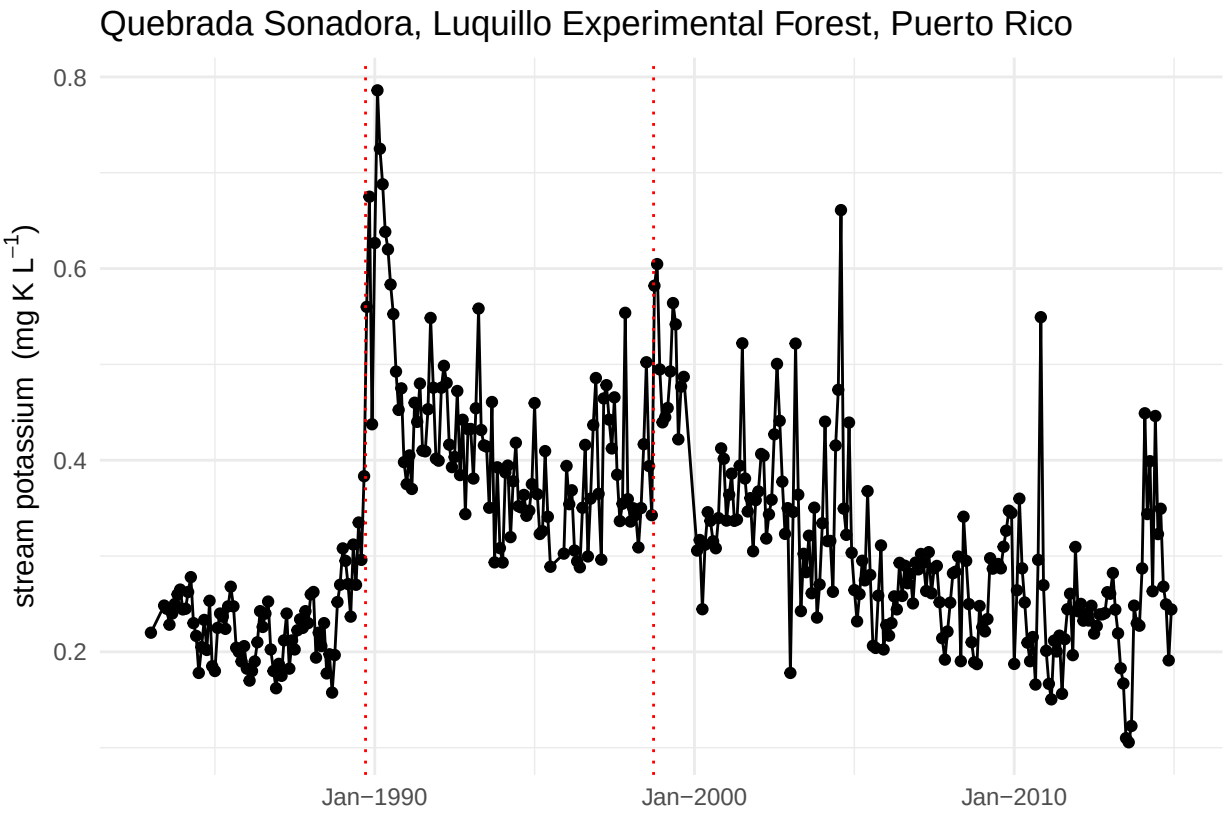
```
## Warning: package 'ggplot2' was built under R version 3.6.1
```


Quebrada Sonadora, Luquillo Experimental Forest, Puerto Rico
stream nitrate (µg N L^{-1})
300
200
100
0
Jan−1990
Jan−2000
Jan−2010



K

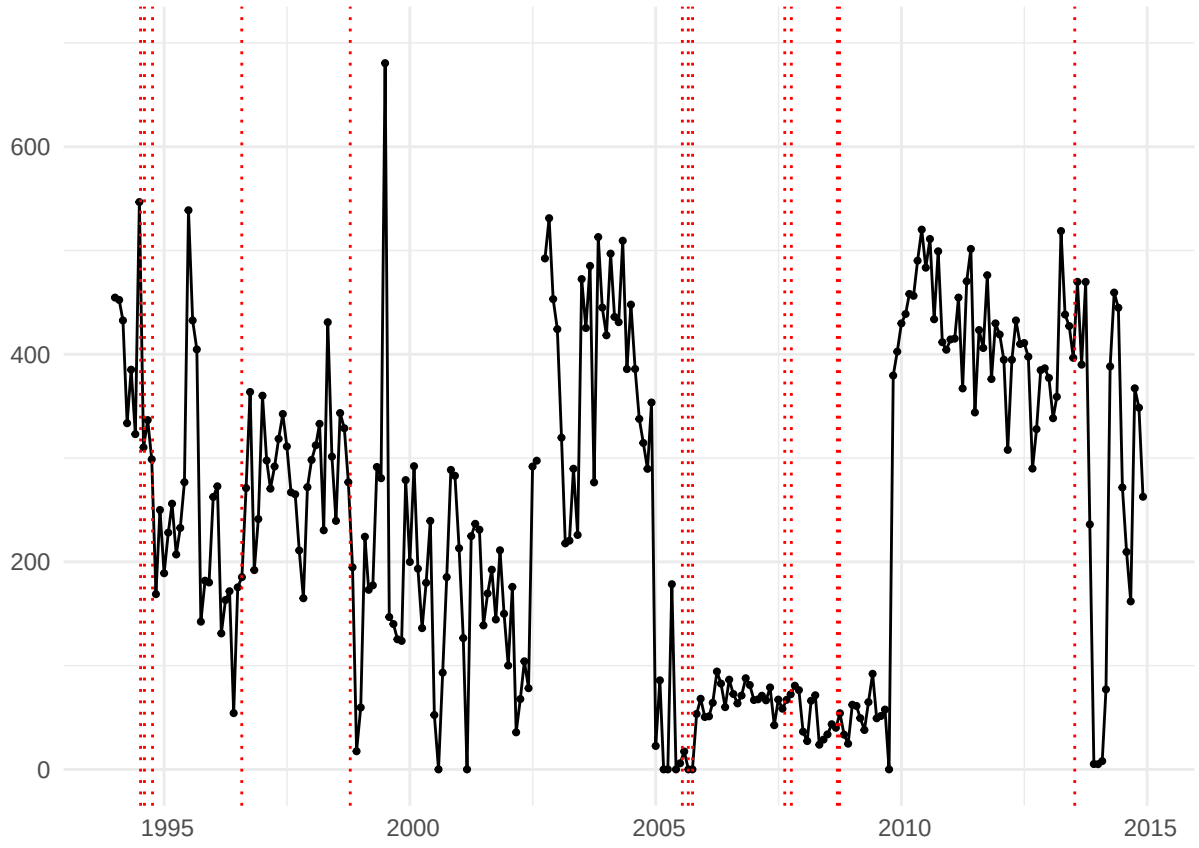
```
g_LUQ_K <- ggplot(aes(Month_Yr, `K (mg/L)`), data = LUQ_K) + geom_line() + geom_point() +
                scale_x_date(date_labels = "%b-%Y") + xlab("") +
                ylab(expression("stream potassium"*"  (mg K L"^-1* ")")) + theme_minimal() +
geom_vline(xintercept = as.Date("09-18-1989", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-21-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + g

g_LUQ_K
```



