Analysis_MovSpd_TempDisc

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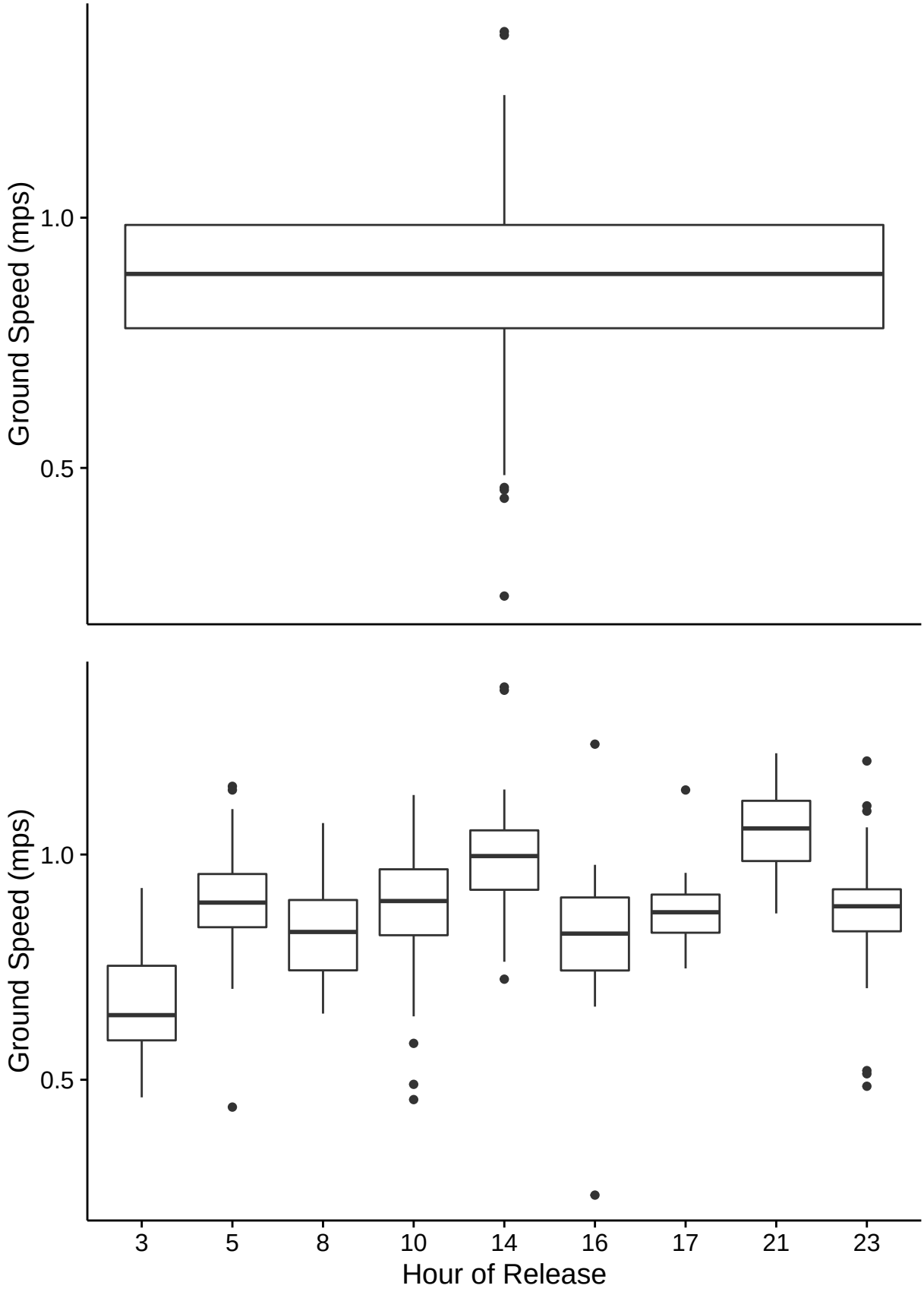
Movement Speed (mean spd per track)

