SURE Project

August 25, 2022

Objective

Validate predictions using LANDSAT data for kelp area.

```
# set a directory
w.dir <- here()
d.dir <- here('data')

# load kelp area csv
area_df <- read.csv(paste(d.dir, 'NC_Landsat_kelp_area_1984_2021.csv', sep ='/')) %>%
  glimpse()
```

```
## Rows: 5,748,336
## Columns: 6
## $ lat          <dbl> 42.00981, 42.00981, 42.00981, 42.00981, 42.00981, 42.0098~
## $ lon          <dbl> -124.2244, -124.2244, -124.2244, -124.2244, -124.2244, -1~
## $ year_quarter <chr> "1984 1", "1984 2", "1984 3", "1984 4", "1985 1", "1985 2~
## $ area         <int> NA, 0, 105, 0, 0, 0, NA, 0, NA, 0, 0, 0, 0, NA, 0, NA, NA~
## $ year         <int> 1984, 1984, 1984, 1984, 1985, 1985, 1985, 1985, 1986, 198~
## $ quarter      <int> 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, ~
```

```
# vector of year
area_df$year %>% unique() # 1984 - 2021
```

```
##  [1] 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
## [16] 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
## [31] 2014 2015 2016 2017 2018 2019 2020 2021
```

```
area_df$year %>% unique() %>% length() # 38
```

```
## [1] 38
```

```
# Landsat kelp quarters: Q1 = Winter, Q2 = Spring, Q3 = Summer, Q4 = Fall
# make an sf object from dataframe
kelp_area <- area_df %>%
  filter(quarter == 3) %>%
  mutate_at(vars(year, quarter), list(as.factor)) %>%
  st_as_sf(coords = c('lon', 'lat'))

# load kelp density predictions csv
density_df <- read.csv(paste(d.dir, 'NC_kelp_density_predictions.csv', sep ='/')) %>%
  glimpse()
```

```