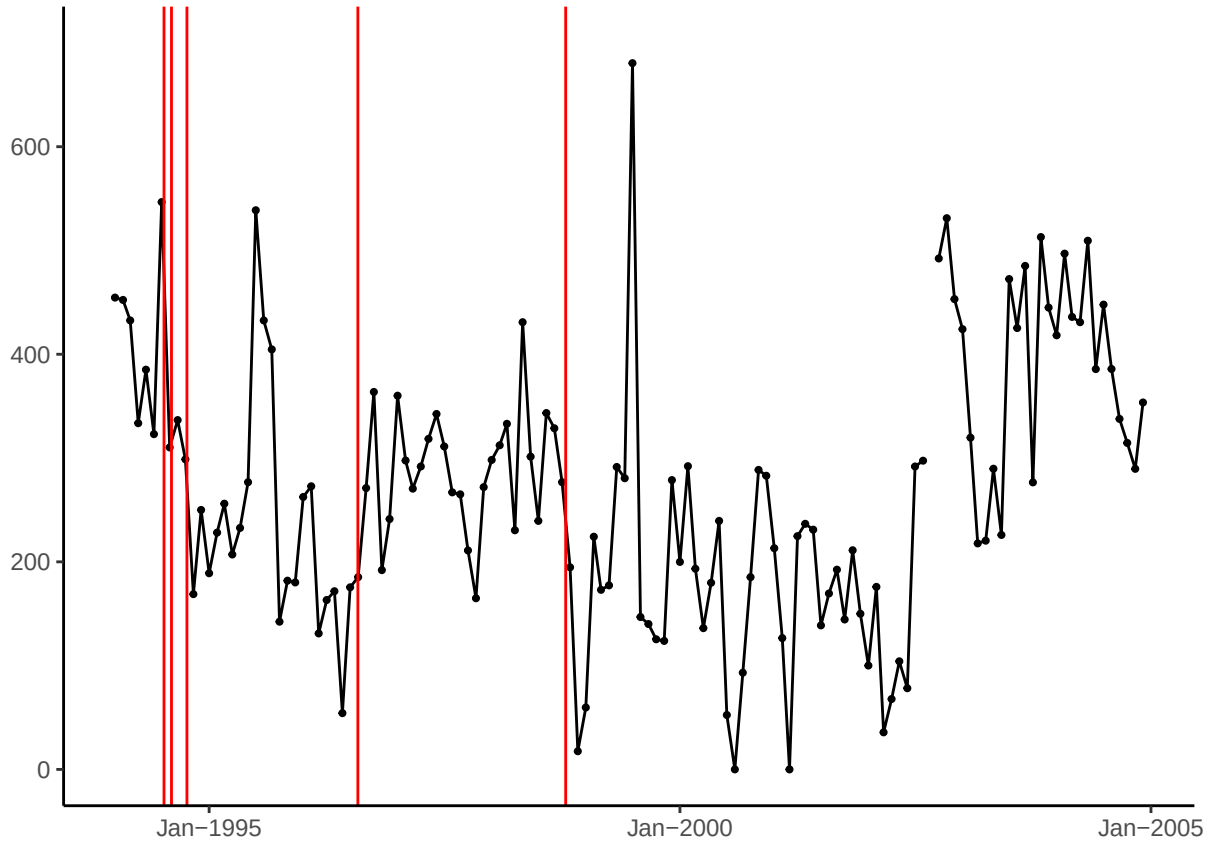
FUSHAN

NO3 - N

```
## Warning: Removed 1 rows containing missing values (geom_point).
```



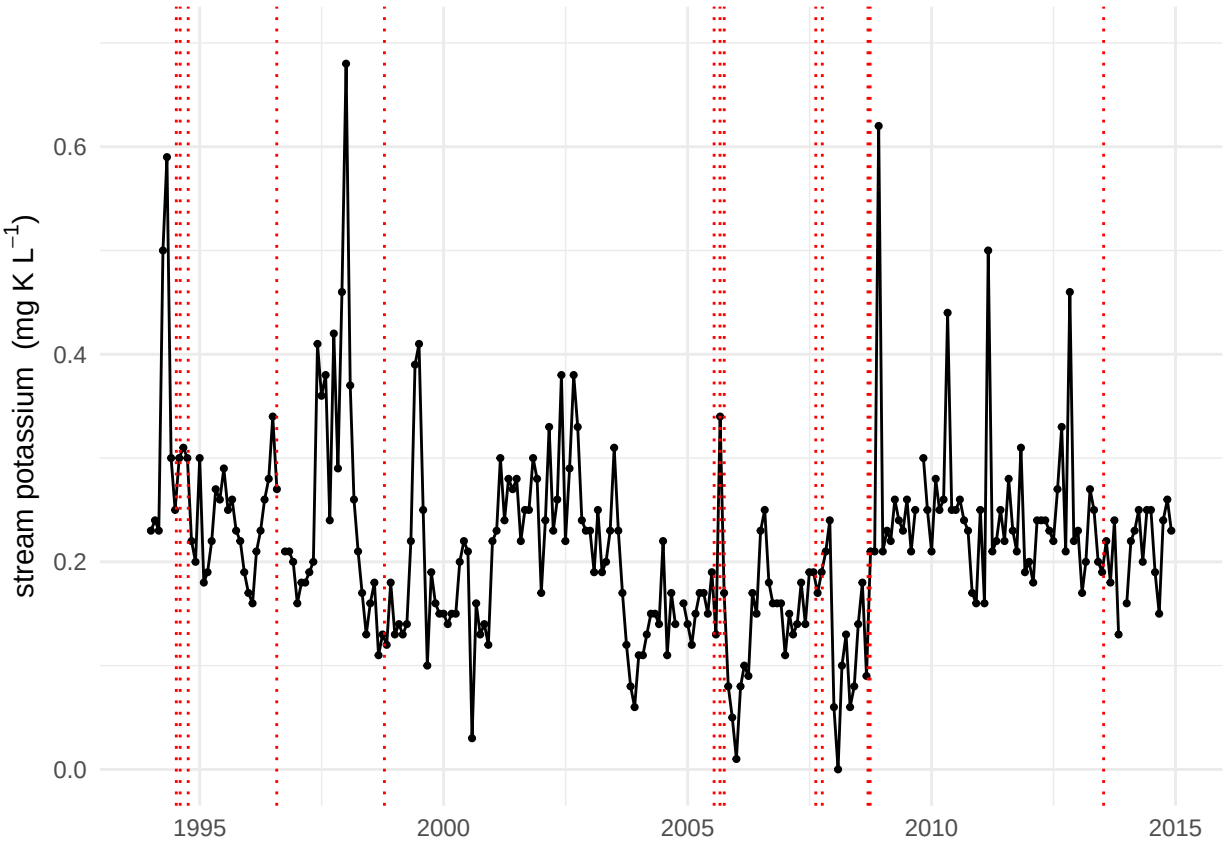

```
## Warning: Removed 1 rows containing missing values (geom_point).
```



