Vulnerability

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##Calculating perceptions of vulnerability based upon the exposure, sensitivity, and adaptive capacity of survey participants. ##saves figures into folder ("../figures/vulnerability)

Looking at the correlation between risk and vulnerability ranks when calculated following Cinner (2012), where r = e + s and v = e + s - ac versus using the euclidean distance method (Levin and Samhouri 2012) risk = sqrt(e^2 + s^2) and v = sqrt(e^2 + s^2 (1-ac)^2).

## risk\_rank risk\_euc\_rank vuln\_rank vuln\_euc\_rank  
## risk\_rank 1.0000000 0.9795007 0.9280633 0.9115440  
## risk\_euc\_rank 0.9795007 1.0000000 0.9095548 0.9195278  
## vuln\_rank 0.9280633 0.9095548 1.0000000 0.9849656  
## vuln\_euc\_rank 0.9115440 0.9195278 0.9849656 1.0000000

Components of vulnerability when we subset by each unique combination of fisheries. #subseting by fishery

## `summarise()` ungrouping output (override with `.groups` argument)

## # A tibble: 67 x 7  
## listoffisheries exposure\_avg sensitivity\_avg adaptive\_avg risk\_avg  
## <chr> <dbl> <dbl> <dbl> <dbl>  
## 1 "" NaN 0.361 0.444 NaN   
## 2 "crab" 0.75 0.264 0.389 0.810  
## 3 "geoduck or ho~ 0.625 0.306 0.444 0.741  
## 4 "geoduck or ho~ 0.583 0.653 0.417 0.876  
## 5 "groundfish" 0.875 0.722 0.208 1.16   
## 6 "groundfish, h~ 0.4 0.278 0.389 0.487  
## 7 "halibut longl~ 0.5 0.491 0.574 NaN   
## 8 "halibut longl~ 0.5 0.25 0.639 0.559  
## 9 "halibut longl~ 1 0.5 0.222 1.12   
## 10 "halibut longl~ 0.5 0.556 0.417 0.747  
## # ... with 57 more rows, and 2 more variables: vuln\_euc\_avg <dbl>, count <int>

Or we can look at vulnerability based upon everyone that participates in a particular fishery regardless of what else they fish for.