## Rows: 400
## Columns: 5
## $ site_name <chr> "Caspar", "Caspar North", "Dark Gulch", "Flat Iron Rock", "F~
## $ year      <int> 2006, 2006, 2006, 2006, 2006, 2006, 2006, 2006, 2006, 2006, ~
## $ fit       <dbl> 0.5090384, 0.5003366, 0.5309656, 0.7382968, NA, 0.8228083, N~
## $ longitude <dbl> -123.8220, -123.8213, -123.7762, -124.1578, -123.2450, -123.~
## $ latitude  <dbl> 39.36173, 39.36443, 39.24030, 41.05942, 38.51060, 39.35503, ~
```

```r
# make an sf object from dataframe
kelp_density <- density_df %>%
  mutate_at(vars(year), list(as.factor)) %>%
  rename(lon = longitude, lat = latitude) %>%
  st_as_sf(coords = c('lon', 'lat'))
```

To compute a distance matrix between each site location and the kelp area for each summer, and find the closest landsat pixel to each site.

```r
# calculate the distance and match predicted kelp density to Landsat kelp area
site_name <- kelp_density[, c('site_name', 'geometry')] %>% unique()
area_1984 <- filter(kelp_area, year == 1984) # 37818
# distance matrix for 1984
mx <- st_distance(st_sfc(area_1984$geometry), st_sfc(site_name$geometry))
colnames(mx) <- site_name$site_name
head(mx)
```

```
##        Caspar Caspar North Dark Gulch Flat Iron Rock Fort Ross Frolic Cove
## [1,] 2.678480     2.675913   2.805551      0.9527113  3.633694    2.684829
## [2,] 2.678531     2.675964   2.805605      0.9527328  3.633787    2.684879
## [3,] 2.678581     2.676015   2.805659      0.9527545  3.633881    2.684929
## [4,] 2.678632     2.676066   2.805714      0.9527763  3.633975    2.684980
## [5,] 2.678212     2.675645   2.805284      