# Groundfish multivariate analyses - Compare Years by Area

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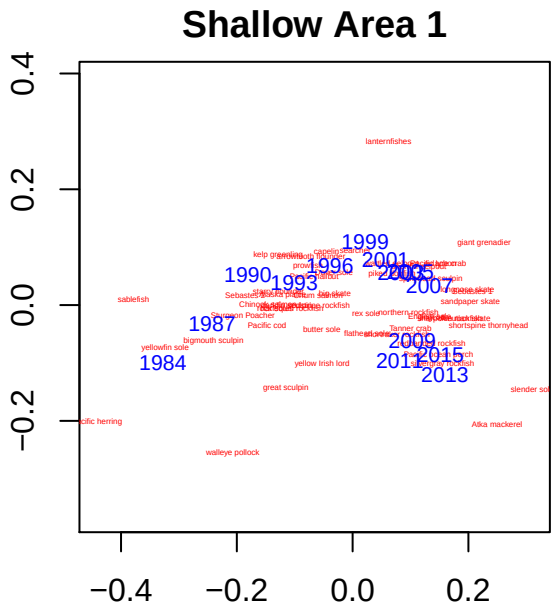
## 1. nMDS

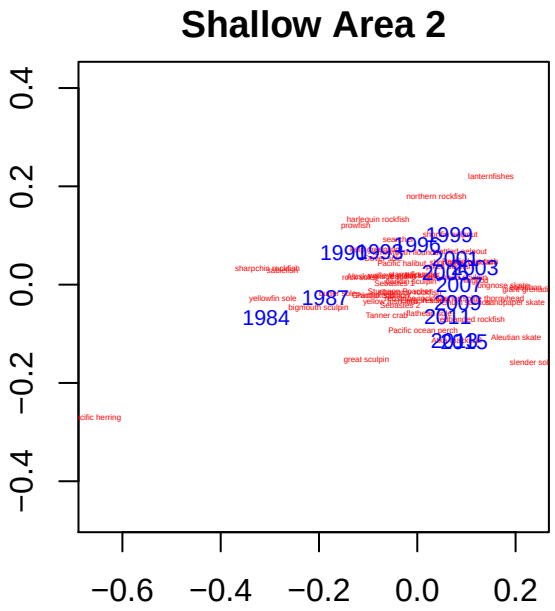
Transformation is Wisconsin-style double transformation (normalizes taxa to % abundance, then normalizes abundances to the maximum for each species) of sqrt-transformed data.

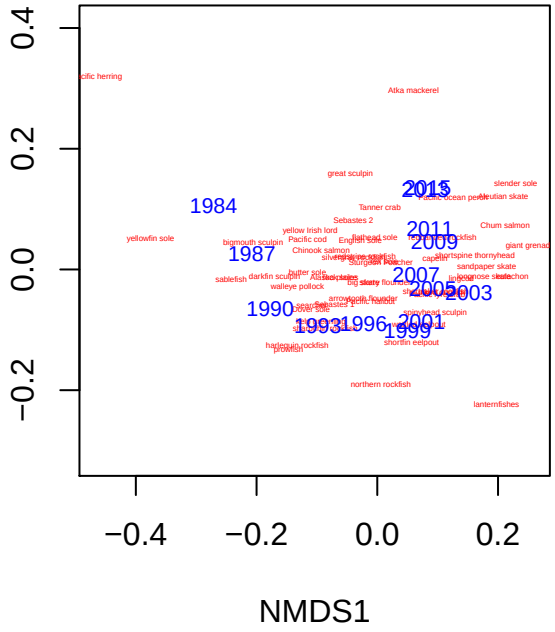
**Sorry the text is so small. It's necessary for legibility because there are so many species. Enlarge the output pdf to see species names.**

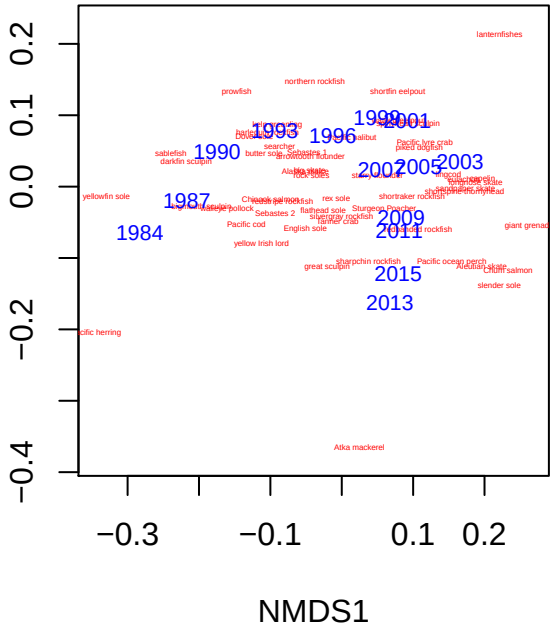
### Shallow areas

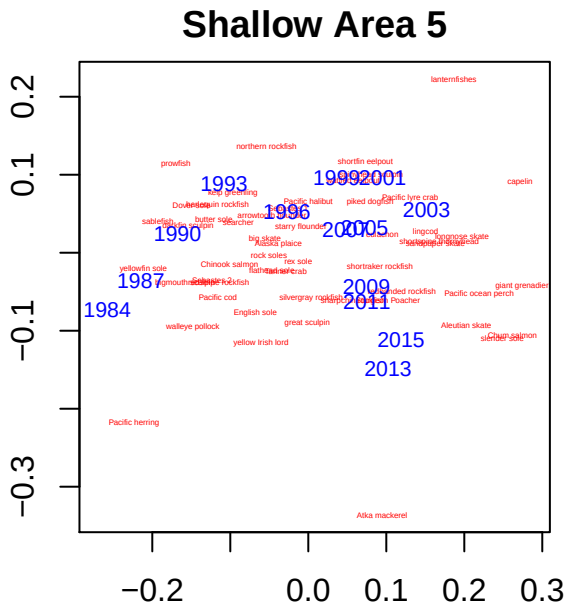
Area 10 is Total

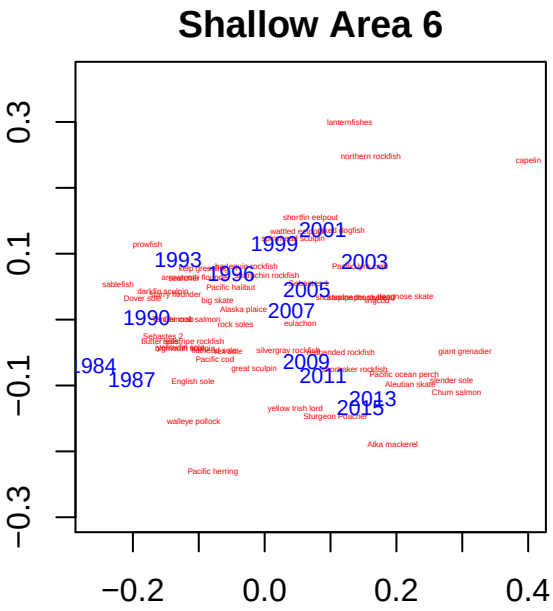

Shallow Area 1
NMDS1
0.4
0.2
0.0
−0.2
−0.4
−0.2
0.0
0.2
1999
2001
1990
1996
1993
2005
2007
1987
2009
2011
2015
2013
1984
lanternfishes
giant grenadier
sablefish
Pacific cod
butter sole
shortspine thornyhead
sandpaper skate
bigmouth sculpin
yellowfin sole
yellow Irish lord
great sculpin
slender sole
Atka mackerel
walleye pollock

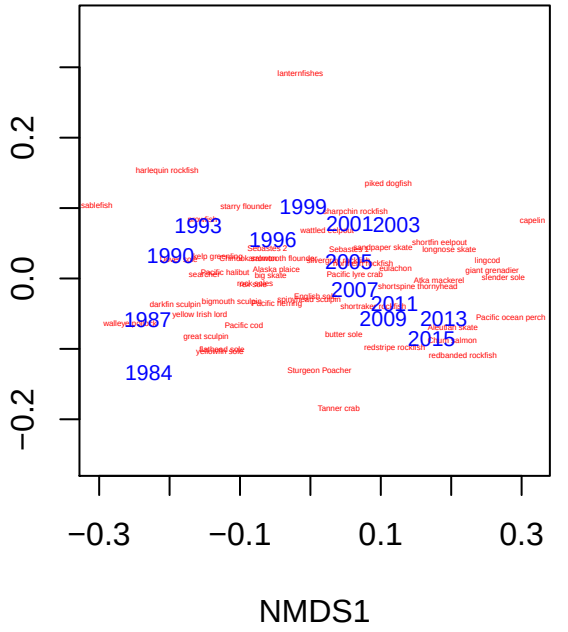

Shallow Area 2
NMDS1
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.4
−0.2
0.0
0.2
lanternfishes
northern rockfish
harlequin rockfish
prowfish
1999
1993
1996
2001
2003
2005
2007
2009
2011
2015
1987
1984
yellowfin sole
bigmouth sculpin
Tanner crab
Pacific ocean perch
Aleutian skate
great sculpin
slender sole

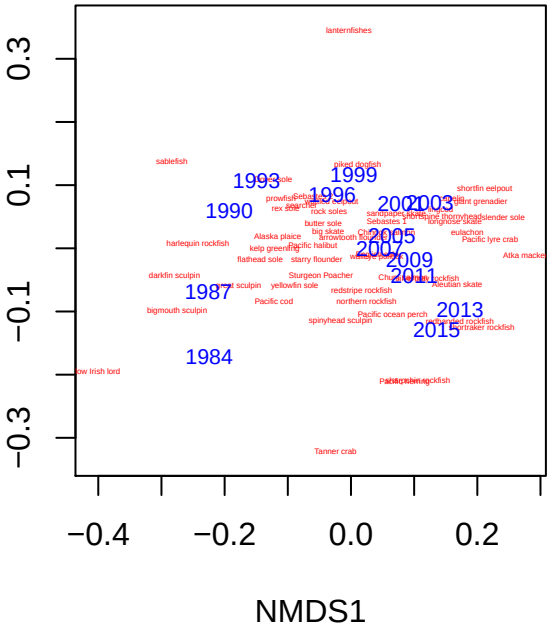

Shallow Area 3
NMDS1
0.4
0.2
0.0
−0.2
−0.4
−0.2
0.0
0.2
Atka mackerel
great sculpin
slender sole
1984
Tanner crab
Sebastes 2
Chum salmon
yellowfin sole
yellow Irish lord
1987
Pacific cod
English sole
giant grenadier
Chinook salmon
shortspine thornyhead
sablefish
darkfin sculpin
sandpaper skate
walleye pollock
1990
1993
1996
1999
2001
2003
2005
2007
2009
2011
2015
shortfin eelpout
northern rockfish
lanternfishes

