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Introducing selfisher: open source software for statistical analyses of fishing gear selectivity

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Published in:
Canadian Journal of Fisheries and Aquatic Sciences

Link to article, DOI:
10.1139/cjfas-2021-0099

Publication date:
2022

Document Version
Other version

Link back to DTU Orbit

Citation (APA):
Brooks, M. E., Melli, V., Savina, E. A. C. M., Santos, J., Millar, R. B., O'Neill, F. G., Veiga-Malta, T., Krag, L. A., & Feekings, J. P. (2022). Introducing selfisher: open source software for statistical analyses of fishing gear selectivity. *Canadian Journal of Fisheries and Aquatic Sciences*, *79*(8), 1189-1197. https://doi.org/10.1139/cjfas-2021-0099

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Supplementary material C: Catch comparison on unpaired hauls

20 Oct 2021

This example deals with data from an experiment originally published by Savina et al. (2017). Two soak tactics, i.e., 12h at day and 12h at night, were compared in the Danish gillnet plaice fishery to estimate whether a change in soak tactics could help to catch less of the unwanted bycatch, i.e., the invertebrate edible crab (*Cancer pagurus*). The method developed by Herrmann et al. (2017) for assessing the relative length-dependent catch efficiency effect of changing from soak tactic *Day* to *Night* was used. This example is representative of experimental fishing where the catch data obtained for two different gear designs were not collected in pairs, and can allow for a different number of deployments.

Preliminaries

```
library(selfisher)
library(plyr) # for aggregating data across hauls
library(ggplot2); theme_set(theme_bw())
library(splines) # for bs function
```

Data structure

Load the data and check out the variables. This is a subset of the original dataset (one species, two soak durations). The data contains the length measurement of each individual to the nearest mm below (carapace width), as specified in the column "width". Every day for 7 days (I to VII), three fleets (each consisting of three gillnets tied together, and labelled A, B and C) were soaked for 12 h during the day (*Day*) and three others during the night (*Night*). Each deployment of a fleet is considered as a "haul" (with haul name written as Day_Soak_Fleet). Gear unit design is the soak tactic, specified in the column "tactic", with two levels: 12h at day (*Day*) and 12h at night (*Night*). "total" gives the number of individuals for each length class and haul. There was no sub-sampling.

```
data("compcrab")
head(compcrab)
```

```
## # A tibble: 6 x 4
## # Groups:   width, haul [6]
##   width haul        tactic total
##   <dbl> <fct>       <fct>  <int>
## 1  58.5 VII_Night_B Night      1
## 2  63.5 VI_Night_B  Night      1
## 3  64.5 I_Night_B   Night      1
## 4  66.5 VII_Day_A   Day        1
## 5  69.5 VII_Night_B Night      1
## 6  70.5 VI_Night_B  Night      1
```

```
summary(compcrab)
```

```
##      width                haul       tactic        total
##  Min.   : 58.5   VII_Night_A: 49   Day  :117   Min.   :1.000
##  1st Qu.: 99.5   VI_Night_B : 38   Night:446   1st Qu.:1.000
##  Median :115.5   V_Night_B  : 34               Median :1.000
##  Mean   :117.2   VII_Night_B: 33               Mean   :1.181
##  3rd Qu.:133.5   V_Night_A  : 28               3rd Qu.:1.000
##  Max.   :197.5   I_Night_B  : 27               Max.   :5.000
##                  (Other)    :354
```

Here we can see that all hauls are contained in one data frame, organized into what is called "long format", with *Day* and *Night* one after the other (unpaired).

Transforming data

For a model in `selfisher`, we need to convert counts into proportions and totals. We use the 'ddply' function to calculate the proportion of fish entering one of the gear design (here *Night*) for each length class and haul, i.e., 1 for *Night* and 0 for *Day*.

```
dat = ddply(compcrab, ~width+haul+tactic, mutate,
                prop = as.numeric(tactic == "Night")
                )
```

Catch comparison

The following is a typical model for catch comparison of multiple haul data without subsampling using spline with the `bs` function.

```
mod = selfisher(prop ~ bs(width, df = 3), total = total, haul = haul, pool = tactic, data = dat)
```

This models the proportion of fish in *Night* versus *Day* (`prop`) as a function of `width`. The `selfisher` function takes the `total` number of fish in *Day* and *Night* using a separate argument, `total`. The argument `haul` needs to be specified in order to perform double-bootstrapping as demonstrated below. Otherwise, it could be omited from the model specification as it doesn't affect the fit. The `haul` argument tells the software how to group the data for resampling in the bootstrapping procedure. `pool` represents the different pools of hauls, i.e., one for each soak tactic, that is used in double bootstrap to produce same number of hauls by pool. Indeed, because the catch data obtained for *Day* and *Night* were not collected in pairs (and may not have the same total number of deployments), we sum data of the deployments carried out with *Day*, and data of the deployments carried out with *Night*.