K

```
g_FUS_K <- ggplot(aes(date, `K (mg/L)`), data = FUS_K) + geom_line() + geom_point(size = 0.75) +
                scale_x_date(date_labels = "%Y") + xlab("") +
                ylab(expression("stream potassium"*"  (mg K L"^-1* ")")) + theme_minimal() +
geom_vline(xintercept = as.Date("07-10-1994", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("08-08-1994", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("10-07-1994", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("07-31-1996", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("10-15-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("07-18-2005", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("08-31-2005", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("10-02-2005", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("08-18-2007", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("10-06-2007", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-12-2008", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-28-2008", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("07-12-2013", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + y

g_FUS_K
```

```
## Warning: Removed 4 rows containing missing values (geom_point).
```




```
## ALL TOGETHER
### need to subset LUQ data
g_LUQ_NO3_short <- ggplot(aes(Month_Yr, `NO3 (ugN/L)`), data = LUQ_NO3[127:351,]) + geom_line() +
                  geom_point(size = 0.75) +
                  scale_x_date(date_labels = "%Y") + xlab("") +
                  ylab("") + theme_minimal() +
geom_vline(xintercept = as.Date("09-18-1989", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-21-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + y


g_LUQ_K_short <- ggplot(aes(Month_Yr, `K (mg/L)`), data = LUQ_K[129:372,]) + geom_line() +
                  geom_point(size = 0.75) +
                  scale_x_date(date_labels = "%Y") + xlab("") +
                  ylab("") + theme_minimal() +
geom_vline(xintercept = as.Date("09-18-1989", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-21-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + y
```

```
####
library(ggpubr)
```

```
## Warning: package 'ggpubr' was built under R version 3.6.1
```

```
## Loading required package: magrittr
```

```
tiff()

double_K <- ggarrange(g_LUQ_K_short, g_FUS_K + ylab(""), nrow = 2, labels = "AUTO")
```

```
## Warning: Removed 4 rows containing missing values (geom_point).
```

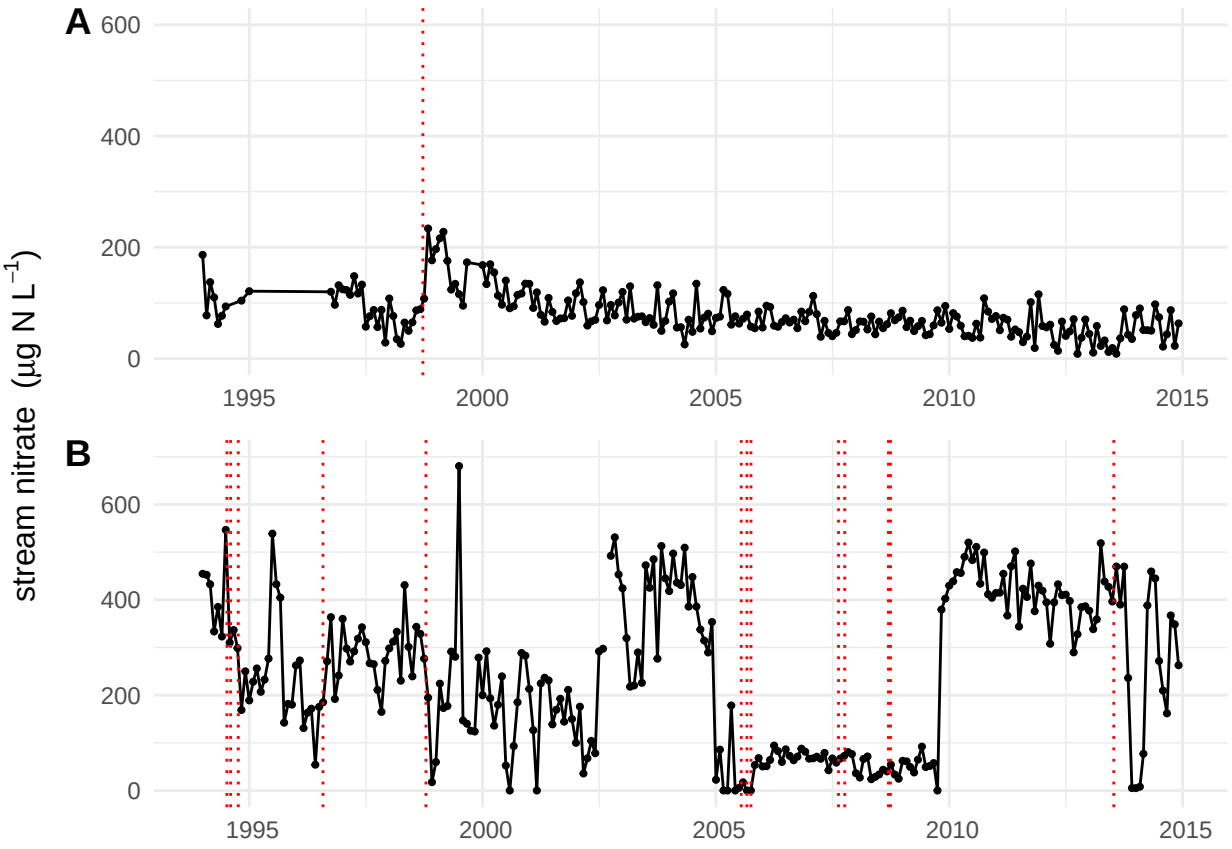
```
double_K <- annotate_figure(double_K, left = text_grob(expression("stream potassium"*"  (mg K L"^-1* ")

double_K


tiff(filename = "Streams_potassium.tiff", width = 18.5, height = 5.745, units = "cm",res = 600, compress
double_K
dev.off()
```

```
## pdf
##   2
```

```
#### ggarrange
double_NO3 <- ggarrange(g_LUQ_NO3_short, g_FUS_NO3, nrow = 2, labels = "AUTO")
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```