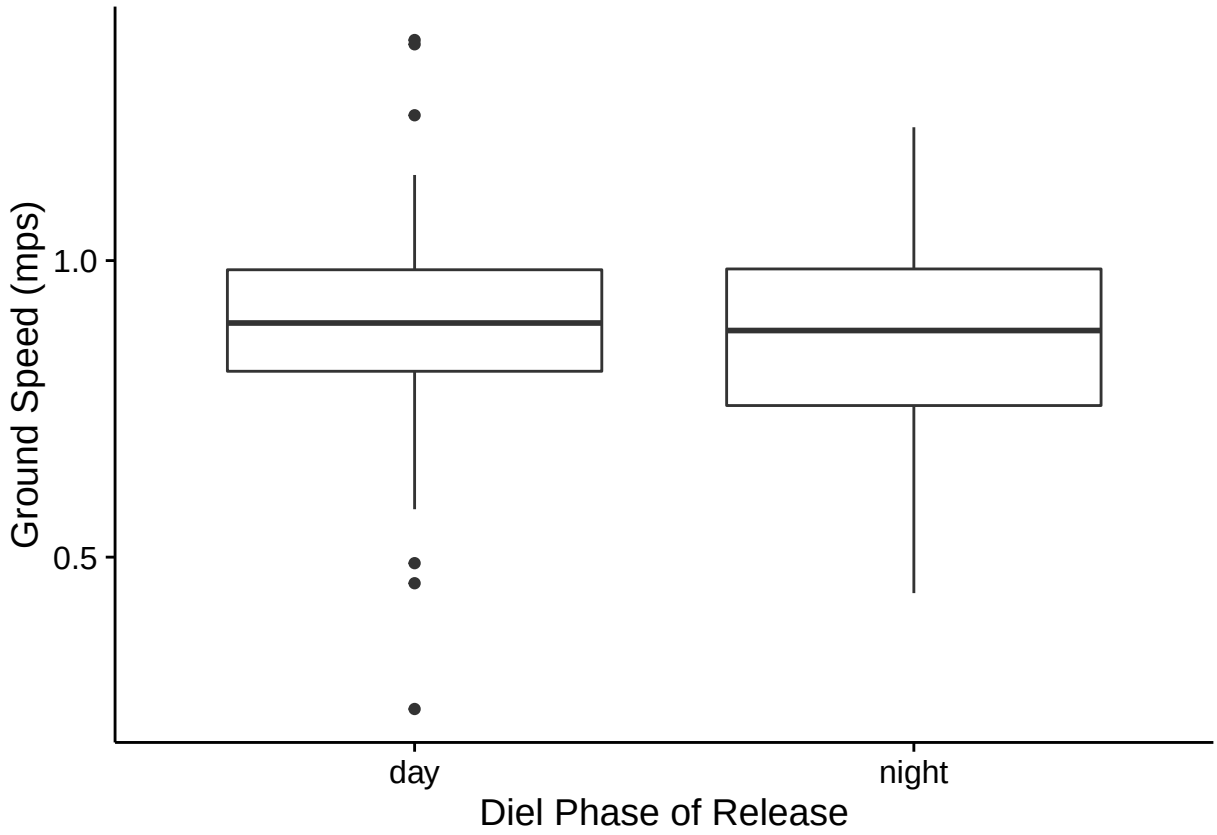
Using the dataset filtered and discretized by time, we'll calculate the mean movement speed per track
Visualize with a variety of plots