Then we create a new data set to make predictions on.

```
newdata = expand.grid(width = unique(dat$width),
                total = 1,
                haul = 0,
                tactic = NA) #not used as a predictor, so it doesn't matter

newdata$prop = predict(mod, newdata = newdata, type = "response")
```

Bootstrap to get CI on predictions

The code below runs in parallel on Mac and Linux computers as written here, but a Windows version was given above. This call to the function `bootSel` predicts the response variable based on the model `mod` and the covariates in `newdata`. Then we calculate the quantiles of the bootstrapped response variable, and transform the proportion into a catch ratio.

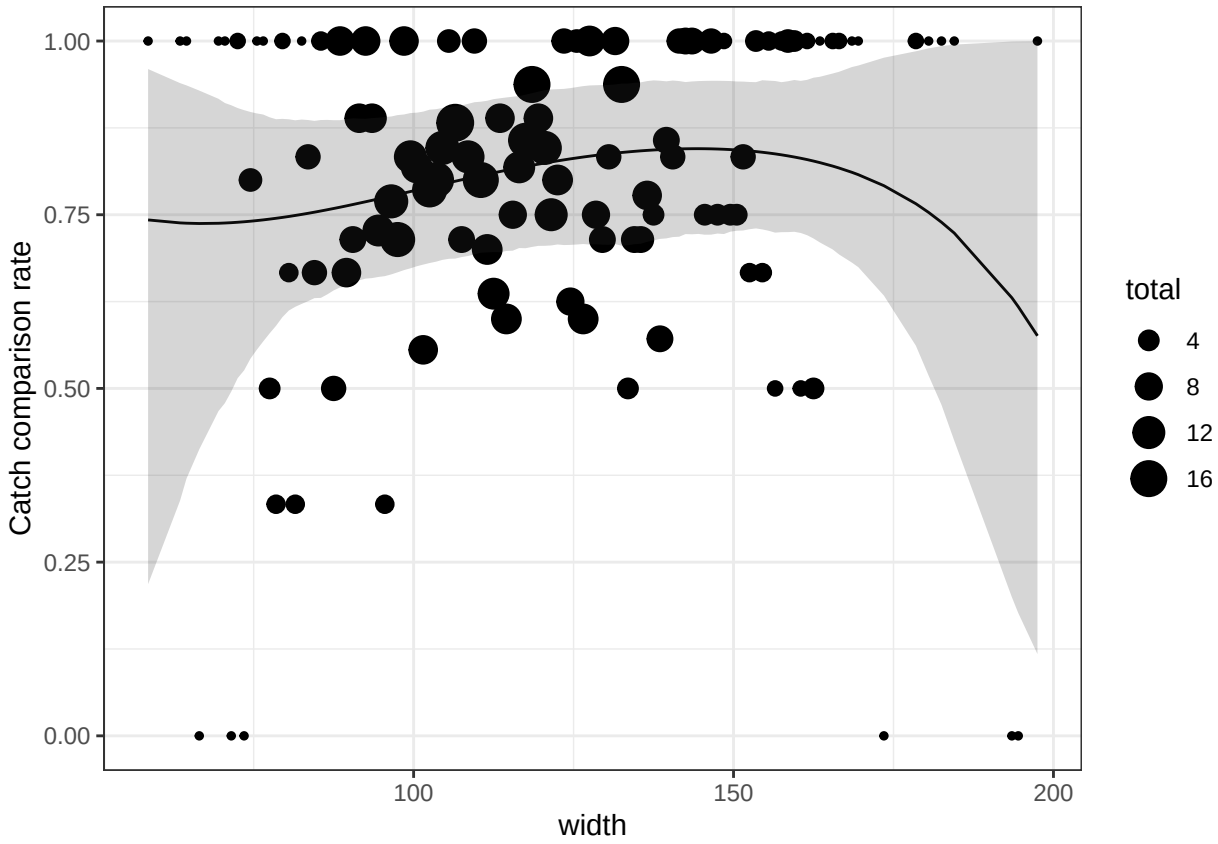
```
bs = bootSel(mod, nsim = 1000, parallel = "multicore", ncpus = 4,
                      FUN = function(mod){predict(mod, newdata = newdata, type = "response")})

quants = apply(bs$t, 2, quantile, c(0.025, 0.5, 0.975))
newdata[,c("lo", "mid", "hi")] = t(quants)

bs$CR = bs$t/(1-bs$t)
CRquants = apply(bs$CR, 2, quantile, c(0.025, 0.5, 0.975))
newdata[,c("CRlo", "CRmid", "CRhi")] = t(CRquants)
```