```
double_NO3 <- annotate_figure(double_NO3, left = text_grob(expression("stream nitrate"*"  ("* mu*"g N L

double_NO3
```




```
tiff(filename = "Streams_nitrate.tiff", width = 18.5, height = 5.745, units = "cm",res = 600, compressi
double_NO3
dev.off()
```

```
## pdf
##   2
```

```
##############################
## After Bill McDowells email:
### 1) Plot only through 2004 (i.e. to 2015)

## ALL TOGETHER
### need to subset LUQ data
g_LUQ_NO3_short <- ggplot(aes(Month_Yr, `NO3 (ugN/L)`), data = LUQ_NO3[127:351,]) + geom_line() +
                  geom_point(size = 0.75) +
                  scale_x_date(date_labels = "%Y") + xlab("") +
                  ylab("") + theme_minimal() +
geom_vline(xintercept = as.Date("09-18-1989", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-21-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + y


g_LUQ_K_short <- ggplot(aes(Month_Yr, `K (mg/L)`), data = LUQ_K[129:372,]) + geom_line() +
                  geom_point(size = 0.75) +
                  scale_x_date(date_labels = "%Y") + xlab("") +
                  ylab("") + theme_minimal() +
geom_vline(xintercept = as.Date("09-18-1989", format = "%m-%d-%Y"), col = "red",  linetype="dotted") +
geom_vline(xintercept = as.Date("09-21-1998", format = "%m-%d-%Y"), col = "red",  linetype="dotted") + y
```

```
####
library(ggpubr)

tiff()

double_K <- ggarrange(g_LUQ_K_short, g_FUS_K + ylab(""), nrow = 2, labels = "AUTO")
```

```
## Warning: Removed 4 rows containing missing values (geom_point).
```

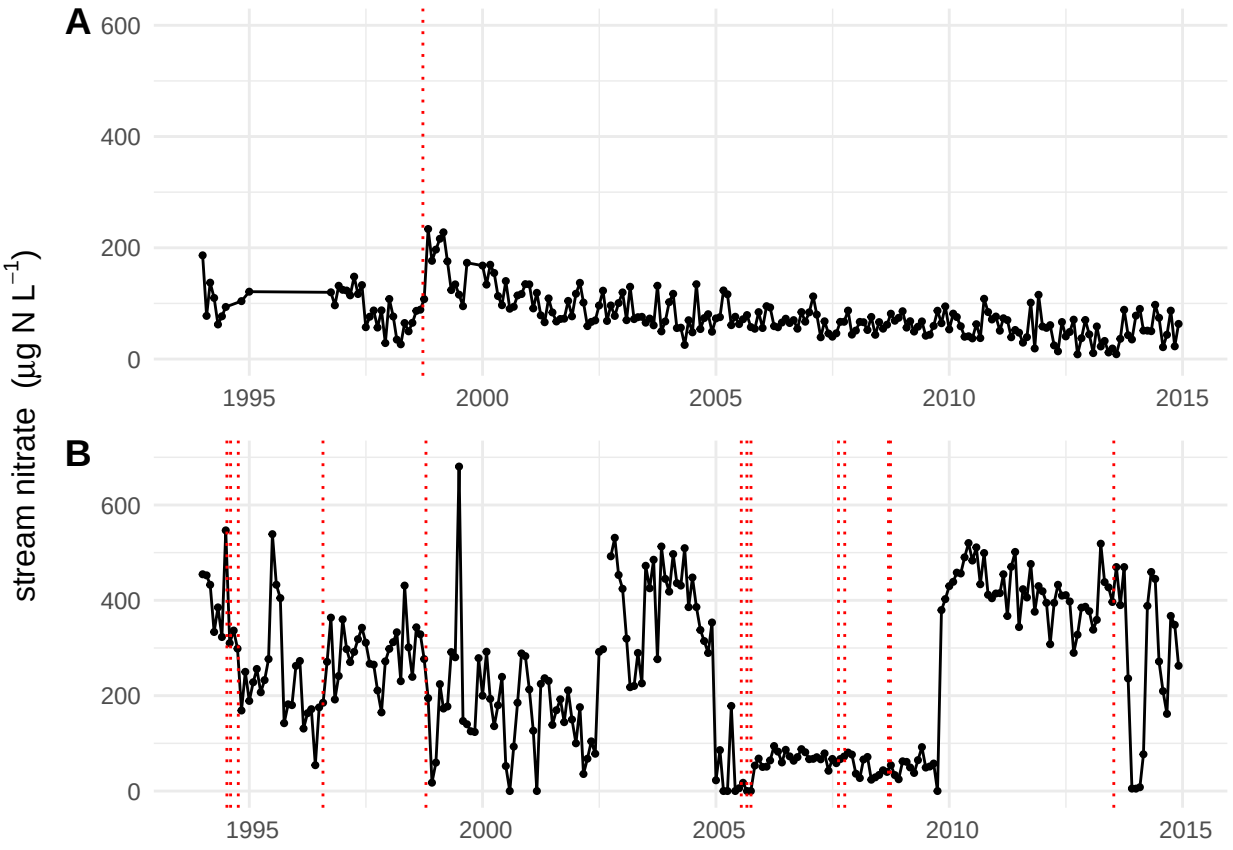
```
double_K <- annotate_figure(double_K, left = text_grob(expression("stream potassium"*"  (mg K L"^-1* ")

double_K


tiff(filename = "Streams_potassium.tiff", width = 18.5, height = 5.745, units = "cm",res = 600, compress
double_K
dev.off()
```

```
## pdf
##   2
```

```
#### ggarrange
double_NO3 <- ggarrange(g_LUQ_NO3_short, g_FUS_NO3, nrow = 2, labels = "AUTO")
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```