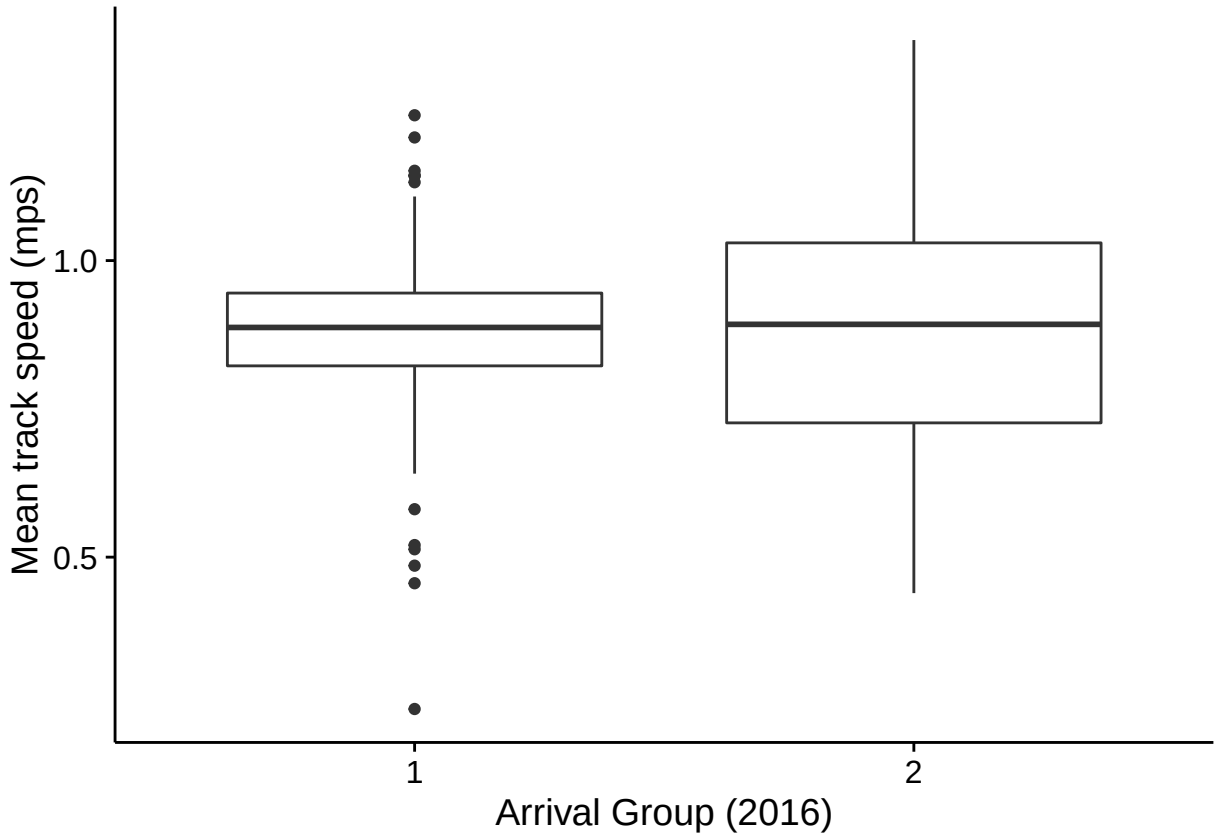
Calculate overall path speeds

Using path length and passage time

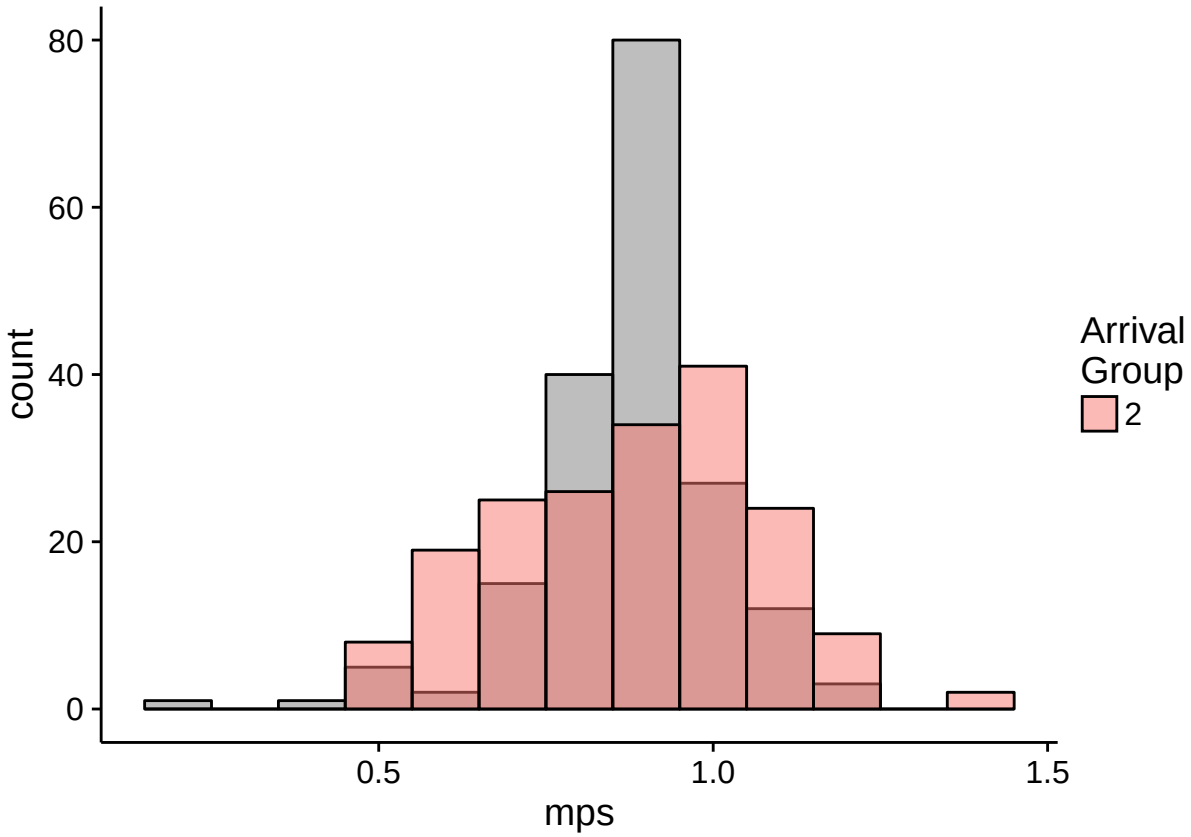
Plot all speeds

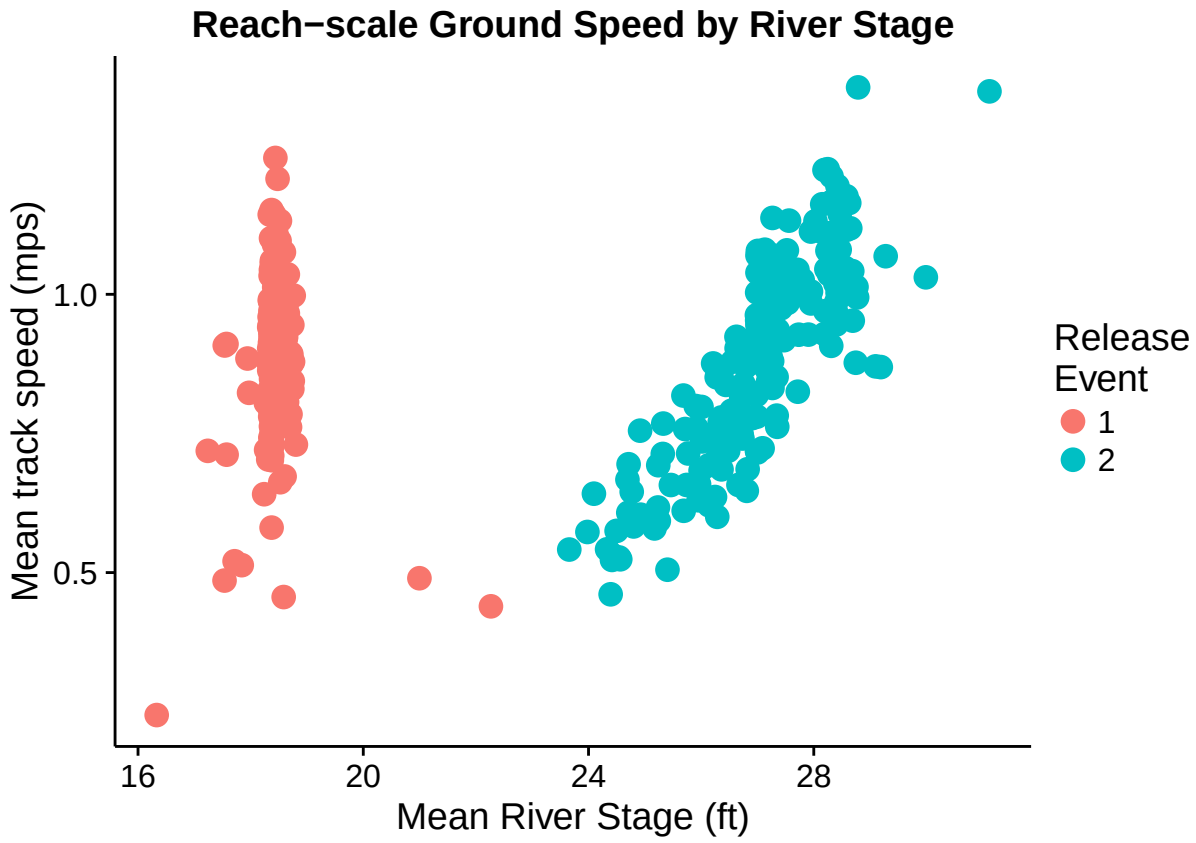



Ground Speed (mps)
1.0
0.5
day
night
Diel Phase of Release




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


80
60
40
20
0
count
0.5
1.0
1.5
mps
Arrival
Group
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
## -0.66763 -0.09466  0.00113  0.11018  0.47884
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.762502   0.015922  47.891  < 2e-16 ***
```

```
## RelHr       0.009320   0.001122   8.306 1.87e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1514 on 372 degrees of freedom
## Multiple R-squared:  0.1564, Adjusted R-squared:  0.1542
## F-statistic: 68.99 on 1 and 372 DF,  p-value: 1.867e-15
```

```
  #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)
```

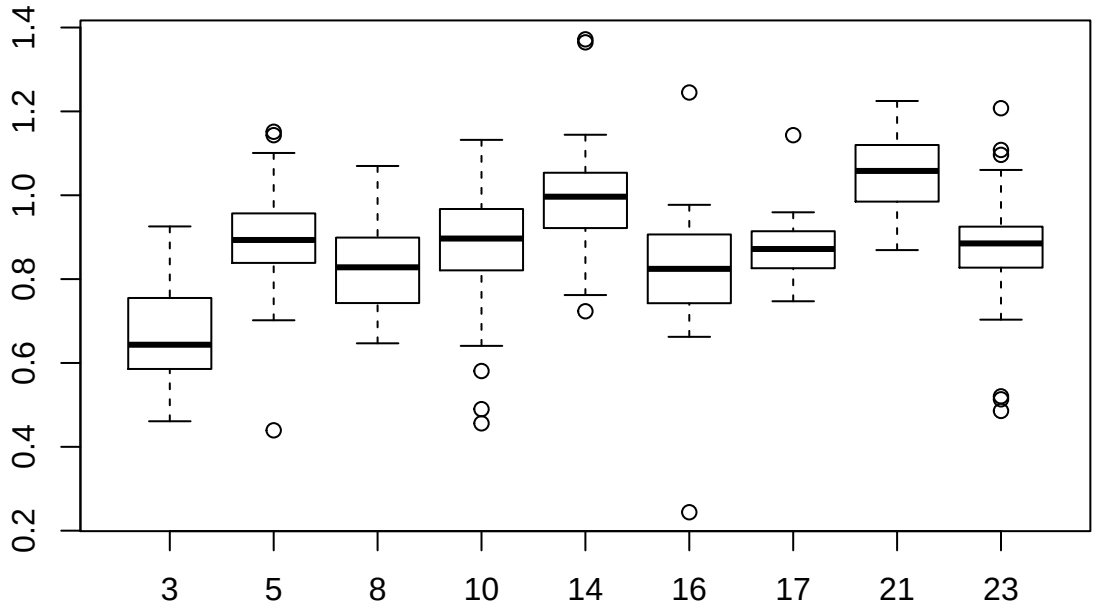
```
##
## Call:
## lm(formula = mps ~ 0 + RelHrfac, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.57027 -0.07142  0.00299  0.07044  0.43074
##
## Coefficients:
##            Estimate Std. Error t value Pr(>|t|)
## RelHrfac3   0.66585    0.01761   37.81   <2e-16 ***
## RelHrfac5   0.89687    0.01744   51.44   <2e-16 ***
## RelHrfac8   0.83540    0.01816   45.99   <2e-16 ***
## RelHrfac10  0.87646    0.01816   48.26   <2e-16 ***
## RelHrfac14  0.99019    0.01816   54.52   <2e-16 ***
## RelHrfac16  0.81426    0.02784   29.24   <2e-16 ***
## RelHrfac17  0.88227    0.03113   28.34   <2e-16 ***
## RelHrfac21  1.05759    0.01877   56.34   <2e-16 ***
## RelHrfac23  0.87072    0.01727   50.42   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1245 on 365 degrees of freedom
## Multiple R-squared:  0.981,  Adjusted R-squared:  0.9806
## F-statistic:  2096 on 9 and 365 DF,  p-value: < 2.2e-16
```

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