##average vulnerability by fishery

## fishery avg\_exposure avg\_sensitivity avg\_ac ac\_sd  
## 1 salmon troll 0.6487981 0.5843621 0.3878601 0.20067572  
## 2 salmon seine 0.7240385 0.5470085 0.3888889 0.14027090  
## 3 salmon gillnet 0.6393018 0.5884503 0.3764620 0.15374013  
## 4 herring roe gillnet 0.6080208 0.5708333 0.4083333 0.14281014  
## 5 herring roe seine 0.6473485 0.6439394 0.4267677 0.15329344  
## 6 herring spawn on kelp 0.6116667 0.6611111 0.2944444 0.08914893  
## 7 tuna troll 0.5769676 0.6203704 0.4290123 0.14519108  
## 8 tuna international 0.6423611 0.4791667 0.4791667 0.09453971  
## 9 tuna US 0.5763889 0.6759259 0.6018519 0.05782406  
## 10 hake 0.7812500 0.6111111 0.4166667 0.23570226  
## 11 sardine 0.6166667 0.6481481 0.3703704 0.13127266  
## 12 groundfish 0.7072917 0.5648148 0.3333333 0.17391640  
## 13 halibut longline 0.5697173 0.5157407 0.4648148 0.14087343  
## 14 sablefish longline 0.6337500 0.5222222 0.4638889 0.14875455  
## 15 sablefish trap 0.5859375 0.7152778 0.5000000 0.12213802  
## 16 rockfish 0.5915278 0.4629630 0.4944444 0.15294003  
## 17 lingcod 0.6202546 0.5409357 0.4005848 0.15830782  
## 18 dogfish 0.7300000 0.4444444 0.4500000 0.17055646  
## 19 shrimp trawl 0.5000000 0.5694444 0.3333333 0.07856742  
## 20 euphausiid 0.2083333 0.8333333 0.5833333 0.07856742  
## 21 prawn shrimp trap 0.5640351 0.5716374 0.4195906 0.13253838  
## 22 crab 0.6229167 0.4131944 0.4201389 0.15173708  
## 23 geoduck or horseclam 0.6333333 0.4500000 0.4166667 0.03402069  
## 24 red urchin 0.5440476 0.7142857 0.3968254 0.15105449  
## 25 green urchin 0.5729167 0.6805556 0.3750000 0.12318643  
## 26 sea cucumber 0.6236111 0.6712963 0.3981481 0.10343882  
## avg\_risk risk\_sd avg\_risk\_euc avg\_vulnerability avg\_vulnerabilty\_euc  
## 1 1.2091307 0.37205399 0.9009308 0.8212706 1.0968241  
## 2 1.2710470 0.23110839 0.9285212 0.8821581 1.1241473  
## 3 1.2109284 0.32351825 0.8990224 0.8344664 1.1035129  
## 4 1.1788542 0.34075188 0.8548285 0.7705208 1.0493256  
## 5 1.2912879 0.23968866 0.9359068 0.8645202 1.1120159  
## 6 1.2727778 0.21367594 0.9085747 0.9783333 1.1580847  
## 7 1.1973380 0.29126823 0.8609385 0.7683256 1.0429329  
## 8 0.9609375 0.72363074 0.9073614 0.4817708 1.0689902  
## 9 1.2523148 0.31398823 0.8912167 0.6504630 0.9785275  
## 10 1.3923611 0.45667313 0.9925224 0.9756944 1.1800542  
## 11 1.2648148 0.19636617 0.9024180 0.8944444 1.1102697  
## 12 1.2721065 0.42417095 0.9133000 0.9387731 1.1495696  
## 13 1.0474769 0.32817998 0.7897275 0.5826620 0.9691596  
## 14 1.1559722 0.39131631 0.8369155 0.6920833 1.0099499  
## 15 1.3012153 0.33887389 0.9385892 0.8012153 1.0751457  
## 16 1.0544907 0.29428985 0.7679961 0.5600463 0.9310340  
## 17 1.1285453 0.39289035 0.8470840 0.7279605 1.0436144  
## 18 1.1744444 0.25608641 0.8701212 0.7244444 1.0317256  
## 19 1.0694444 0.09820928 0.7591946 0.7361111 1.0132197  
## 20 1.0416667 0.45176267 0.8772473 0.4583333 0.9782568  
## 21 1.1356725 0.19360104 0.8300547 0.7160819 1.0214091  
## 22 1.0361111 0.18021641 0.7793571 0.6159722 0.9746099  
## 23 1.0833333 0.19934306 0.8107082 0.6666667 0.9999471  
## 24 1.2583333 0.17583575 0.9084512 0.8615079 1.1001892  
## 25 1.2534722 0.18988538 0.8967701 0.8784722 1.0947374  
## 26 1.2949074 0.16082750 0.9234263 0.8967593 1.1044422

Components of vulnerability based upon the unique combination of regions someone fishes in.

#use the same method to look at regions #subseting by region

## `summarise()` ungrouping output (override with `.groups` argument)

## # A tibble: 50 x 7  
## listofregions exposure\_avg sensitivity\_avg adaptive\_avg risk\_avg vuln\_euc\_avg  
## <chr> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 central coast 0.562 0.611 0.389 0.859 1.06   
## 2 Haida Gwaii 0.672 0.465 0.514 0.819 0.955  
## 3 Haida Gwaii,~ 0.5 0.25 0.639 0.559 0.666  
## 4 Haida Gwaii,~ 0.25 0.639 0.472 0.735 0.906  
## 5 Haida Gwaii,~ 0.75 0.509 0.537 NaN 1.05   
## 6 Haida Gwaii,~ 0.646 0.676 0.398 0.940 1.12   
## 7 Haida Gwaii,~ 0.558 0.583 0.306 0.829 1.08   
## 8 Haida Gwaii,~ 0.5 0.556 0.25 0.747 1.06   
## 9 Haida Gwaii,~ 0.521 0.514 0.264 0.755 1.06   
## 10 Haida Gwaii,~ 0.725 0.389 0.431 0.870 1.04   
## # ... with 40 more rows, and 1 more variable: count <int>

