SURE Project

August 17, 2022

Objective

Compare spatial predictions of kelp to "in situ" survey data. Compare each year and location.

Extraction

Extract the predicted *log* kelps density of every year (2004 - 2021) for each site in the North Coast.

```
# set a directory
w.dir <- here()
d.dir <- here('data')
r.dir <- here('spatial_data/sp_predictions_5.1.1_V2')
rock.dir <- here('spatial_data/sp_predictions_5.1.1_V2_rock')

# read and transform the observed data to the log scale
df <- read.csv(paste(d.dir,
                     'RCCA_kelp_inverts_NC_depth-zones_wave_clim_temp_nit_subs_orbvel_npp.csv',
                     sep = '/')) %>%
  dplyr::select(site_name, year, transect, zone, latitude, longitude, den_NERLUE) %>%
  mutate_at(vars(year, transect, zone, site_name), list(as.factor)) %>%
  mutate(log_den_NERLUE = log(den_NERLUE))
head(df)
```

```
##   site_name year transect  zone latitude longitude den_NERLUE log_den_NERLUE
## 1    Caspar 2018        1 INNER 39.36173  -123.822          0           -Inf
## 2    Caspar 2018        2 INNER 39.36173  -123.822          0           -Inf
## 3    Caspar 2018        3 INNER 39.36173  -123.822          0           -Inf
## 4    Caspar 2018        4 OUTER 39.36173  -123.822          0           -Inf
## 5    Caspar 2018        5 OUTER 39.36173  -123.822          0           -Inf
## 6    Caspar 2018        6 OUTER 39.36173  -123.822          0           -Inf
```

Note that log(0) returns -Inf.

```
filter(df, den_NERLUE == 0) %>% count() # 719 0's
```

```
##     n
## 1 719
```

How to deal with log(0)?

```
df$log_den_NERLUE <- replace(df$log_den_NERLUE, df$log_den_NERLUE == -Inf, 0)
head(df)
```

```
##   site_name year transect  zone latitude longitude den_NERLUE log_den_NERLUE
## 1    Caspar 2018        1 INNER 39.36173  -123.822          0              0
## 2    Caspar 2018        2 INNER 39.36173  -123.822          0              0
## 3    Caspar 2018        3 INNER 39.36173  -123.822          0              0
## 4    Caspar 2018        4 OUTER 39.36173  -123.822          0              0
## 5    Caspar 2018        5 OUTER 39.36173  -123.822          0              0
## 6    Caspar 2018        6 OUTER 39.36173  -123.822          0              0
```

Calculate the mean and standard error of kelps density of every year for each site by zone (INNER/OUTER).

```
obs <- df %>%
  group_by(site_name, year, zone) %>%
  summarise_at(vars(log_den_NERLUE), list(mean = mean, se = std.error), na.rm = TRUE) %>%
  pivot_wider(names_from = zone, values_from = c(mean, se))
head(obs)
```

```
## # A tibble: 6 x 6
## # Groups:   site_name, year [6]
##   site_name year  mean_INNER mean_OUTER se_INNER se_OUTER
##   <fct>     <fct>      <dbl>      <dbl>    <dbl>    <dbl>
## 1 Caspar    2008       4.38        3.03   0.150     0.996
## 2 Caspar    2010       4.37        4.17   0.0664    0.586
## 3 Caspar    2014       0.799       0      0.799     0
## 4 Caspar    2015       0           0      0         0
## 5 Caspar    2016       0           0      0         0
## 6 Caspar    2017       0           0      0         0
```

Extract the predicted *log* kelps density of every year for each site.

```
# read the .csv file
site <- read.csv(paste(d.dir,
                       'RCCA_North_Coast_sites.csv',
                       sep = '/'))
# convert from .csv to .shp
site_shp <- st_as_sf(site, coords = c('longitude', 'latitude'), crs = 'EPSG:4326')
# write the file
st_write(site_shp, paste0(d.dir, '/RCCA_North_Coast_sites.shp'), append = FALSE)
```

```
## Deleting layer 'RCCA_North_Coast_sites' using driver 'ESRI Shapefile'
## Writing layer 'RCCA_North_Coast_sites' to data source
##   '/Users/chuntingzheng/Desktop/Git_Repositories/Chunting_Spatial_Analyses/data/RCCA_North_Coast_site
## Writing 25 features with 5 fields and geometry type Point.
```

```
# declaring an empty data frame
pred <- data.frame(site_name = character(),
                   year = numeric(),
                   fit = numeric())
```

```
for (i in c(2006:2021)) {
  rast <- rast(paste0(r.dir, paste0('/', i, '_Nereo_preds_NC_V4_5.1.1_V2.tif')))
  ext <- terra::extract(rast, vect(site_shp$geometry)) %>%
    mutate(site_name = site$site_name, year = as.factor(i), .before = fit) %>%
    dplyr::select(-ID)
  pred <- rbind(pred, ext)
}

head(pred)
```

```
##        site_name year       fit
## 1         Caspar 2006 0.5090384
## 2   Caspar North 2006 0.5003366
## 3     Dark Gulch 2006 0.5309656
## 4 Flat Iron Rock 2006 0.7382968
## 5      Fort Ross 2006       NaN
## 6    Frolic Cove 2006 0.8228083
```

Comparison

Compare the predicted data to observed data.

```
dim(obs)
```

```
## [1] 193   6
```

```
dim(pred)
```

```
## [1] 400   3
```

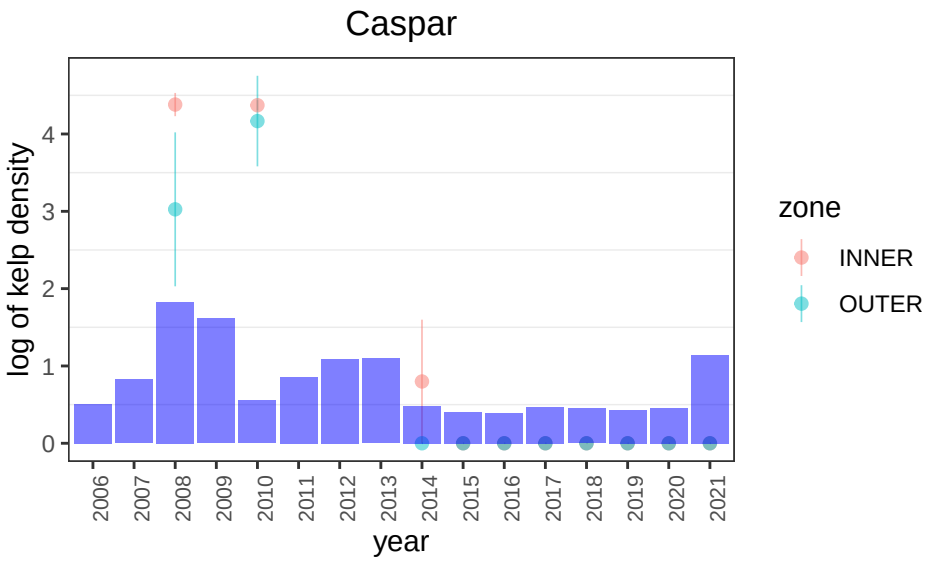
```
kelp_data <- left_join(pred, obs, by = c('site_name', 'year')) %>%
  group_by(site_name) %>%
  arrange(year, .by_group = TRUE) %>%
  relocate(fit, .after = last_col())
head(kelp_data)
```