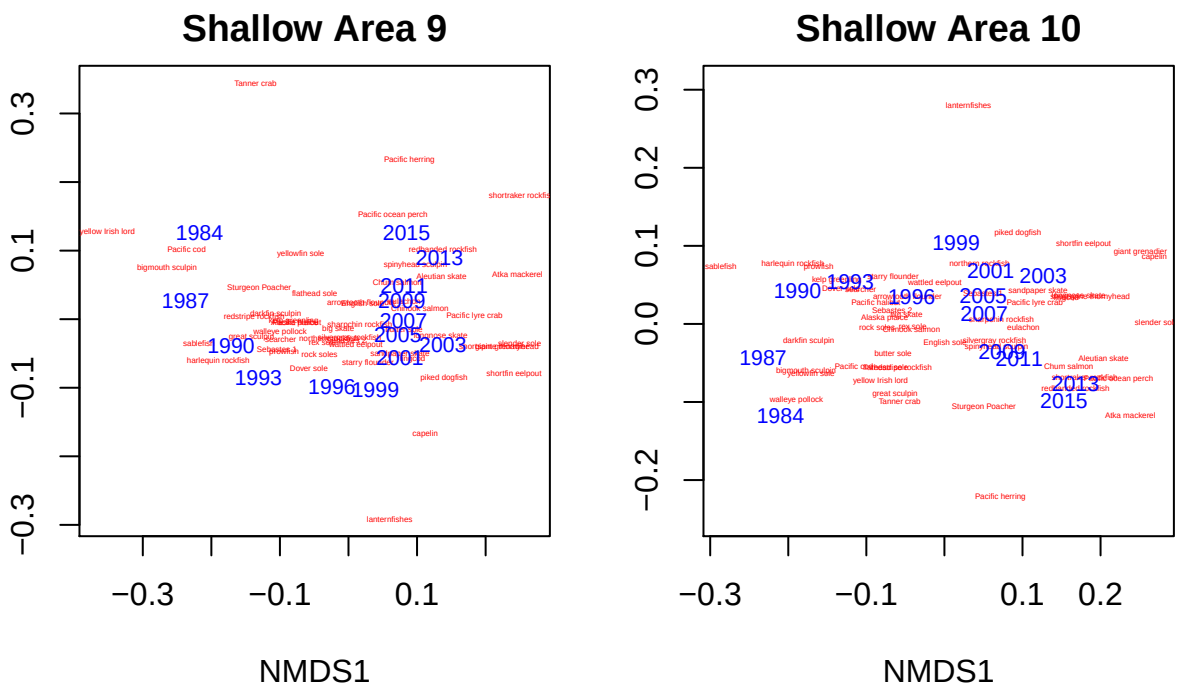

Shallow Area 4
NMDS1
0.2
0.1
0.0
−0.2
−0.4
−0.3
−0.1
0.1
0.2
lanternfishes
northern rockfish
prowfish
shortfin eelpout
1999
1993
1996
2001
1990
2003
2007
2005
1987
2009
2011
1984
sablefish
butter sole
darkfin sculpin
yellowfin sole
rex sole
shortraker rockfish
Pacific cod
English sole
flathead sole
giant grenadier
yellow Irish lord
2015
2013
Atka mackerel


Shallow Area 5
NMDS1
−0.2
0.0
0.1
0.2
0.3
−0.3
−0.1
0.1
0.2
1984
1987
1990
1993
1996
2003
2005
2007
2009
2011
2013
2015
lanternfishes
northern rockfish
prowfish
shortfin eelpout
capelin
Pacific halibut
piked dogfish
Pacific lyre crab
sablefish
big skate
Alaska plaice
rock soles
rex sole
Chinook salmon
shortraker rockfish
yellowfin sole
Pacific cod
giant grenadier
redbanded rockfish
Pacific ocean perch
English sole
great sculpin
Aleutian skate
walleye pollock
yellow Irish lord
Pacific herring
Atka mackerel


Shallow Area 6
NMDS1
−0.2
0.0
0.2
0.4
−0.3
−0.1
0.1
0.3
1984
1987
1990
1993
1996
1999
2001
2003
2005
2007
2009
2011
2013
2015
lanternfishes
northern rockfish
capelin
shortfin eelpout
prowfish
sablefish
Pacific halibut
big skate
Alaska plaice
rock soles
eulachon
Pacific cod
great sculpin
English sole
giant grenadier
Pacific ocean perch
Aleutian skate
Churn salmon
yellow Irish lord
walleye pollock
Sturgeon Poacher
Atka mackerel
Pacific herring

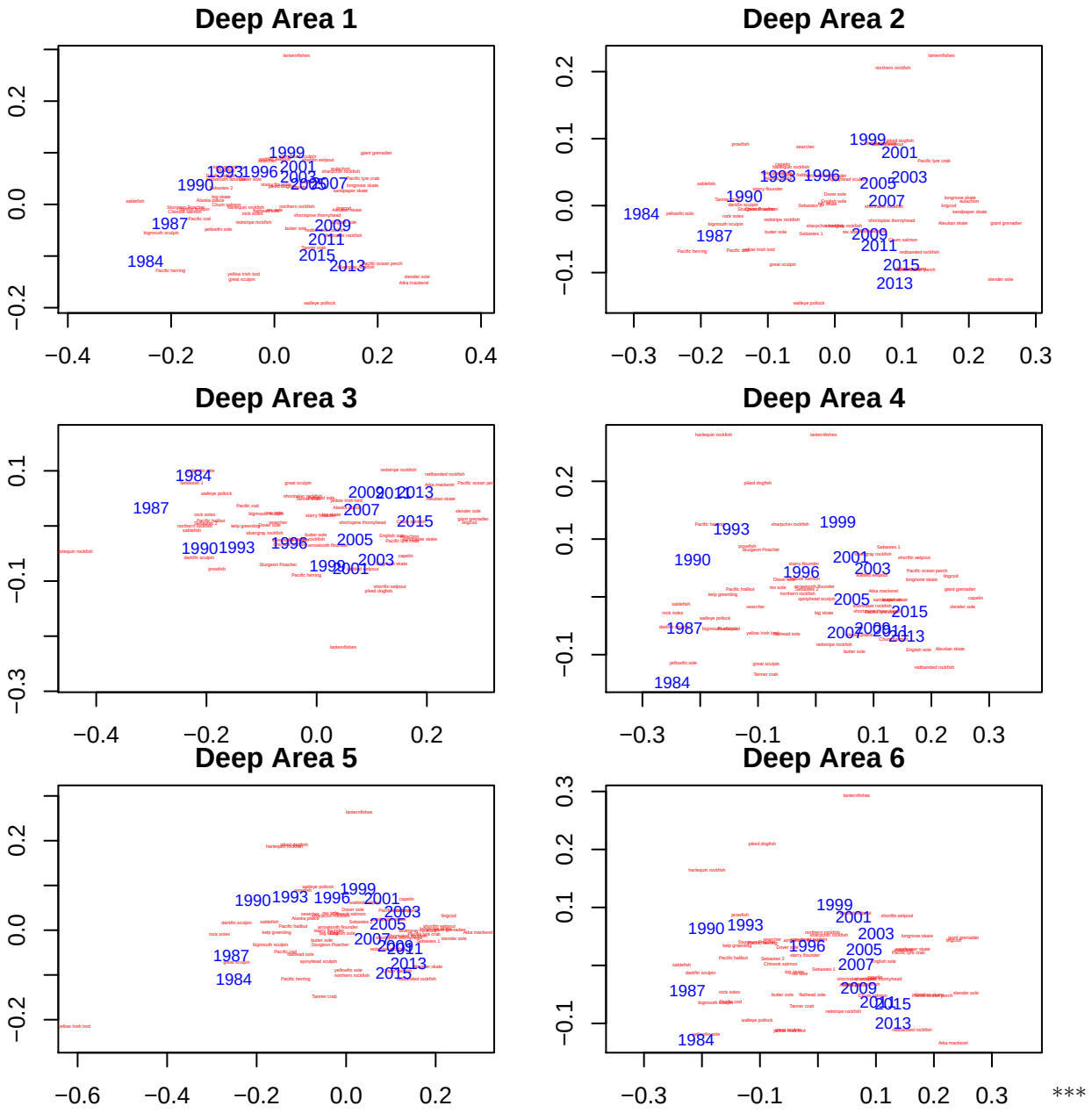

Shallow Area 7
NMDS1
−0.3
−0.1
0.1
0.3
−0.2
0.0
0.2
1984
1987
1990
1993
1996
1999
2001
2003
2005
2007
2009
2011
2013
2015
lanternfishes
harlequin rockfish
piked dogfish
sablefish
starry flounder
shortspine thornyhead
capelin
shortfin eelpout
longnose skate
lingcod
Pacific halibut
Alaska plaice
big skate
rock soles
Atka mackerel
slender sole
darkfin sculpin
bigmouth sculpin
Pacific herring
yellow Irish lord
Pacific cod
great sculpin
butter sole
redstripe rockfish
redbanded rockfish
Sturgeon Poacher
Tanner crab


Shallow Area 8
NMDS1
−0.4
−0.2
0.0
0.2
−0.3
−0.1
0.1
0.3
1984
1987
1990
1993
1996
1999
2001
2003
2005
2007
2009
2011
2013
2015
lanternfishes
sablefish
piked dogfish
shortfin eelpout
Pacific halibut
rock soles
eulachon
harlequin rockfish
Alaska plaice
kelp greenling
Pacific lyre crab
flathead sole
starry flounder
Atka mackerel
darkfin sculpin
Sturgeon Poacher
yellowfin sole
Pacific cod
redstripe rockfish
bigmouth sculpin
spinyhead sculpin
Pacific ocean perch
northern rockfish
Tanner crab




## Deep areas

Area 6 is Total




## 2. PCA

Methods: Used vegan package in R, function rda(). Raw CPUEs vary by many orders of magnitude (10^-7 to 10^2 in shallow areas, 10^-5 to 10^2 in deep areas), therefore, to prevent the most abundant species from driving the result and allow all species to contribute equally to the result, cpues were standardized prior to analysis (Legendre & Legendre 1998) - means that PCs were extracted from correlation matrices, not dispersion matrices.

