Analysis_MovSpd_TempDisc

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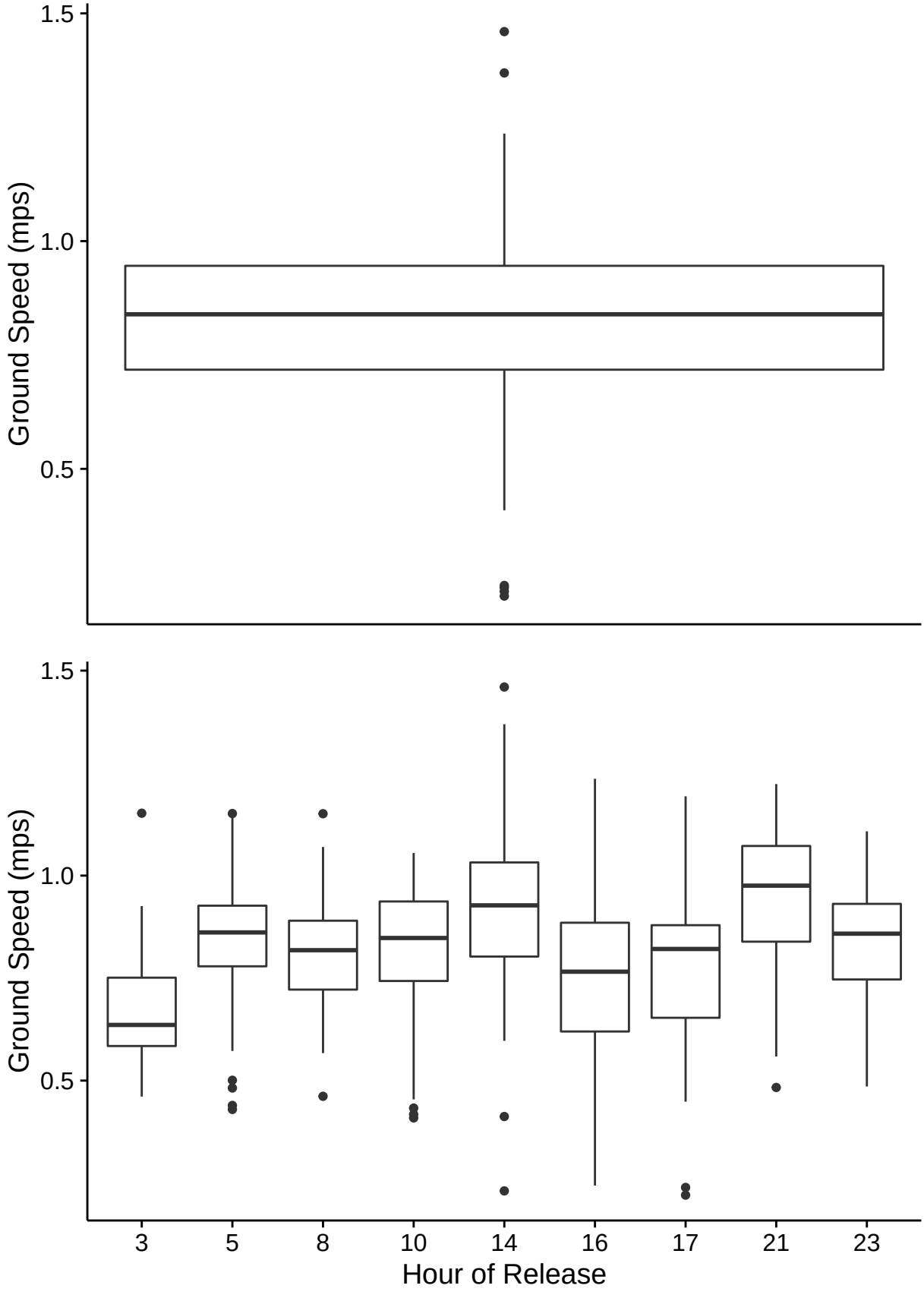
Movement Speed (mean spd per track)