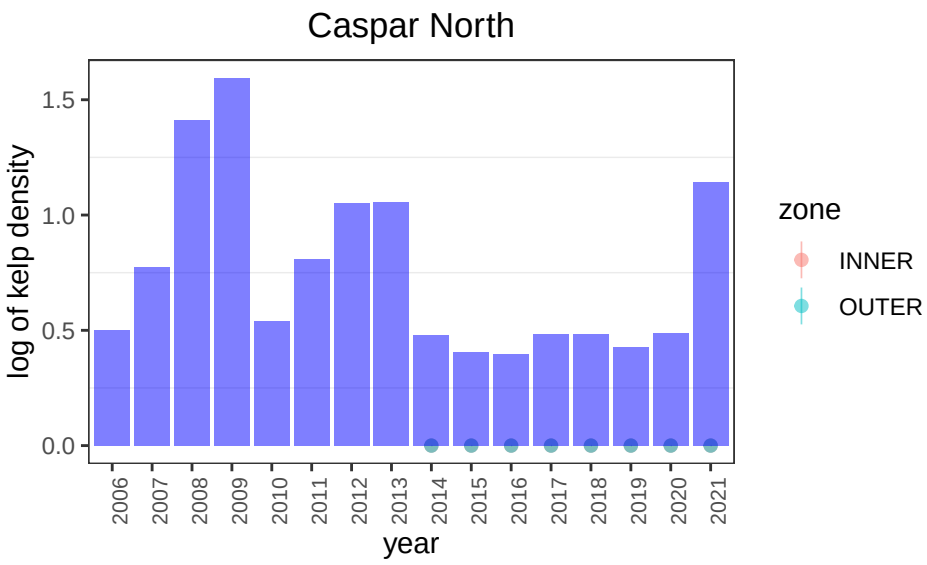
```
## # A tibble: 6 x 7
## # Groups:   site_name [1]
##   site_name year  mean_INNER mean_OUTER se_INNER se_OUTER   fit
##   <chr>     <fct>      <dbl>      <dbl>    <dbl>    <dbl> <dbl>
## 1 Caspar    2006       NA         NA     NA         NA     0.509
## 2 Caspar    2007       NA         NA     NA         NA     0.827
## 3 Caspar    2008        4.38       3.03   0.150     0.996 1.83
## 4 Caspar    2009       NA         NA     NA         NA     1.62
## 5 Caspar    2010        4.37       4.17   0.0664    0.586 0.554
## 6 Caspar    2011       NA         NA     NA         NA     0.857
```

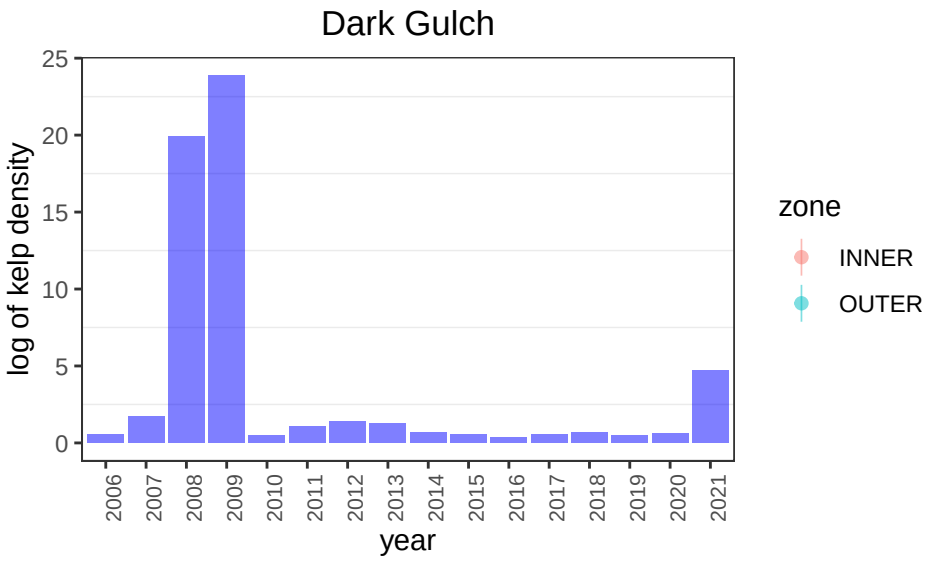
Plotting

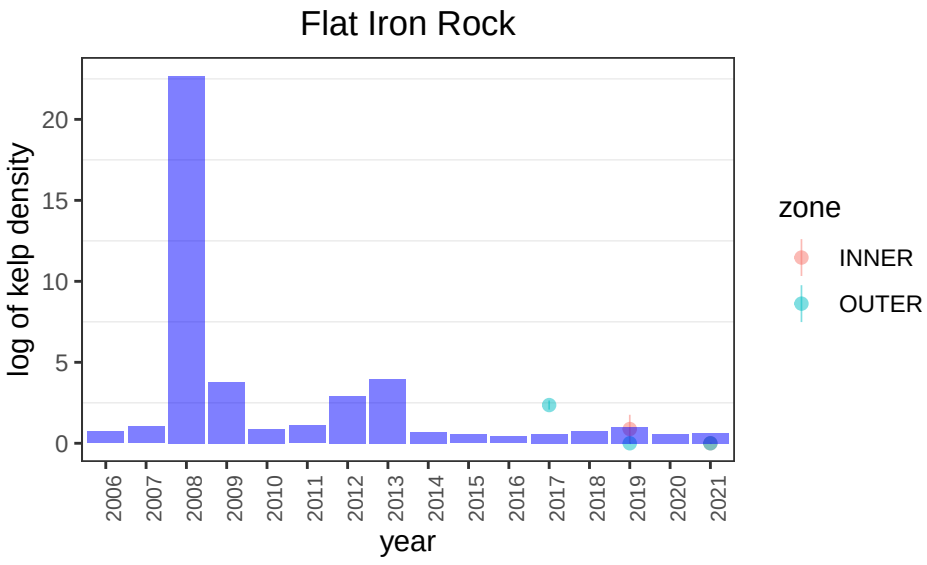
Plot log of kelps density vs year for each site.