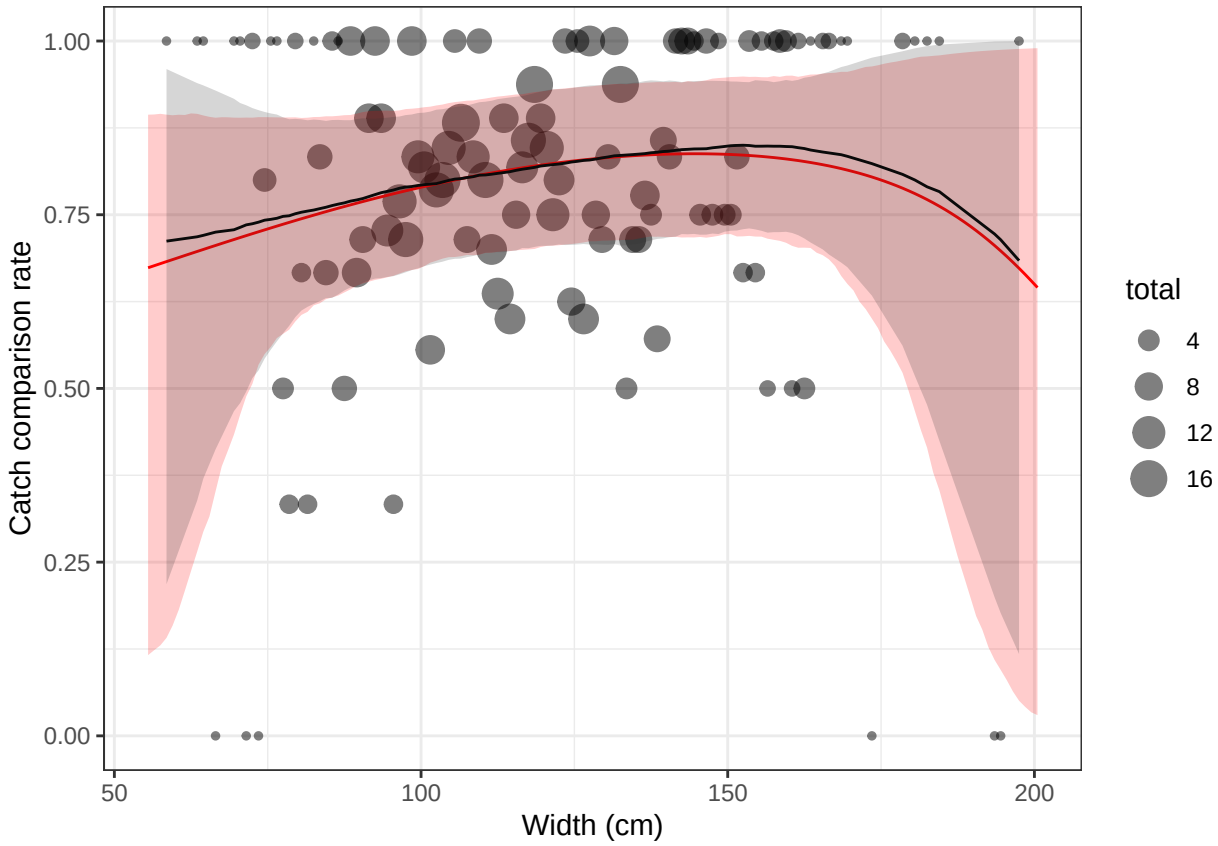
Plot predictions

For plotting, we need to aggregate the hauls.

```
sumdat = ddply(dat, ~width, summarize,
                prop = sum(total*prop)/sum(total),
                total = sum(total),
                CR = sum(prop)/sum(1-prop)
                )
```