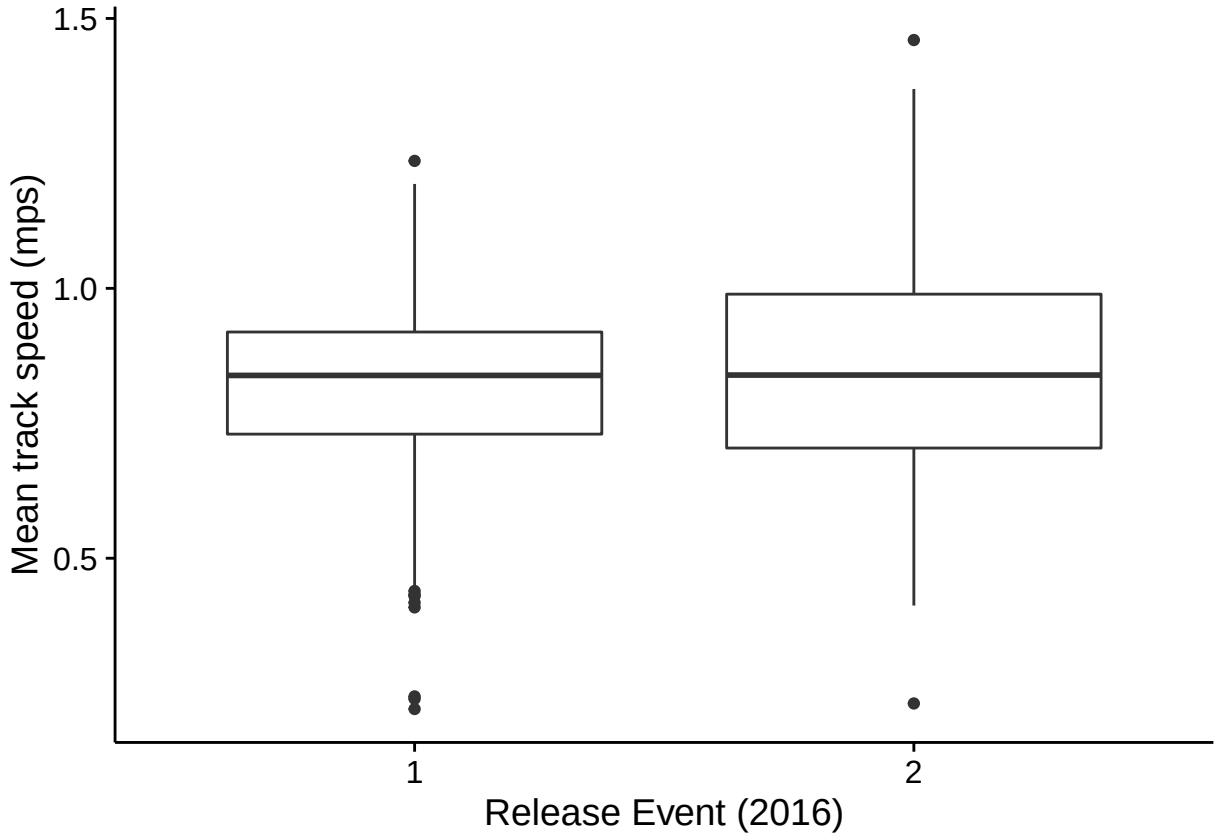
Using the dataset filtered and discretized by time, we'll calculate the mean movement speed per track
Visualize with a variety of plots