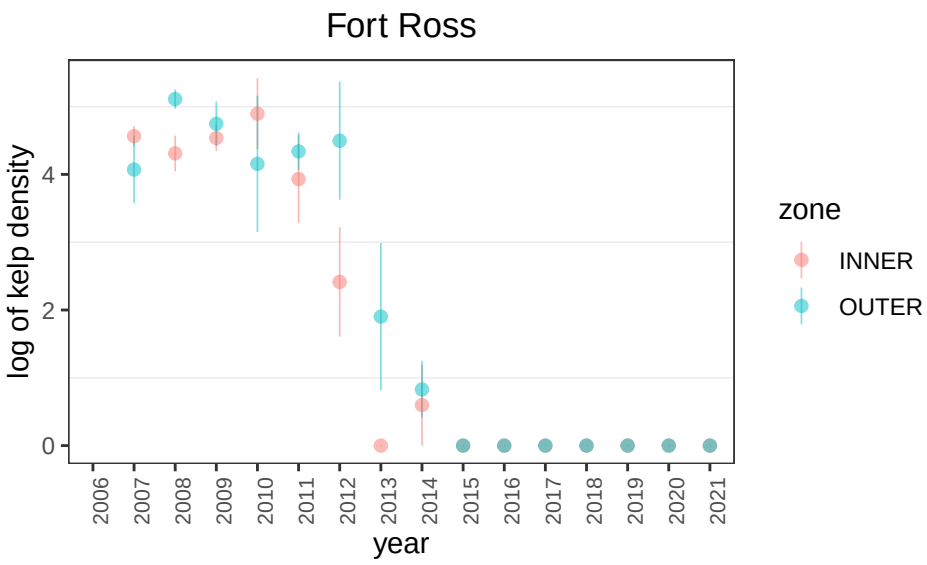
```
# kelp_data %>%
#   pivot_longer(
#     -c('site_name', 'year', 'fit'),
#     names_to = c('.value', 'zone'),
#     names_sep = '_'
#     ) %>%
#   filter(site_name == 'Caspar') %>%
#   ggplot(aes(x = year, y = mean, fill = zone)) +
#   geom_bar(position = 'dodge', stat = 'identity')

sites <- unique(kelp_data$site_name)
kelp_longer <- kelp_data %>%
    pivot_longer(
      -c('site_name', 'year', 'fit'),
      names_to = c('.value', 'zone'),
      names_sep = '_'
      )

for (i in sites) {
  plot <- kelp_longer %>%
    filter(site_name == i) %>%
    ggplot() +
    geom_pointrange(aes(
      x = year, y = mean, group = zone, color = zone,
      ymin = mean - se, ymax = mean + se
      ), alpha = 0.5, size = 0.3) +
    geom_bar(aes(x = year, y = fit),
             stat = 'identity', position = 'dodge',
             fill = 'blue', alpha = 0.3) +
    theme_bw() +
    theme(axis.text.x = element_text(angle = 90, size = 8),
          plot.title = element_text(hjust = 0.5),
          panel.grid.major = element_blank()) +
    labs(y = 'log of kelp density', title = i)
  print(plot)
}
```

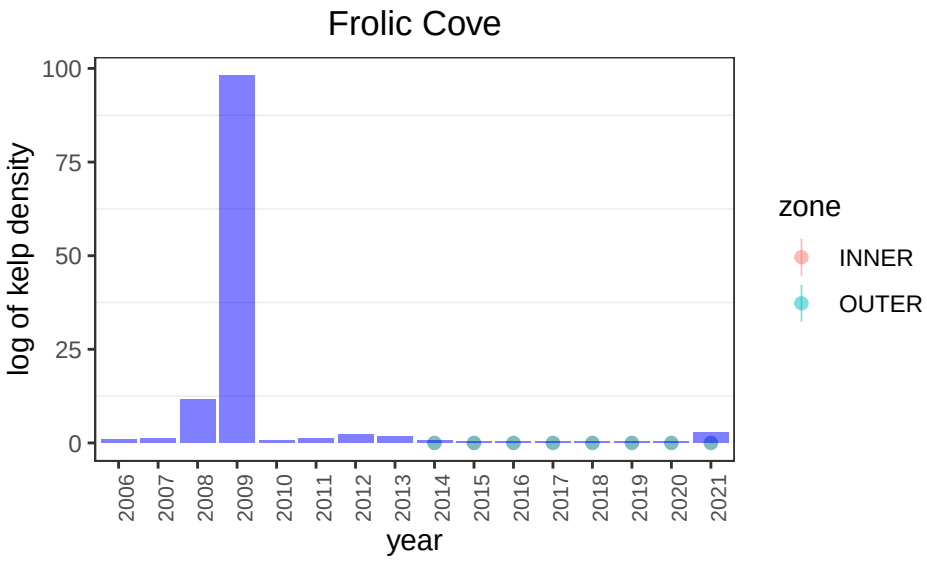

Caspar
log of kelp density
0
1
2
3
4
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

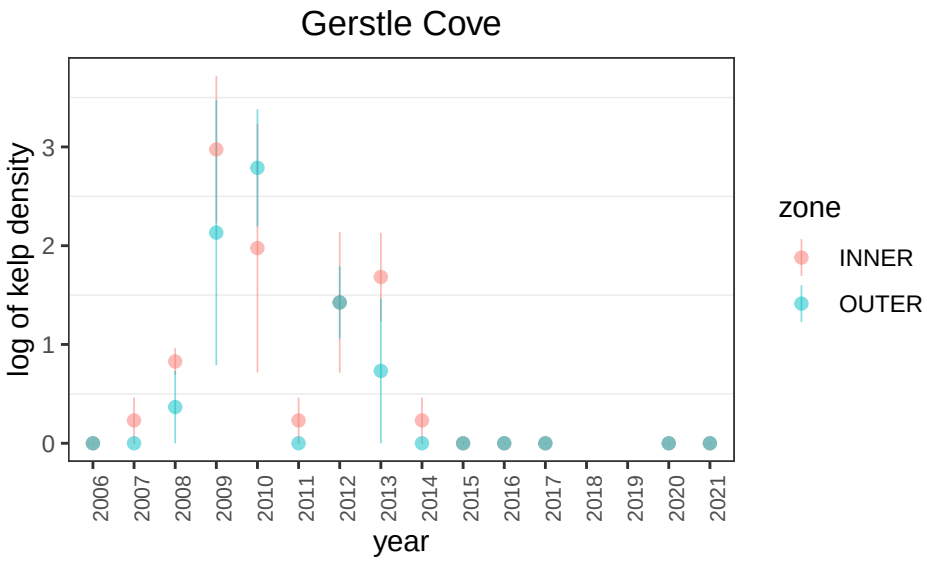

Caspar North
log of kelp density
0.0
0.5
1.0
1.5
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

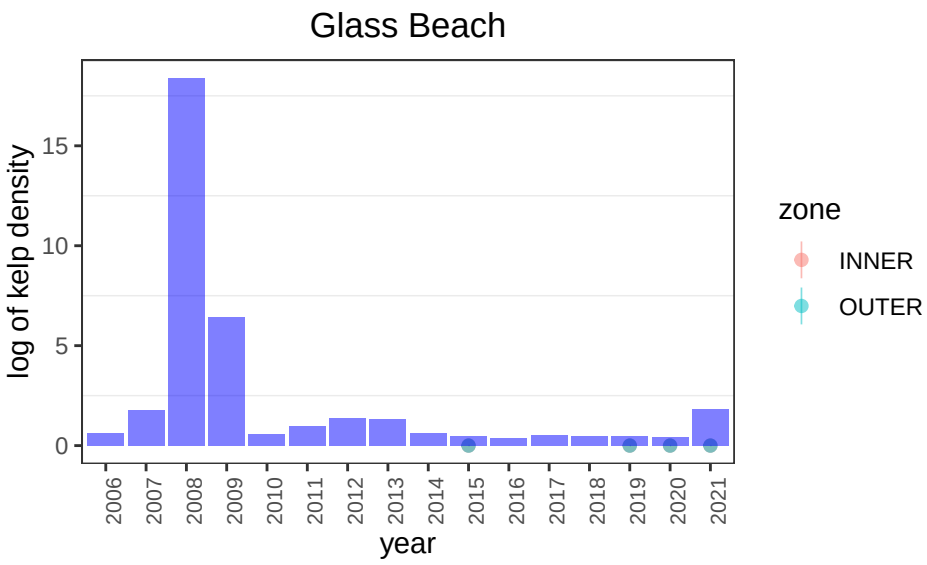

Dark Gulch
log of kelp density
0
5
10
15
20
25
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