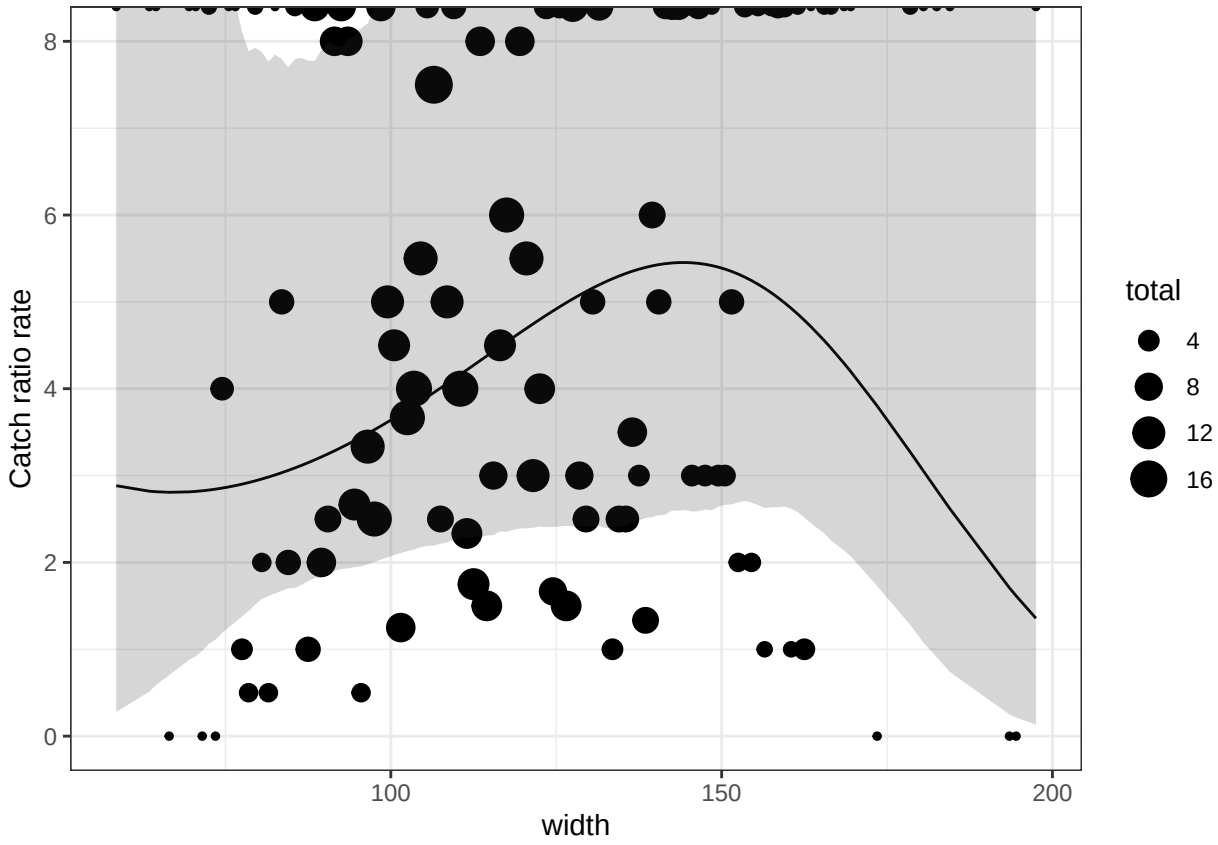
```
ggplot(sumdat, aes(width, prop))+geom_point(aes(size=total))+
   geom_line(data = newdata)+
   geom_ribbon(data = newdata, aes(ymin = lo, ymax = hi), alpha = 0.2)+
     ylab("Catch comparison rate")
```


1.00
0.75
0.50
0.25
0.00
Catch comparison rate
100
150
200
width
total
4
8
12
16



This graphical comparison to the published results in Savina et al. (2017; in red) shows that the estimated catch comparison curves and relative CIs are very similar. Here the black line is the median from the bootstraps, rather than the MLE.

```
ggplot(sumdat, aes(width, prop/(1-prop))) + geom_point(aes(size = total))+
   geom_line(data = newdata)+
   geom_ribbon(data = newdata, aes(ymin = CRlo, ymax = CRhi), alpha = 0.2)+
    ylab("Catch ratio rate")+
    coord_cartesian(ylim = c(0,8))
```



The catch comparison curves properly reflected the trend in the experimental points. The experimental rates were subject to increasing binomial noise outside the length classes representing the main bulk of the catches. The results for edible crab showed significantly higher catches for 12 h at night compared to 12 h at day. On average, there were four times more catches for 12 h at night than 12 h at day. There was no strong indication of a length dependency in the data.

References

Herrmann, B., Sistiaga, M., Rindahl, L., Tatone, I. (2017). Estimation of the effect of gear design changes on catch efficiency: methodology and a case study for a Spanish longline fishery targeting hake (Merluccius merluccius). Fisheries Research, 185, 153-160.

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