0.9524415  3.633432    2.684561
## [6,] 2.677894     2.675327   2.804962      0.9521502  3.633077    2.684243
##      Gerstle Cove Glass Beach MacKerricher North Mendocino Headlands Monument
## [1,]     3.557617    2.590761           2.552208            2.735943 3.120724
## [2,]     3.557704    2.590815           2.552264            2.735994 3.120777
## [3,]     3.557792    2.590868           2.552320            2.736045 3.120830
## [4,]     3.557879    2.590922           2.552377            2.736096 3.120883
## [5,]     3.557354    2.590494           2.551941            2.735675 3.120456
## [6,]     3.557004    2.590173           2.551617            2.735357 3.120136
##      Ocean Cove Pebble Beach Point Arena Lighthouse Point Arena MPA (M2)
## [1,]   3.574772     3.409586               3.096108             3.102896
## [2,]   3.574862     3.409666               3.096160             3.102949
## [3,]   3.574951     3.409745               3.096213             3.103002
## [4,]   3.575040     3.409824               3.096265             3.103054
## [5,]   3.574510     3.409322               3.095840             3.102629
## [6,]   3.574158     3.408979               3.095520             3.102308
##      Point Arena Ref Portuguese Beach Pyramid Point Russian Gulch Salt Point
## [1,]        3.142715         2.739189    0.01674596      2.713811   3.559378
## [2,]        3.142770         2.739241    0.01690645      2.713863   3.559466
## [3,]        3.142824         2.739293    0.01707312      2.713915   3.559553
## [4,]        3.142879         2.739345    0.01724579      2.713966   3.559641
## [5,]        3.142448         2.738921    0.01650201      2.713544   3.559116
## [6,]        3.142126         2.738602    0.01610019      2.713224   3.558766
```