```
##
##   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     0.231025   0.024781   9.323  < 0.001 ***
## 8 - 3 == 0     0.169555   0.025298   6.702  < 0.001 ***
## 10 - 3 == 0    0.210609   0.025298   8.325  < 0.001 ***
## 14 - 3 == 0    0.324343   0.025298  12.821  < 0.001 ***
## 16 - 3 == 0    0.148411   0.032945   4.505  < 0.001 ***
## 17 - 3 == 0    0.216418   0.035765   6.051  < 0.001 ***
## 21 - 3 == 0    0.391739   0.025739  15.220  < 0.001 ***
## 23 - 3 == 0    0.204872   0.024663   8.307  < 0.001 ***
## 8 - 5 == 0    -0.061470   0.025178  -2.441  0.25749
## 10 - 5 == 0   -0.020416   0.025178  -0.811  0.99633
## 14 - 5 == 0    0.093318   0.025178   3.706  0.00719 **
## 16 - 5 == 0   -0.082614   0.032852  -2.515  0.22083
## 17 - 5 == 0   -0.014607   0.035680  -0.409  0.99998
## 21 - 5 == 0    0.160714   0.025620   6.273  < 0.001 ***
## 23 - 5 == 0   -0.026153   0.024540  -1.066  0.97761
## 10 - 8 == 0    0.041054   0.025686   1.598  0.79934
## 14 - 8 == 0    0.154788   0.025686   6.026  < 0.001 ***
## 16 - 8 == 0   -0.021144   0.033244  -0.636  0.99935
## 17 - 8 == 0    0.046863   0.036041   1.300  0.92806
## 21 - 8 == 0    0.222184   0.026120   8.506  < 0.001 ***
## 23 - 8 == 0    0.035318   0.025061   1.409  0.88986
## 14 - 10 == 0   0.113734   0.025686   4.428  < 0.001 ***
## 16 - 10 == 0  -0.062198   0.033244  -1.871  0.62527
## 17 - 10 == 0   0.005809   0.036041   0.161  1.00000
## 21 - 10 == 0   0.181130   0.026120   6.934  < 0.001 ***
## 23 - 10 == 0  -0.005737   0.025061  -0.229  1.00000
## 16 - 14 == 0  -0.175932   0.033244  -5.292  < 0.001 ***
## 17 - 14 == 0  -0.107926   0.036041  -2.995  0.06875 .
## 21 - 14 == 0   0.067395   0.026120   2.580  0.19207
## 23 - 14 == 0  -0.119471   0.025061  -4.767  < 0.001 ***
## 17 - 16 == 0   0.068007   0.041765   1.628  0.78205
## 21 - 16 == 0   0.243328   0.033580   7.246  < 0.001 ***
## 23 - 16 == 0   0.056461   0.032763   1.723  0.72417
## 21 - 17 == 0   0.175321   0.036352   4.823  < 0.001 ***
## 23 - 17 == 0  -0.011545   0.035598  -0.324  1.00000
## 23 - 21 == 0  -0.186866   0.025506  -7.326  < 0.001 ***
## ---
## 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
## -0.63028 -0.09815  0.01299  0.10511  0.49081
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.867519   0.026992  32.140   <2e-16 ***
## RelEv       0.006743   0.017044   0.396    0.693
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.1648 on 372 degrees of freedom
## Multiple R-squared:  0.0004206,  Adjusted R-squared:  -0.002266
## F-statistic: 0.1565 on 1 and 372 DF,  p-value: 0.6926
```

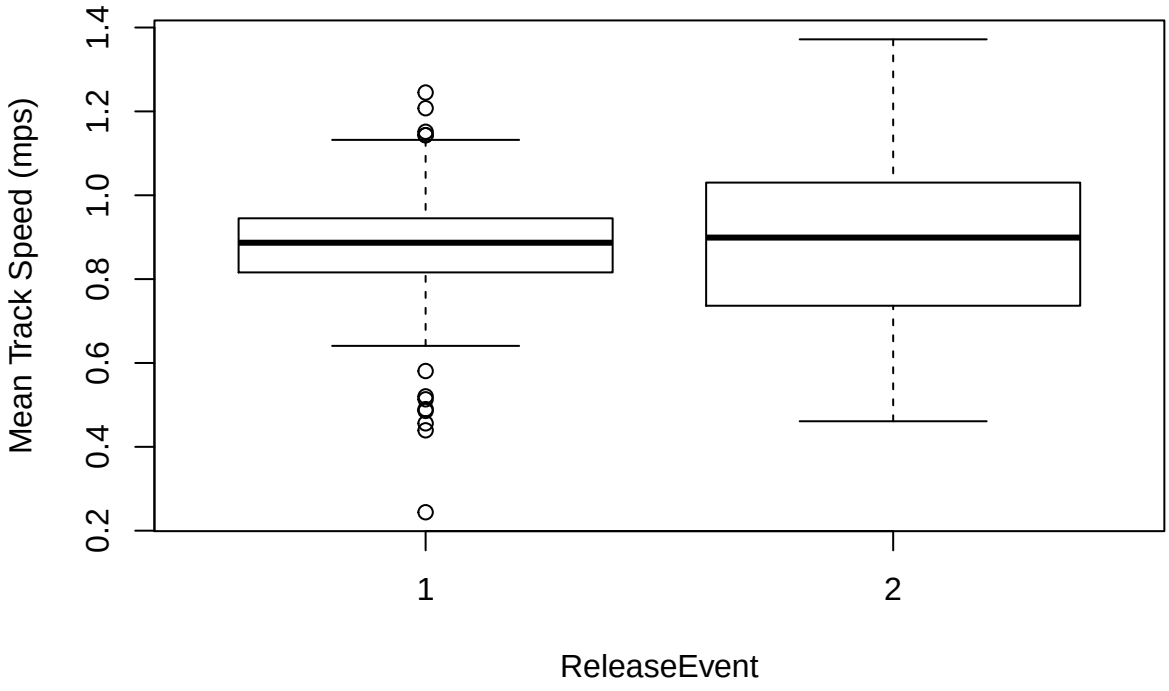
```
  #plot(mps.RelEv)  # meets assumptions pretty well?