Calculate overall path speeds

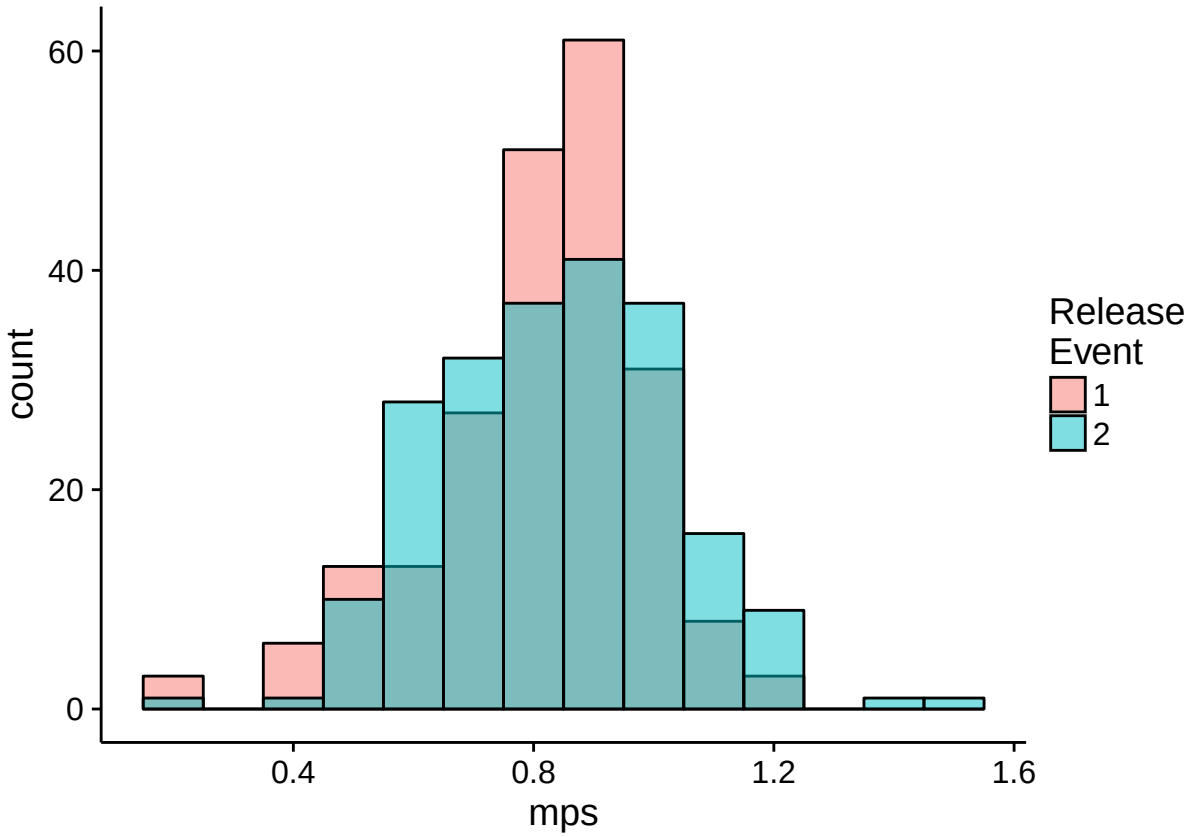
Using path length and passage time

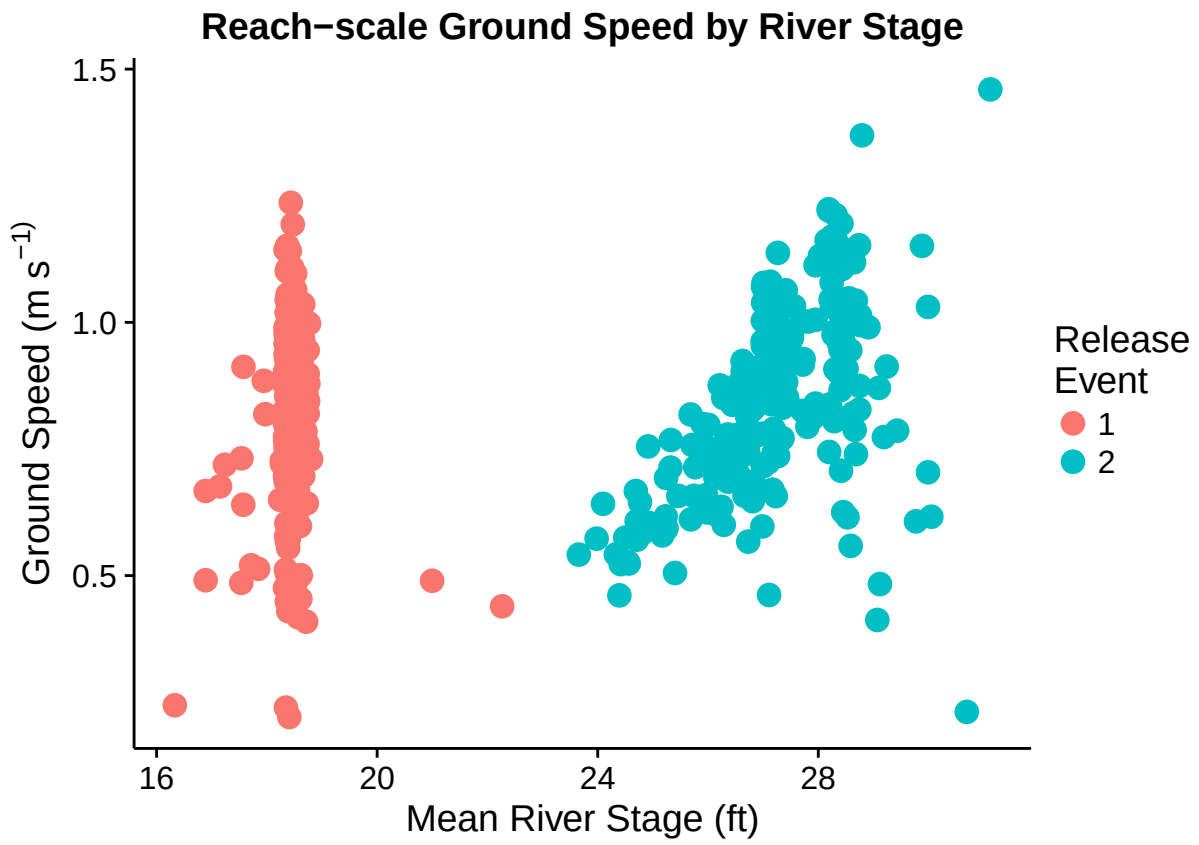
Plot all speeds






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


60
40
20
0
count
0.4
0.8
1.2
1.6
mps
Release
Event
1
2




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

Statistical effect of release hour alone

There is a significant effect of release hour, both then it is considered as a continuous variable and as a factor, but the models and the plots indicate that the effect is very small. We will include the release hour as a mixed effect in future models, but because there is such a huge spread in release hours we won't analyze these groups seperately.

```
mps.RelHr <- lm(mps ~ (RelHr), data=pathspd)
 summary(mps.RelHr)
```

```
##
## Call:
## lm(formula = mps ~ (RelHr), data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.63274 -0.11012  0.01251  0.11446  0.62550
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.746175   0.018309  40.755  < 2e-16 ***
```

```
## RelHr       0.006309   0.001271   4.964 9.99e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1808 on 428 degrees of freedom
## Multiple R-squared:  0.05444,    Adjusted R-squared:  0.05223
## F-statistic: 24.64 on 1 and 428 DF,  p-value: 9.986e-07
```

```
  #plot(mps.RelHr)  # meets assumptions just fine!

  # post-hoc test designed for linear models with factor predictor: multcomp::glht() was recommended
    pathspd$RelHrfac = factor(pathspd$RelHr)
    testmod = lm(mps ~ 0+RelHrfac, data = pathspd)
     summary(testmod)
```

```