Or if we average by anyone that fishes in a particular region. ##average vulnerability by region

## region avg\_exposure avg\_sensitivity avg\_ac avg\_risk  
## 1 offshore 0.5562500 0.5717593 0.5092593 1.0816551  
## 2 Haida Gwaii 0.6079776 0.5334596 0.4324495 1.0999842  
## 3 north coast 0.6252558 0.5550926 0.3773148 1.1490856  
## 4 central coast 0.6146850 0.5535714 0.3935185 1.1536210  
## 5 NVI 0.6556052 0.5598765 0.3697531 1.1717747  
## 6 WCVI 0.6668356 0.5935673 0.4027778 1.2428545  
## 7 SG 0.6768519 0.5555556 0.3900966 1.2176932  
## 8 SJF 0.6527778 0.5254630 0.4305556 1.1782407  
## 9 IW 0.6979167 0.4907407 0.5185185 0.9560185  
## 10 USW 0.5322917 0.5763889 0.5486111 1.1086806  
## avg\_vulnerability avg\_risk\_euc avg\_vulnerability\_euc  
## 1 0.5723958 0.8522650 0.9990761  
## 2 0.6675347 0.8426071 1.0255192  
## 3 0.7717708 0.8685346 1.0809517  
## 4 0.7601025 0.8577152 1.0632117  
## 5 0.8020216 0.8861715 1.0944004  
## 6 0.8400768 0.9170305 1.1068825  
## 7 0.8275966 0.9051877 1.0963290  
## 8 0.7476852 0.8600172 1.0383122  
## 9 0.4375000 1.0147195 1.1323335  
## 10 0.5600694 0.7901604 0.9292506

##exploratory figures

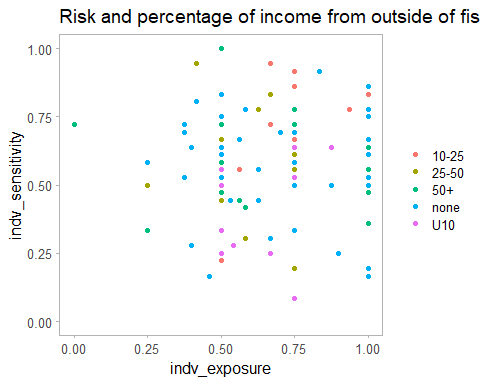
Chart, scatter chart

Description automatically generatedVisualizing risk.

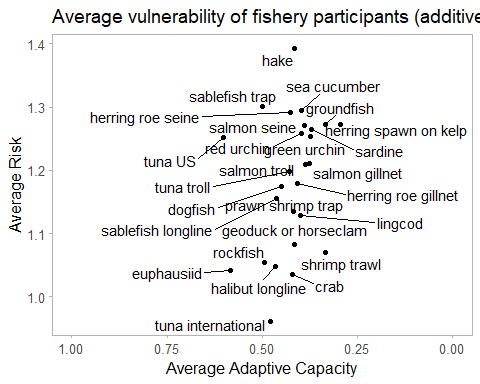
Chart, scatter chart

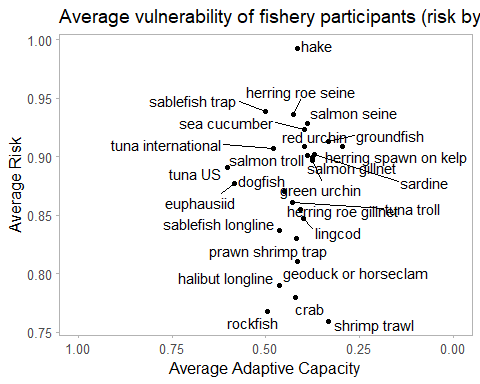
Description automatically generated

##visualizing individual risk (exposure v sensitivity)



