Statistical analysis of the effect of environmental variables on abundance of flounder

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Contents


```
# load packages
packages <- c("ggplot2", "MASS", "mgcv", "rmarkdown", "tinytex")
lapply(packages, library, character.only = TRUE)
```

```
## Loading required package: nlme
```

```
## This is mgcv 1.9-1. For overview type 'help("mgcv-package")'.
```

```
## [[1]]
## [1] "ggplot2"   "stats"     "graphics"  "grDevices" "utils"     "datasets"
## [7] "methods"   "base"
##
## [[2]]
## [1] "MASS"      "ggplot2"   "stats"     "graphics"  "grDevices" "utils"
## [7] "datasets"  "methods"   "base"
##
## [[3]]
##  [1] "mgcv"      "nlme"      "MASS"      "ggplot2"   "stats"     "graphics"
##  [7] "grDevices" "utils"     "datasets"  "methods"   "base"
##
## [[4]]
##  [1] "rmarkdown" "mgcv"      "nlme"      "MASS"      "ggplot2"   "stats"
##  [7] "graphics"  "grDevices" "utils"     "datasets"  "methods"   "base"
##
## [[5]]
##  [1] "tinytex"   "rmarkdown" "mgcv"      "nlme"      "MASS"      "ggplot2"
##  [7] "stats"     "graphics"  "grDevices" "utils"     "datasets"  "methods"
## [13] "base"
```

```
knitr::opts_chunk$set(fig.path = "figure/", dev = "png")
```

Data preparation and exploration

```
# load data
df <- read.csv("data.csv")
# describe data
colnames(df)
```

```
##  [1] "site"        "net"         "year"        "lat"         "long"
##  [6] "distshore"   "trawl"       "area"        "chlorophyll" "tempavg"
## [11] "tempstdev"   "sal"         "bod"         "nh3"         "po4"
## [16] "depth"       "nflounder"
```

```
dim(df)
```

```
## [1] 2763   17
```