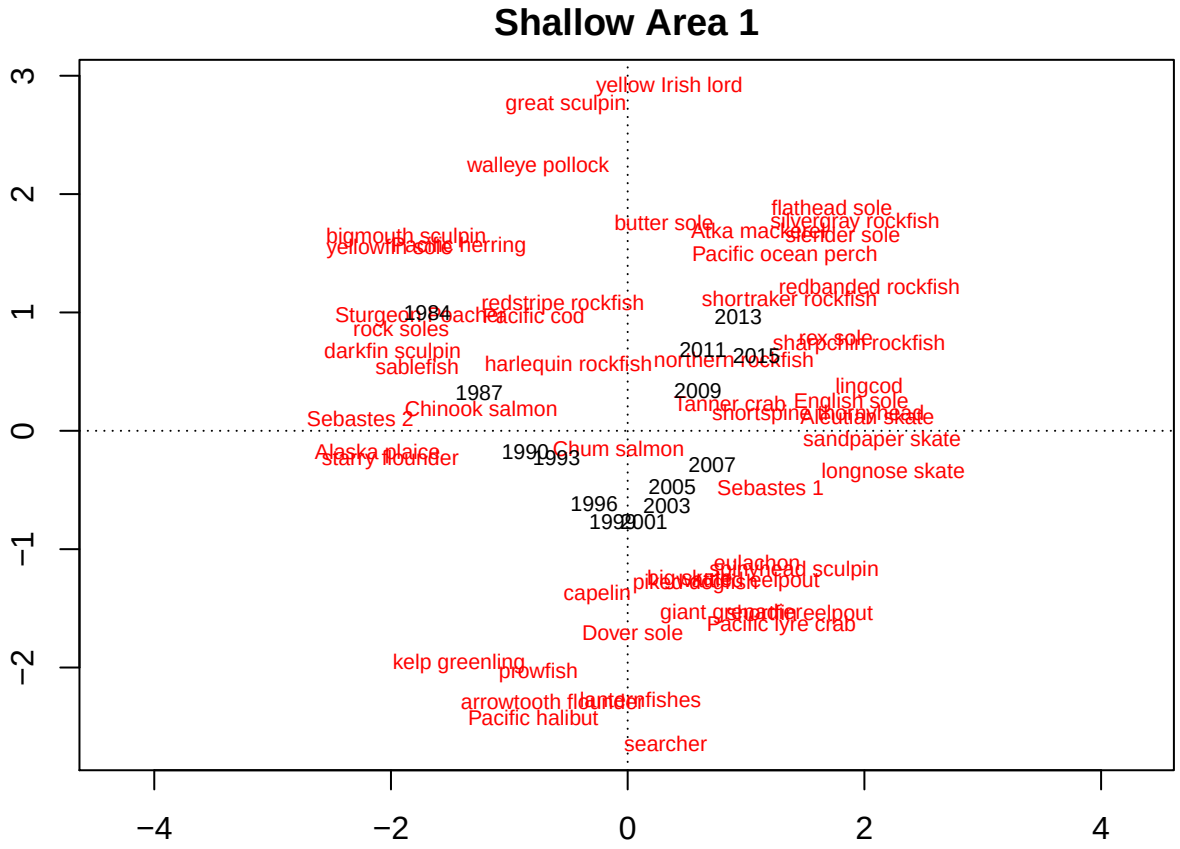
### Shallow areas

Area 10 is Total

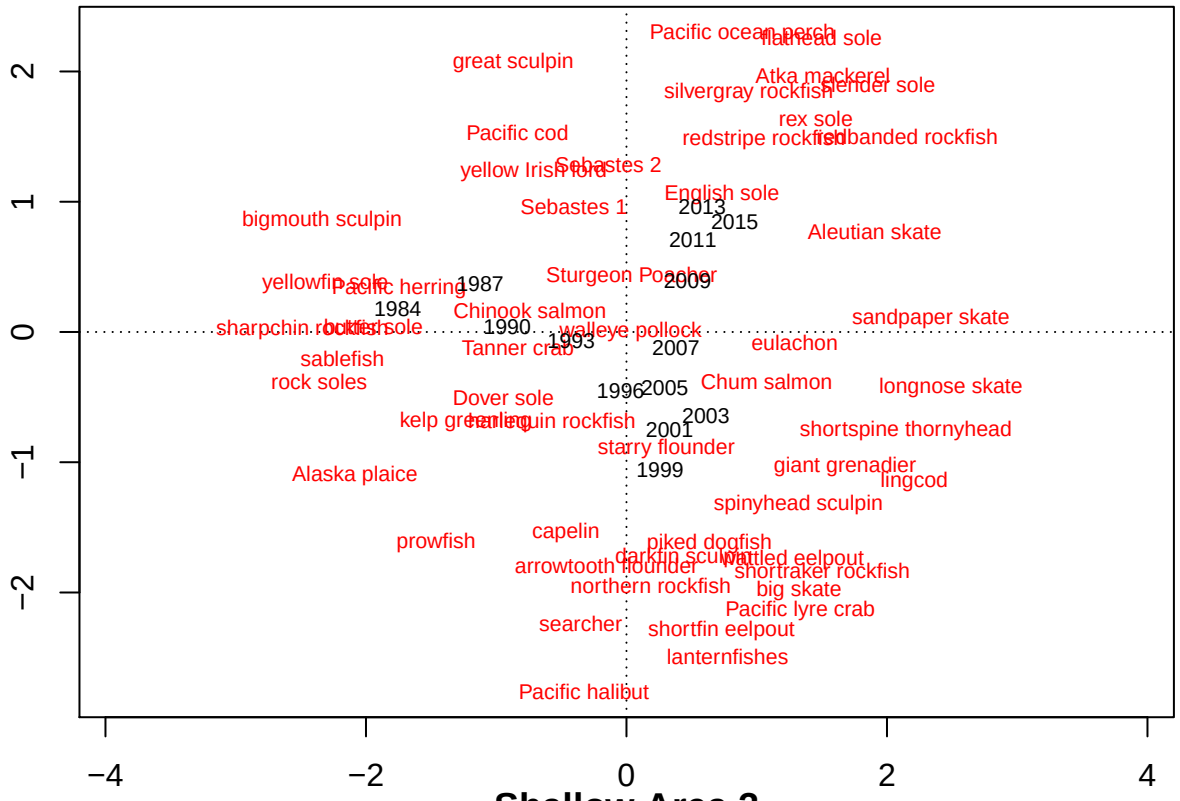
% of total variance explained by PC1 & PC2 (Area 10 = Total):

```
##    Area       PC1       PC2
## 1     1 0.3519725 0.2048984
## 2     2 0.2915416 0.1887890
## 3     3 0.2834110 0.1964664
## 4     4 0.2998676 0.1878989
## 5     5 0.3035660 0.2050751
## 6     6 0.3427620 0.2280674
## 7     7 0.3380583 0.1769048
## 8     8 0.3498791 0.2463860
## 9     9 0.3640909 0.1794389
## 10   10 0.3373172 0.2248949
```

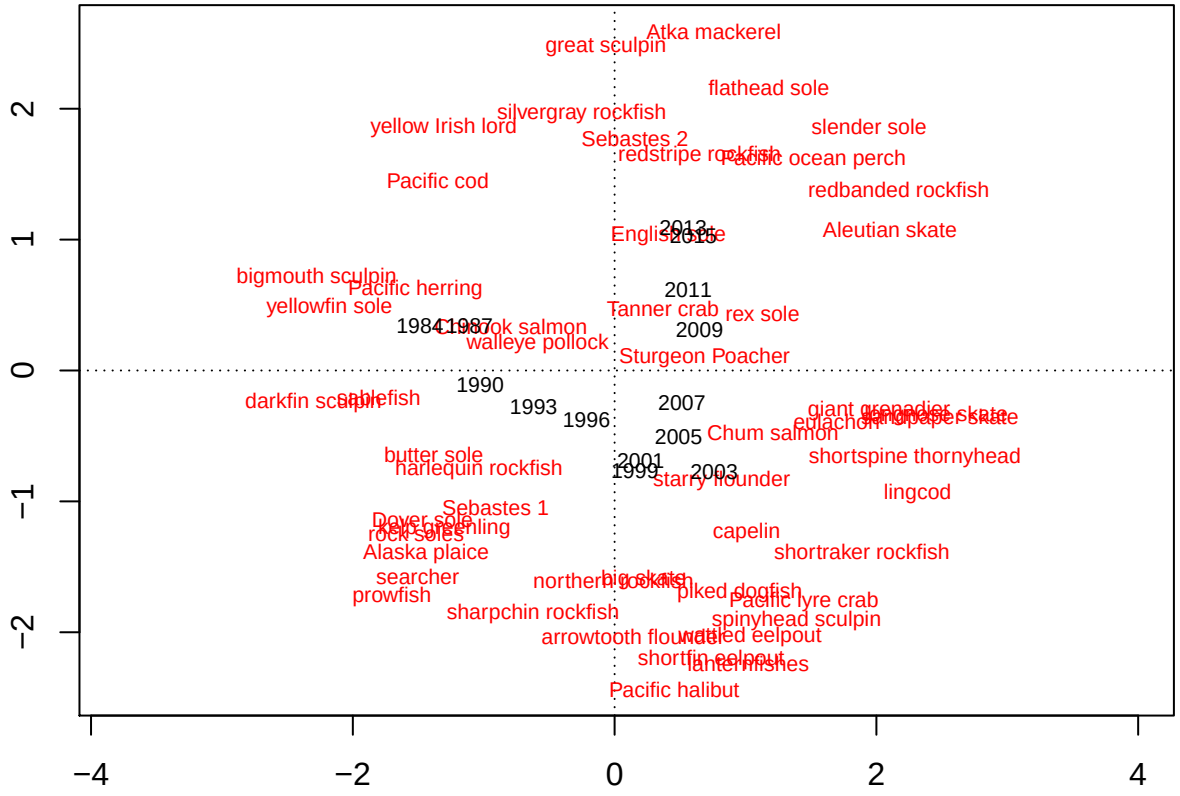
Plots for shallow areas. Note that I've removed arrows for species scores and did some wonky scaling of species scores to make them legible in the plots (divided each species score by species StDev - although their relative positions are preserved in the plots, this is technically incorrect because I've already standardized data prior to analysis). This will need to be changed if used in a publication - see .Rmd file for correct code.