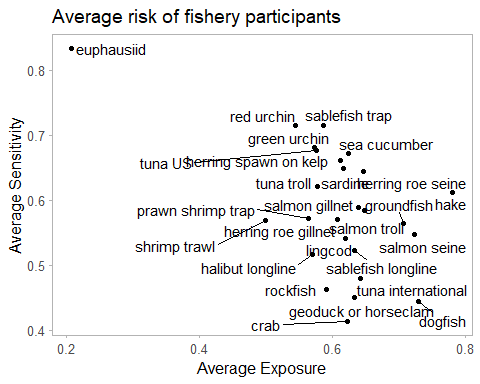
##considering average vulnerability based upon fishery participation

First plot is additive risk, second is euclidean distance. ##considering average risk based upon fishery participation



Count of people participating in each fishery – some small numbers, may want to consider combining some for previous figures

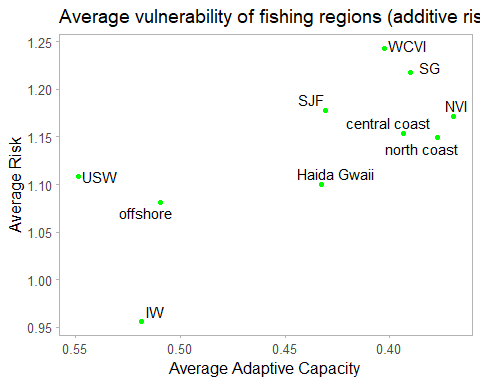
## salmon\_troll salmon\_seine salmon\_gillnet   
## 27 13 38   
## herring\_roe\_gillnet herring\_roe\_seine herring\_spawn\_on\_kelp   
## 20 11 5   
## tuna\_troll tuna\_international tuna\_us   
## 18 4 3   
## hake\_midtrawl sardine groundfish\_trawl   
## 2 3 6   
## halibut\_longline lingcod\_hl sablefish\_longline   
## 30 19 10   
## sablefish\_trap rockfish\_hl dogfish\_hl   
## 4 15 5   
## shrimp\_trawl euphausiid\_trawl prawn\_shrimp\_trap   
## 2 2 19   
## crab\_trap geoduck\_horseclam\_dive redseaurchin\_dive   
## 8 5 7   
## greenseaurchin\_dive seacucumber\_dive other   
## 4 6 3

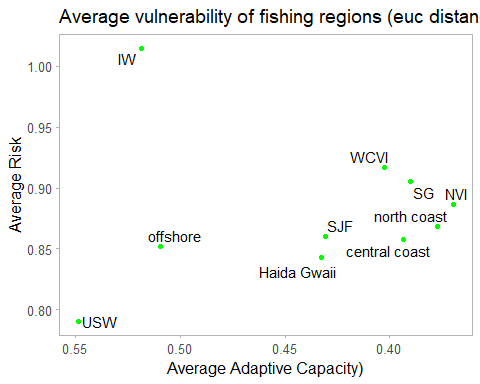


There was no ask in the survey about euphasiid warming – throws off the exposure value for this one.

##considering average vulnerability based upon region fished

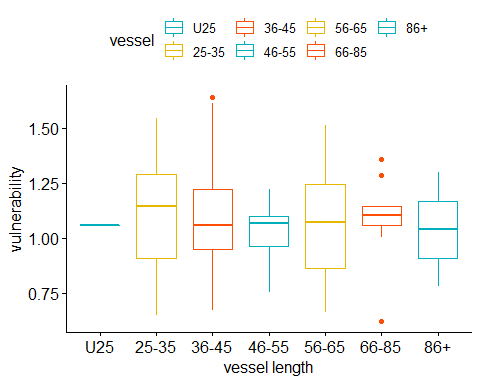
First one is additive risk, second one is risk by Euclidean distance





##exploring and visualizing differences in vulnerability and adaptive capacity between groups

##anova of vulnerability for vessel length

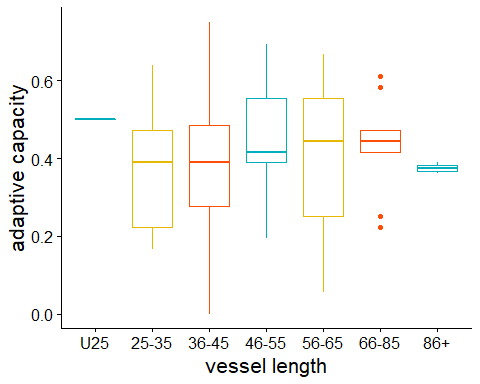


#anova  
euc\_vessel\_aov<-aov(indv\_vulnerability\_euc ~ vessel, data = responses)  
summary(euc\_vessel\_aov)