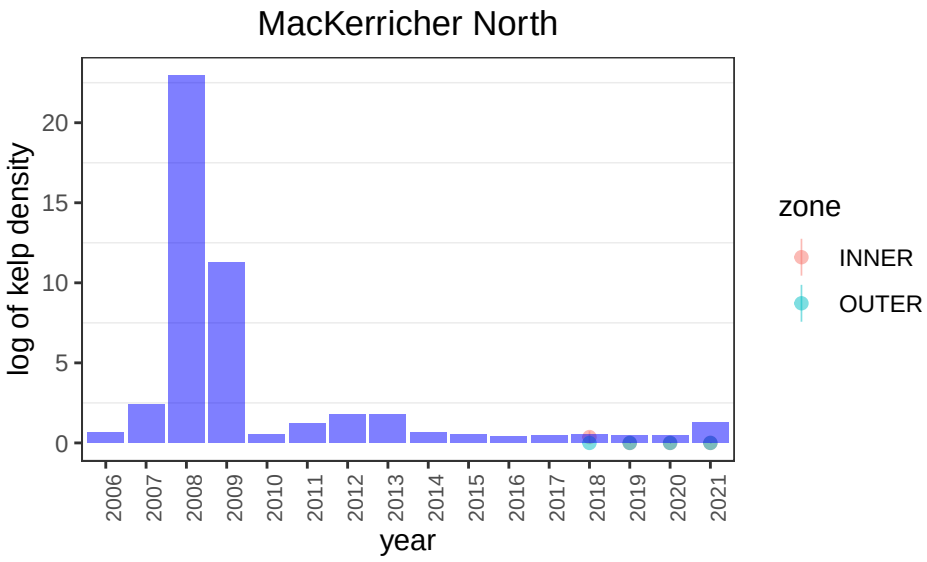

Flat Iron Rock
log of kelp density
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

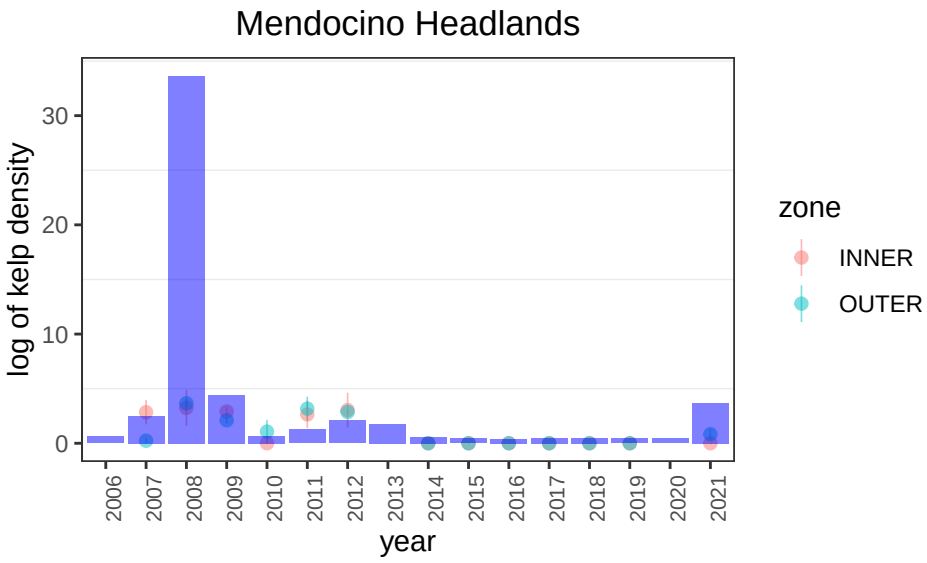

Fort Ross
log of kelp density
4
2
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

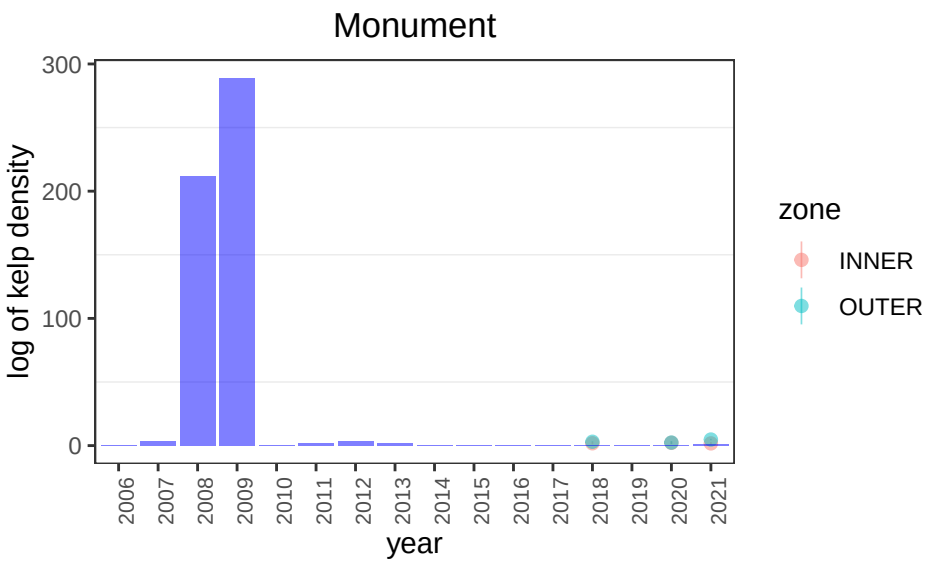

Frolic Cove
log of kelp density
100
75
50
25
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

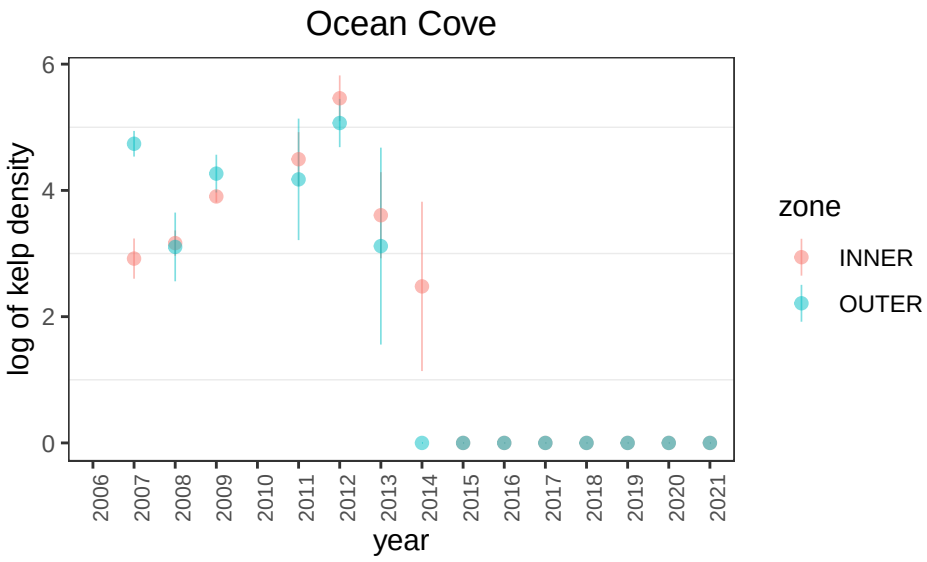

Gerstle Cove
log of kelp density
0
1
2
3
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