```
##      Stillwater Sonoma Stornetta Timber Cove  Trinidad Van Damme
## [1,]          3.593450  3.111776    3.605898 0.9585312  2.771222
## [2,]          3.593541  3.111829    3.605990 0.9585594  2.771274
## [3,]          3.593632  3.111883    3.606081 0.9585876  2.771327
## [4,]          3.593722  3.111936    3.606173 0.9586160  2.771379
## [5,]          3.593188  3.111508    3.605636 0.9582617  2.770955
## [6,]          3.592836  3.111187    3.605283 0.9579642  2.770635
```

```
area_1984 <- area_df %>%
  filter(quarter == 3 & year == 1984) %>%
  select(-year_quarter) %>%
  mutate(
    site_name = apply(mx, 1, FUN = function(x) names(x) [which.min(x)]),
    .before = lat
  )
  # group_by(site_name) %>%
  # summarise(mean_area = mean(area, na.rm = TRUE),
  #           se_area = std.error(area, na.rm = TRUE))
head(area_1984)
```

```
##       site_name      lat       lon area year quarter
## 1 Pyramid Point 42.00981 -124.2244  105 1984       3
## 2 Pyramid Point 42.00980 -124.2248    0 1984       3
## 3 Pyramid Point 42.00980 -124.2252    0 1984       3
## 4 Pyramid Point 42.00979 -124.2255    0 1984       3
## 5 Pyramid Point 42.00954 -124.2244    0 1984       3
## 6 Pyramid Point 42.00927 -124.2241   93 1984       3
```

```