##
## Call:
## lm(formula = mps ~ 0 + RelHrfac, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.68114 -0.08543  0.01136  0.10783  0.54796
##
## Coefficients:
##            Estimate Std. Error t value Pr(>|t|)
## RelHrfac3   0.67007    0.02361   28.39   <2e-16 ***
## RelHrfac5   0.84173    0.02253   37.36   <2e-16 ***
## RelHrfac8   0.81653    0.02316   35.26   <2e-16 ***
## RelHrfac10  0.81458    0.02338   34.84   <2e-16 ***
## RelHrfac14  0.91204    0.02273   40.12   <2e-16 ***
## RelHrfac16  0.75173    0.03244   23.17   <2e-16 ***
## RelHrfac17  0.75076    0.03372   22.27   <2e-16 ***
## RelHrfac21  0.95179    0.02273   41.87   <2e-16 ***
## RelHrfac23  0.83388    0.02253   37.02   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1686 on 421 degrees of freedom
## Multiple R-squared:  0.9612, Adjusted R-squared:  0.9604
## F-statistic:  1158 on 9 and 421 DF,  p-value: < 2.2e-16
```

```
    posthoc.mod = glht(testmod, linfct = mcp(RelHrfac="Tukey"))
     summary(posthoc.mod)
```

```
## Warning in RET$pfunction("adjusted", ...): Completion with error > abseps

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## Warning in RET$pfunction("adjusted", ...): Completion with error > abseps
```
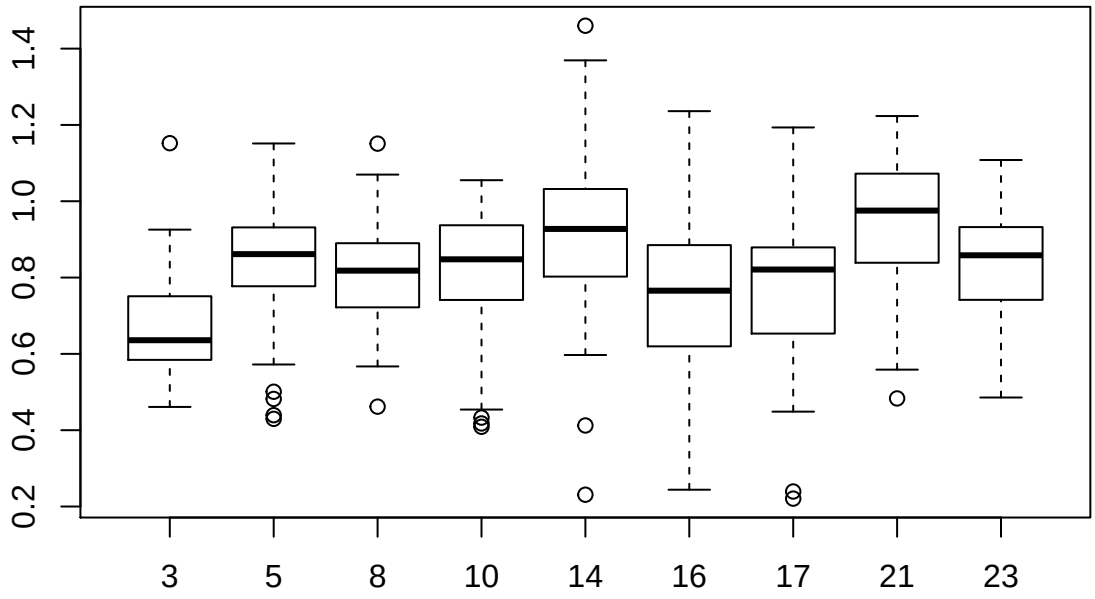

```
## Warning in RET$pfunction("adjusted", ...): Completion with error > abseps

## Warning in RET$pfunction("adjusted", ...): Completion with error > abseps


##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = mps ~ 0 + RelHrfac, data = pathspd)
##
## Linear Hypotheses:
##                Estimate Std. Error t value Pr(>|t|)
## 5 - 3 == 0    0.1716616  0.0326310   5.261  < 0.001 ***
## 8 - 3 == 0    0.1464556  0.0330682   4.429  < 0.001 ***
## 10 - 3 == 0   0.1445117  0.0332238   4.350  < 0.001 ***
## 14 - 3 == 0   0.2419683  0.0327720   7.383  < 0.001 ***
## 16 - 3 == 0   0.0816605  0.0401234   2.035  0.51416
## 17 - 3 == 0   0.0806901  0.0411594   1.960  0.56696
## 21 - 3 == 0   0.2817166  0.0327720   8.596  < 0.001 ***
## 23 - 3 == 0   0.1638112  0.0326310   5.020  < 0.001 ***
## 8 - 5 == 0   -0.0252060  0.0323071  -0.780  0.99727
## 10 - 5 == 0  -0.0271499  0.0324663  -0.836  0.99556
## 14 - 5 == 0   0.0703067  0.0320039   2.197  0.40409
## 16 - 5 == 0  -0.0900011  0.0394985  -2.279  0.35273
## 17 - 5 == 0  -0.0909715  0.0405504  -2.243  0.37389
## 21 - 5 == 0   0.1100550  0.0320039   3.439  0.01769 *
## 23 - 5 == 0  -0.0078504  0.0318594  -0.246  1.00000
## 10 - 8 == 0  -0.0019439  0.0329058  -0.059  1.00000
## 14 - 8 == 0   0.0955127  0.0324496   2.943  0.07952 .
## 16 - 8 == 0  -0.0647951  0.0398604  -1.626  0.78662
## 17 - 8 == 0  -0.0657655  0.0409031  -1.608  0.79671
## 21 - 8 == 0   0.1352609  0.0324496   4.168  0.00117 **
## 23 - 8 == 0   0.0173555  0.0323071   0.537  0.99982
## 14 - 10 == 0  0.0974566  0.0326081   2.989  0.07046 .
## 16 - 10 == 0 -0.0628512  0.0399896  -1.572  0.81652
## 17 - 10 == 0 -0.0638216  0.0410290  -1.556  0.82475
## 21 - 10 == 0  0.1372049  0.0326081   4.208  < 0.001 ***
## 23 - 10 == 0  0.0192995  0.0324663   0.594  0.99962
## 16 - 14 == 0 -0.1603078  0.0396151  -4.047  0.00202 **
## 17 - 14 == 0 -0.1612782  0.0406640  -3.966  0.00274 **
## 21 - 14 == 0  0.0397482  0.0321478   1.236  0.94670
## 23 - 14 == 0 -0.0781572  0.0320039  -2.442  0.25964
## 17 - 16 == 0 -0.0009704  0.0467915  -0.021  1.00000
## 21 - 16 == 0  0.2000561  0.0396151   5.050  < 0.001 ***
## 23 - 16 == 0  0.0821507  0.0394985   2.080  0.48363
## 21 - 17 == 0  0.2010265  0.0406640   4.944  < 0.001 ***
## 23 - 17 == 0  0.0831211  0.0405504   2.050  0.50356
## 23 - 21 == 0 -0.1179054  0.0320039  -3.684  0.00761 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
    boxplot(mps ~ RelHrfac, data = pathspd)
```