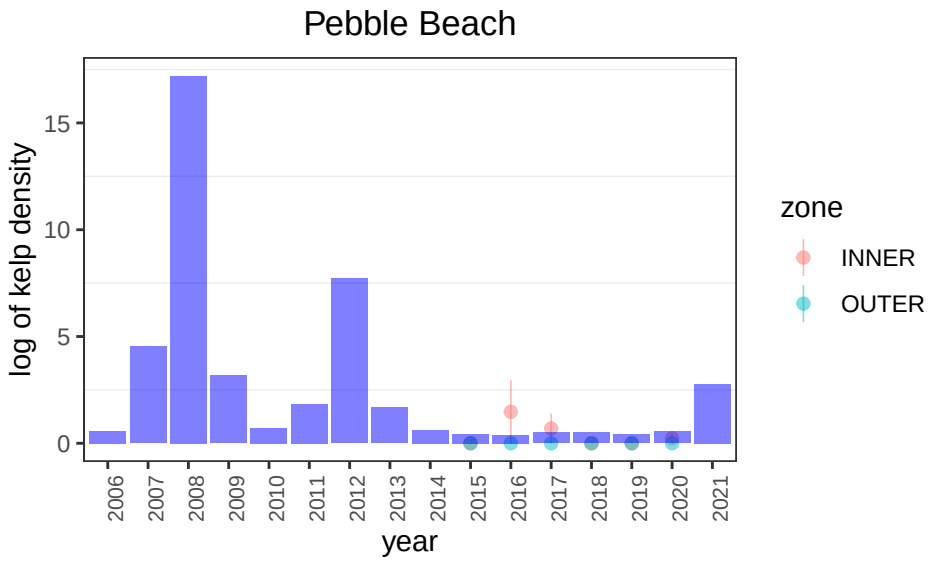

Glass Beach
log of kelp density
0
5
10
15
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

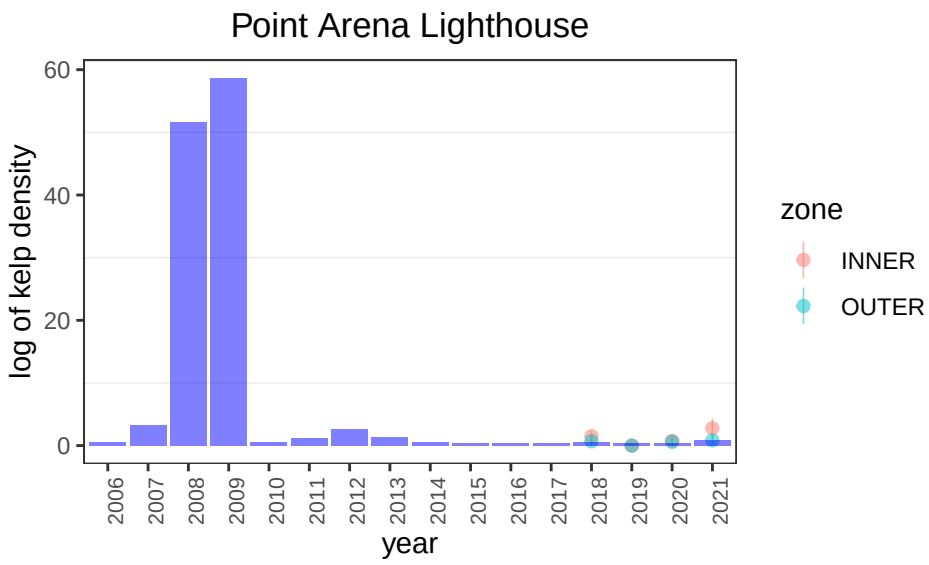

MacKerricher North
log of kelp density
0
5
10
15
20
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

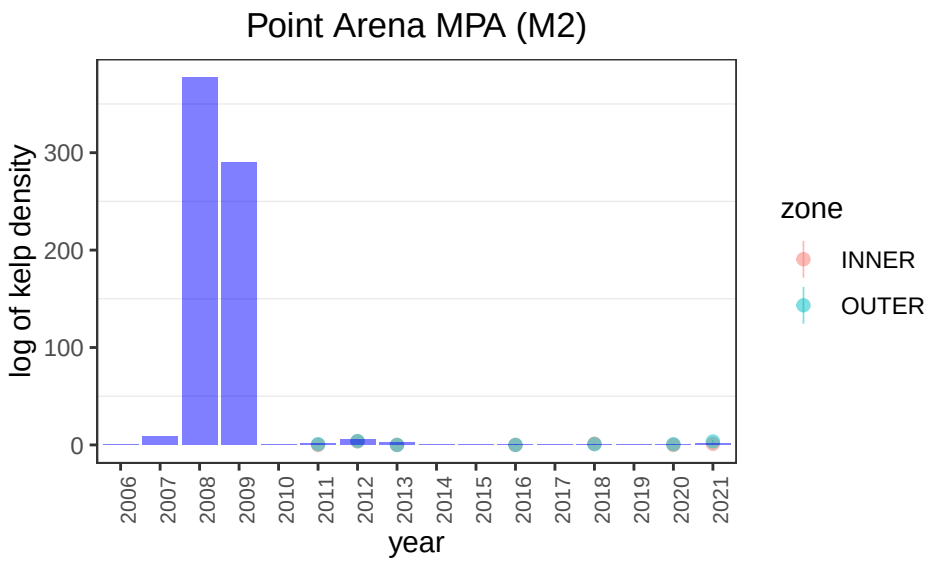

Mendocino Headlands
log of kelp density
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

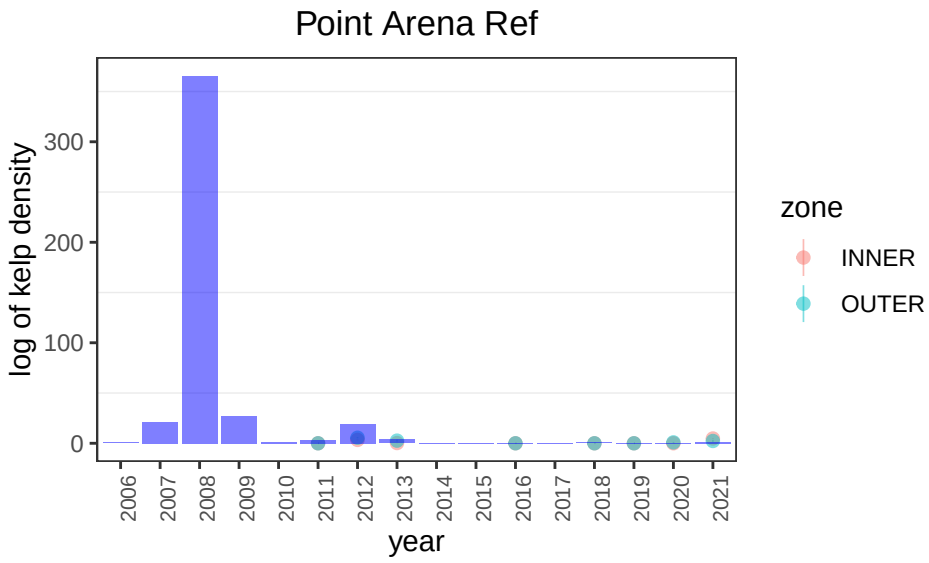

Monument
log of kelp density
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