  # 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 = -0.3963, df = 340.78, p-value = 0.6921
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.04021191  0.02672541
## sample estimates:
## mean in group 1 mean in group 2
##       0.8742626       0.8810058
```

```
   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            0.8742626          0.1364956
## 2        2            0.8810058          0.1886791
```

```
  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
## -0.63473 -0.09832  0.00934  0.10751  0.49520
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.878715   0.012152  72.310   <2e-16 ***
## grp2        -0.002093   0.017049  -0.123    0.902
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1648 on 372 degrees of freedom
## Multiple R-squared:  4.051e-05,  Adjusted R-squared:  -0.002648
```

```
## F-statistic: 0.01507 on 1 and 372 DF,  p-value: 0.9024
```

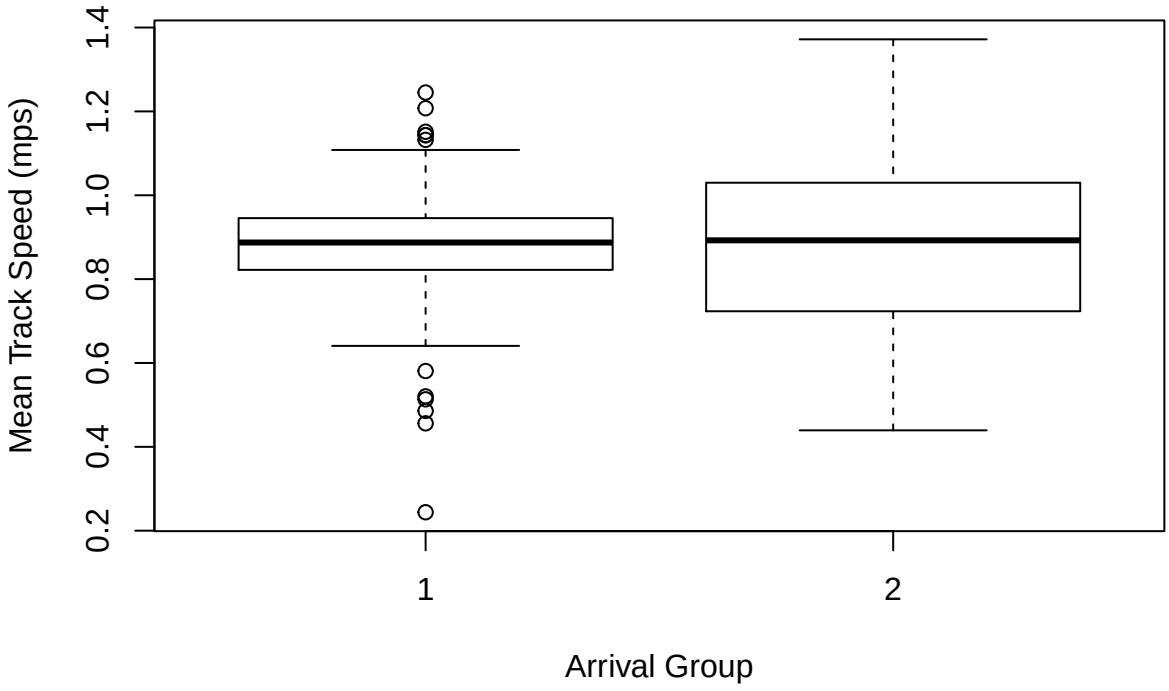
```
  t.test(mps ~ 0+grp, data = pathspd)
```