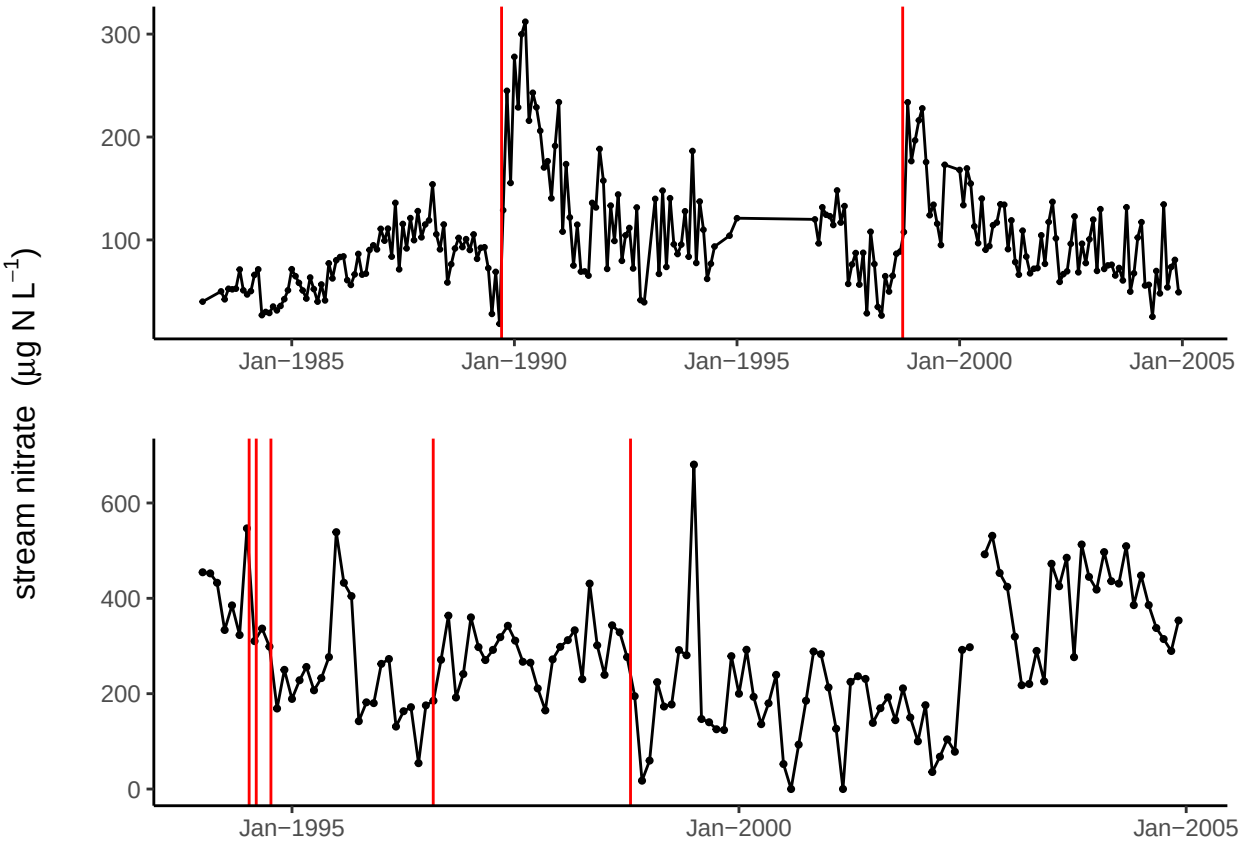
```
double_NO3 <- annotate_figure(double_NO3, left = text_grob(expression("stream nitrate"*"  ("* mu*"g N L

double_NO3
```




```
###################
double_NO3_2 <- ggarrange(g_LUQ_NO3_2, g_FUS_NO3_2, nrow = 2)
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```

```
double_NO3_2 <- annotate_figure(double_NO3_2, left = text_grob(expression("stream nitrate"*"  ("* mu*"g

double_NO3_2
```




```
#
# tiff(filename = "Streams_nitrate.tiff", width = 18.5, height = 5.745, units = "cm",res = 600, compres
# double_NO3
# dev.off()
#



tiff(filename = "Streams_nitrate_2_10.30.19.tiff", width = 18.5, height = 8.6205, units = "cm",res = 60
double_NO3_2
dev.off()
```

```
## pdf
##   2
```

Marsh GPP

```
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 3.6.1
```

```
marshGPP <-  read_xlsx(path = "C:/Users/hogie/Dropbox (Personal)/LUQ LITTERFALL for Hurricane Workshop 4

marshGPP$GPP <-  as.numeric(marshGPP$GPP)
```

```
## Warning: NAs introduced by coercion
```

```
marshGPP$Hurricane <-  as.factor(marshGPP$Hurricane)
```

```
library(tidyverse)
```

```
## -- Attaching packages ------------------------------------------------------ tidyverse 1.2.1 --
```

```
## v tibble  2.1.3     v dplyr   0.8.3
## v tidyr   1.0.0     v stringr 1.4.0
## v purrr   0.3.3     v forcats 0.4.0
```