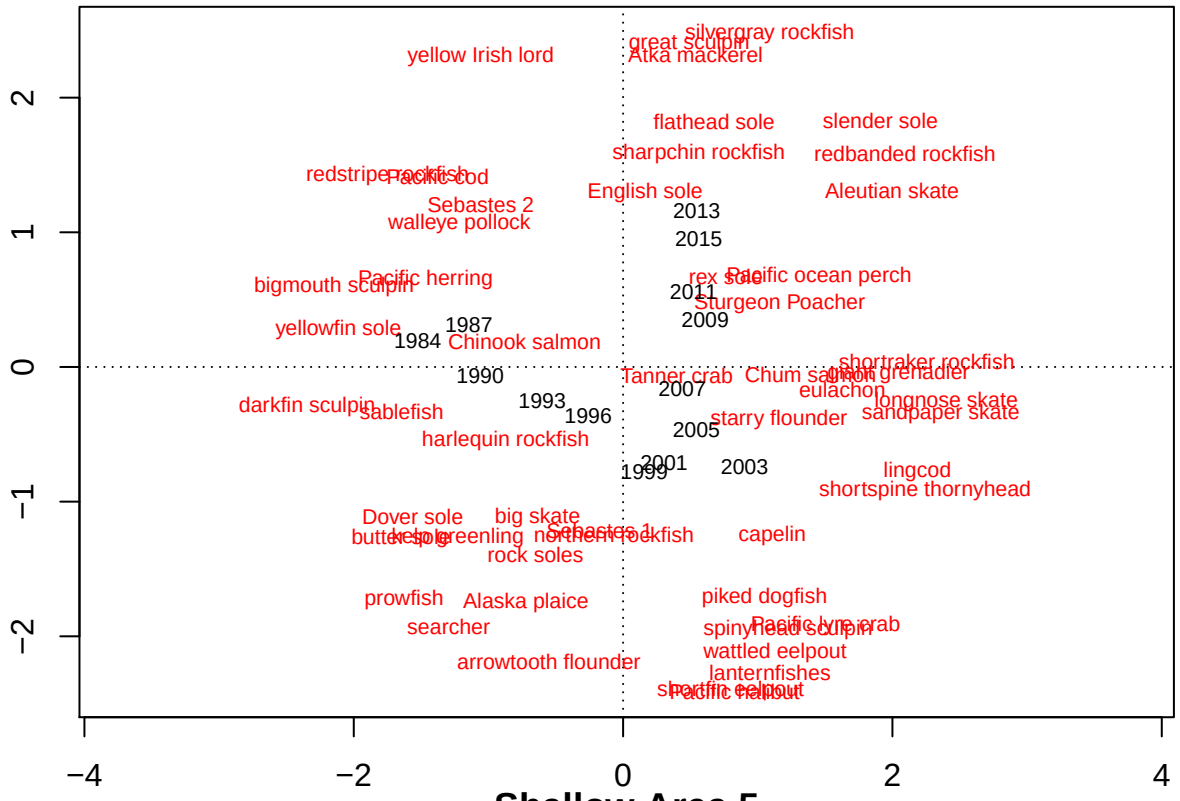
## Shallow Area 2



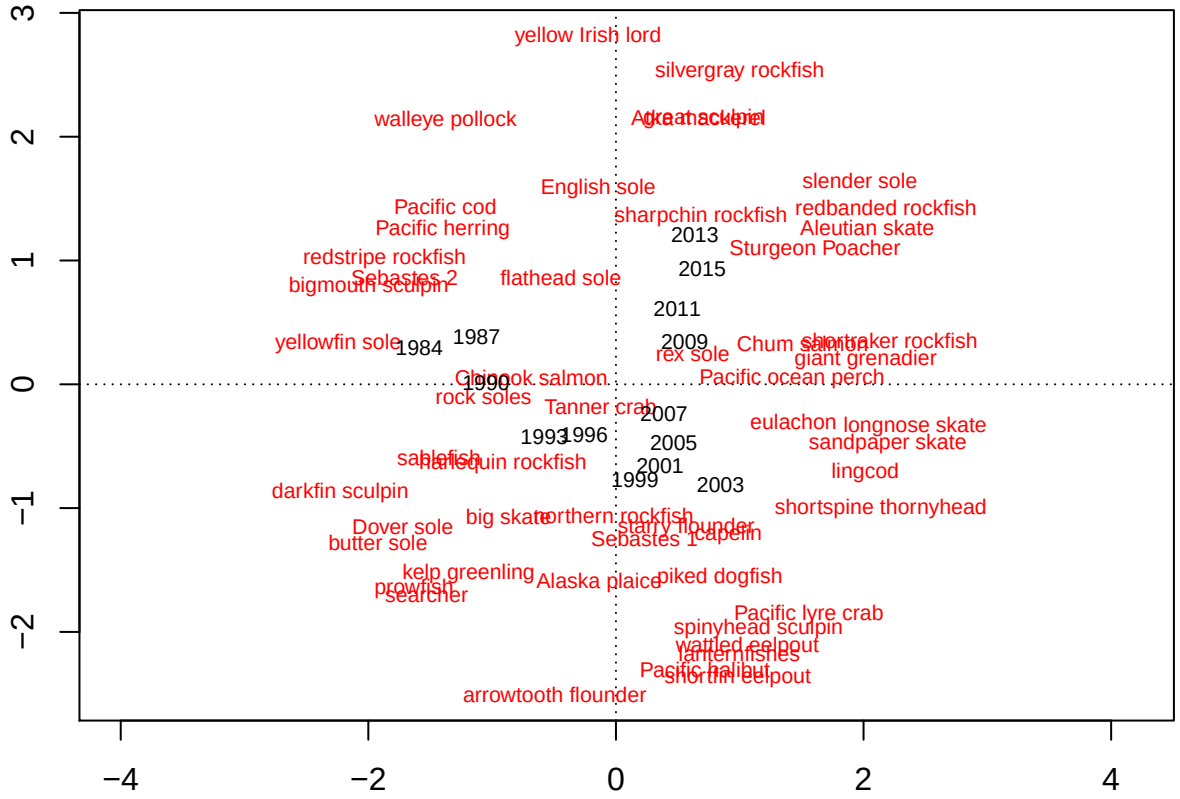

## Shallow Area 3

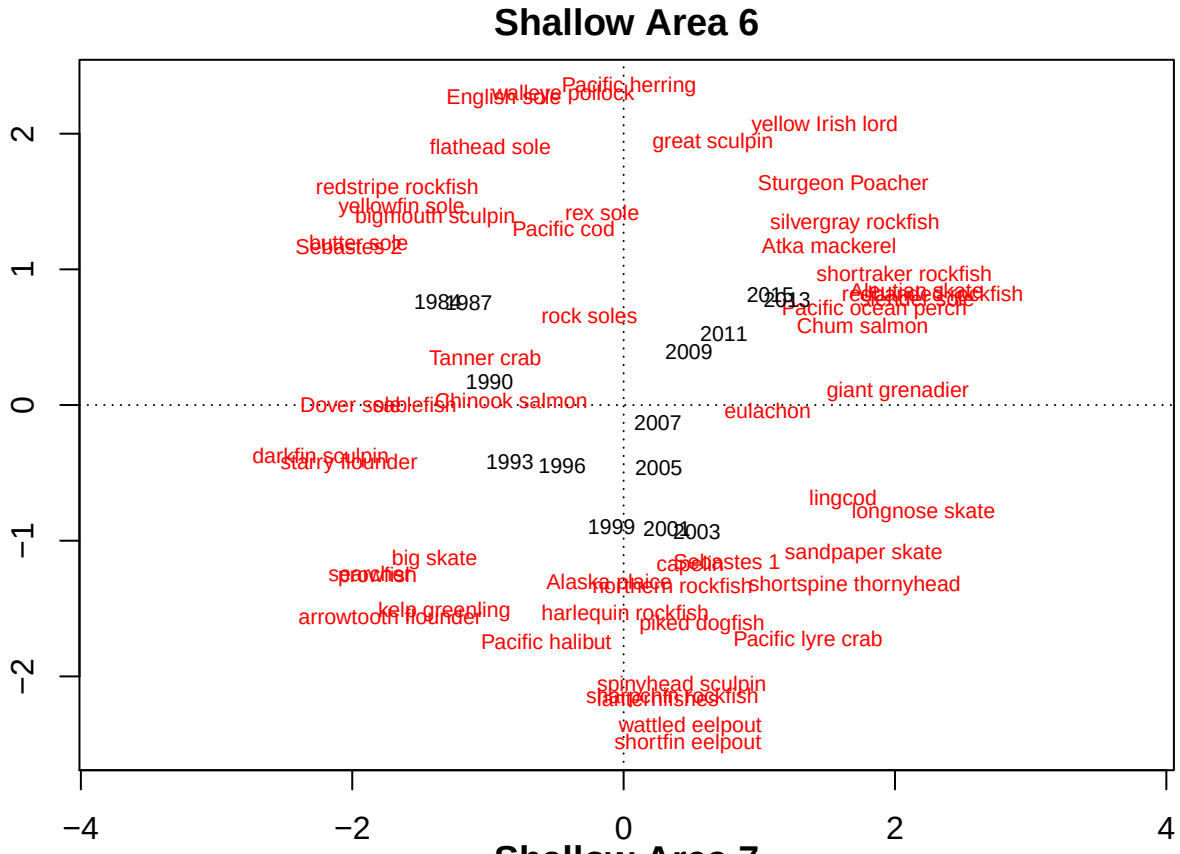


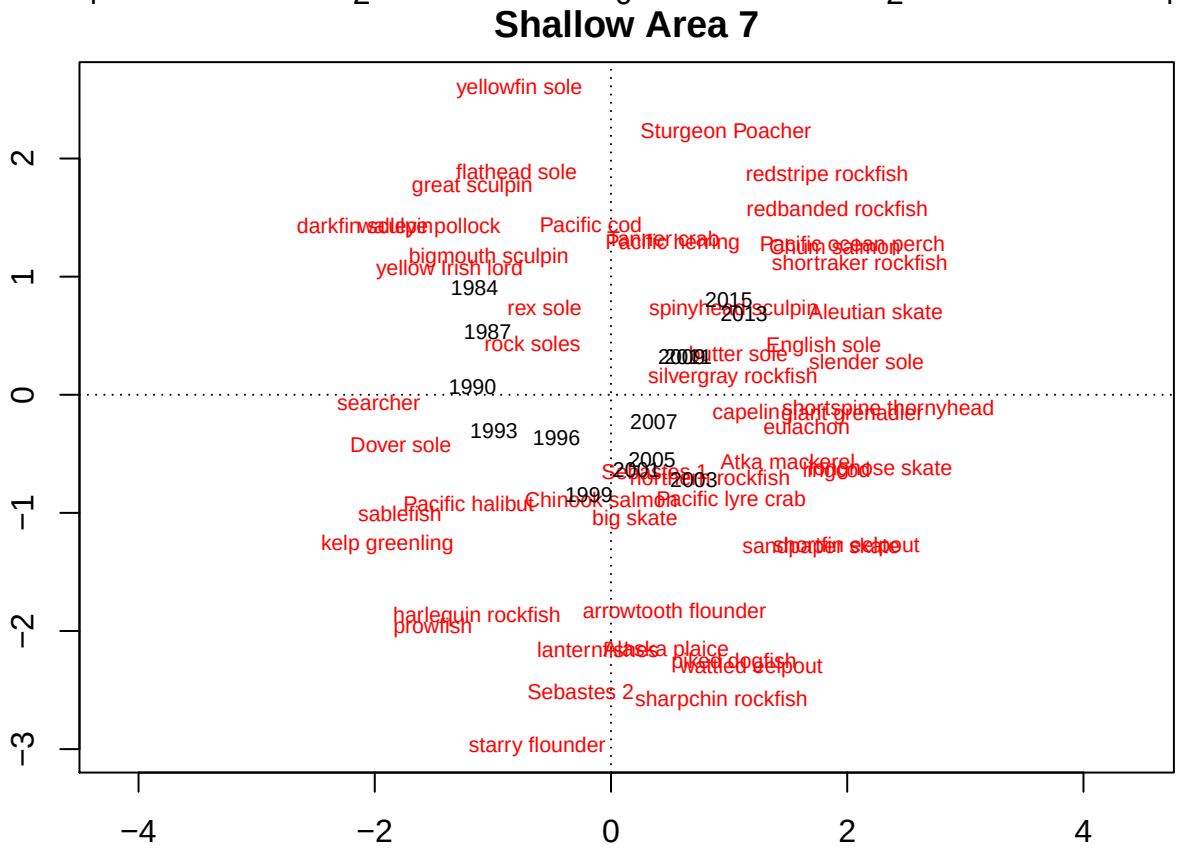
## Shallow Area 4



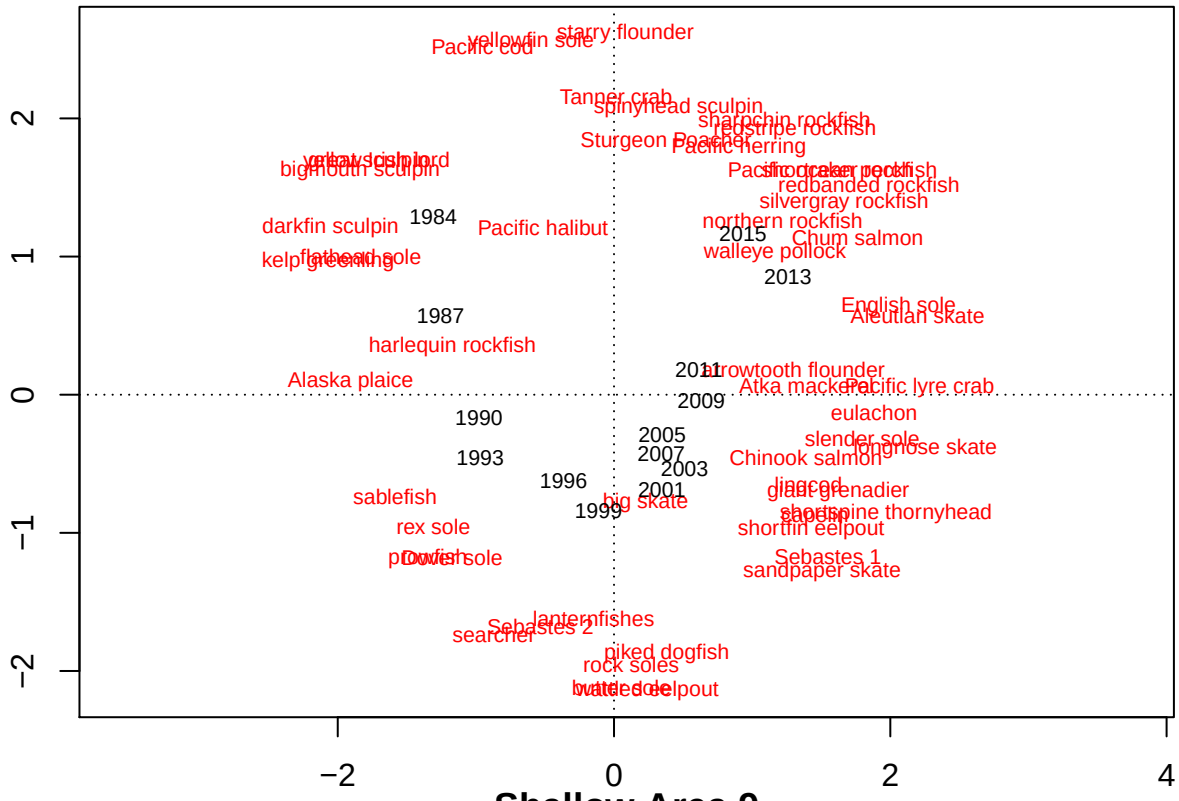

## Shallow Area 5



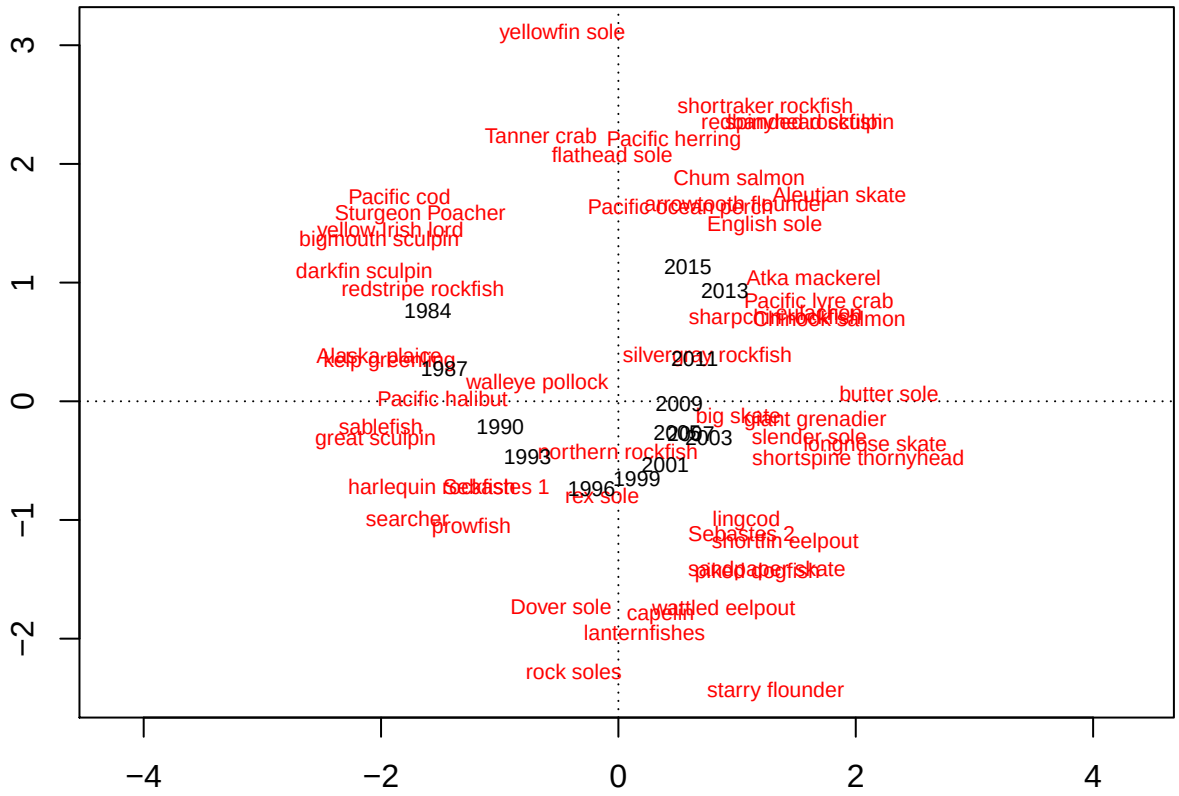

Shallow Area 6
Pacific herring
English sole
walleye pollock
yellow Irish lord
great sculpin
flathead sole
Sturgeon Poacher
redstripe rockfish
yellowfin sole
bigmouth sculpin
rex sole
Pacific cod
silvergray rockfish
butter sole
Sebastes 2
Atka mackerel
shortraker rockfish
1984
1987
2015
2013
Pacific ocean perch
rock soles
Chum salmon
2011
2009
Tanner crab
1990
giant grenadier
Chinook salmon
Dover sole
eulachon
2007
darkfin sculpin
starry flounder
1993
1996
2005
lingcod
longnose skate
1999
2001
2003
sandpaper skate
big skate
Sebastes 1
capelin
Alaska plaice
northern rockfish
shortspine thornyhead
arrowtooth flounder
kelp greenling
harlequin rockfish
piked dogfish
Pacific halibut
Pacific lyre crab
spinyhead sculpin
sharpchin rockfish
wattled eelpout
shortfin eelpout
−4
−2
0
2
4
−2
−1
0
1
2