# using for loop
# declaring an empty data frame
# kelp_area2 <- data.frame(site_name = character(),
#                          lat = numeric(),
#                          lon = numeric(),
#                          area = numeric(),
#                          year = numeric(),
#                          quarter = numeric())
#
# for (i in c(1984:2021)) {
#   area_year <- filter(kelp_area, year == i)
#
#   # distance matrix for year i
#   mx <- st_distance(st_sfc(area_year$geometry), st_sfc(site_name$geometry))
#   colnames(mx) <- site_name$site_name
#
#   area_year <- area_df %>%
#     filter(quarter == 3 & year == i) %>%
#     select(-year_quarter) %>%
#     mutate(
#       site_name = apply(mx, 1, FUN = function(x) names(x) [which.min(x)]),
#       .before = lat
#     )
#
#   kelp_area2 <- rbind(kelp_area2, area_year)
```

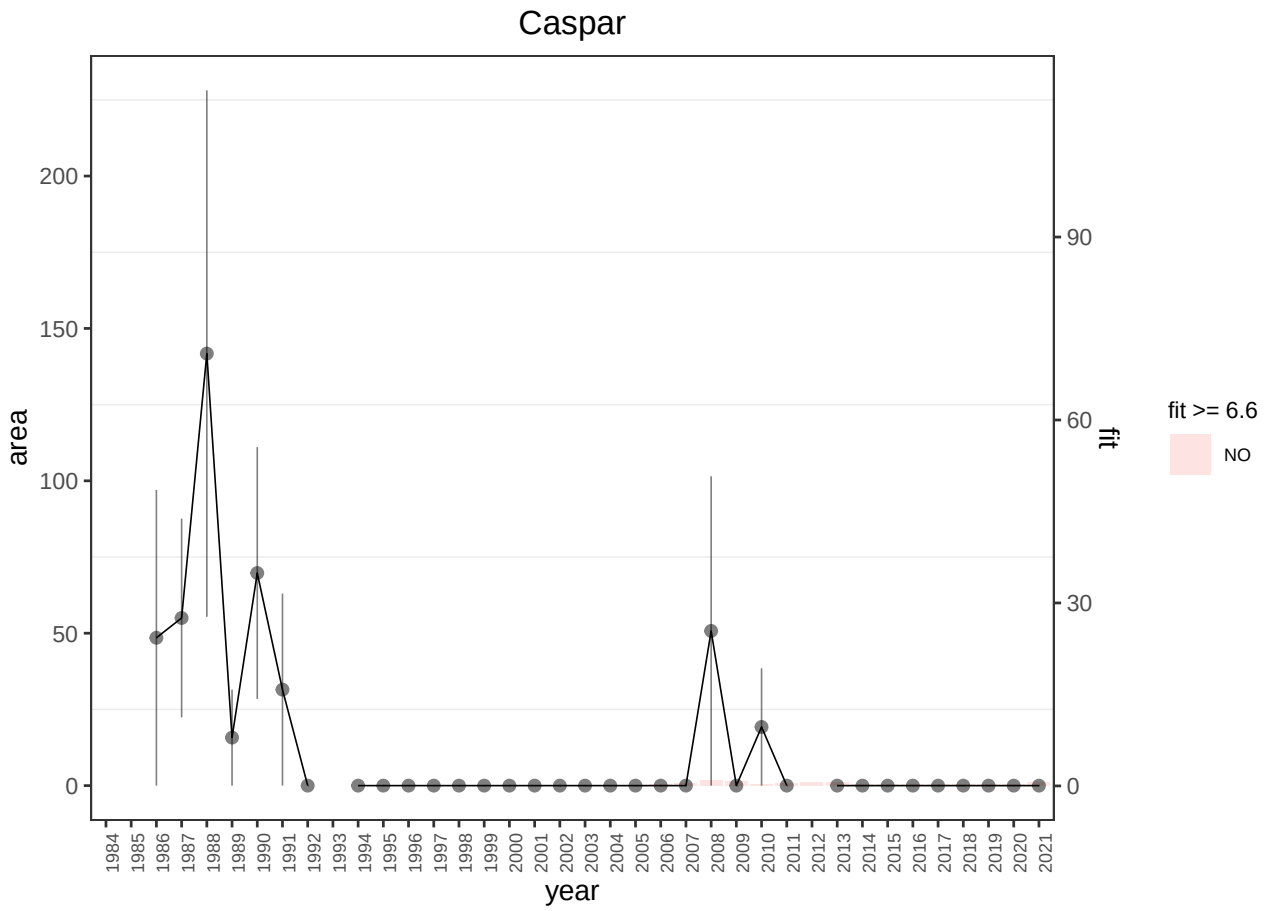
```
# }
# dim(kelp_area2) # 38 * 37818 = 1437084
#
# head(kelp_area2)
#
# write to file
# write.csv(kelp_area2, file.path(d.dir, 'NC_kelp_area_1984_2021_site_name.csv'), row.names = FALSE)
```

```
# plotting
kelp_area <- read.csv(paste(d.dir, 'NC_kelp_area_1984_2021_site_name.csv', sep ='/')) %>%
  mutate_at(vars(year), list(as.factor))

kelp_area3 <- kelp_area %>%
  group_by(site_name, year) %>%
  summarise(mean_area = mean(area, na.rm = TRUE),
            se_area = std.error(area, na.rm = TRUE))

sites <- kelp_area3$site_name %>% unique()

for (i in sites) {
  plot <- ggplot() +
    geom_bar(data = filter(kelp_density, site_name == i),
             aes(x = year, y = fit,
                 fill = ifelse(!is.na(fit) & fit >= 6.6, 'YES', 'NO')),
             stat = 'identity', position = 'dodge', alpha = 0.2) +