```
## Warning: package 'tibble' was built under R version 3.6.1
```

```
## Warning: package 'tidyr' was built under R version 3.6.1
```

```
## Warning: package 'purrr' was built under R version 3.6.1
```

```
## Warning: package 'dplyr' was built under R version 3.6.1
```

```
## -- Conflicts --------------------------------------------------------- tidyverse_conflicts() --
## x tidyr::extract()   masks magrittr::extract()
## x dplyr::filter()    masks stats::filter()
## x dplyr::lag()       masks stats::lag()
## x purrr::set_names() masks magrittr::set_names()
```

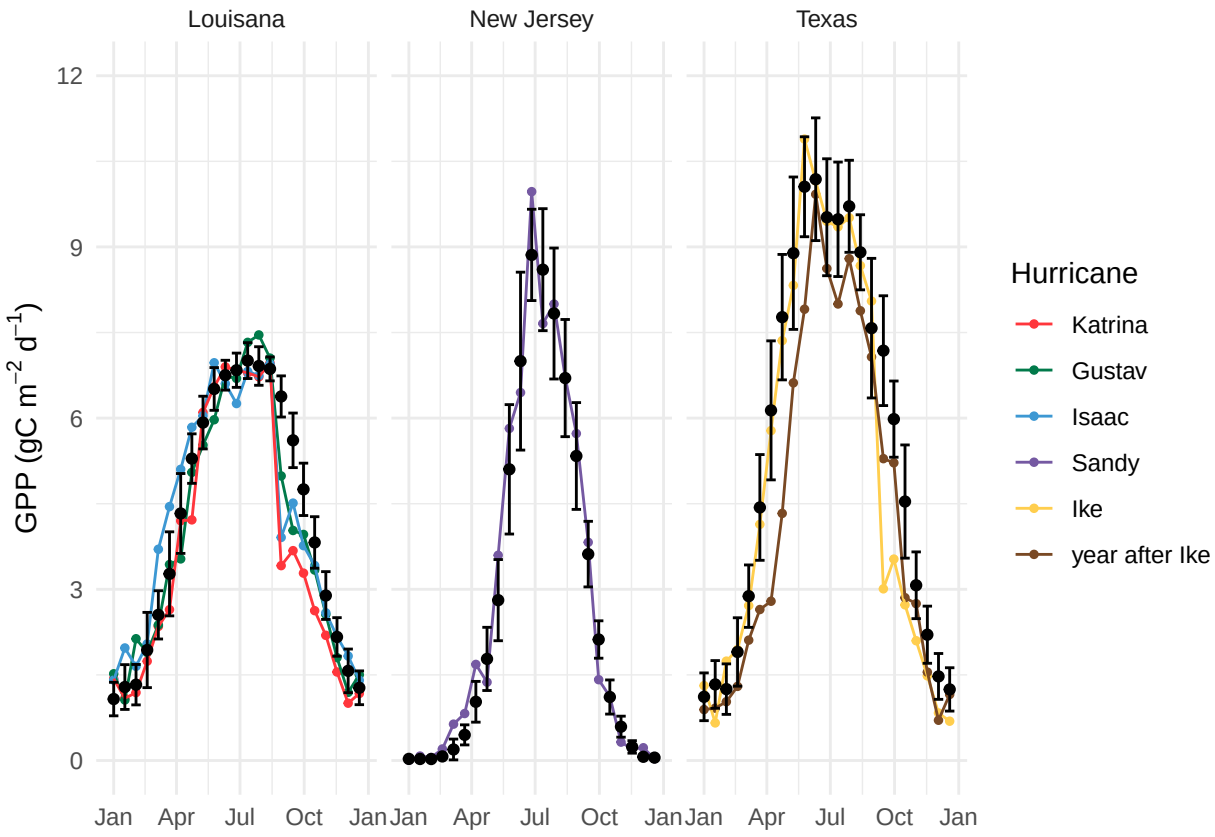
```
std_err <- function(x, na.rm=FALSE) {
  if (na.rm) x <- na.omit(x)
  sqrt(var(x)/length(x))
}

marsh_ordinalGPP <- marshGPP %>% filter(Hurricane == "NA") %>% group_by(Site, `Ordinal Date`) %>% summa
```

```
library(awtools)
library(ggthemes)
```

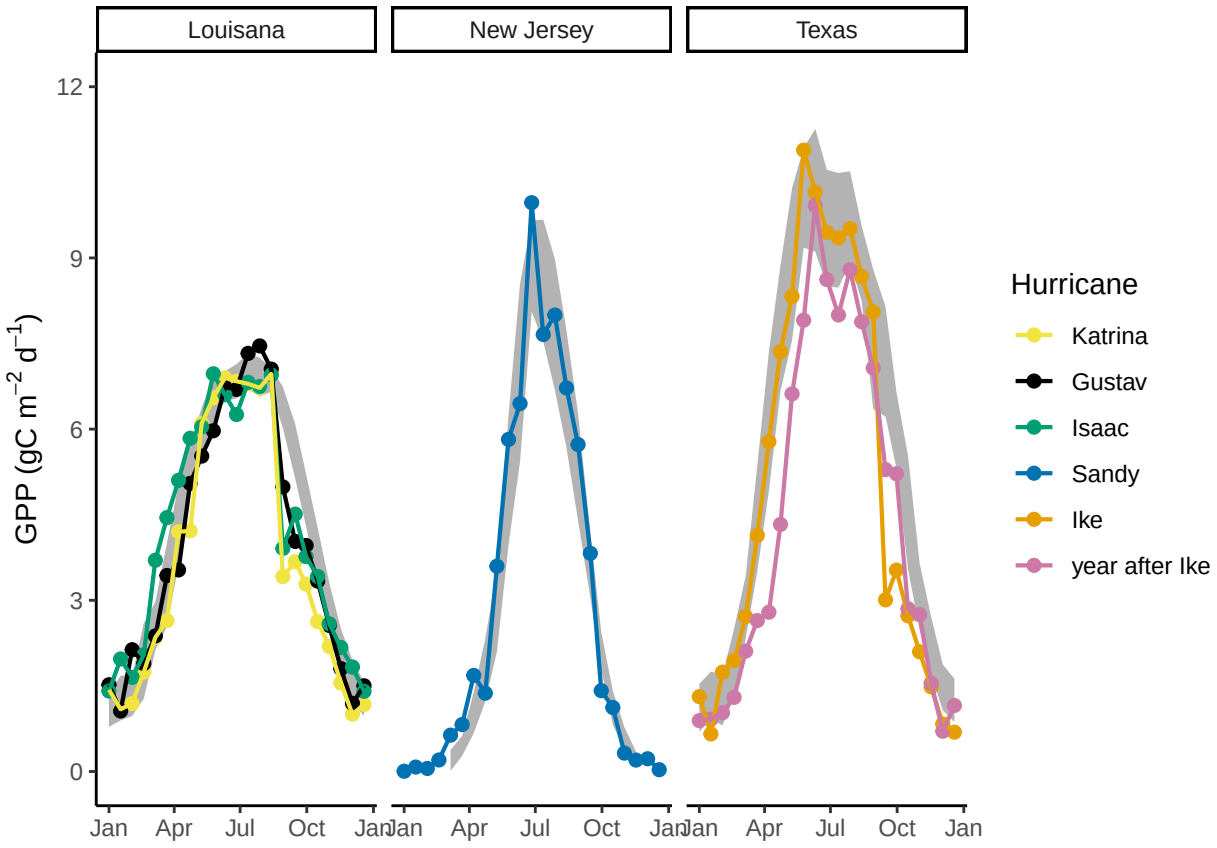
```
## Warning: package 'ggthemes' was built under R version 3.6.1
```