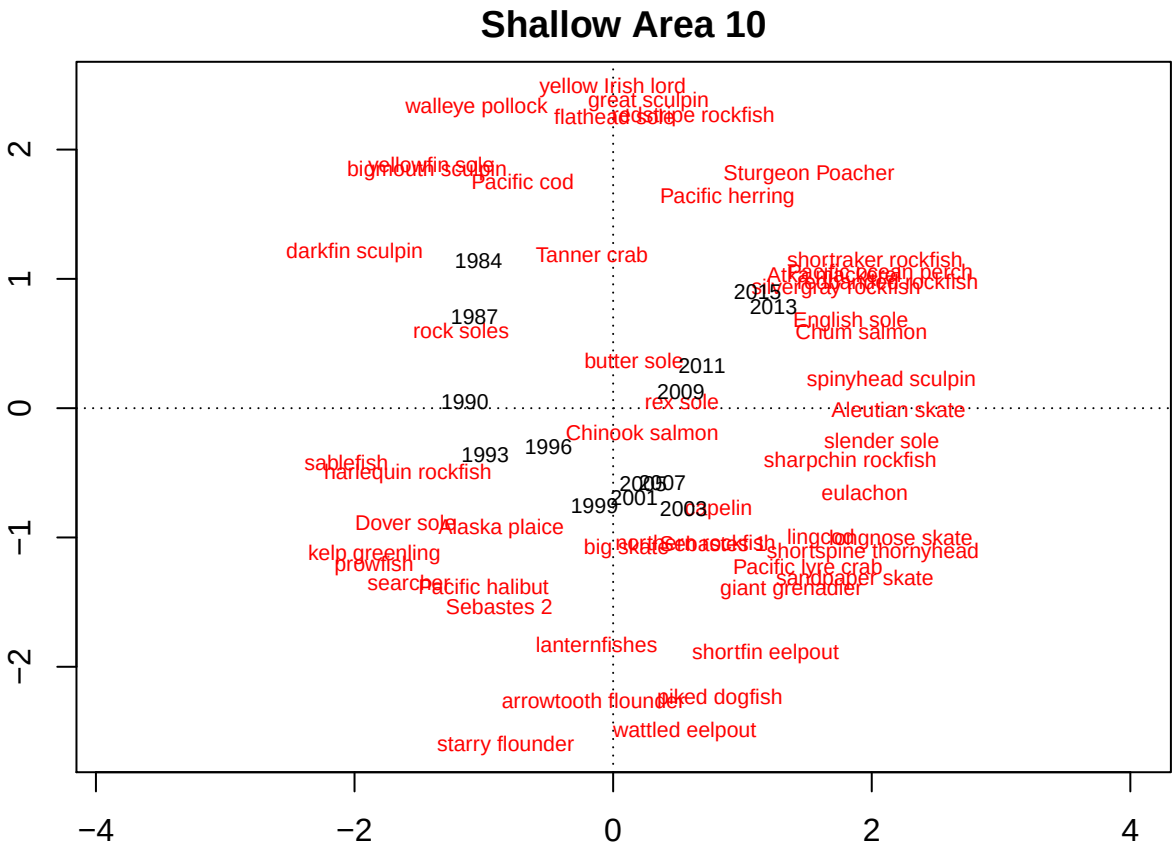

Shallow Area 7
yellowfin sole
Sturgeon Poacher
flathead sole
redstripe rockfish
great sculpin
redbanded rockfish
darkfin sculpin
walleye pollock
Pacific cod
Tanner crab
Pacific herring
Pacific ocean perch
Chum salmon
bigmouth sculpin
shortraker rockfish
yellow Irish lord
1984
2015
2013
rex sole
spinyhead sculpin
Aleutian skate
1987
rock soles
English sole
butter sole
slender sole
silvergray rockfish
1990
searcher
capelin
shortspine thornyhead
giant grenadier
1993
1996
2007
eulachon
Dover sole
2005
Atka mackerel
longnose skate
Sebastes 1
northern rockfish
2001
2003
1999
Chinook salmon
Pacific lyre crab
Pacific halibut
sablefish
big skate
kelp greenling
sandpaper skate
shortfin eelpout
harlequin rockfish
arrowtooth flounder
prowfish
lanternfishes
Alaska plaice
piked dogfish
wattled eelpout
Sebastes 2
sharpchin rockfish
starry flounder
−4
−2
0
2
4
−3
−2
−1
0
1
2