    geom_pointrange(data = filter(kelp_area3, site_name == i),
                    aes(x = year, y = mean_area,
                        ymin = mean_area - se_area,
                        ymax = mean_area + se_area),
                    alpha = 0.5, size = 0.3) +
    geom_line(data = filter(kelp_area3, site_name == i),
              aes(x = year, y = mean_area, group = 1), size = 0.3) +
    scale_y_continuous(name = 'area',
                       sec.axis = sec_axis(~./2, name = 'fit')) +
    labs(fill = 'fit >= 6.6', title = i) +
    theme_bw() +
    theme(axis.text.x = element_text(angle = 90, size = 7),
          plot.title = element_text(hjust = 0.5),
          panel.grid.major = element_blank(),
          legend.title = element_text(size = 9),
          legend.text = element_text(size = 7))
  print(plot)
}
```


Caspar
area
fit
year
fit >= 6.6
NO
0
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1984
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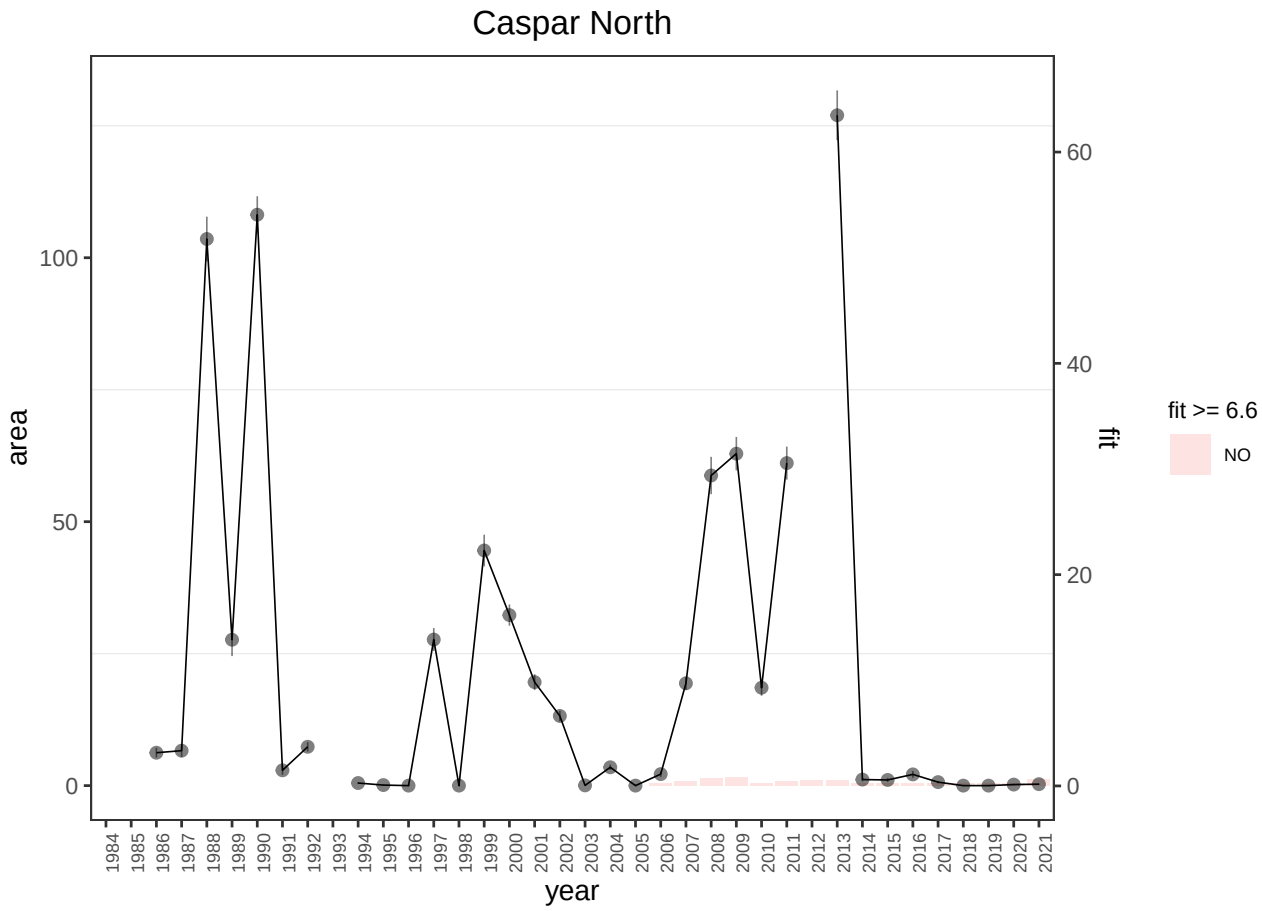
2021


Caspar North
area
fit
year
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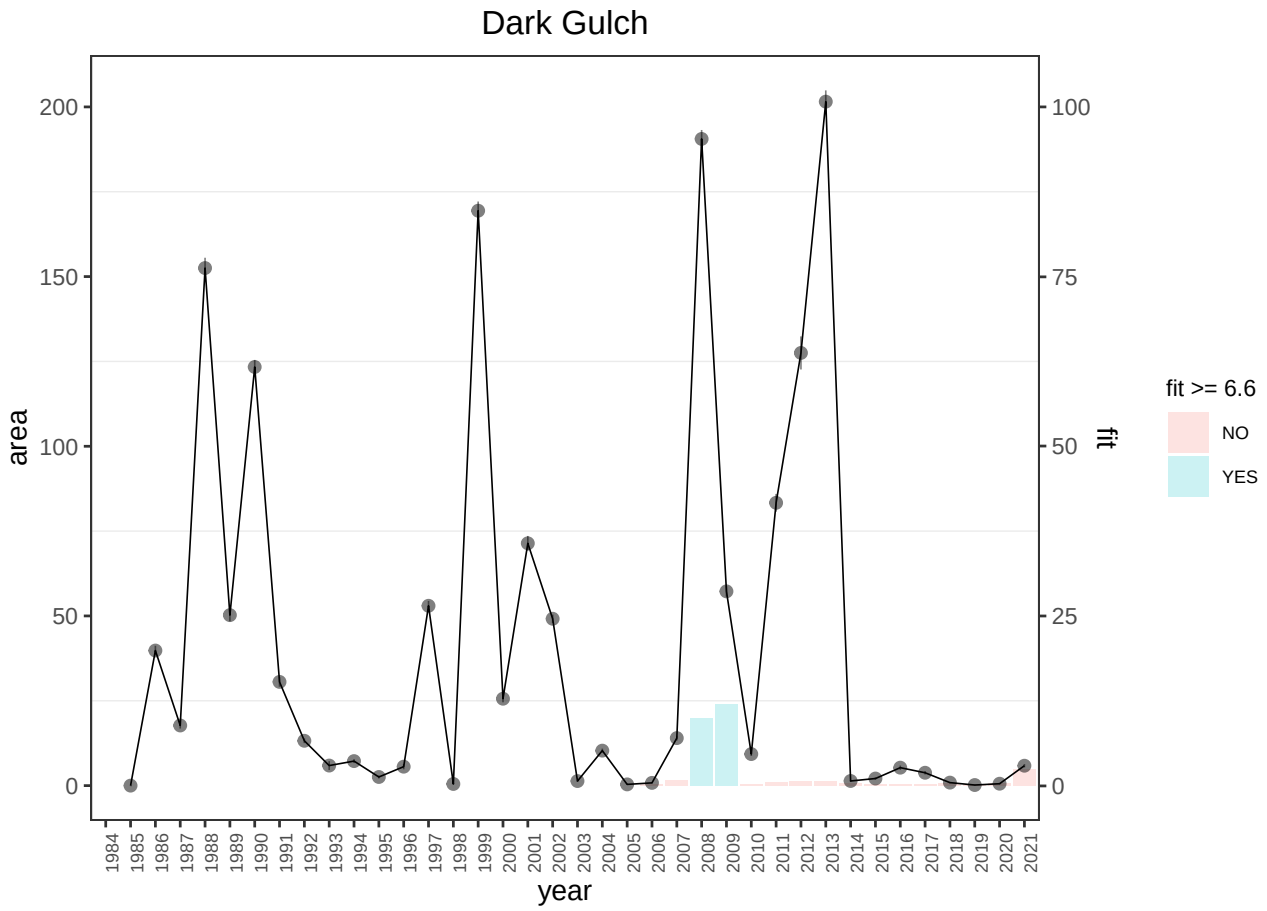
2021
fit >= 6.6
NO


Dark Gulch
area
fit
year
fit >= 6.6
NO
YES
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1984
1985
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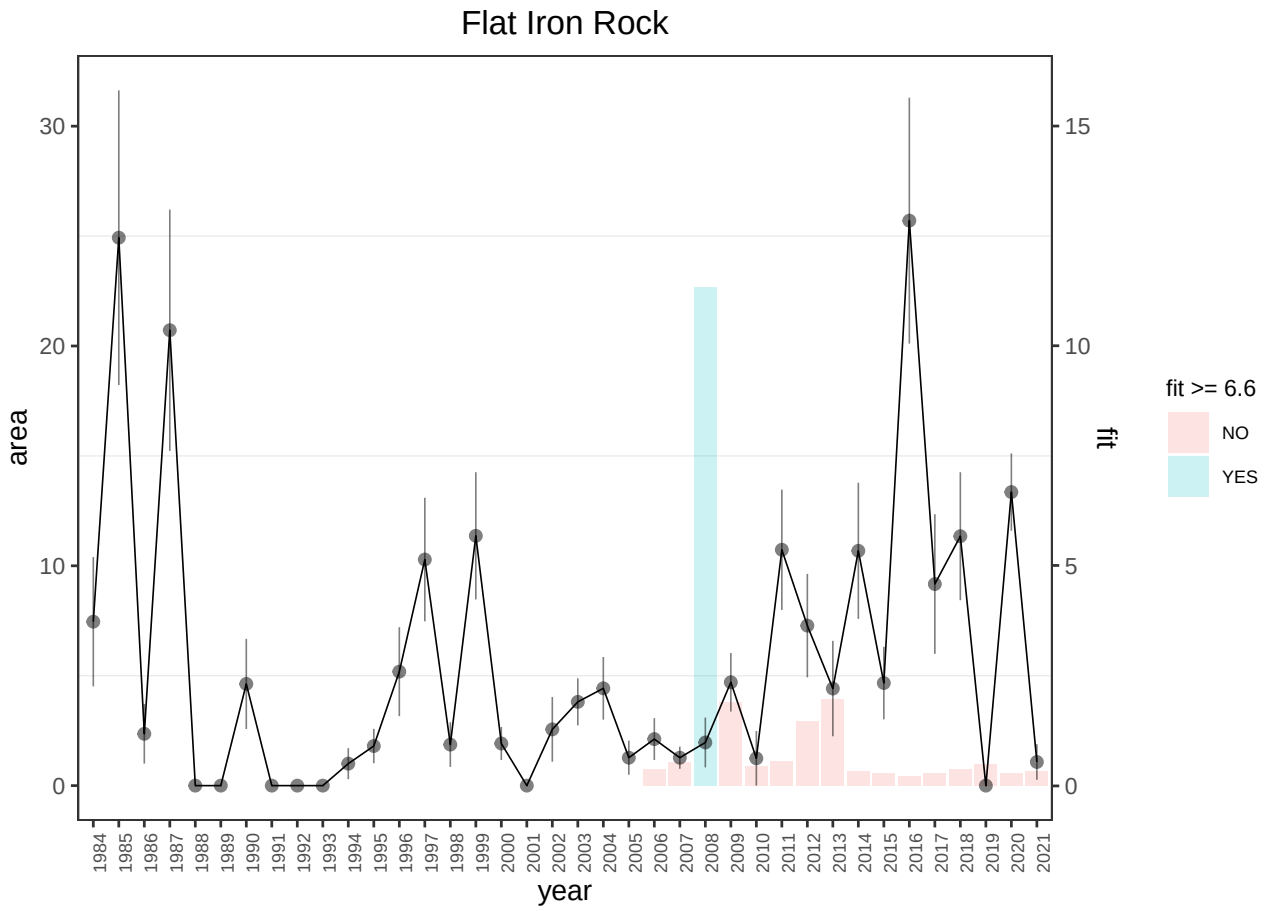
Flat Iron Rock
area
fit
year
fit >= 6.6
NO
YES
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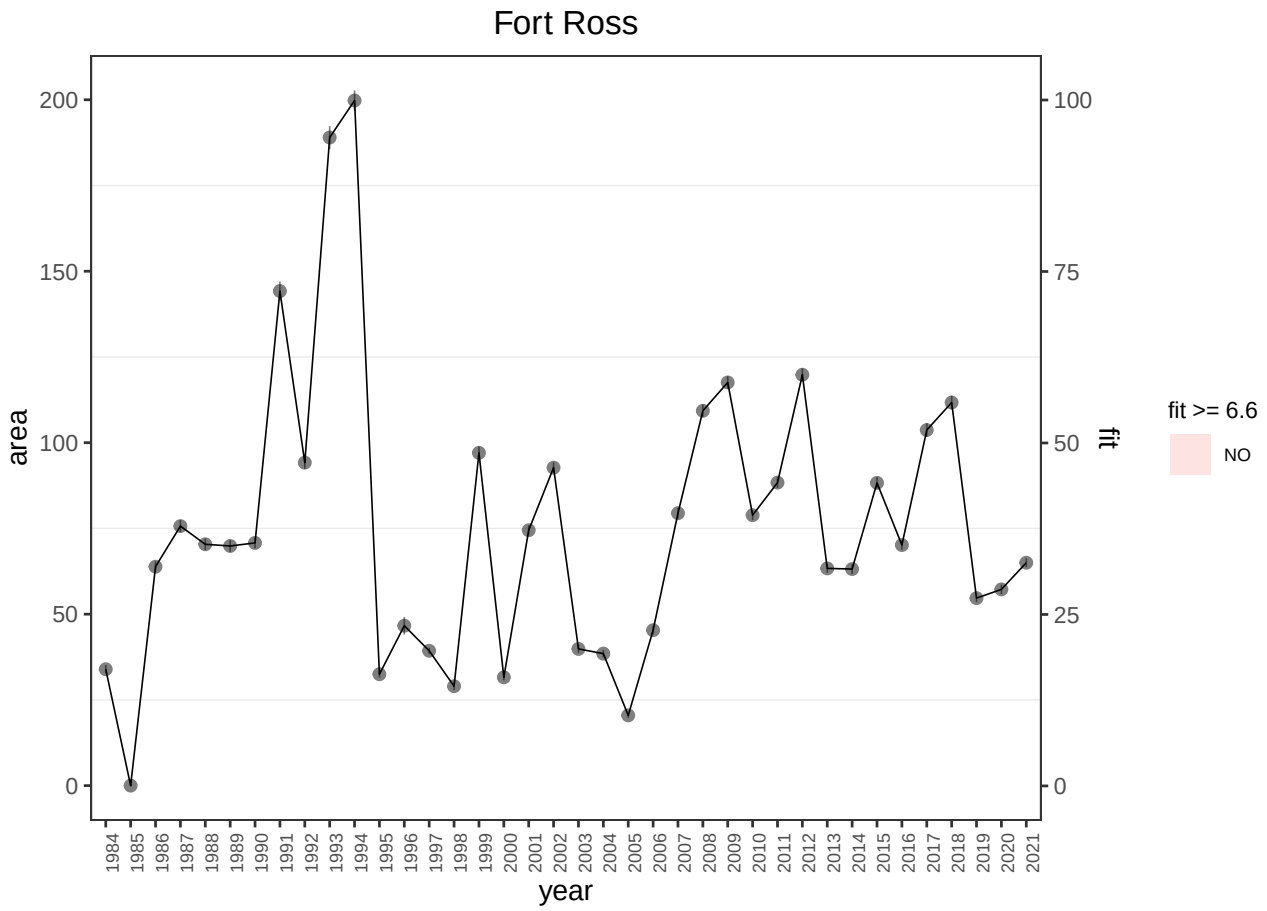
Fort Ross
area
fit
year
fit >= 6.6