Statistical effect of release event alone

Release Events 1,2&3 are not significantly different from one another, nor are 4 and 5 significantly different from one another, but the two groups (1,2,3 vs 4,5) are different. This make sense, as 1,2 and 3 were released before over topping, and 4 and 5 were during the overtopping event.

```
 mps.RelEv <- lm(mps ~ RelEv, data=pathspd)
  summary(mps.RelEv)
```

```
##
## Call:
## lm(formula = mps ~ RelEv, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.61004 -0.11494  0.01821  0.12457  0.61907
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.78183    0.02823  27.695   <2e-16 ***
## RelEv        0.02955    0.01788   1.653   0.0991 .
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1854 on 428 degrees of freedom
## Multiple R-squared:  0.006343,   Adjusted R-squared:  0.004021
## F-statistic: 2.732 on 1 and 428 DF,  p-value: 0.09909
```

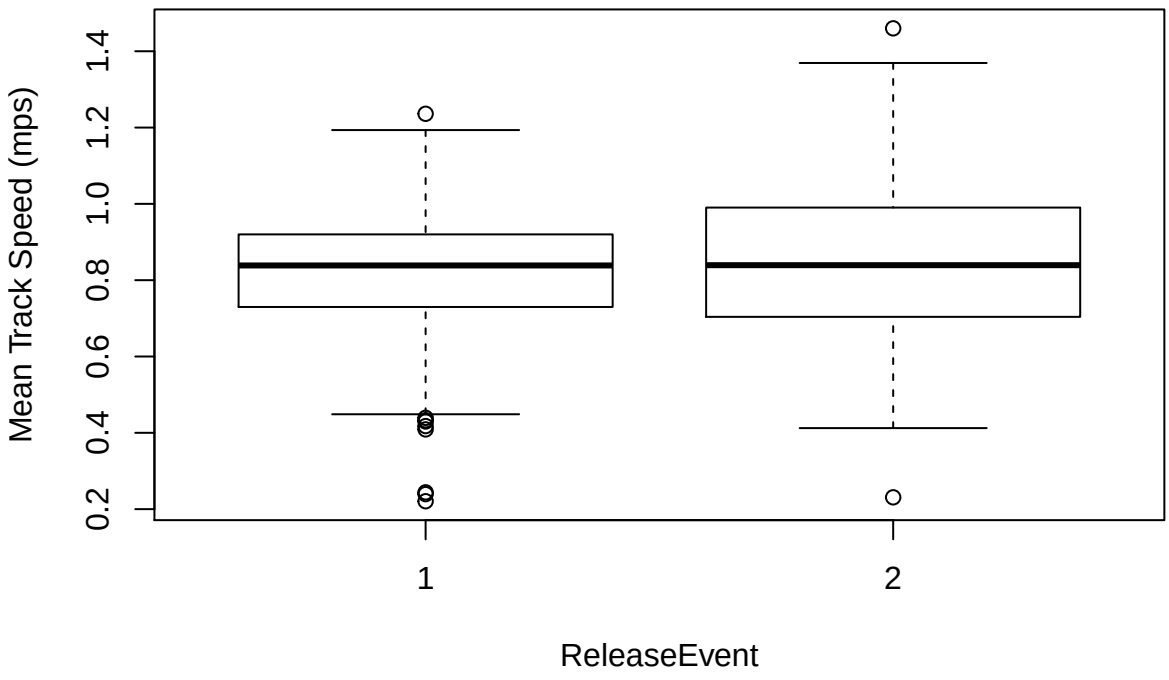
```
  #plot(mps.RelEv)  # meets assumptions pretty well?

  # as an anova test, with tukey posthoc test
  #   testmod = aov(mps ~ 0+RelEvfac, data = pathspd)
  #    summary(testmod)
  #   TukeyHSD(testmod)
   pathspd$RelEvfac = factor(pathspd$RelEv)
   t.test(mps ~ 0+RelEvfac, data = pathspd)
```

```
##
##  Welch Two Sample t-test
##
## data:  mps by RelEvfac
## t = -1.6522, df = 423.66, p-value = 0.09924
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.064711204  0.005605876
## sample estimates:
## mean in group 1 mean in group 2
##       0.8113817       0.8409344
```

```
    summarize(group_by(pathspd, RelEvfac), mean(mps, na.rm=T), sd(mps, na.rm=T))
```

```
## # A tibble: 2 x 3
##   RelEvfac mean(mps, na.rm = T) sd(mps, na.rm = T)
##     <fctr>                <dbl>              <dbl>
## 1        1            0.8113817          0.1766927
## 2        2            0.8409344          0.1937468
```

```
   boxplot(mps ~ RelEvfac, data = pathspd, ylab="Mean Track Speed (mps)", xlab="ReleaseEvent")
```




```
  # phase 2: re-assign the two fish from the first release that arrived with the second release
  pathspd$grp <- NA
   pathspd[pathspd$first < as.POSIXct("2016-03-02"),"grp"] <- 1
   pathspd[pathspd$first > as.POSIXct("2016-03-02"),"grp"] <- 2
   pathspd$grp = factor(pathspd$grp)

 mps.Grp <- lm(mps ~ grp, data=pathspd)
  summary(mps.Grp)
```

```
##
## Call:
## lm(formula = mps ~ grp, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.60655 -0.11516  0.01497  0.12262  0.62255
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.81462    0.01269  64.202   <2e-16 ***
## grp2         0.02283    0.01790   1.275    0.203
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1856 on 428 degrees of freedom
## Multiple R-squared:  0.003784,   Adjusted R-squared:  0.001457
```

```
## F-statistic: 1.626 on 1 and 428 DF,  p-value: 0.203
```

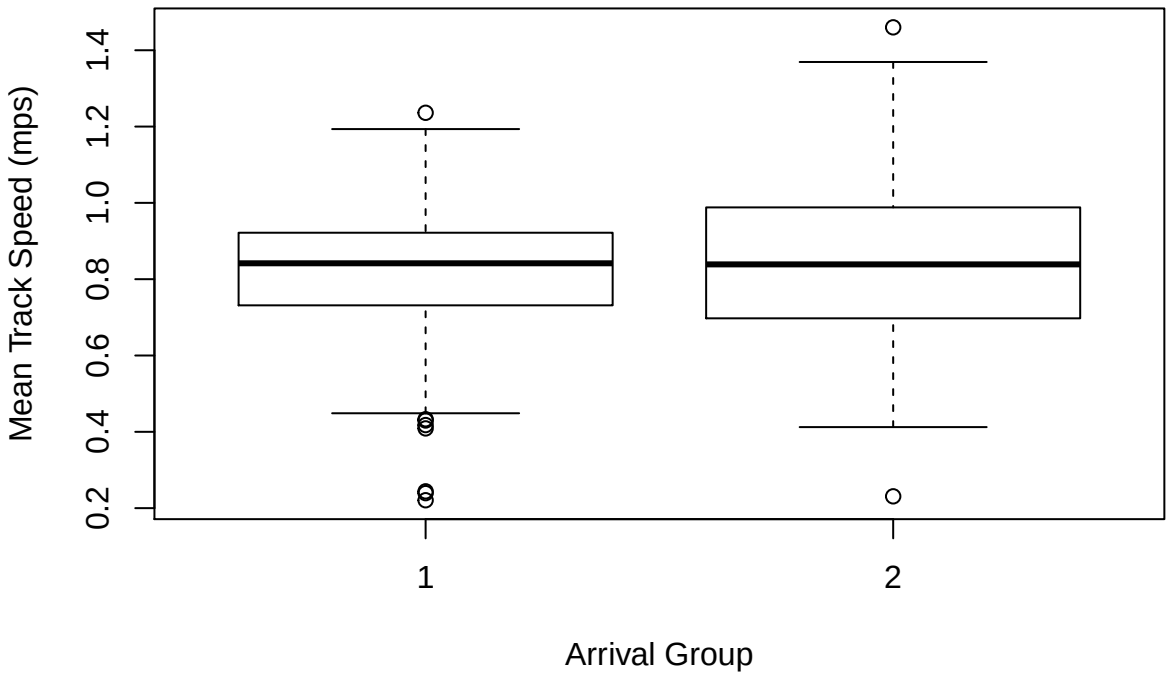
```
  t.test(mps ~ 0+grp, data = pathspd)
```

```
##
##  Welch Two Sample t-test
##
## data:  mps by grp
## t = -1.2758, df = 422.99, p-value = 0.2027
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.05799655  0.01234243
## sample estimates:
## mean in group 1 mean in group 2
##       0.8146227       0.8374498
```

```
   summarize(group_by(pathspd, grp), mean(mps, na.rm=T), sd(mps, na.rm=T))
```

```
## # A tibble: 2 x 3
##      grp mean(mps, na.rm = T) sd(mps, na.rm = T)
##   <fctr>                <dbl>              <dbl>
## 1      1            0.8146227          0.1742634
## 2      2            0.8374498          0.1962138
```

```
  boxplot(mps ~ grp, data = pathspd, ylab="Mean Track Speed (mps)", xlab="Arrival Group")
```