## Df Sum Sq Mean Sq F value Pr(>F)  
## vessel 6 0.043 0.00711 0.132 0.992  
## Residuals 92 4.964 0.05396   
## 6 observations deleted due to missingness

No difference in vulnerability by vessel length – might want to combine to fewer groups

##adaptive capacity by vessel length



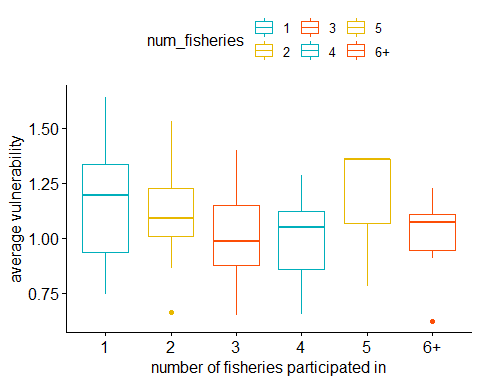
#anova  
ac\_vessel\_aov<-aov(indv\_ac ~ vessel, data = responses)  
summary(ac\_vessel\_aov)

## Df Sum Sq Mean Sq F value Pr(>F)  
## vessel 6 0.0915 0.01524 0.579 0.746  
## Residuals 98 2.5815 0.02634

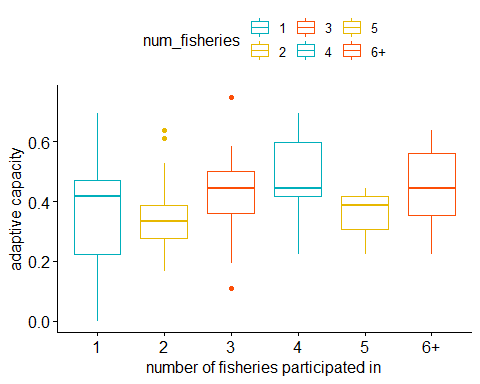
No difference in adaptive capacity by vessel length – same as above, may want to combine groups

**Does how many fisheries people participate in affect their vulnerability?**

##how many fisheries are people participating in and how does that affect vulnerability and adpative capacity



## Df Sum Sq Mean Sq F value Pr(>F)   
## num\_fisheries 5 0.502 0.10044 2.074 0.0756 .  
## Residuals 93 4.505 0.04844   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## 6 observations deleted due to missingness



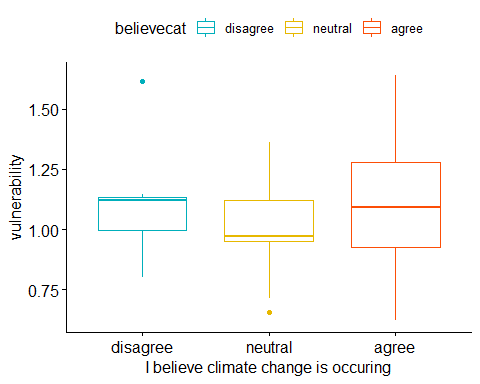
## Df Sum Sq Mean Sq F value Pr(>F)   
## num\_fisheries 5 0.2473 0.04947 2.019 0.0825 .  
## Residuals 99 2.4256 0.02450   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

**Does belief in climate change affect your vulnerability?**

##varibility in vulnerability depending on if you think climate change is happening or not

## believecat meanex meansen meanac meanvuln count  
## <chr> <dbl> <dbl> <dbl> <dbl> <int>  
## 1 agree 0.676 0.555 0.399 1.10 81  
## 2 disagree 0.657 0.619 0.389 1.11 7  
## 3 neutral 0.498 0.567 0.363 1.01 17

Not many in the disagree group



## Df Sum Sq Mean Sq F value Pr(>F)  
## believecat 2 0.119 0.05926 1.164 0.317  
## Residuals 96 4.888 0.05092   
## 6 observations deleted due to missingness