NO
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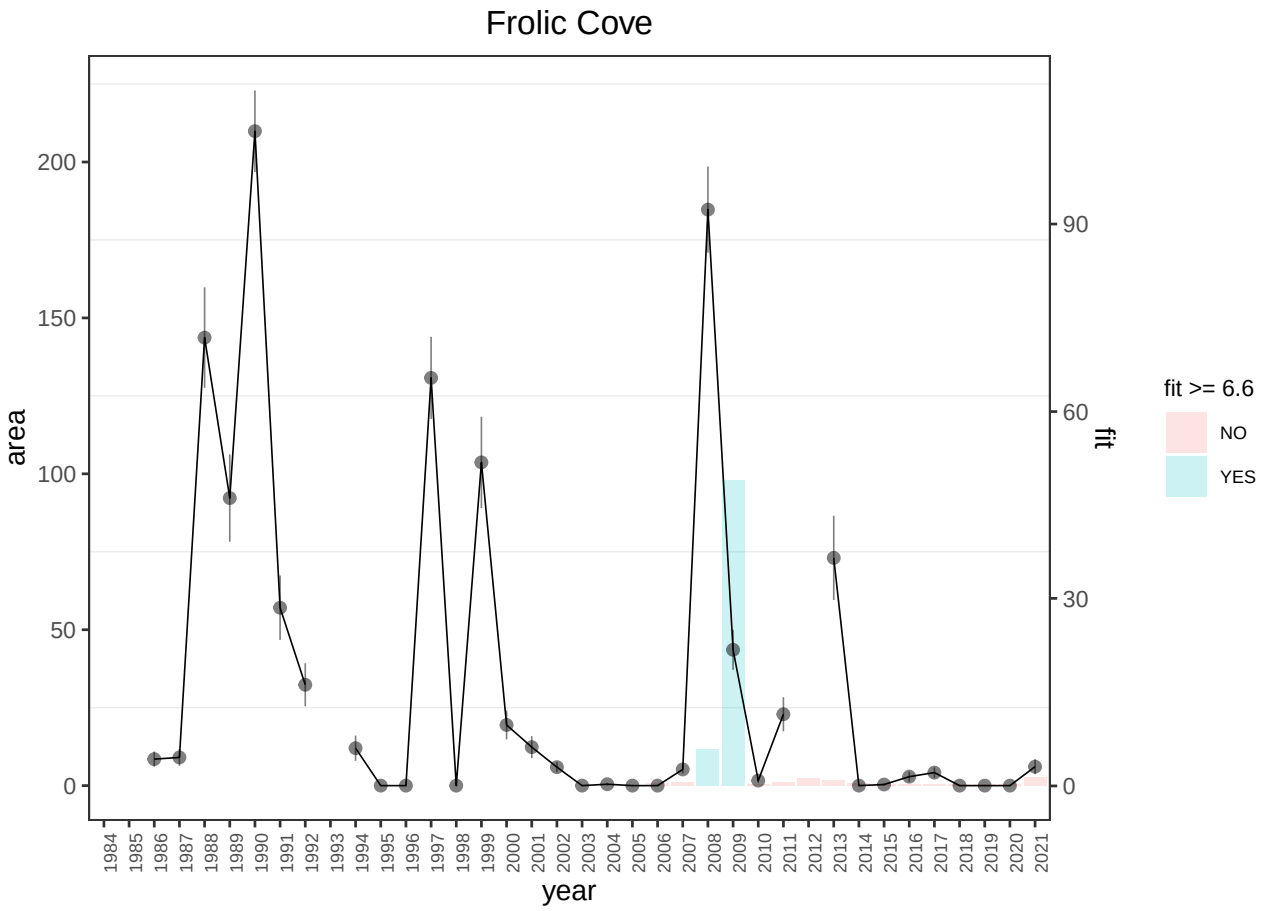
Frolic Cove
area
fit
year
fit >= 6.6
NO
YES
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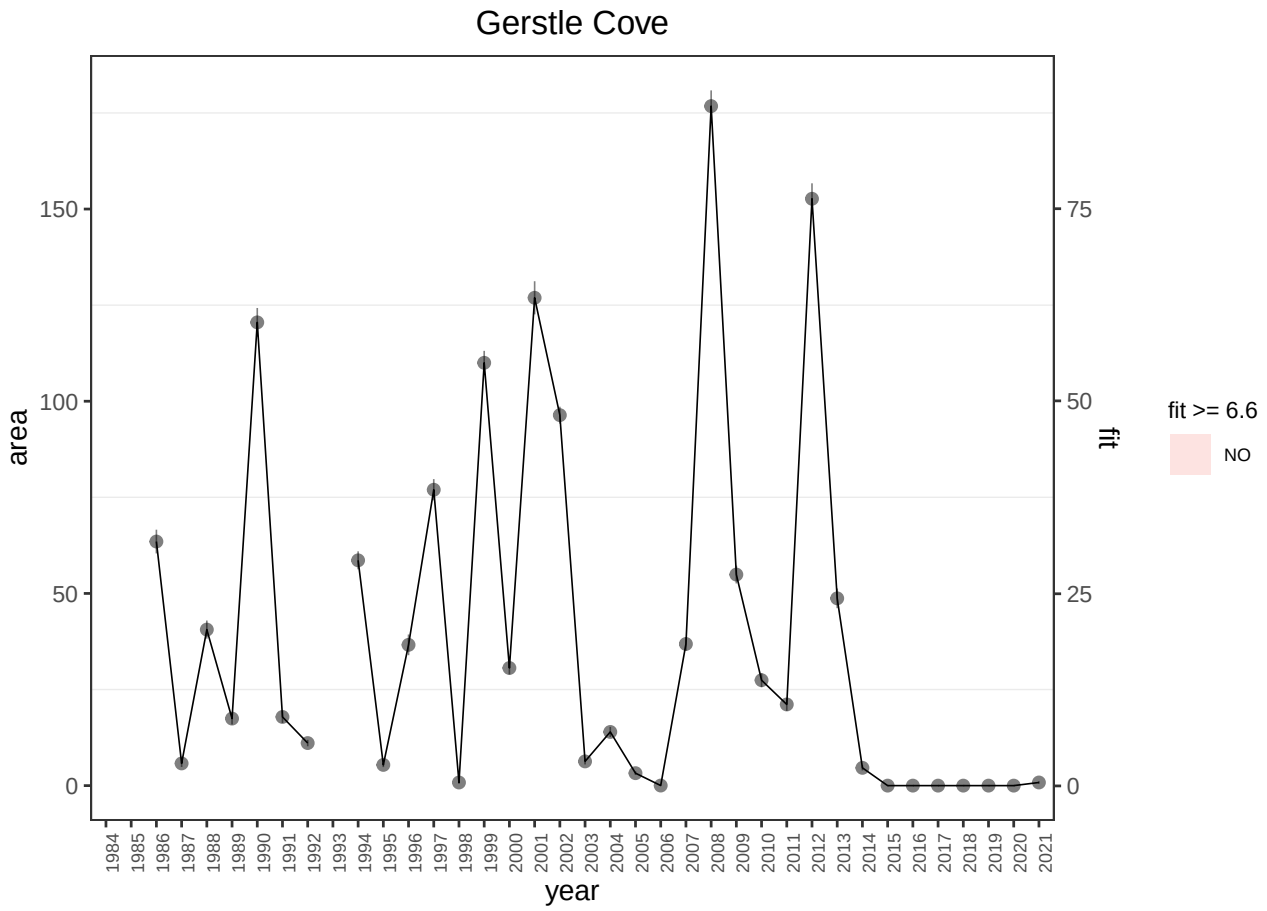
Gerstle Cove
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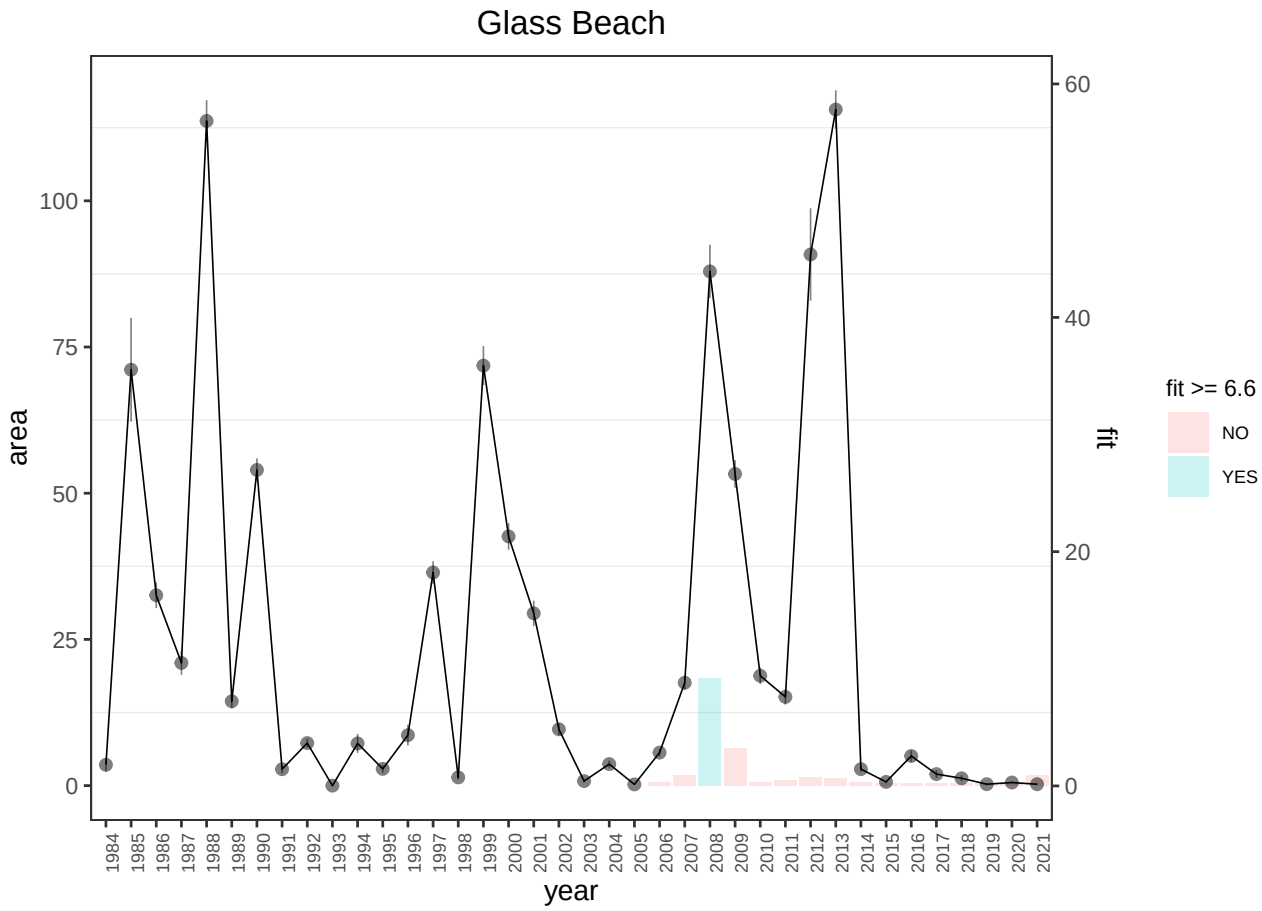
2021
fit >= 6.6
NO


Glass Beach
area
fit
year
fit >= 6.6
NO
YES
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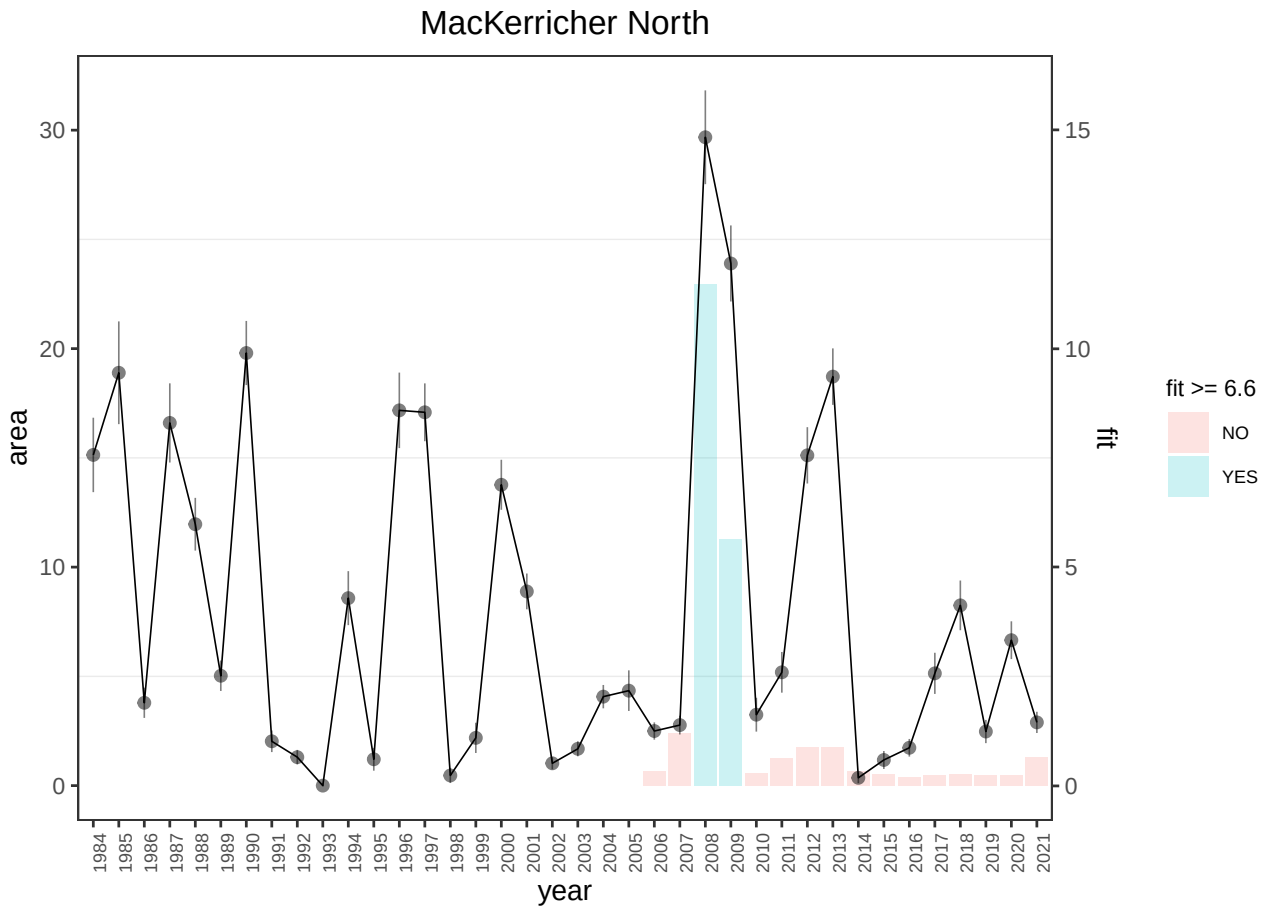
MacKerricher North
area
fit
year
fit >= 6.6
NO
YES
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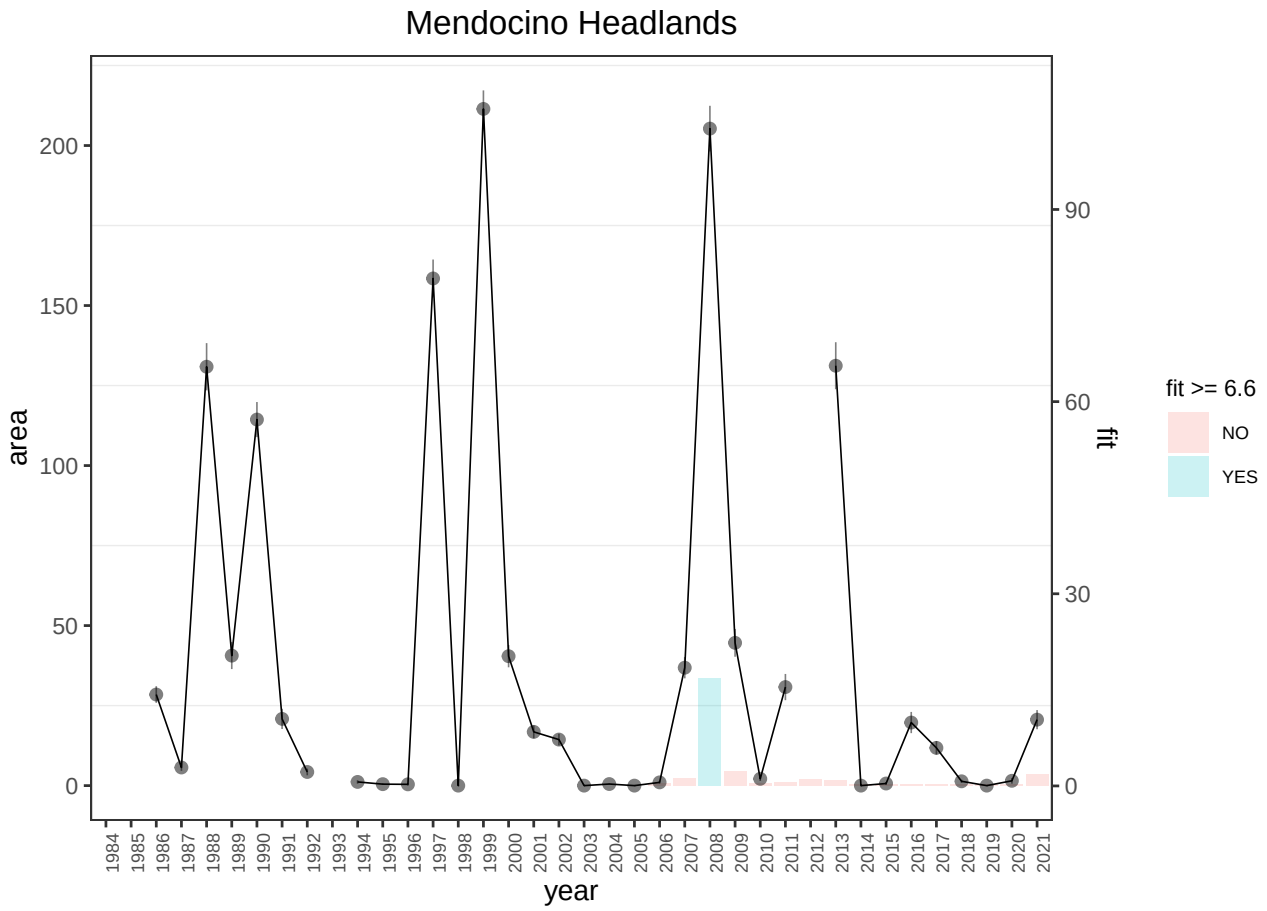
Mendocino Headlands
area
fit
year
fit >= 6.6
NO
YES
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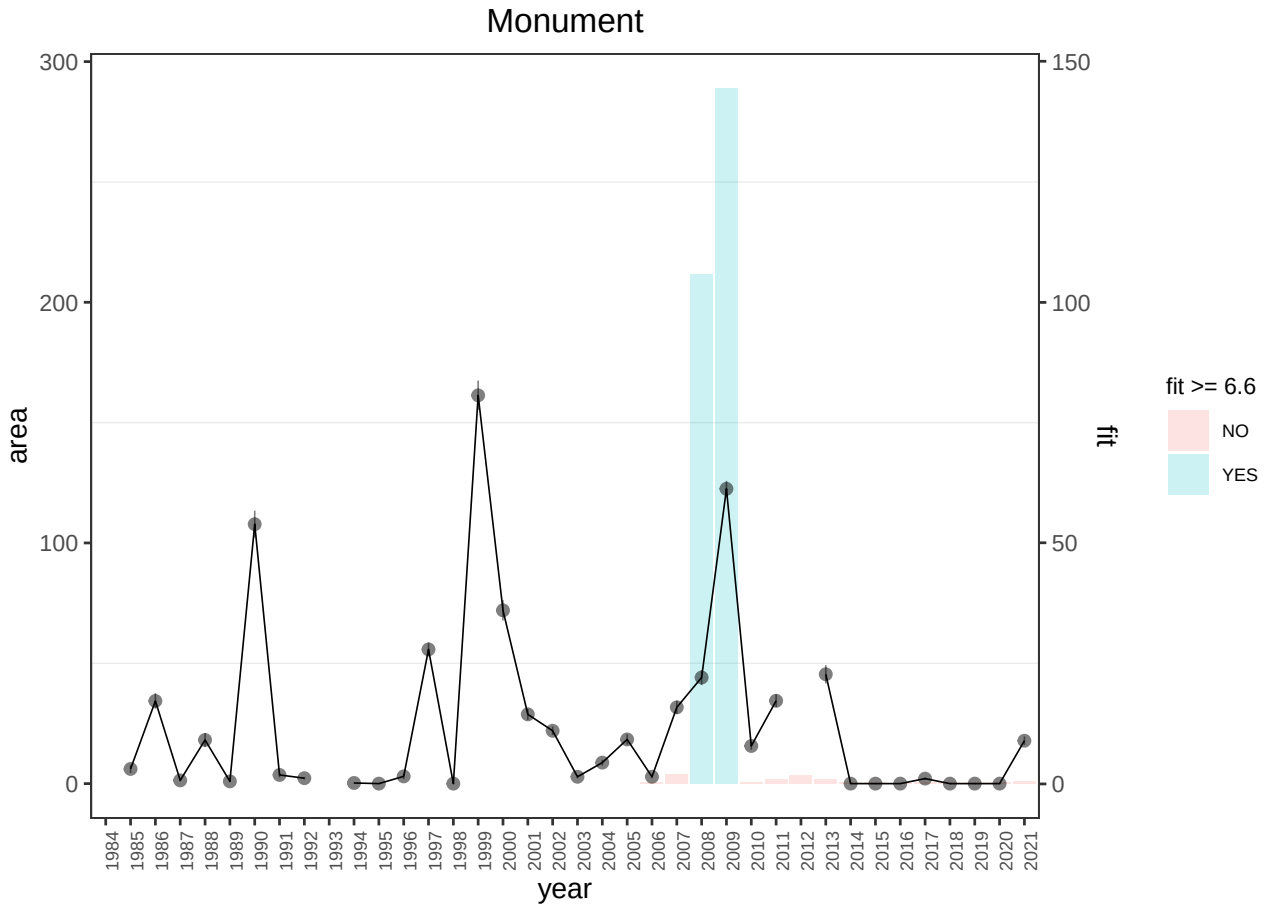
Monument
area
fit
year
fit >= 6.6
NO
YES
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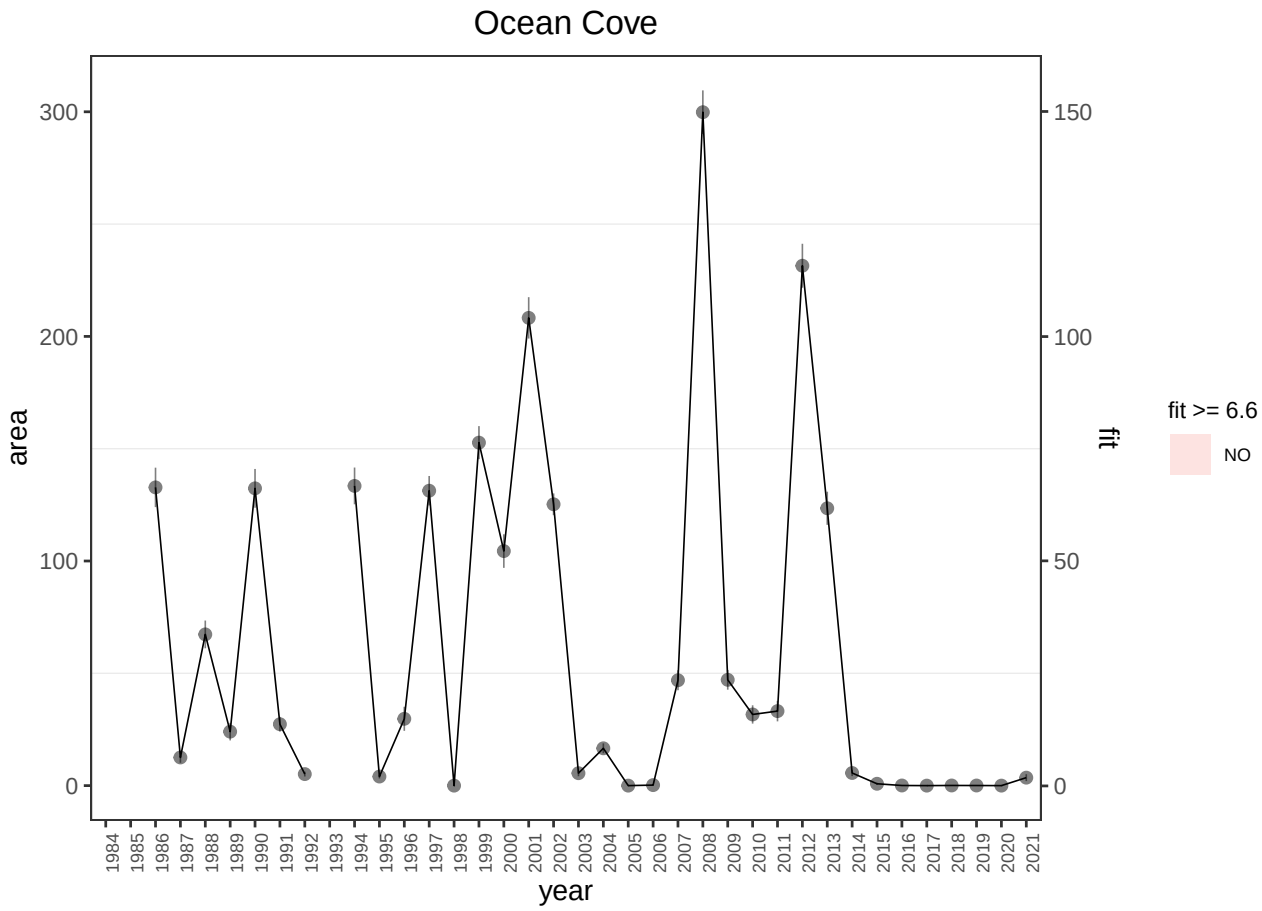
Ocean Cove
area
fit
year
fit >= 6.6
NO
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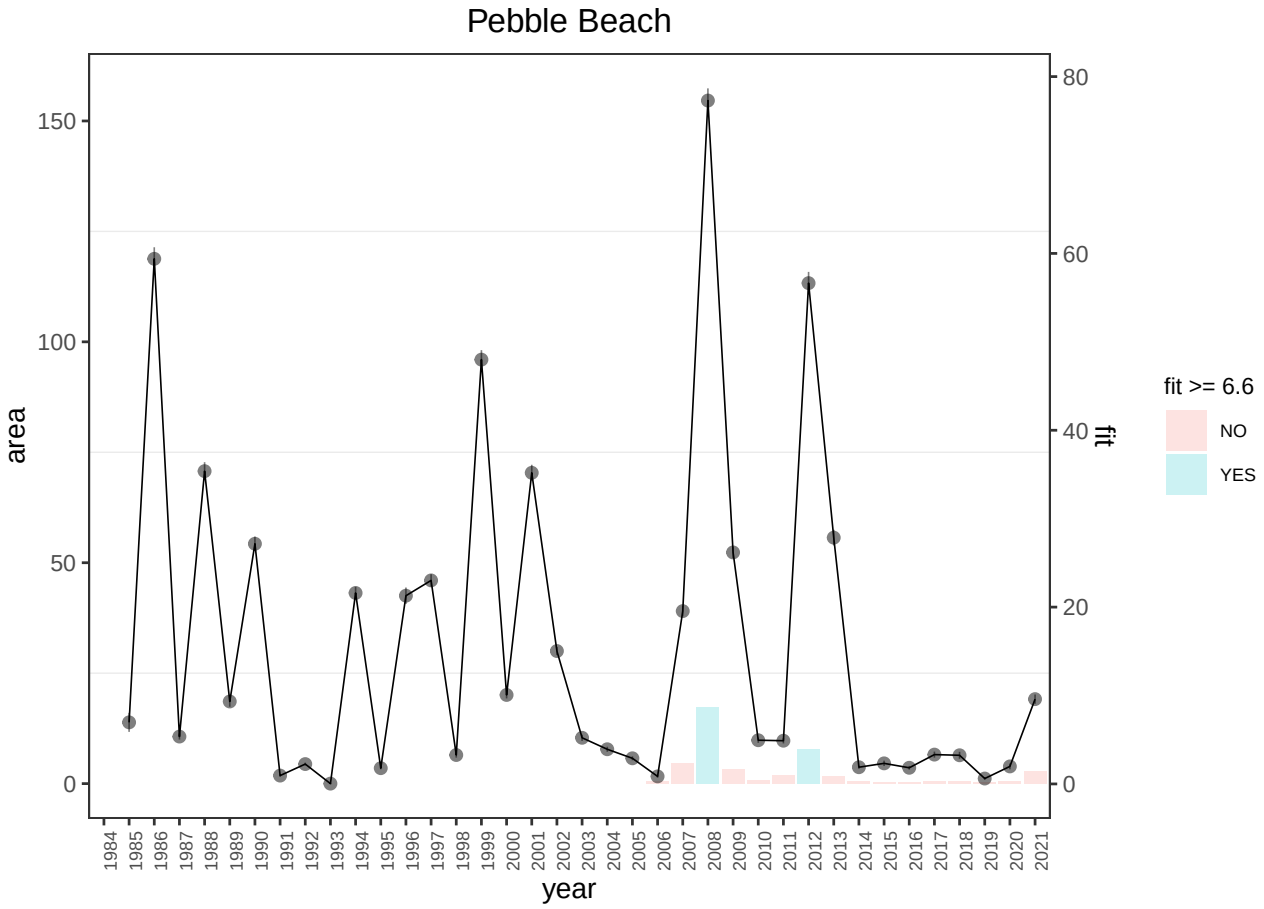
Pebble Beach
area
fit
year
fit >= 6.6
NO
YES
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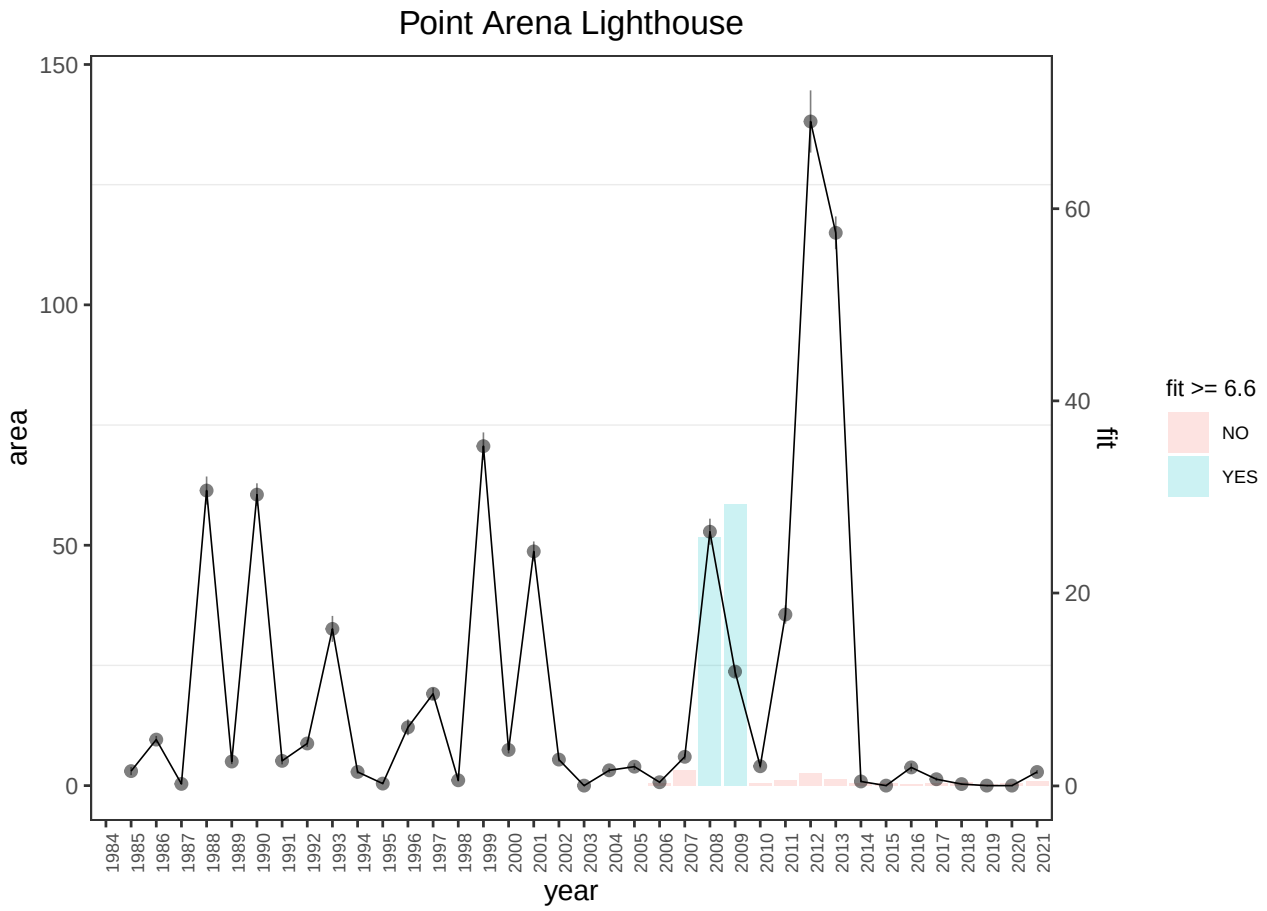
Point Arena Lighthouse
area
fit
year
fit >= 6.6
NO
YES
150
100
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0
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1984
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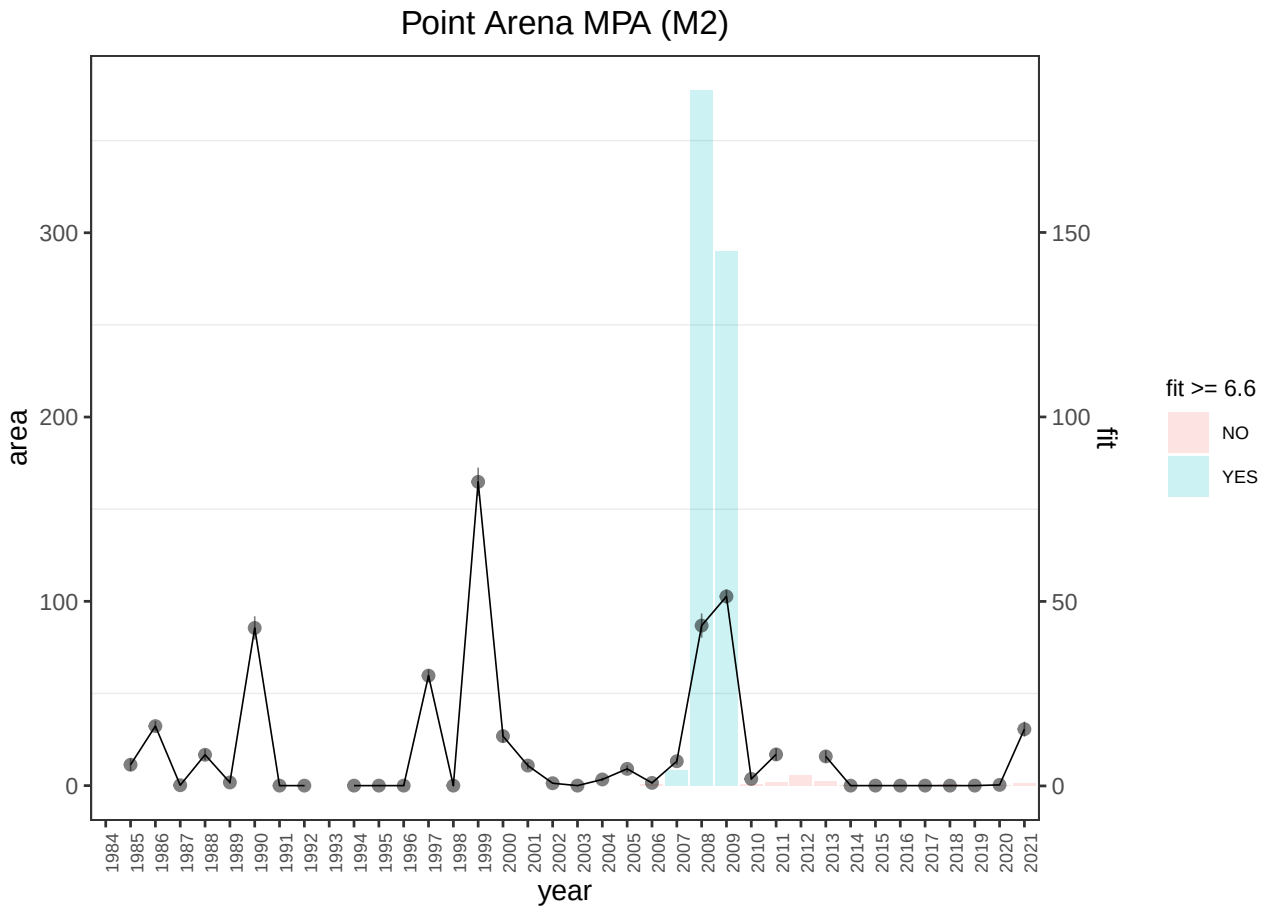
Point Arena MPA (M2)
area
fit
year
fit >= 6.6
NO
YES