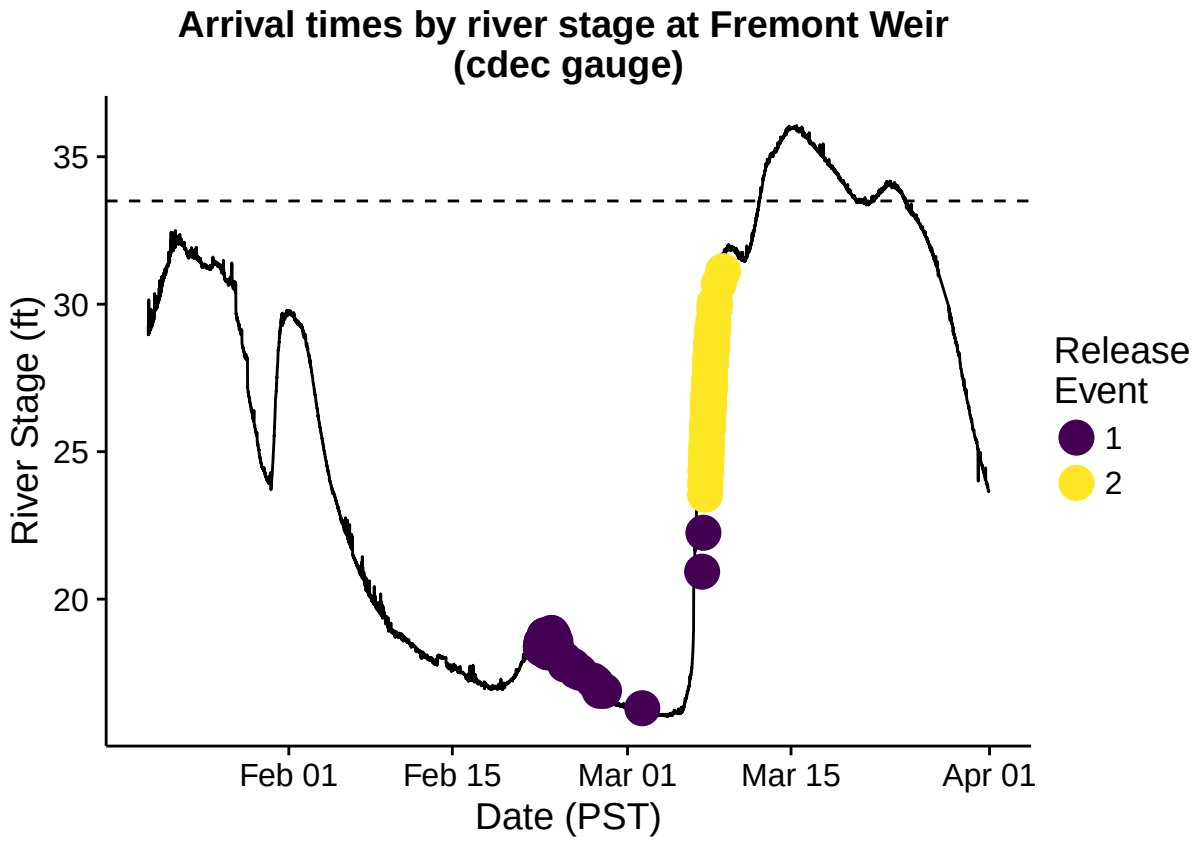
River Stage upon Arrival

```
##   RelEv med.stage mn.stage  sd.stage min.stage max.stage
## 1     1     18.42 18.42792 0.4378858     16.30     22.25
## 2     2     27.17 27.15220 1.3791167     23.54     31.12
```

```
##   grp med.stage mn.stage  sd.stage min.stage max.stage
## 1   1     18.42 18.39836 0.3077201     16.30     18.85
## 2   2     27.17 27.10069 1.4742635     20.93     31.12
```

```
## [1] 22.83977
```

```
## [1] 4.30517
```