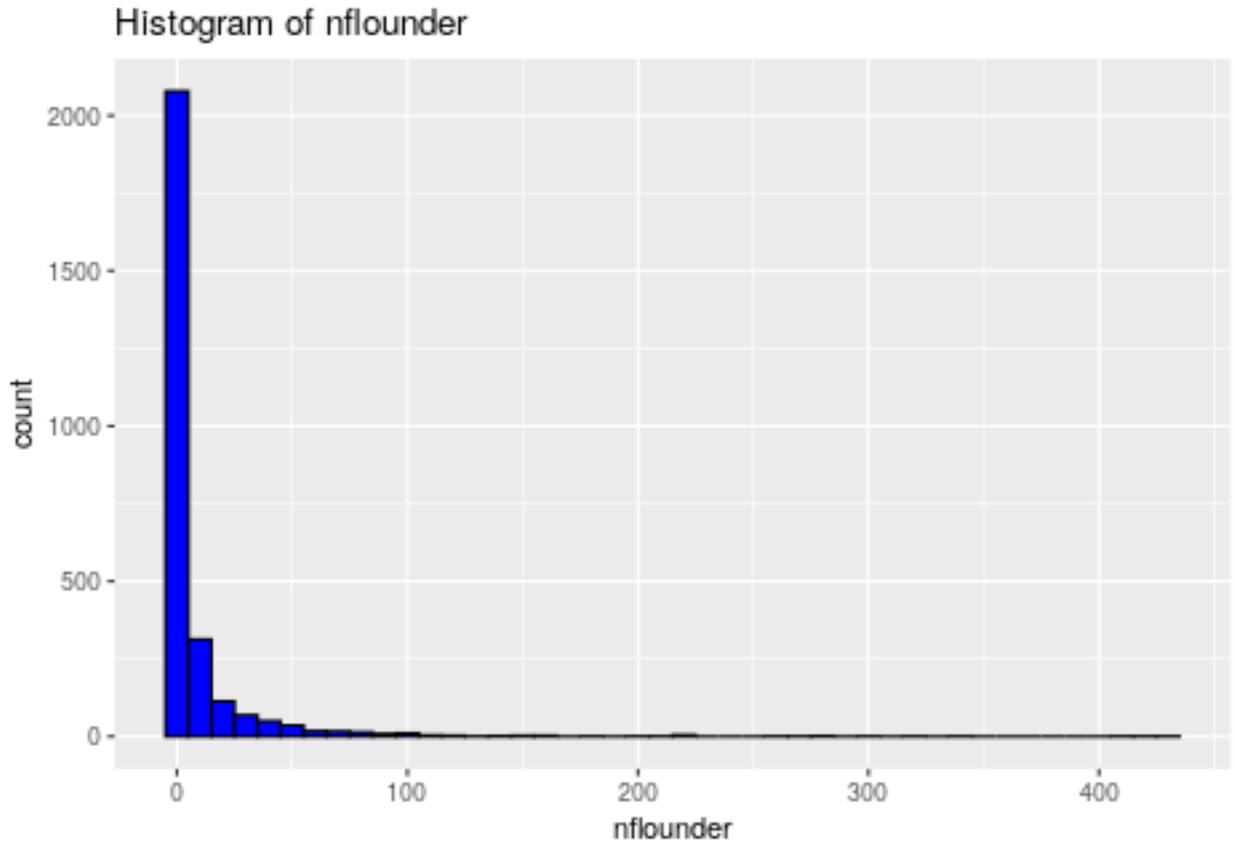
```
df[c("net", "site")]<-lapply(df[c("net", "site")], factor)
summary(df)
```

```
##                                site        net            year
##  Suir Estuary                    : 183   BS  :1264   Min.   :2001
##  Shannon Estuary, Lower          : 163   BT  : 672   1st Qu.:2008
##  Boyne                           : 154   Fyke: 827   Median :2010
##  Barrow Suir Nore Estuary        : 144               Mean   :2011
##  Gweebarra Estuary               : 143               3rd Qu.:2015
##  Barrow Nore Suir Estuary, Upper: 106               Max.   :2019
##  (Other)                         :1870
##       lat             long          distshore          trawl
##  Min.   :51.48   Min.   :-9.966   Min.   :   0.00   Min.   :   0.00
##  1st Qu.:52.28   1st Qu.:-9.074   1st Qu.:  13.90   1st Qu.:   0.00
##  Median :52.66   Median :-8.252   Median :  45.71   Median :   0.00
##  Mean   :52.98   Mean   :-8.025   Mean   : 171.84   Mean   :  32.82
##  3rd Qu.:53.72   3rd Qu.:-6.956   3rd Qu.: 168.15   3rd Qu.:   0.00
##  Max.   :55.09   Max.   :-6.033   Max.   :3097.40   Max.   :1210.00
##
##       area           chlorophyll        tempavg         tempstdev
##  Min.   :  0.0832   Min.   :  1.50   Min.   : 7.305   Min.   :0.04534
##  1st Qu.:  3.0464   1st Qu.:  7.40   1st Qu.:12.773   1st Qu.:3.21952
##  Median :  6.7854   Median : 18.00   Median :13.558   Median :3.90394
##  Mean   : 25.8178   Mean   : 37.57   Mean   :13.480   Mean   :3.75874
##  3rd Qu.: 12.2295   3rd Qu.: 50.30   3rd Qu.:14.455   3rd Qu.:4.54526
##  Max.   :489.4254   Max.   :444.00   Max.   :18.691   Max.   :7.04075
##
##       sal              bod             nh3              po4
##  Min.   : 4.878   Min.   :0.688   Min.   :0.01500   Min.   : 7.909
##  1st Qu.: 7.840   1st Qu.:1.149   1st Qu.:0.04100   1st Qu.:15.595
##  Median :15.609   Median :1.529   Median :0.04600   Median :31.276
```

```
##  Mean   :15.511   Mean   :1.522   Mean   :0.06381   Mean   :28.421
##  3rd Qu.:22.959   3rd Qu.:1.629   3rd Qu.:0.07000   3rd Qu.:38.396
##  Max.   :33.047   Max.   :3.825   Max.   :0.17300   Max.   :83.600
##
##      depth          nflounder
##  Min.   :0.700   Min.   :  0.000
##  1st Qu.:2.500   1st Qu.:  0.000
##  Median :4.030   Median :  1.000
##  Mean   :4.378   Mean   :  9.205
##  3rd Qu.:6.170   3rd Qu.:  5.000
##  Max.   :8.400   Max.   :435.000
##
```

Distribution of nflounder

```
ggplot(df, aes(nflounder)) +
  geom_histogram(binwidth = 10, fill = "blue", color = "black") +
  labs(title = "Histogram of nflounder", x = "nflounder")
```



See how many values fall in each category:

```
# Define the bin width
bin_width <- 10
```

```r
# Define the breaks for the bins
breaks <- seq(min(df$nflounder), max(df$nflounder), by = bin_width)

# Divide the data into bins
bins <- cut(df$nflounder, breaks = breaks, include.lowest = TRUE, right = FALSE)

# Count the number of values in each bin
bin_counts <- table(bins)

# Print the bin counts
print(bin_counts)
```