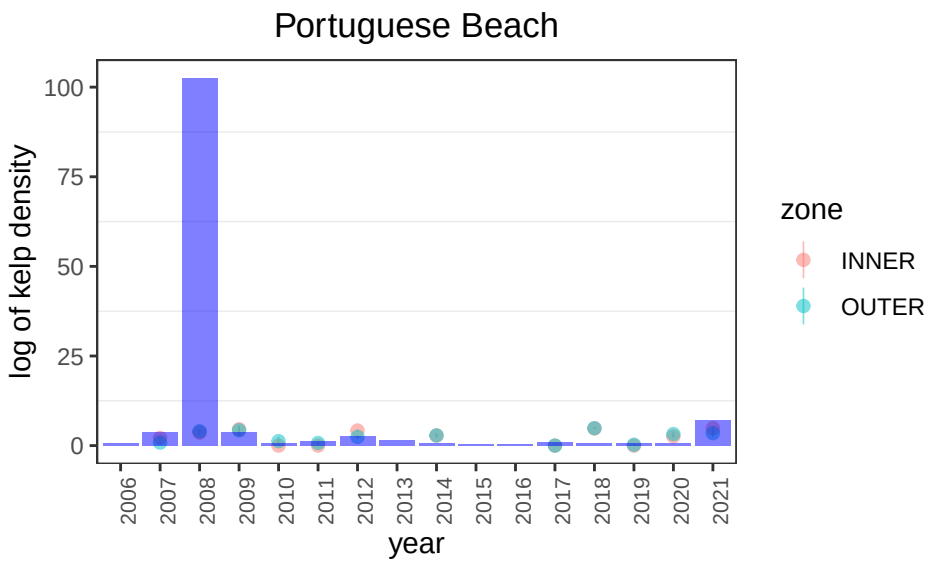

Ocean Cove
log of kelp density
6
4
2
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

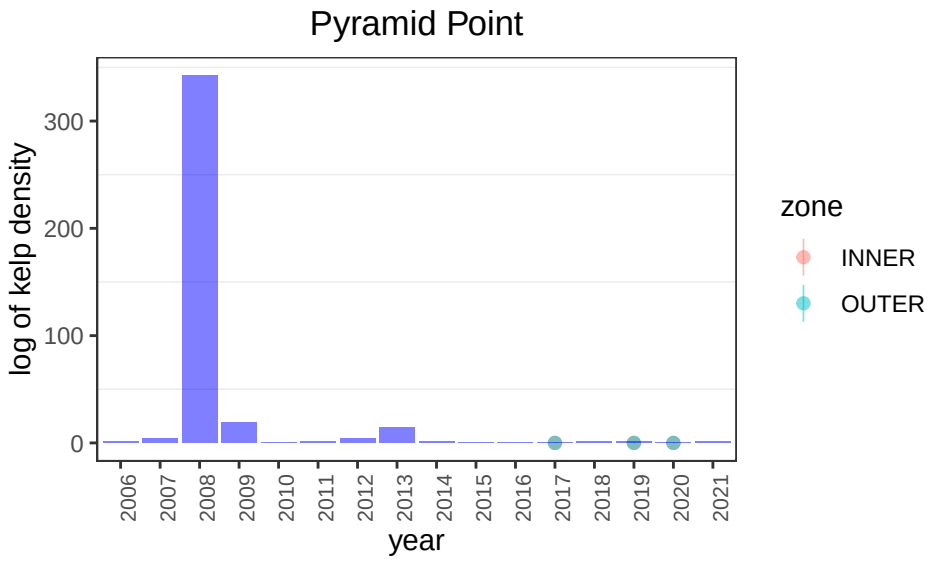

Pebble Beach
log of kelp density
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

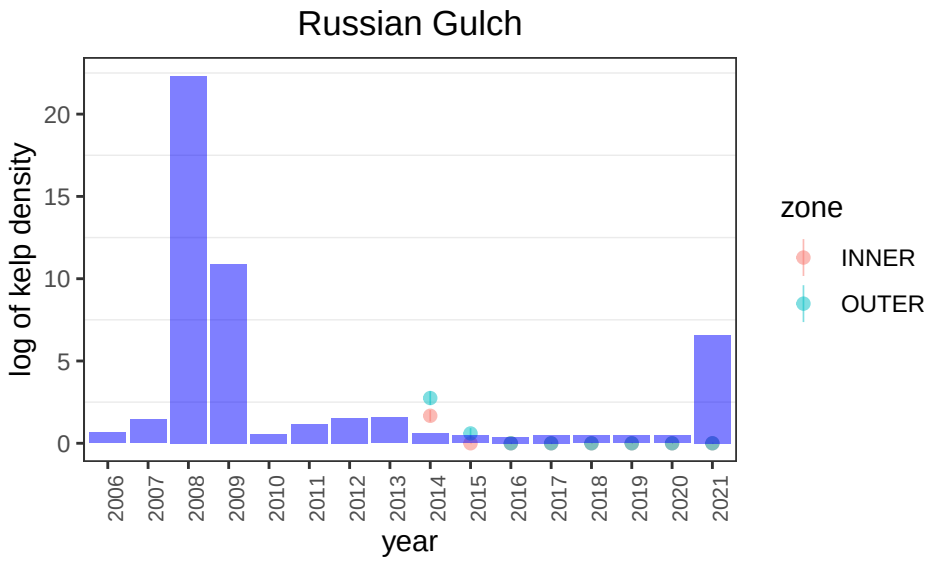

Point Arena Lighthouse
log of kelp density
60
40
20
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

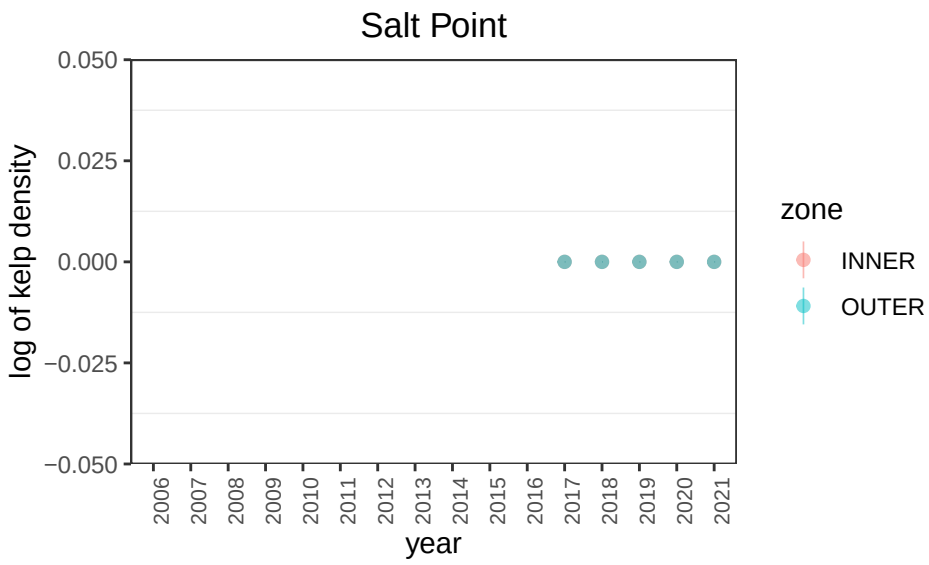

Point Arena MPA (M2)
log of kelp density
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