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

build linear model to combine river stage, release event, and release hour (circular)

```r
omega = 2*pi/24
 cosrelhr = cos(omega*pathspd$RelHr)
 sinrelhr = sin(omega*pathspd$RelHr)

fullmod = lm(mps ~ factor(RelEv) + sinrelhr + cosrelhr + mnStg, data=pathspd)
  summary(fullmod)
```

```
##
## Call:
## lm(formula = mps ~ factor(RelEv) + sinrelhr + cosrelhr + mnStg,
##     data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.85723 -0.08173  0.01589  0.10621  0.42391
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.493357   0.168426  -2.929  0.00358 **
## factor(RelEv)2 -0.590157   0.081199  -7.268 1.76e-12 ***
## sinrelhr       -0.002119   0.012802  -0.166  0.86860
## cosrelhr        0.002489   0.011928   0.209  0.83477
## mnStg           0.070789   0.009089   7.788 5.26e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1715 on 425 degrees of freedom
## Multiple R-squared:  0.1553, Adjusted R-squared:  0.1474
## F-statistic: 19.54 on 4 and 425 DF,  p-value: 9.017e-15
```

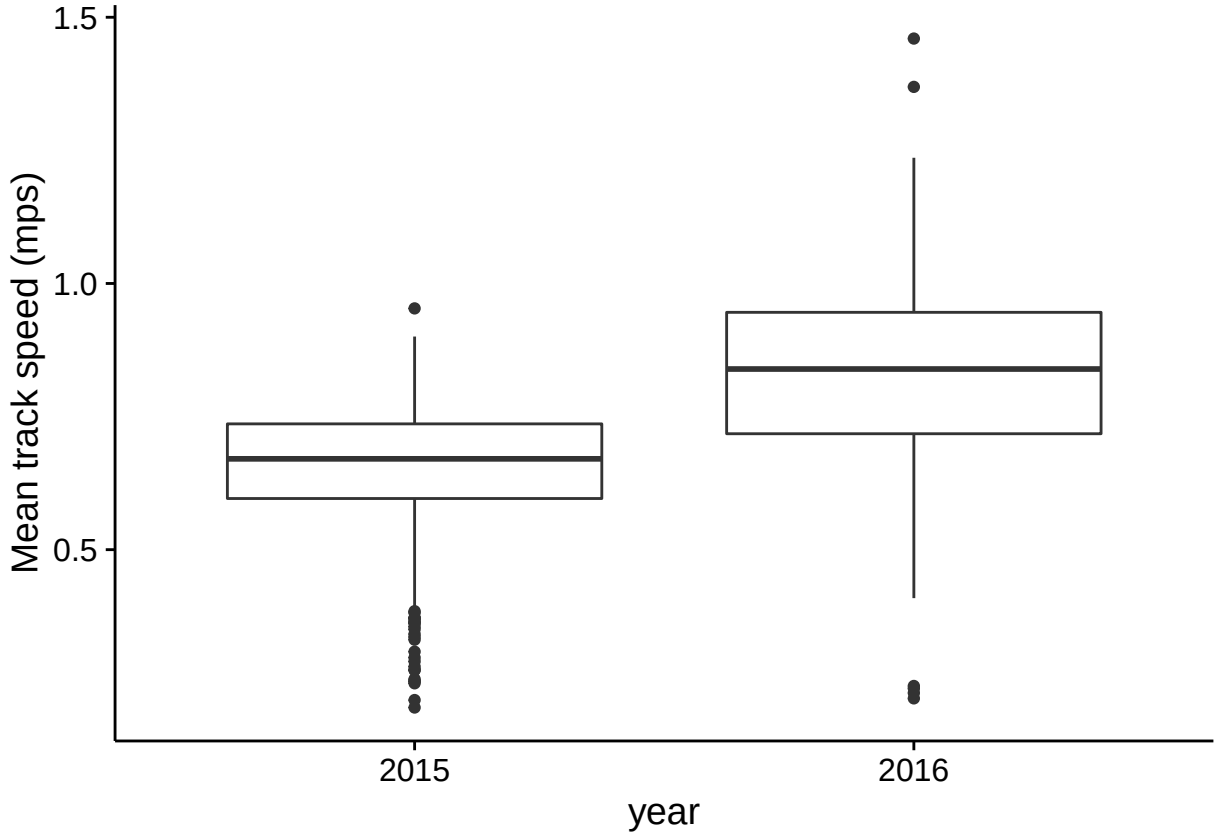
```r
 # plot(fullmod)  # meets assumptions well enough to be trusted
```

read in and run 2015 data for comparision

```
## [1] 14.56148
```

```
## [1] 0.0597606
```

Plot simple year comparisons




```
##
##  Welch Two Sample t-test
##
## data:  psyr$mps by psyr$year
## t = -16.014, df = 762.9, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1952181 -0.1525825
## sample estimates:
## mean in group 2015 mean in group 2016
##          0.6521890          0.8260893
```

```
## # A tibble: 2 x 3
##    year mean(mps)   sd(mps)
##   <chr>     <dbl>     <dbl>
## 1  2015 0.6521890 0.1290638
## 2  2016 0.8260893 0.1857500
```