```
##
##  Welch Two Sample t-test
##
## data:  mps by grp
## t = 0.12349, df = 333.13, p-value = 0.9018
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.03124504  0.03543086
## sample estimates:
## mean in group 1 mean in group 2
##       0.8787155       0.8766226
```

```
   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            0.8787155          0.1302828
## 2      2            0.8766226          0.1924719
```

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



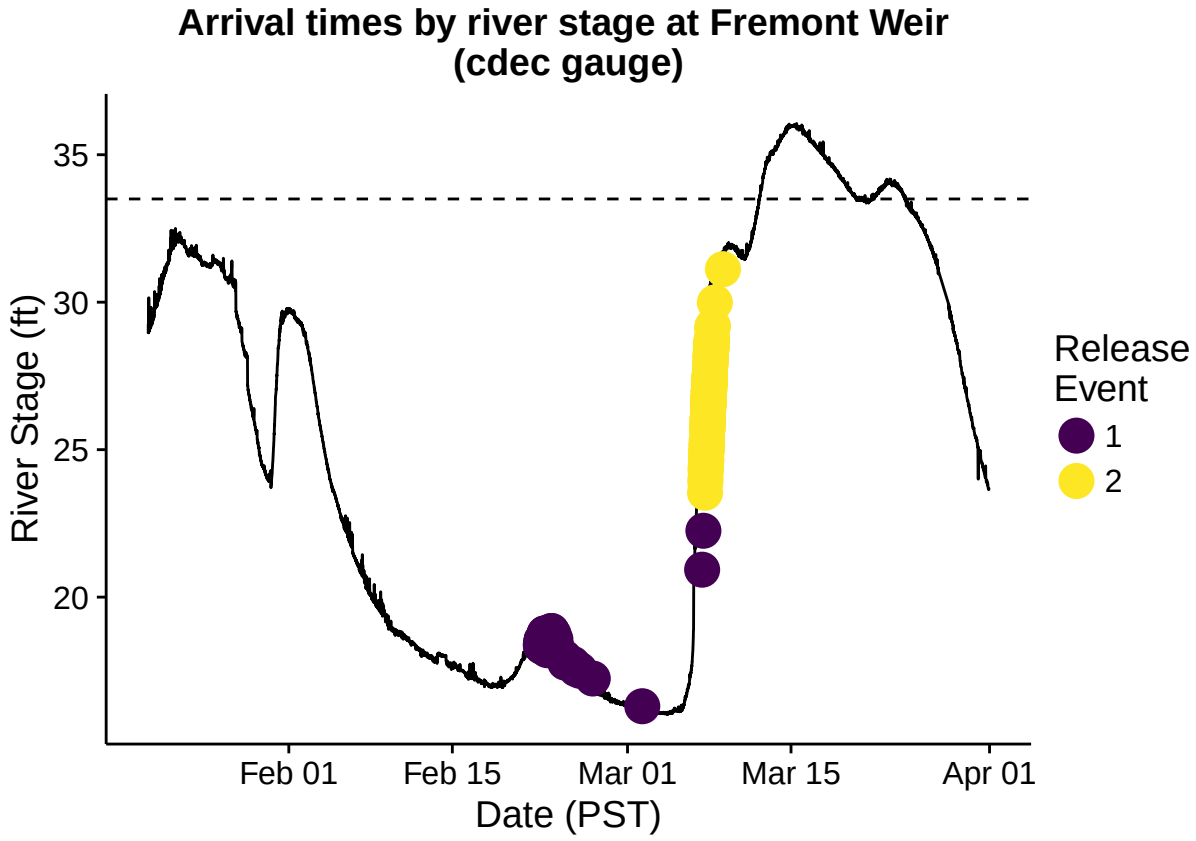
River Stage upon Arrival

```
##   RelEv med.stage mn.stage  sd.stage min.stage max.stage
## 1     1     18.42 18.44634 0.4304398     16.30     22.25
## 2     2     27.03 26.95830 1.3046151     23.54     31.12
```

```
##   grp med.stage mn.stage  sd.stage min.stage max.stage
## 1   1    18.420 18.41217 0.2708551     16.30     18.85
## 2   2    27.015 26.90179 1.4108041     20.93     31.12
```

```
## [1] 22.75891
```

```
## [1] 4.2544
```




```
## 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(grp) + sinrelhr + cosrelhr + mnStg, data=pathspd)
  summary(fullmod)
```