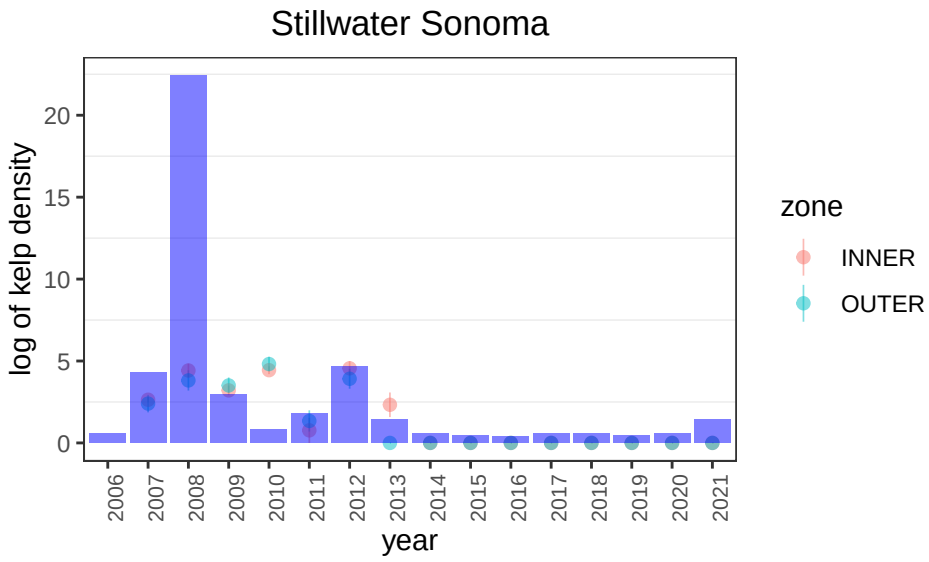

Point Arena Ref
log of kelp density
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

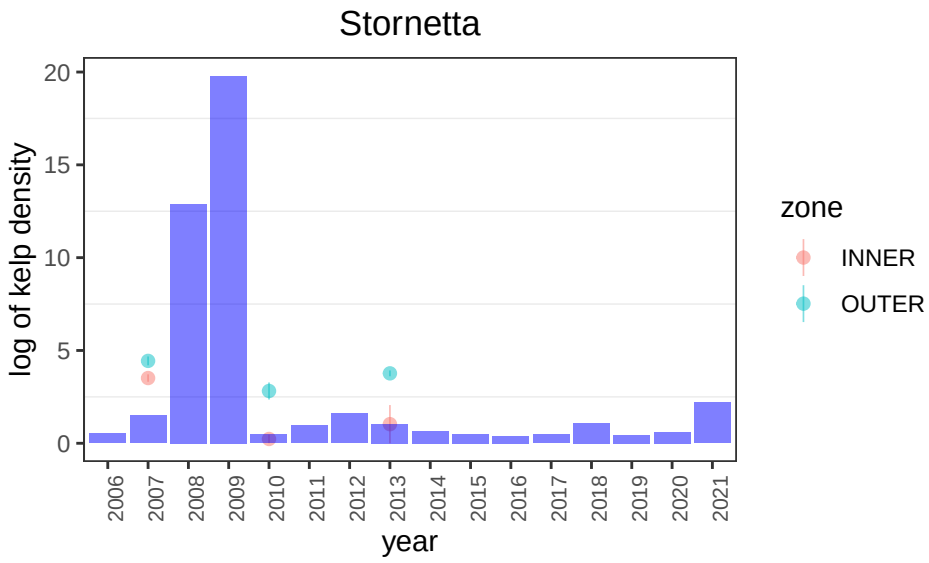

Portuguese Beach
log of kelp density
100
75
50
25
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

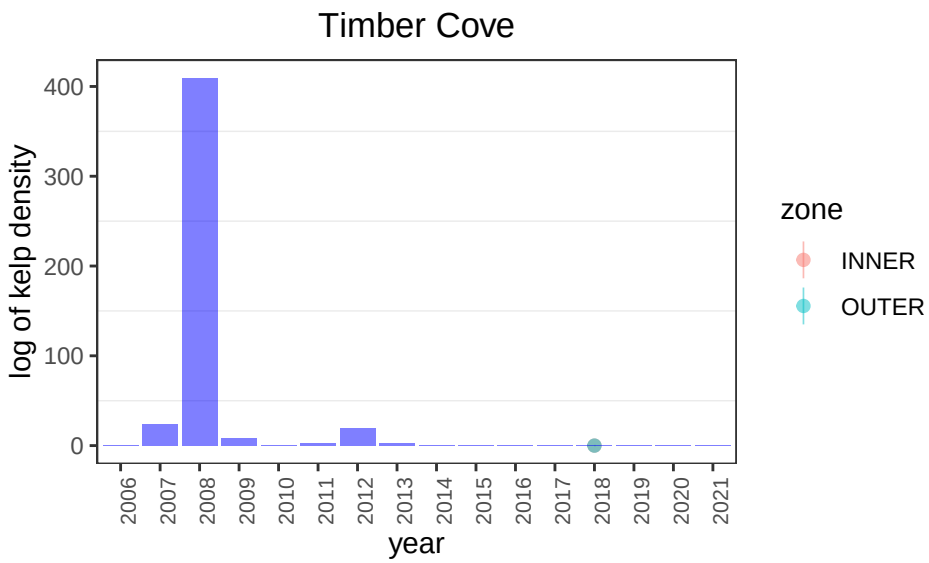

Pyramid Point
log of kelp density
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

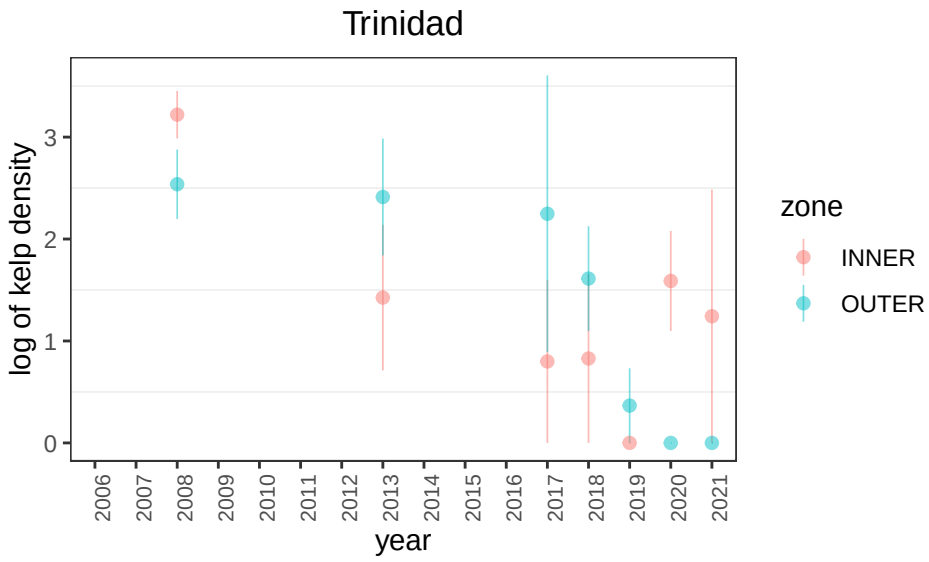

Russian Gulch
log of kelp density
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