## Shallow Area 8




## Shallow Area 9





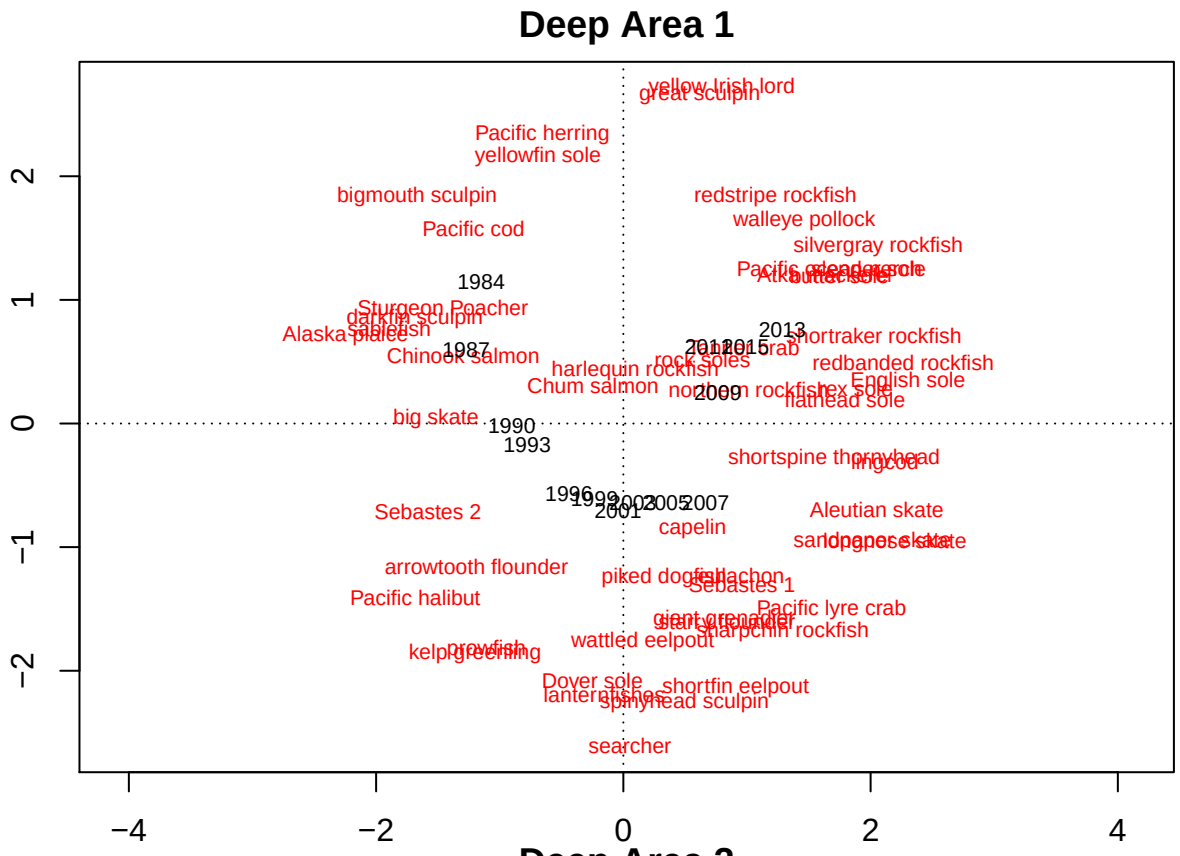

## Deep areas

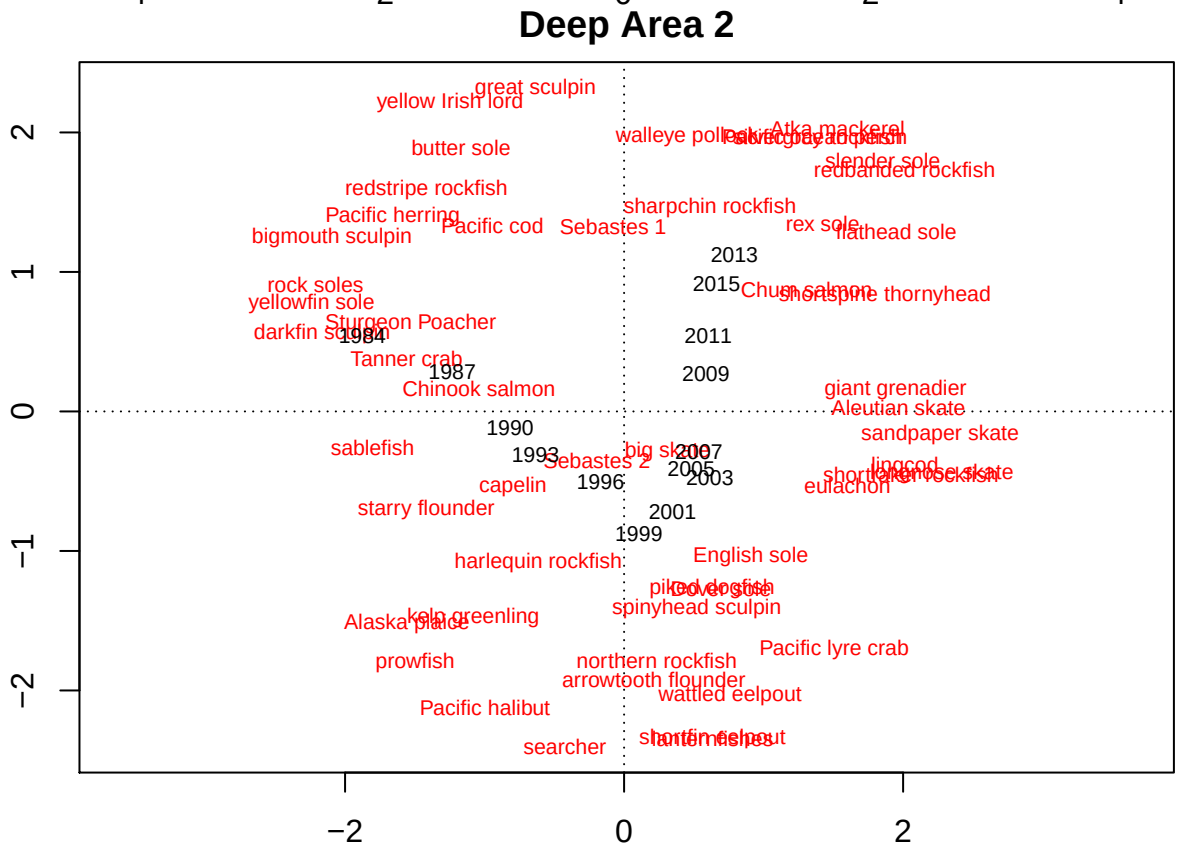
Area 6 is Total

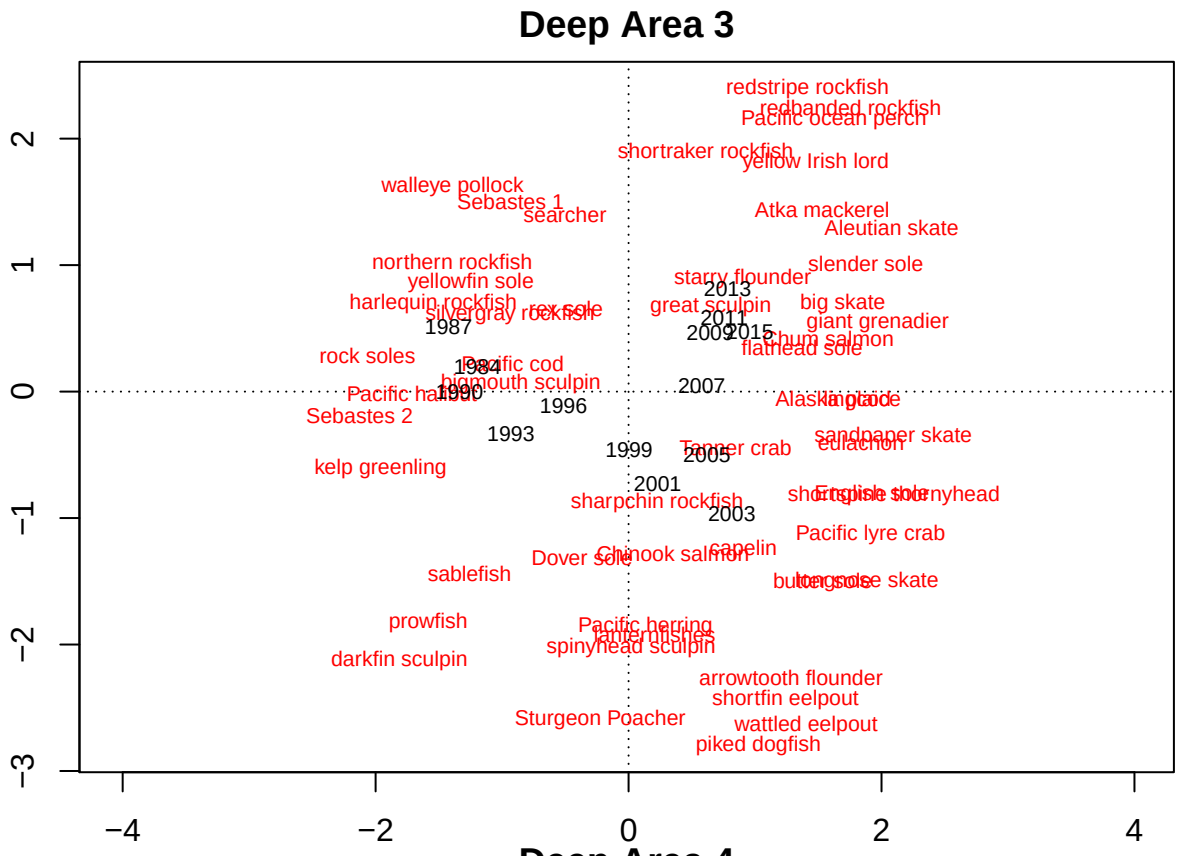
% of total variance explained by PC1 & PC2 (Area 6 = Total):

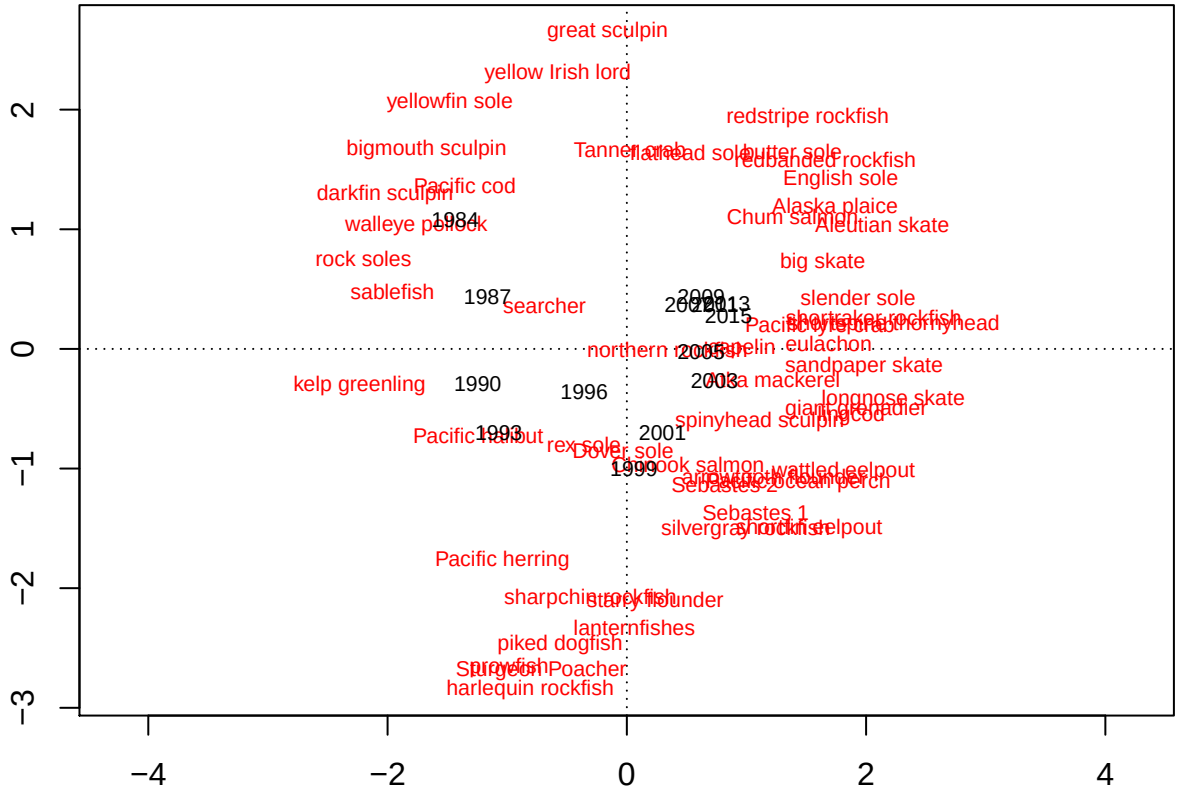
```
##   Area       PC1       PC2
## 1    1 0.3378644 0.2105648
## 2    2 0.3405090 0.1898041
## 3    3 0.3935400 0.1444878
## 4    4 0.3759332 0.1649310
## 5    5 0.3554989 0.1661971
## 6    6 0.3765467 0.1725329
```

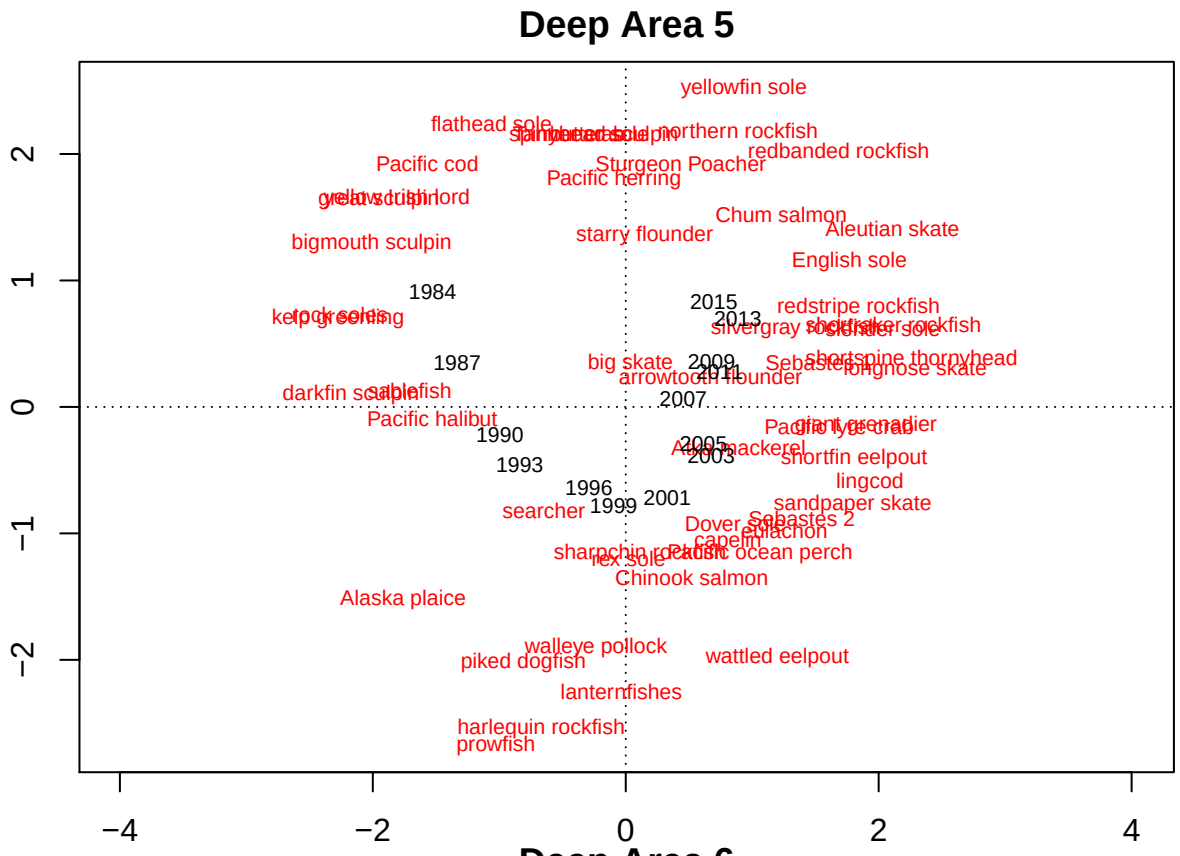
Plots for deep areas. See note above about scaling of species scores.