```
gg.RUSTY <- ggplot(aes(x = `Ordinal Date`, y=avgGPP), data = marsh_ordinalGPP) + geom_point(data = mars

gg.RUSTY
```

```
## Warning: Removed 6 rows containing missing values (geom_errorbar).
```




```
gg.RUSTY_NOV <- ggplot(aes(x = `Ordinal Date`, y=avgGPP), data = marsh_ordinalGPP) +    geom_ribbon(aes

gg.RUSTY_NOV
```



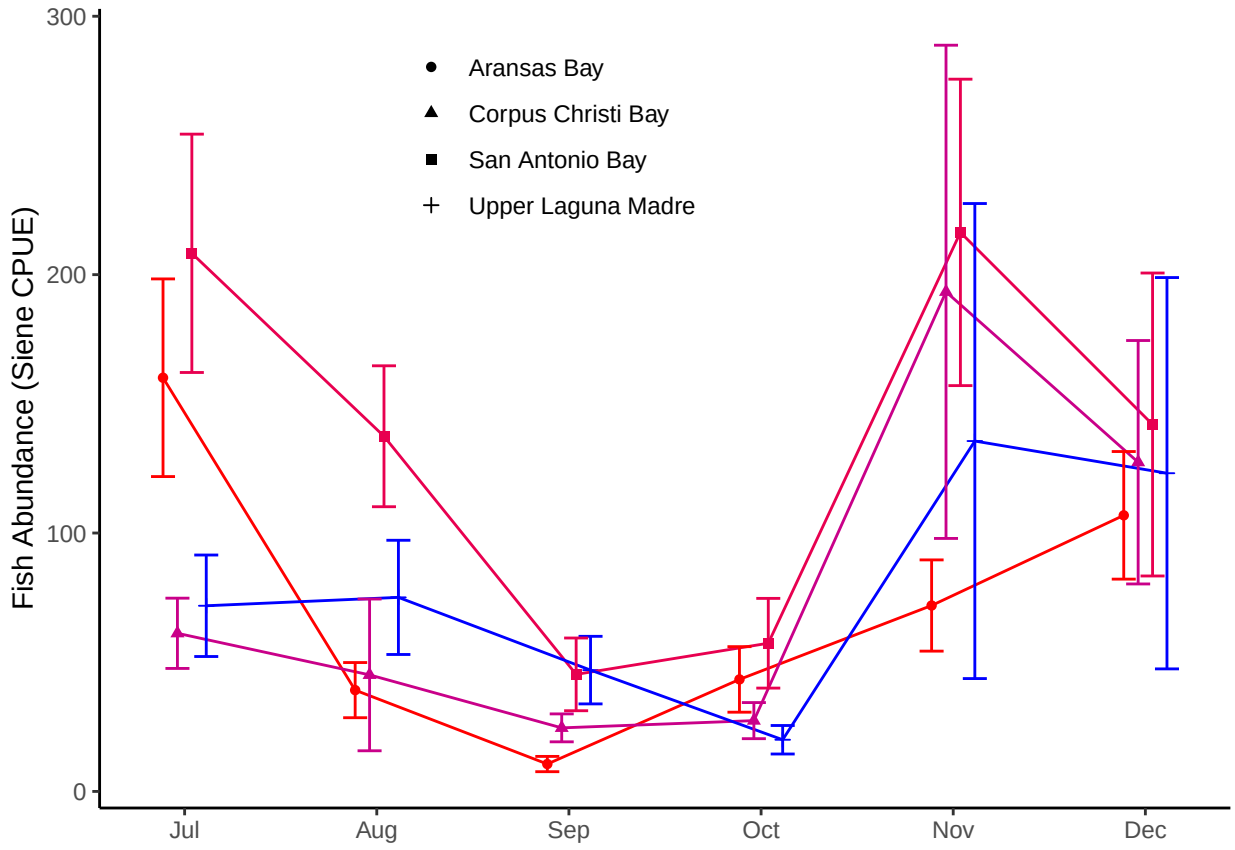
Fish Abundances

```
library(readr)
bag_seine <- read_csv("CONCEPTUAL PAPER/Rusty & Chris Data/Supplement.2F.BagSeine.csv",
col_types = cols(Date = col_date(format = "%m/%d/%Y")))

delta_catch <- read_csv("CONCEPTUAL PAPER/Rusty & Chris Data/Supplement.2G.HistoricDeltaCatch.csv")
```

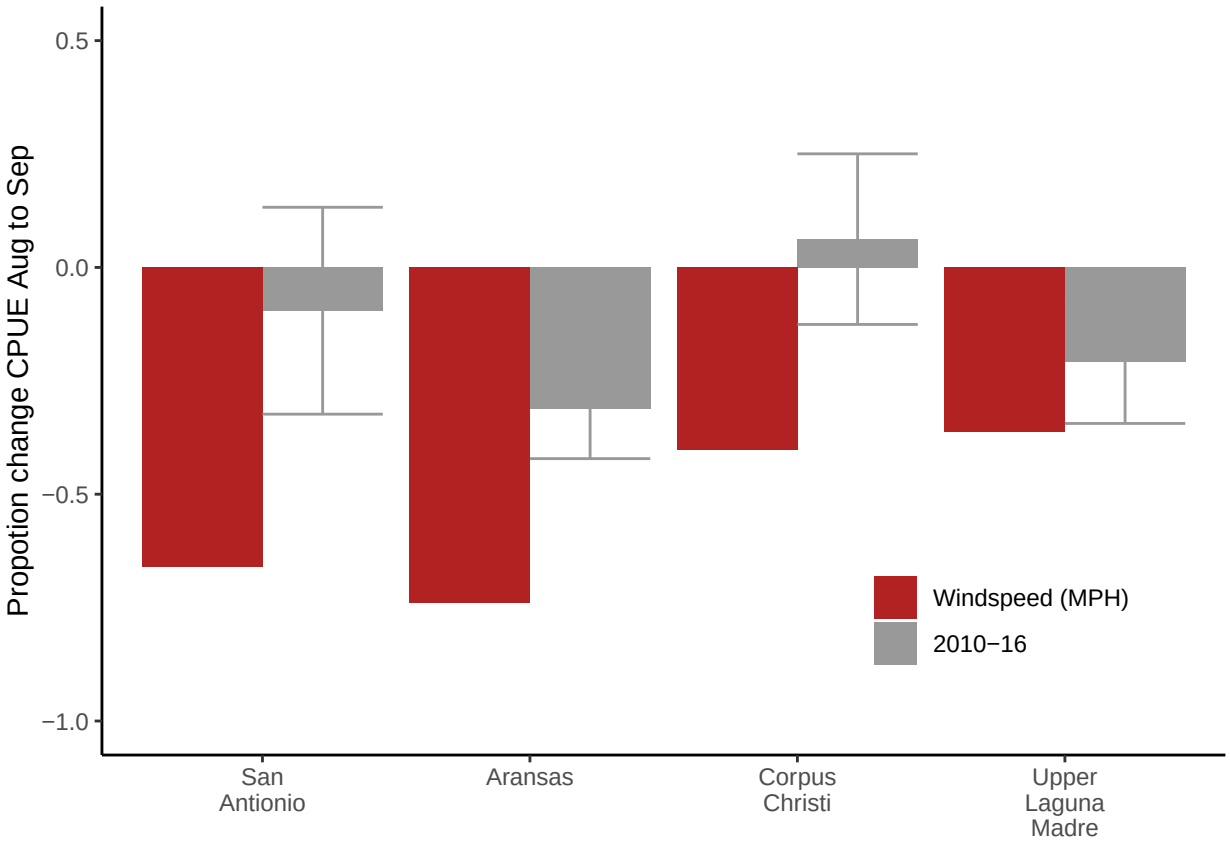
```
## Parsed with column specification:
## cols(
##   Year = col_double(),
##   Period = col_character(),
##   Estuary.Name = col_character(),
##   PerChangeAug.Sept = col_double()
## )
```