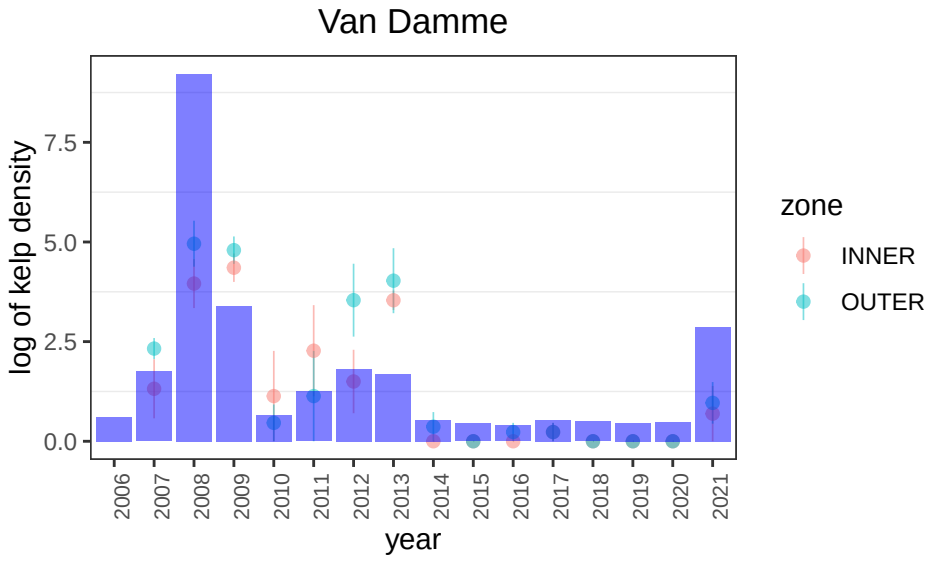

Salt Point
log of kelp density
0.050
0.025
0.000
−0.025
−0.050
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER


Stillwater Sonoma
log of kelp density
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER


Stornetta
log of kelp density
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER

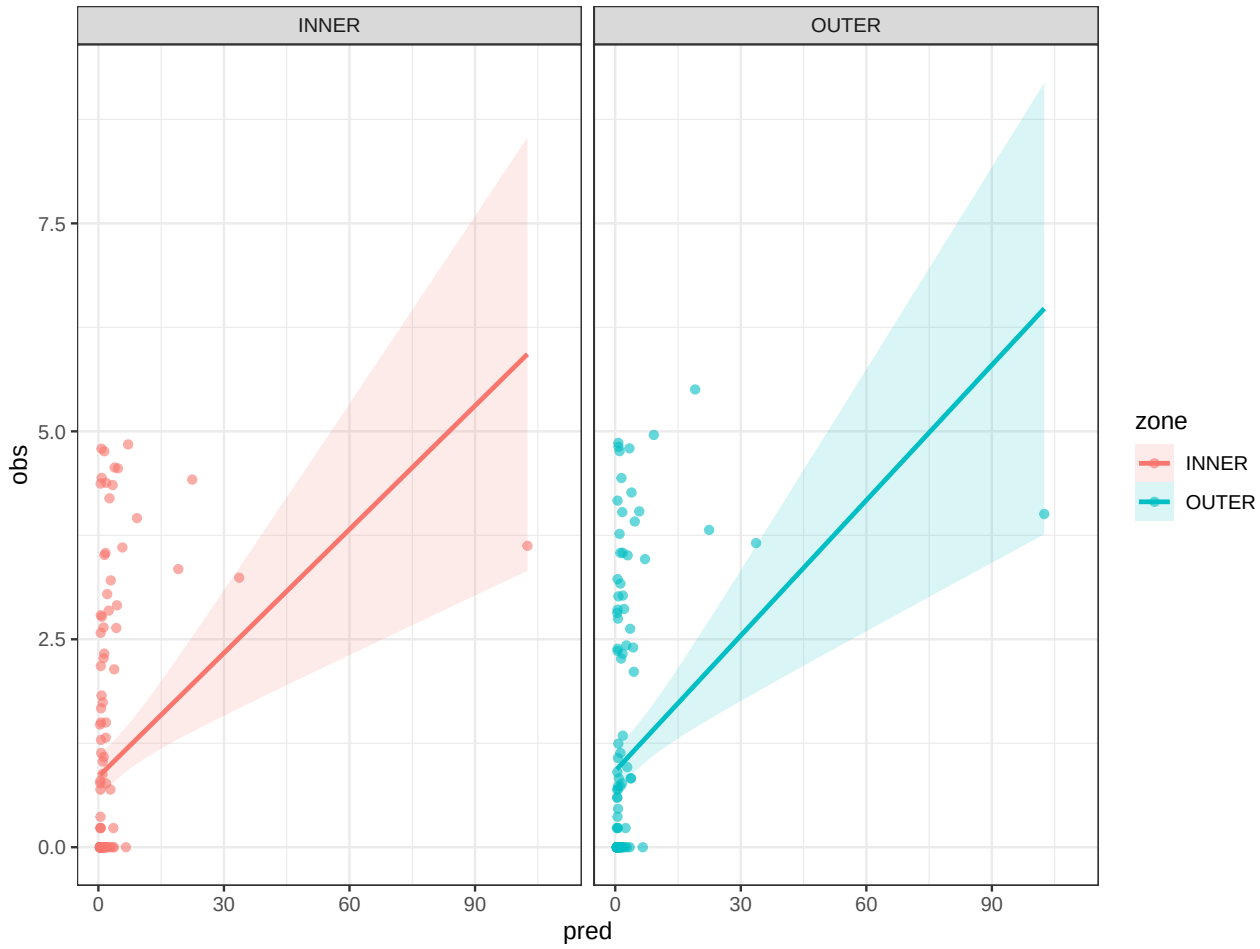

Timber Cove
log of kelp density
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER


Trinidad
log of kelp density
3
2
1
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
year
zone
INNER
OUTER



Plot obs. vs pred.

```
kelp_longer %>%
  ggplot(aes(x = fit, y = mean, color = zone)) +
  geom_point(alpha = 0.6) +
  geom_smooth(method = 'lm', alpha = 0.15, aes(fill = zone)) +
  xlim(NA, 110) +
  labs(x = 'pred', y = 'obs') +
  facet_wrap(~zone, ncol = 2) +
  theme_bw()
```


INNER
OUTER
obs
pred
7.5
5.0
2.5
0.0
0
30
60
90
zone
INNER
OUTER