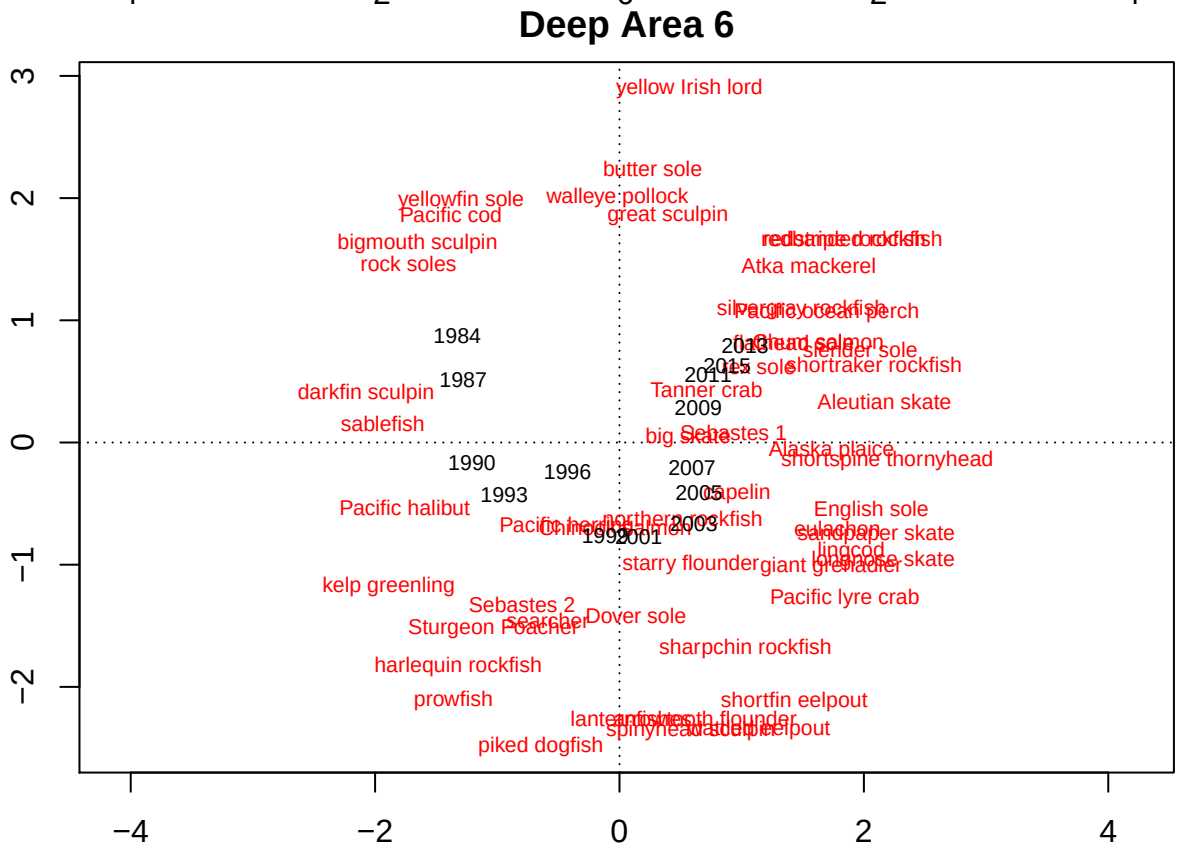

Deep Area 1
yellow Irish lord
great sculpin
Pacific herring
yellowfin sole
bigmouth sculpin
redstripe rockfish
walleye pollock
Pacific cod
silvergray rockfish
1984
Sturgeon Poacher
darkfin sculpin
sablefish
Alaska plaice
2013
shortraker rockfish
1987
Chinook salmon
rock soles
redbanded rockfish
harlequin rockfish
English sole
Chum salmon
flathead sole
big skate
1990
1993
shortspine thornyhead
lingcod
1996
Sebastes 2
Aleutian skate
capelin
arrowtooth flounder
Pacific halibut
Sebastes 1
Pacific lyre crab
sharpchin rockfish
wattled eelpout
kelp greenling
prowfish
Dover sole
shortfin eelpout
spinyhead sculpin
searcher
−4
−2
0
2
4
−2
−1
0
1
2


Deep Area 2
great sculpin
yellow Irish lord
butter sole
redstripe rockfish
Pacific herring
Pacific cod
Sebastes 1
bigmouth sculpin
rex sole
flathead sole
2013
2015
rock soles
yellowfin sole
Sturgeon Poacher
1984
2011
Tanner crab
1987
2009
Chinook salmon
giant grenadier
Aleutian skate
1990
sandpaper skate
sablefish
1993
2007
Sebastes 2
2005
capelin
1996
2003
starry flounder
2001
1999
harlequin rockfish
English sole
Dover sole
spinyhead sculpin
Alaska plaice
Pacific lyre crab
prowfish
northern rockfish
arrowtooth flounder
wattled eelpout
Pacific halibut
searcher
−2
0
2
−2
−1
0
1
2


Deep Area 3
redstripe rockfish
redbanded rockfish
Pacific ocean perch
shortraker rockfish
yellow Irish lord
walleye pollock
Sebastes 1
searcher
Atka mackerel
Aleutian skate
northern rockfish
yellowfin sole
slender sole
starry flounder
harlequin rockfish
great sculpin
big skate
giant grenadier
rex sole
1987
2009
2015
chum salmon
flathead sole
rock soles
Pacific cod
1984
bigmouth sculpin
2007
Pacific halibut
1990
Alaska plaice
Sebastes 2
1996
sandpaper skate
1993
eulachon
1999
Tanner crab
2005
kelp greenling
2001
sharpchin rockfish
English sole
2003
Pacific lyre crab
capelin
Dover sole
Chinook salmon
sablefish
butter sole
longnose skate
prowfish
Pacific herring
lanternfishes
spinyhead sculpin
darkfin sculpin
arrowtooth flounder
shortfin eelpout
Sturgeon Poacher
wattled eelpout
piked dogfish
−4
−2
0
2
4
−3
−2
−1
0
1
2


Deep Area 4
great sculpin
yellow Irish lord
yellowfin sole
redstripe rockfish
bigmouth sculpin
Tanner crab
flathead sole
butter sole
redbanded rockfish
English sole
Pacific cod
darkfin sculpin
Alaska plaice
1984
Chum salmon
walleye pollock
Aleutian skate
rock soles
big skate
sablefish
1987
searcher
slender sole
shortraker rockfish
Pacific lyre crab
eulachon
capelin
sandpaper skate
kelp greenling
1990
1996
Atka mackerel
longnose skate
giant grenadier
spinyhead sculpin
Pacific cod
1993
2001
Pacific halibut
rex sole
Dover sole
Chinook salmon
wattled eelpout
Sebastes 2
Pacific ocean perch
Sebastes 1
shortfin eelpout
Pacific herring
sharpchin rockfish
starry flounder
lanternfishes
piked dogfish
Sturgeon Poacher
harlequin rockfish
−4
−2
0
2
4
−3
−2
−1
0
1
2


Deep Area 5
yellowfin sole
flathead sole
northern rockfish
redbanded rockfish
Pacific cod
Sturgeon Poacher
Pacific herring
yellow Irish lord
Chum salmon
Aleutian skate
starry flounder
bigmouth sculpin
English sole
1984
2015
redstripe rockfish
kelp greenling
rock soles
2013
shortraker rockfish
1987
big skate
2009
shortspine thornyhead
2011
arrowtooth flounder
longnose skate
darkfin sculpin
sablefish
2007
Pacific halibut
1990
2005
2003
shortfin eelpout
1993
lingcod
1996
2001
sandpaper skate
searcher
1999
Sebastes 2
eulachon
capelin
sharpchin rockfish
Pacific ocean perch
Dover sole
Chinook salmon
Alaska plaice
walleye pollock
wattled eelpout
piked dogfish
lanternfishes
harlequin rockfish
prowfish
−4
−2
0
2
4
−2
−1
0
1
2


Deep Area 6
yellow Irish lord
butter sole
yellowfin sole
walleye pollock
Pacific cod
great sculpin
bigmouth sculpin
redstripe rockfish
rock soles
Atka mackerel
silvergray rockfish
Pacific ocean perch
1984
Chum salmon
2013
shortraker rockfish
2015
rock soles
2011
darkfin sculpin
1987
Tanner crab
2009
Aleutian skate
sablefish
big skate
Sebastes 1
Alaska plaice
1990
1996
2007
shortspine thornyhead
1993
2005
capelin
Pacific halibut
English sole
northern rockfish
2003
eulachon
1999
2001
sandpaper skate
lingcod
starry flounder
giant grenadier
longnose skate
kelp greenling
Pacific lyre crab
Sebastes 2
Dover sole
Sturgeon Poacher
sharpchin rockfish
harlequin rockfish
prowfish
shortfin eelpout
arrowtooth flounder
piked dogfish
−4
−2
0
2
4
−2
−1
0
1
2
3