```
##
## Call:
## lm(formula = mps ~ factor(grp) + sinrelhr + cosrelhr + mnStg,
##     data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.44836 -0.06935  0.00130  0.06673  0.35022
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -1.257366   0.121663 -10.335   <2e-16 ***
## factor(grp)2 -0.991657   0.056939 -17.416   <2e-16 ***
## sinrelhr     -0.008175   0.009468  -0.863    0.388
## cosrelhr     -0.010113   0.008304  -1.218    0.224
## mnStg         0.116058   0.006554  17.708   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1125 on 369 degrees of freedom
## Multiple R-squared:  0.5384, Adjusted R-squared:  0.5334
## F-statistic: 107.6 on 4 and 369 DF,  p-value: < 2.2e-16
```

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

dielmod = lm(mps ~ factor(grp) + diel + mnStg, data=pathspd)
  summary(dielmod)
```

```
##
## Call:
## lm(formula = mps ~ factor(grp) + diel + mnStg, data = pathspd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.44361 -0.06552  0.00131  0.06324  0.36291
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -1.317405   0.107834 -12.217   <2e-16 ***
## factor(grp)2 -1.018700   0.050703 -20.091   <2e-16 ***
## dielnight    -0.001799   0.011722  -0.153    0.878
## mnStg         0.119284   0.005797  20.578   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

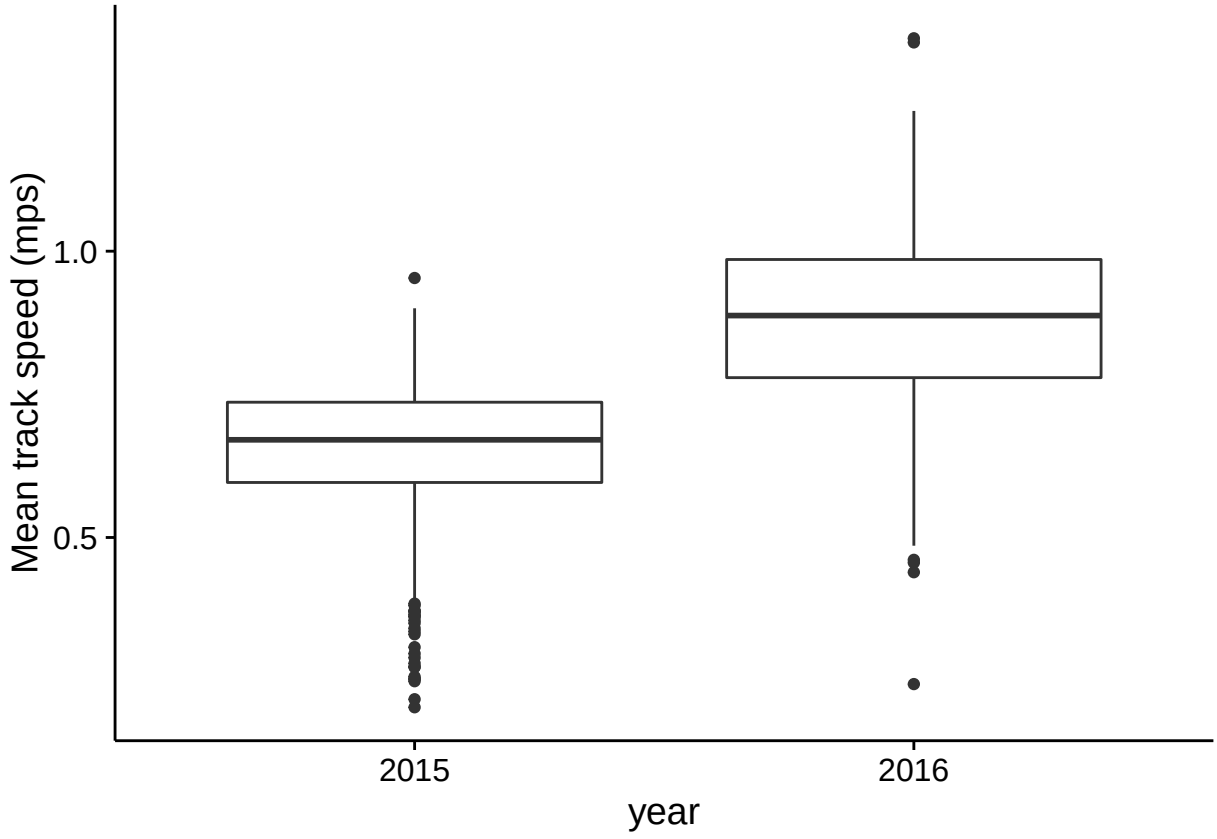
```
## Residual standard error: 0.1126 on 370 degrees of freedom
## Multiple R-squared:  0.5358, Adjusted R-squared:  0.5321
## F-statistic: 142.4 on 3 and 370 DF,  p-value: < 2.2e-16
```

read in and run 2015 data for comparision

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

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

Plot simple year comparisons




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

```
##
##  Welch Two Sample t-test
##
## data:  psyr$mps by psyr$year
## t = -21.483, df = 701.42, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.2460686 -0.2048578
```

```
## sample estimates:
## mean in group 2015 mean in group 2016
##          0.6521890          0.8776522
```

```
## # A tibble: 2 x 3
##    year mean(mps)   sd(mps)
##   <chr>     <dbl>     <dbl>
## 1  2015 0.6521890 0.1290638
## 2  2016 0.8776522 0.1646197
```