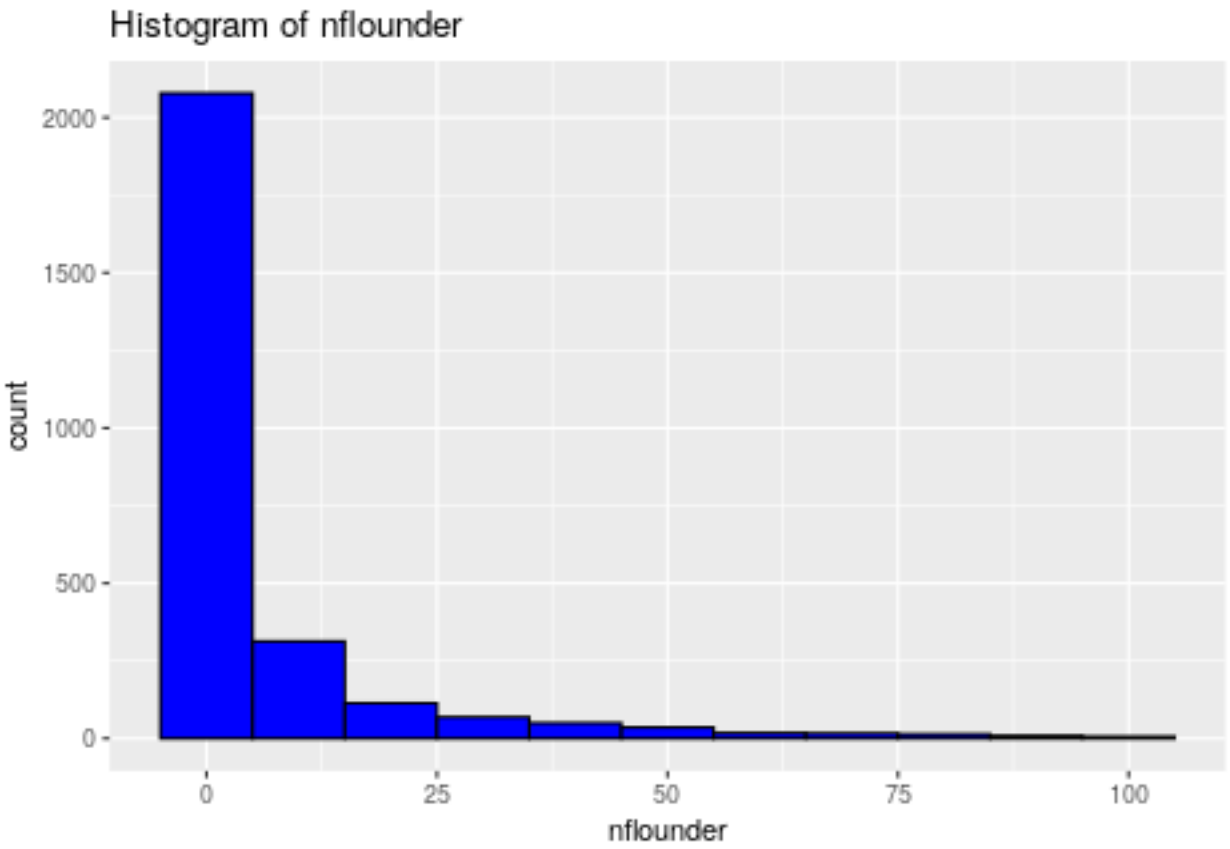
```
## bins
##    [0,10)   [10,20)   [20,30)   [30,40)   [40,50)   [50,60)   [60,70)   [70,80)
##      2245       205        94        57        44        20        19        16
##   [80,90)  [90,100) [100,110) [110,120) [120,130) [130,140) [140,150) [150,160)
##        10        13         7         5         1         2         2         3
## [160,170) [170,180) [180,190) [190,200) [200,210) [210,220) [220,230) [230,240)
##         2         1         0         0         2         1         4         0
## [240,250) [250,260) [260,270) [270,280) [280,290) [290,300) [300,310) [310,320)
##         0         1         0         1         2         0         1         0
## [320,330) [330,340) [340,350) [350,360) [360,370) [370,380) [380,390) [390,400)
##         1         1         0         0         0         0         0         0
## [400,410) [410,420) [420,430]
##         0         2         0
```

Lets truncate values above 100 for modelling convenience.

```r
original_nrow <- nrow(df)
df <- subset(df, nflounder <= 100)
removed_nrow <- original_nrow-nrow(df)
conditional_var <- var(df$nflounder, na.rm=TRUE)
conditional_mean <- mean(df$nflounder, na.rm=TRUE)
```

We removed 39 from 2763. Let's visualise distribution of nflounder again.

```r
ggplot(df, aes(nflounder)) +
  geom_histogram(binwidth = 10, fill = "blue", color = "black") +
  labs(title = "Histogram of nflounder", x = "nflounder")
```



As we can see data is still highly overdispersed, the conditional variance (208.0536609) exceeds the conditional mean (6.5179883). In situations like this negative binomial is an appropriate distribution to use.