No difference in vulnerability

## Df Sum Sq Mean Sq F value Pr(>F)   
## believecat 2 0.440 0.22024 4.955 0.00895 \*\*  
## Residuals 96 4.267 0.04445   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## 6 observations deleted due to missingness

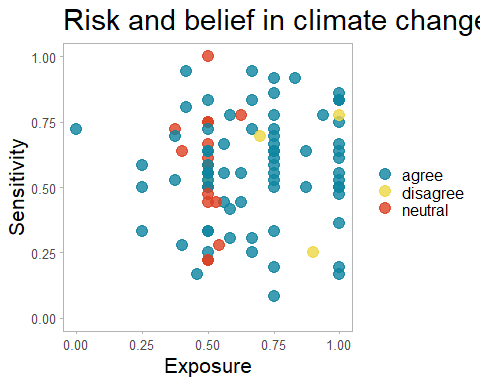
## Tukey multiple comparisons of means  
## 95% family-wise confidence level  
##   
## Fit: aov(formula = indv\_exposure ~ believecat, data = responses)  
##   
## $believecat  
## diff lwr upr p adj  
## disagree-agree -0.01930159 -0.2176542 0.17905103 0.9708589  
## neutral-agree -0.17803758 -0.3128561 -0.04321908 0.0062296  
## neutral-disagree -0.15873599 -0.3841302 0.06665824 0.2194312

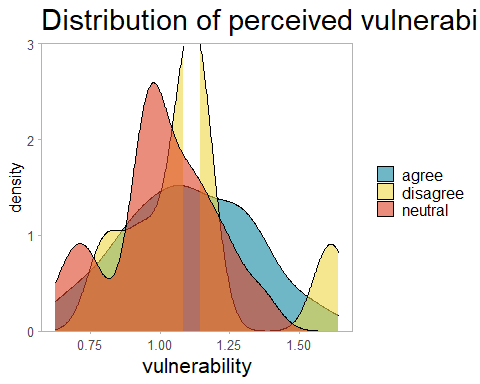
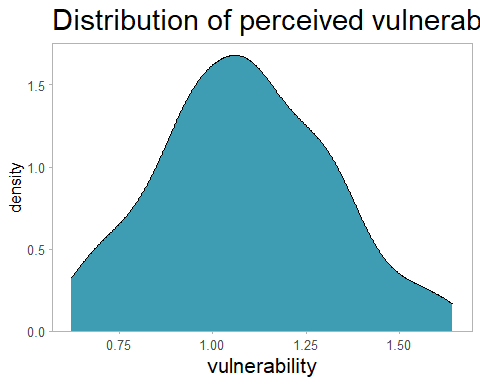
There is a difference between the neutral and agree groups in their exposure. Given the unequal group size, will need to confirm this with a stats test besides anova.

## Df Sum Sq Mean Sq F value Pr(>F)  
## believecat 2 0.027 0.01345 0.297 0.744  
## Residuals 102 4.621 0.04530

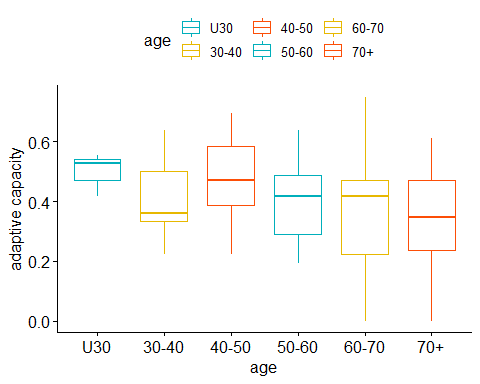
## Df Sum Sq Mean Sq F value Pr(>F)  
## believecat 2 0.0188 0.009376 0.36 0.698  
## Residuals 102 2.6542 0.026021

No difference in sensitivity or adaptive capacity

##scatterplot of risk depending on your belief in climate change 

##distribution of vulnerability ##vulnerability plots used in tnc talk 

**Does age affect your vulnerability?**



## Df Sum Sq Mean Sq F value Pr(>F)  
## age 5 0.1991 0.03982 1.594 0.169  
## Residuals 99 2.4738 0.02499

No difference – could again do fewer groups if we want