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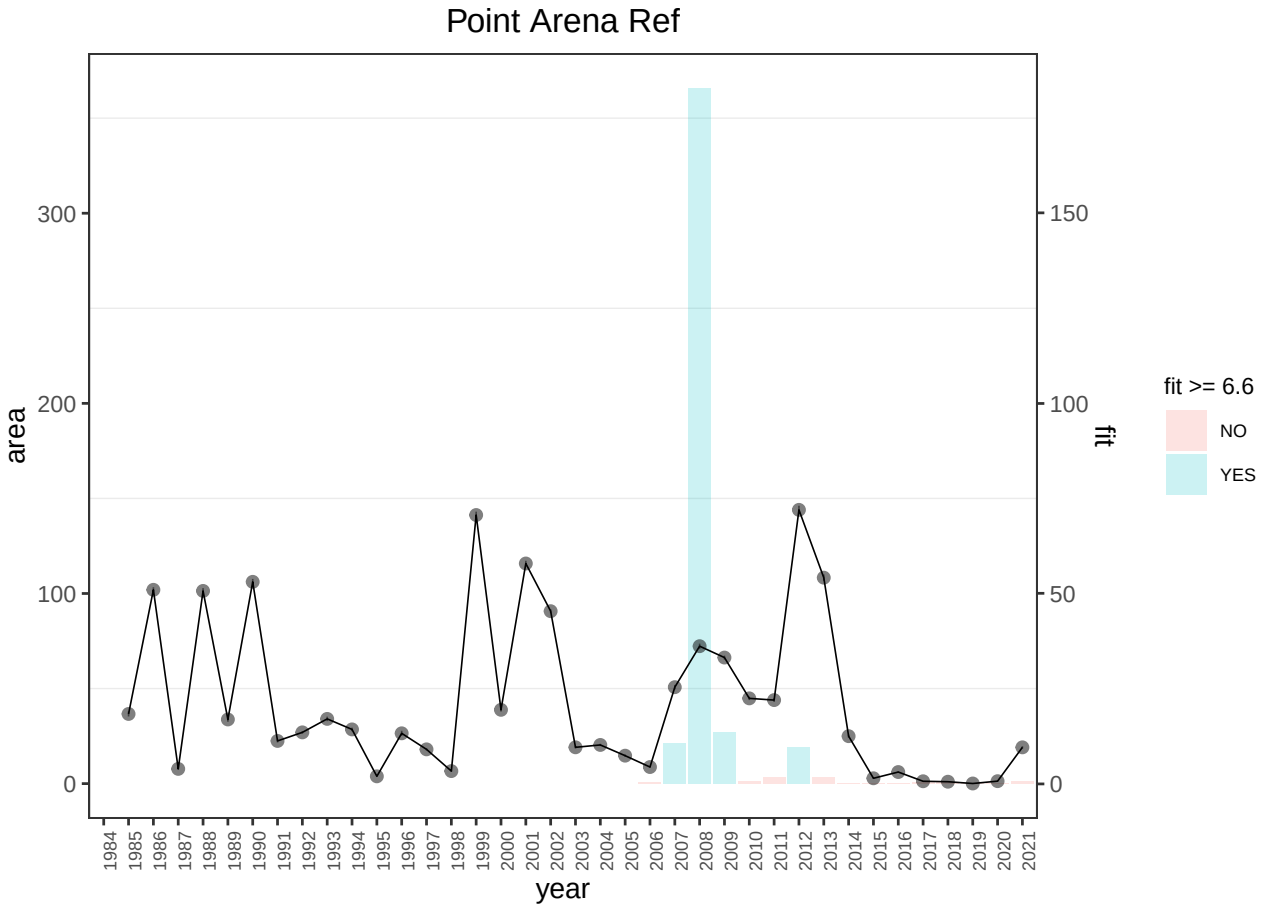
Point Arena Ref
area
fit
year
fit >= 6.6
NO
YES
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1984
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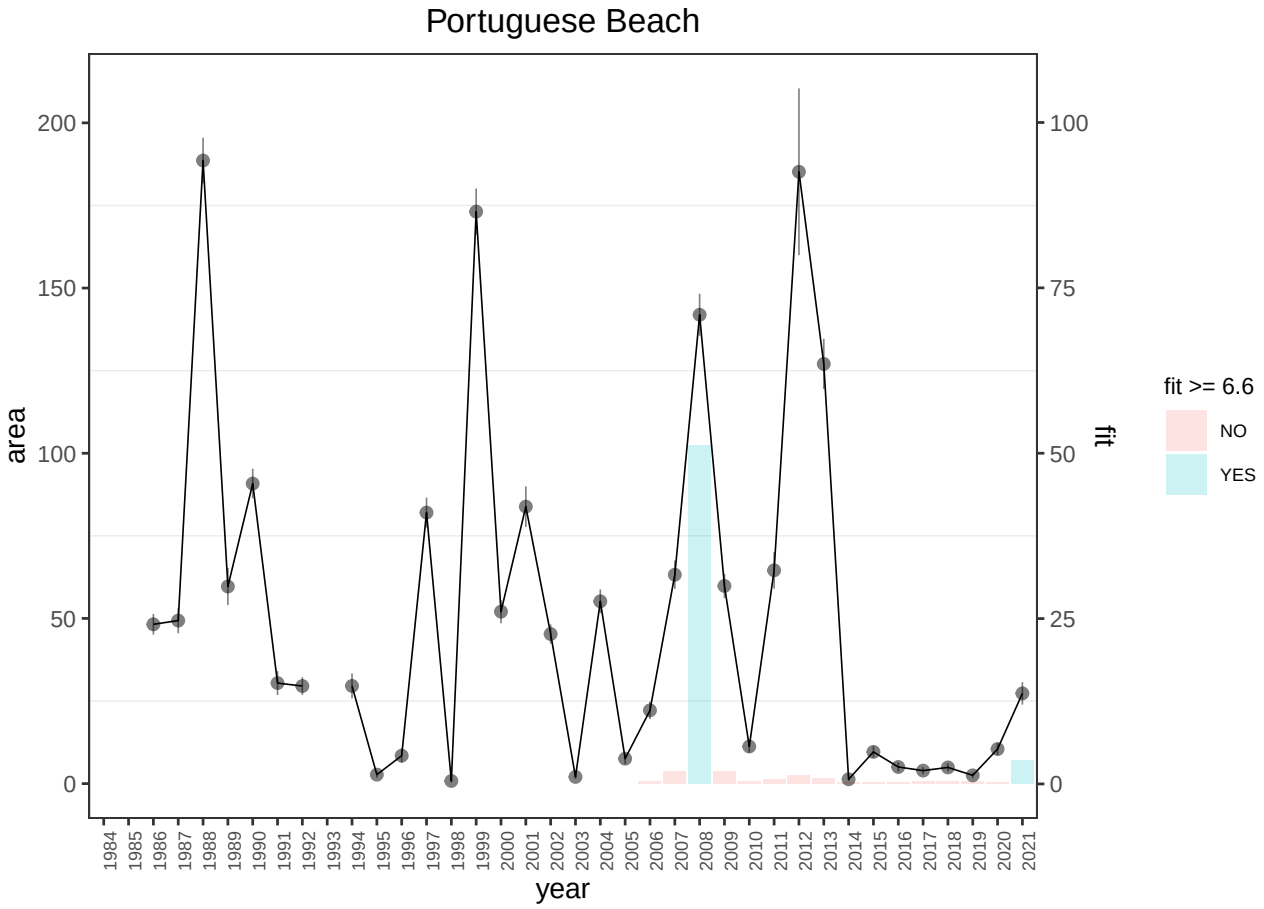
Portuguese Beach
area
fit
year
fit >= 6.6
NO
YES
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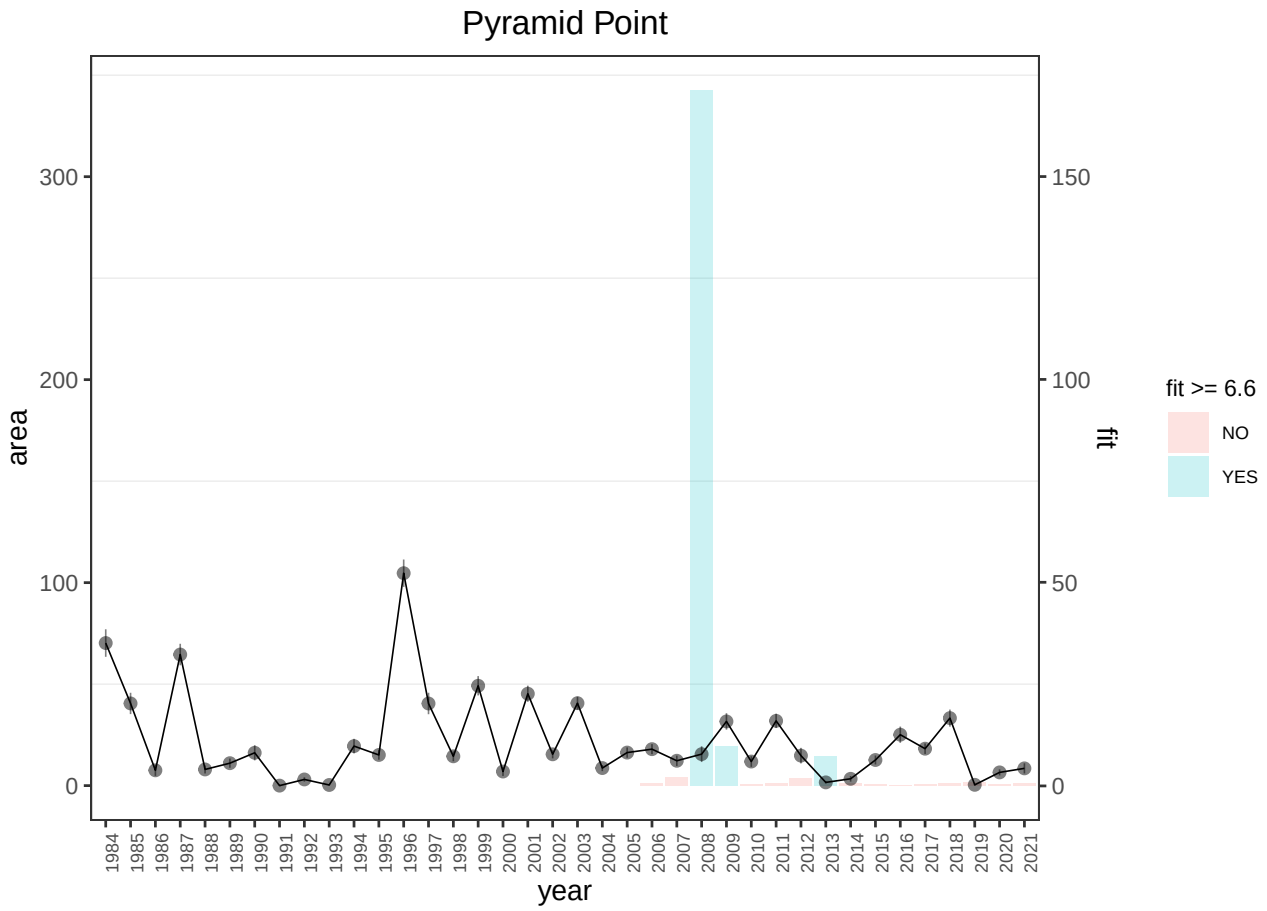
Pyramid Point
area
fit
year
fit >= 6.6
NO
YES
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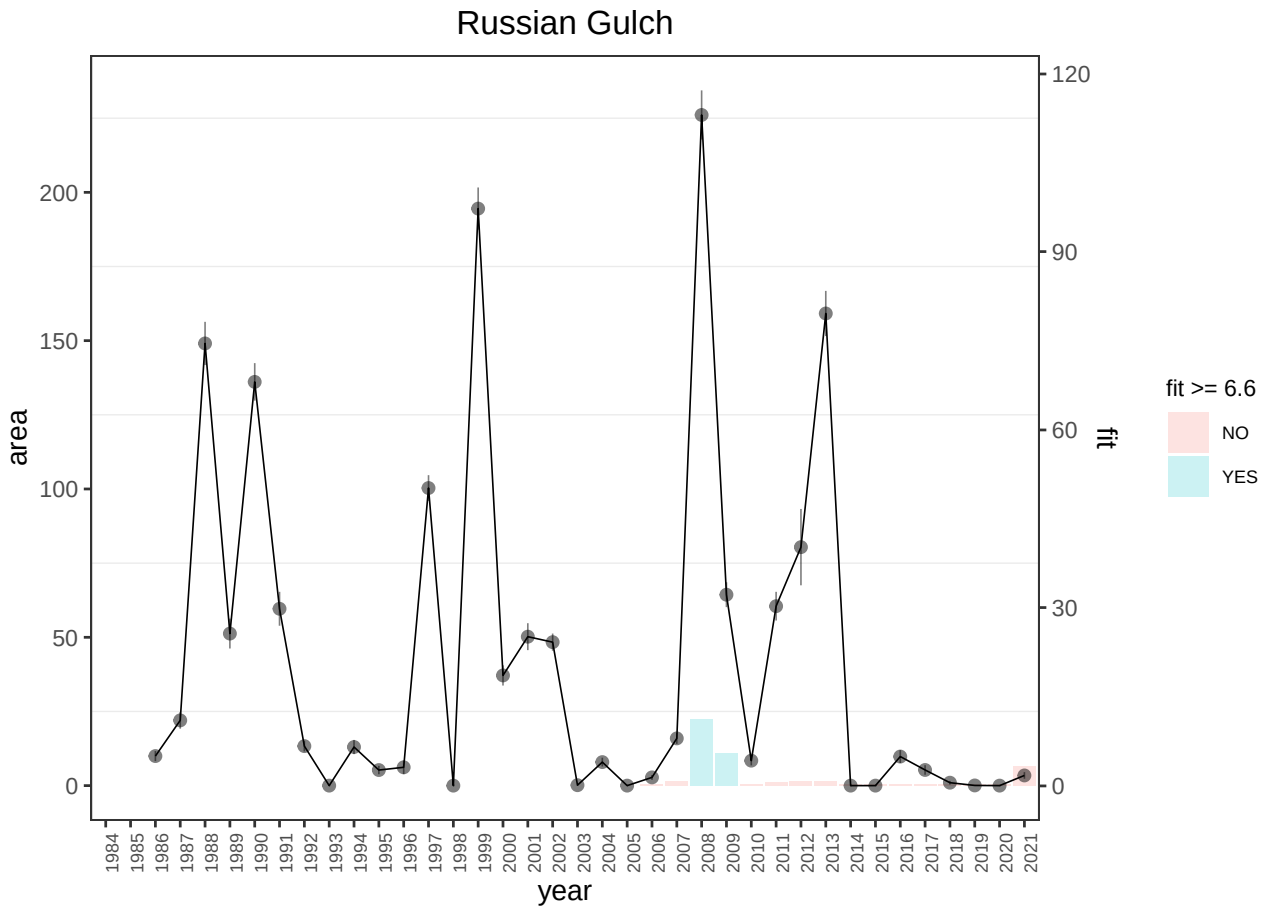
Russian Gulch
area
fit
year
fit >= 6.6
NO
YES
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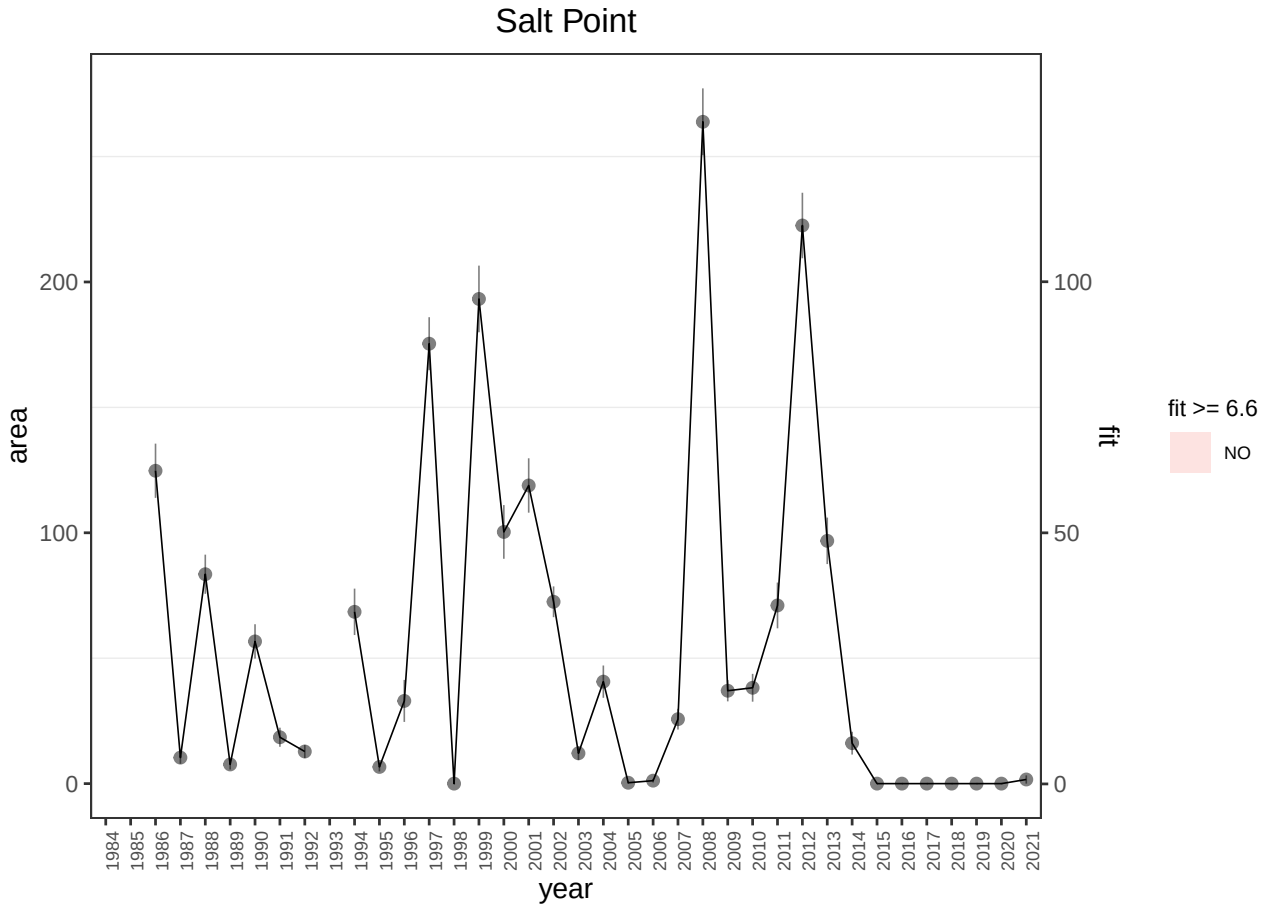
Salt Point
area
fit
year
200
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fit >= 6.6
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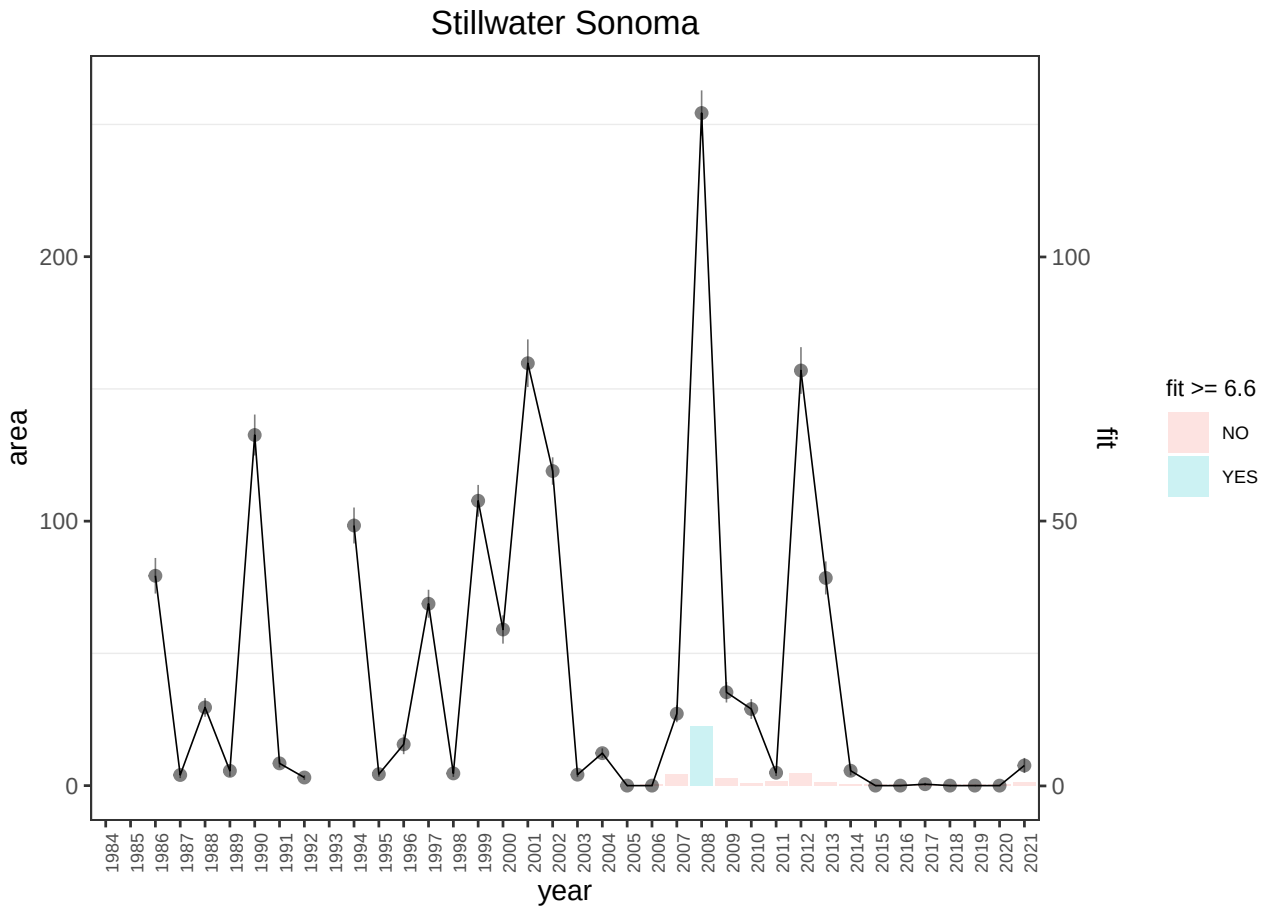
Stillwater Sonoma
area
fit
year
fit >= 6.6
NO
YES
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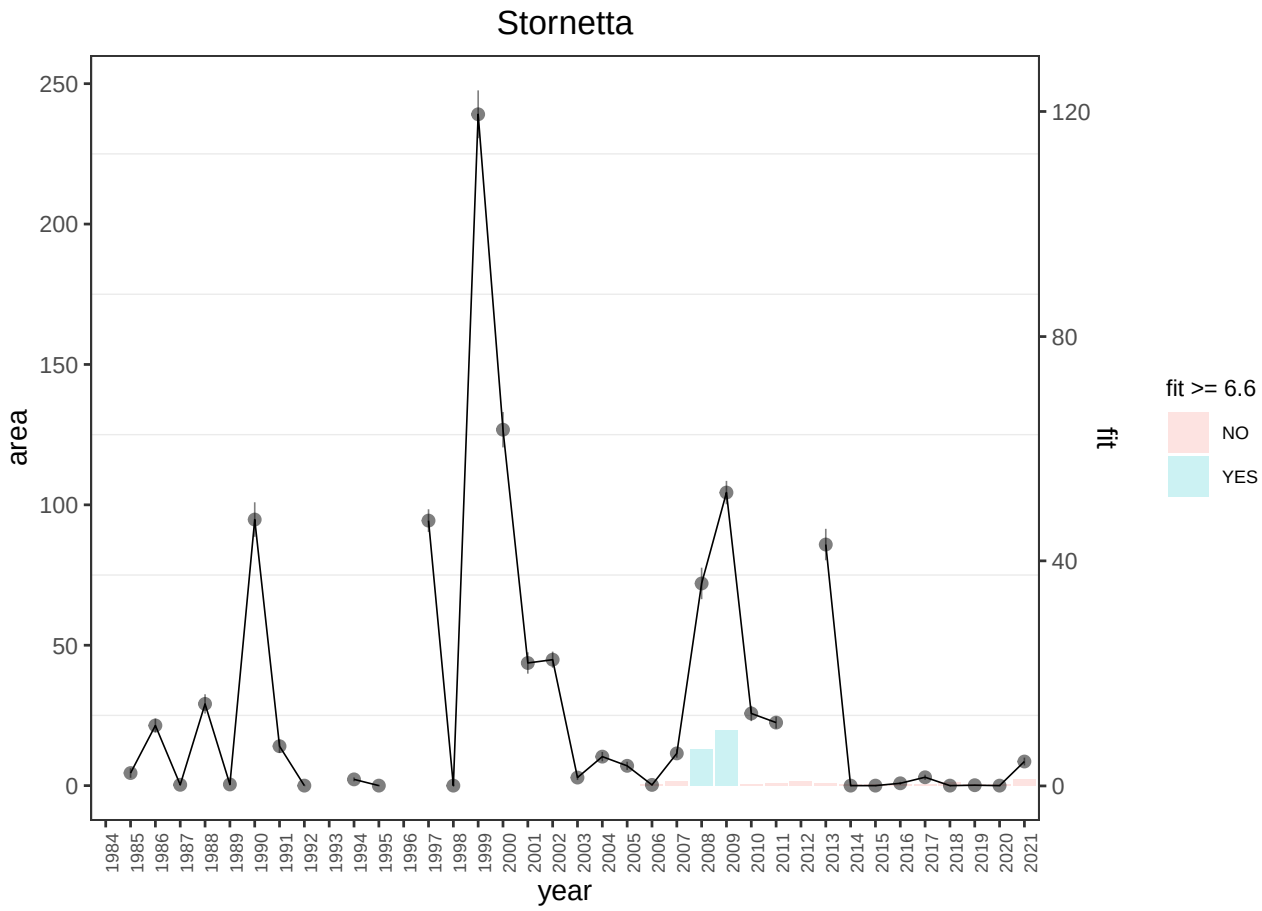
Stornetta
area
fit
year
fit >= 6.6
NO
YES
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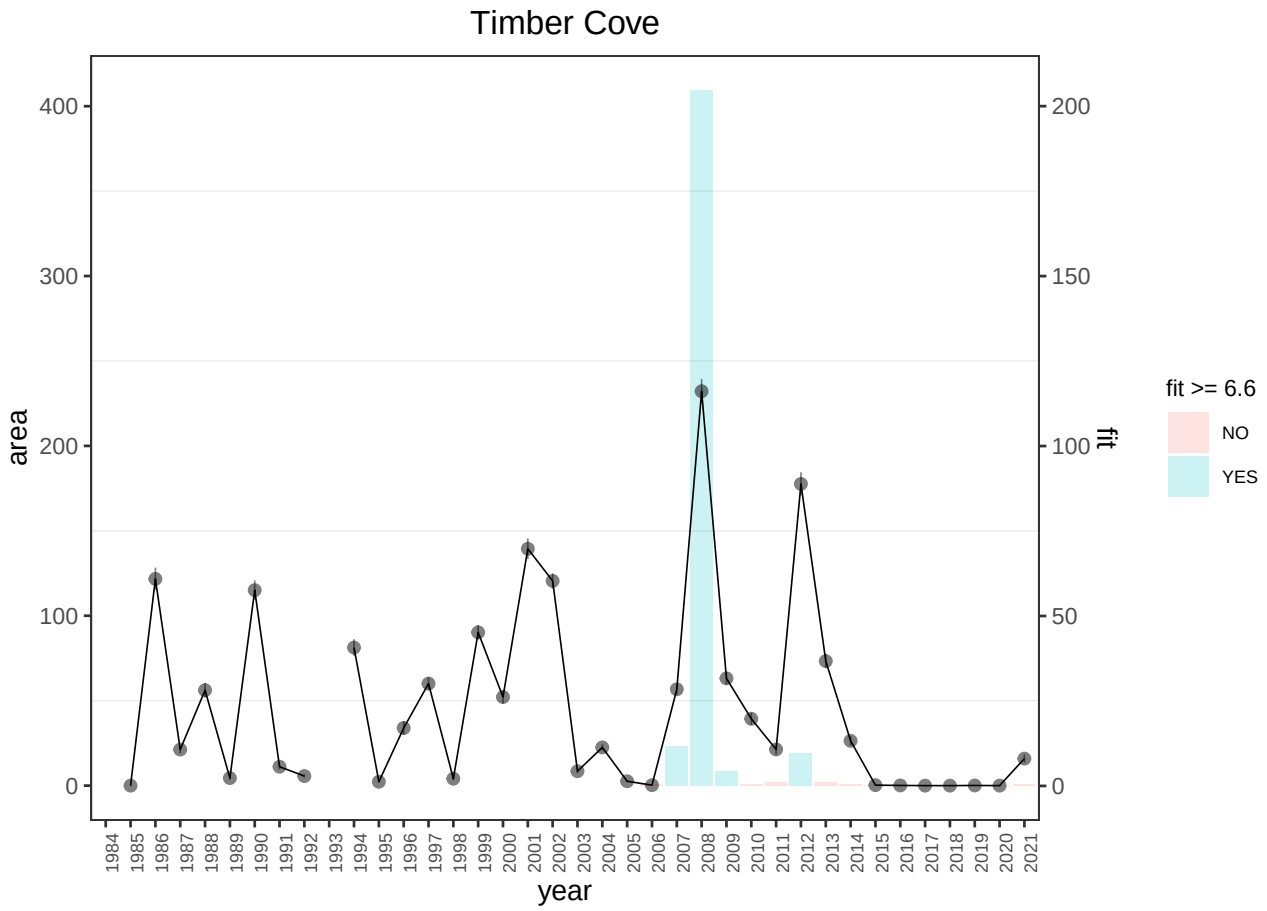
Timber Cove
area
fit
year
fit >= 6.6
NO
YES
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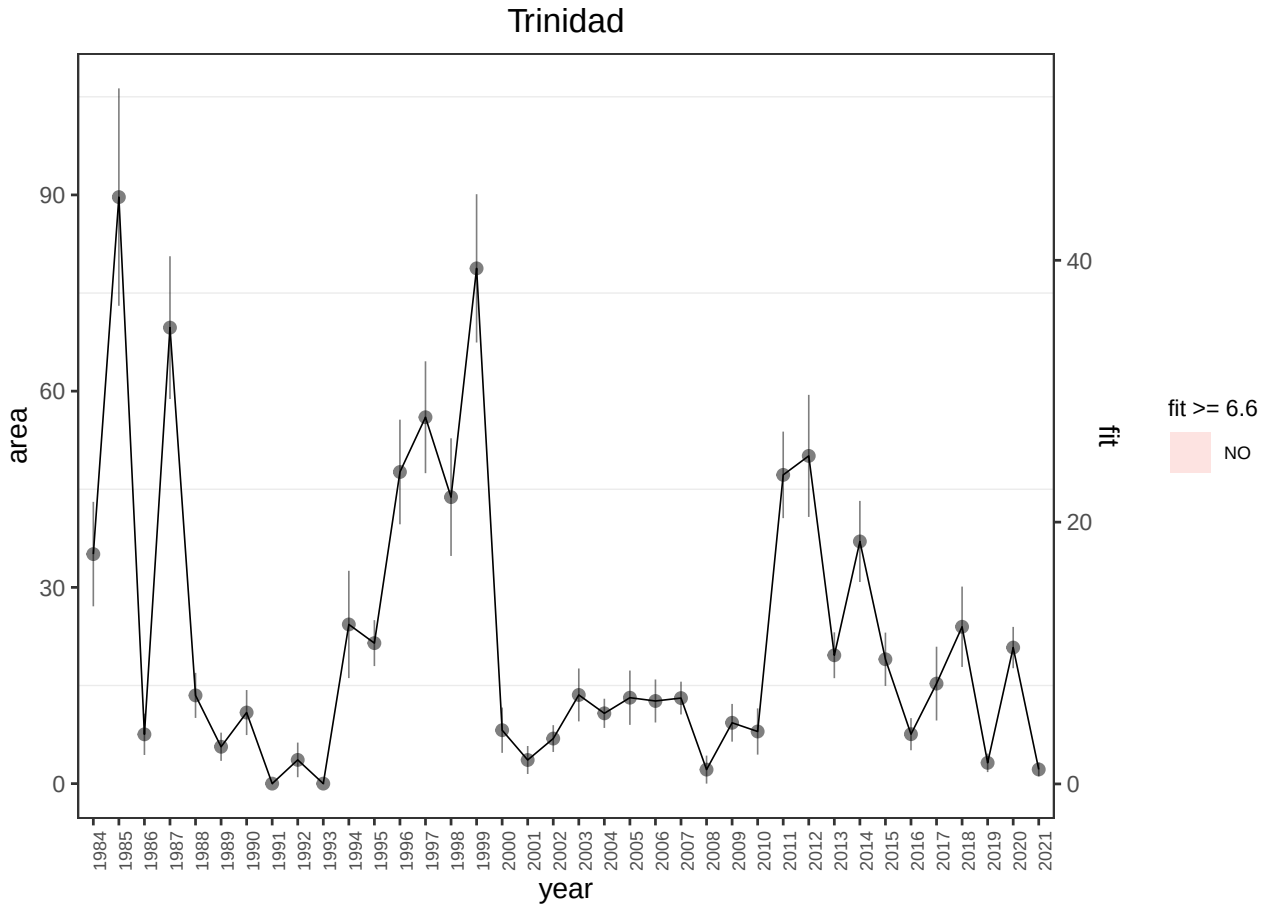
Trinidad
area
fit
year
fit >= 6.6
NO
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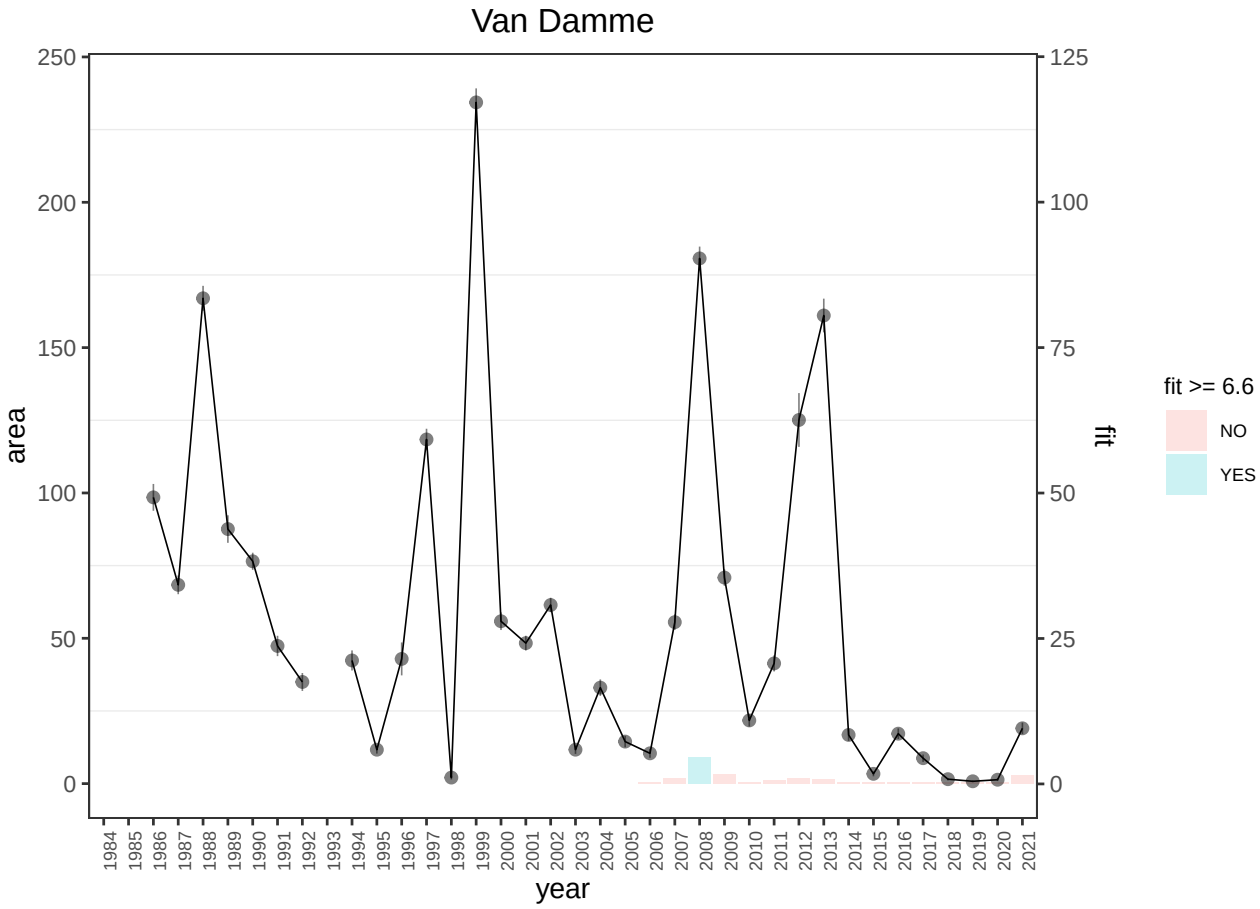
Van Damme
area
fit
year
fit >= 6.6
NO
YES
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125
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