Correlation analysis

```
df_numeric <- df[sapply(df, is.numeric)]
cor_matrix <- cor(df_numeric, use = "complete.obs")
print(cor_matrix)
```

```
##                    year           lat        long    distshore        trawl
## year         1.000000000  0.0049817860 -0.06511398  0.088010356 -0.119769828
## lat          0.004981786  1.0000000000  0.04506691 -0.005444478  0.093568489
## long        -0.065113977  0.0450669064  1.00000000 -0.224120769  0.043158598
## distshore    0.088010356 -0.0054444775 -0.22412077  1.000000000  0.144581861
## trawl       -0.119769828  0.0935684891  0.04315860  0.144581861  1.000000000
## area         0.067678064 -0.0007925651 -0.10255599  0.164351090 -0.028732391
## chlorophyll  0.070847279 -0.0322708516  0.14170391  0.020114161  0.003544562
## tempavg      0.093554648 -0.2230929909 -0.04791776  0.084518093 -0.022062488
## tempstdev   -0.156715923 -0.0234881935 -0.05046801  0.096050784  0.025851643
## sal         -0.204827187  0.3989884868 -0.12004630 -0.050253948  0.029244586
## bod         -0.125186675 -0.3154381712  0.25662766 -0.113689564  0.051555411
## nh3         -0.269058242 -0.1454581609  0.24194535 -0.078002487  0.013807491
## po4         -0.159703341 -0.1719509276  0.50093553  0.038484470 -0.036196786
## depth        0.118780600 -0.3806972918  0.20077301  0.045172606 -0.005677570
```

```
## nflounder   -0.096151776 -0.1291115877  0.18078237 -0.132022226 -0.002051093
##                     area  chlorophyll     tempavg   tempstdev         sal
## year         0.0676780642  0.070847279  0.09355465 -0.15671592 -0.20482719
## lat         -0.0007925651 -0.032270852 -0.22309299 -0.02348819  0.39898849
## long        -0.1025559916  0.141703905 -0.04791776 -0.05046801 -0.12004630
## distshore    0.1643510905  0.020114161  0.08451809  0.09605078 -0.05025395
## trawl       -0.0287323909  0.003544562 -0.02206249  0.02585164  0.02924459
## area         1.0000000000 -0.007407639 -0.07788099  0.11644657 -0.09950945
## chlorophyll -0.0074076388  1.000000000  0.18577262  0.10878705  0.03726607
## tempavg     -0.0778809900  0.185772616  1.00000000  0.20038897 -0.19076514
## tempstdev    0.1164465703  0.108787049  0.20038897  1.00000000 -0.04111293
## sal         -0.0995094464  0.037266065 -0.19076514 -0.04111293  1.00000000
## bod         -0.1491648863  0.148704747 -0.05496218  0.08648001  0.12076372
## nh3         -0.0667732092 -0.026391337 -0.07254021  0.02594419  0.41822587
## po4          0.1422456757 -0.101320955 -0.02263963  0.05345896 -0.14777738
## depth        0.1227755778 -0.028296778  0.13414873  0.01176289 -0.64814422
## nflounder   -0.0897024377  0.015470871  0.07377867  0.04200609 -0.19505829
##                      bod         nh3         po4       depth    nflounder
## year        -0.12518667 -0.26905824 -0.15970334  0.11878060 -0.096151776
## lat         -0.31543817 -0.14545816 -0.17195093 -0.38069729 -0.129111588
## long         0.25662766  0.24194535  0.50093553  0.20077301  0.180782366
## distshore   -0.11368956 -0.07800249  0.03848447  0.04517261 -0.132022226
## trawl        0.05155541  0.01380749 -0.03619679 -0.00567757 -0.002051093
## area        -0.14916489 -0.06677321  0.14224568  0.12277558 -0.089702438
## chlorophyll  0.14870475 -0.02639134 -0.10132096 -0.02829678  0.015470871
## tempavg     -0.05496218 -0.07254021 -0.02263963  0.13414873  0.073778667
## tempstdev    0.08648001  0.02594419  0.05345896  0.01176289  0.042006088
## sal          0.12076372  0.41822587 -0.14777738 -0.64814422 -0.195058290
## bod          1.00000000  0.42517649  0.35803600 -0.12377171  0.085604235
## nh3          0.42517649  1.00000000  0.48816749 -0.37503797 -0.015704750
## po4          0.35803600  0.48816749  1.00000000  0.18052167  0.059434892
## depth       -0.12377171 -0.37503797  0.18052167  1.00000000  0.113621304
## nflounder    0.08560423 -0.01570475  0.05943489  0.11362130  1.000000000
```

Data modelling

Negative binomial GLM

Lets fit a negative binomial generalized linear model.

```
m.glm <- glm.nb(nflounder ~. , data = df)
```

m.glm.stp –>

linearity assumptions –> homogeneity variance –> influential points –>