```
avg.bag_siene <- bag_seine %>% group_by(Estuary, Month) %>%  summarise(avg = mean(`Total Catch`, na.rm =

avg.delta_catch<- delta_catch[delta_catch$Period == "PreHarvey",] %>% group_by(Estuary.Name) %>% summari

avg.bag_siene <- bag_seine %>% group_by(Estuary, Month) %>%  summarise(avg = mean(`Total Catch`, na.rm =
                                                              avg.bag_siene$wind_speed <- c(rep(140, 6),
```

```
gg.ChrisPatrick1 <- ggplot(aes(x = `Month`, y=avg, color = wind_speed, shape = Estuary), data = avg.bag_

gg.ChrisPatrick1
```

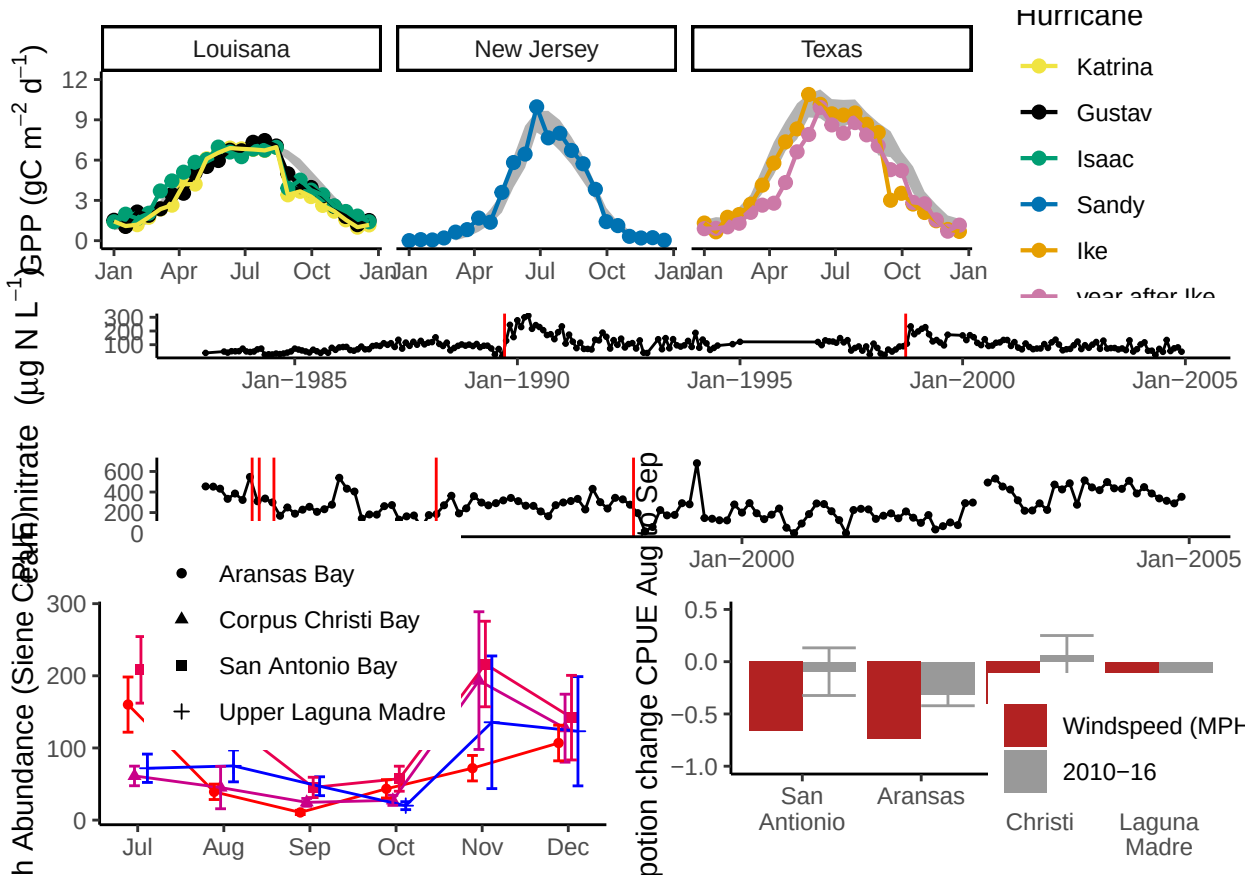



```
avg.bag_siene2 <- bag_seine %>% group_by(Estuary, Date) %>%  summarise(avg = mean(`Total Catch`, na.rm =

xxx <- cbind(delta_catch[delta_catch$Period == "Harvey",c(3,4)], rep(NA, 4))

colnames(xxx) <- c("Estuary.Name", "avg", "se")

Estuary_frame <-  rbind(rbind(cbind(xxx, period = rep("Windspeed (MPH)", 4))), rbind(cbind(avg.delta_ca

Estuary_frame$Estuary.Name <- factor(Estuary_frame$Estuary.Name, levels = c("San Antonio Bay", "Aransas

gg.ChrisPatrick2 <- ggplot(aes(x = Estuary.Name, y = avg, fill = period), data = Estuary_frame) + geom_

gg.ChrisPatrick2

## Warning: Removed 4 rows containing missing values (geom_errorbar).
```




```
#tiff(filename = "FFFFF.tiff", width = 19.05, height = 19.05, units = "cm", res = 600, compression = "l
ggarrange(gg.RUSTY_NOV, double_NO3_2, ggarrange(gg.ChrisPatrick1, gg.ChrisPatrick2, ncol =2), nrow = 3)
```

```
## Warning: Removed 4 rows containing missing values (geom_errorbar).
```


Louisana
New Jersey
Texas
GPP (gC m^{-2} d^{-1})
Hurricane
Katrina
Gustav
Isaac
Sandy
Ike
Jan
Apr
Jul
Oct
Jan−1985
Jan−1990
Jan−1995
Jan−2000
Jan−2005
(µg N L^{-1})
Aransas Bay
Corpus Christi Bay
San Antonio Bay
Upper Laguna Madre
Jul
Aug
Sep
Oct
Nov
Dec
Windspeed (MPH
2010−16
San Antionio
Aransas
Christi
Laguna Madre

```
#dev.off()
```