Risk & Metiers

Emma Fuller

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# Introduction

Previous work has suggested that fishermen participate in a diverse set of fisheries to reduce exposure to risk. In Alaska, Sethi, Reimer, and Knapp (2014) found that the larger and more diverse a community's fishing portfolio was, the less variable yearly revenues were. Similarly, Kasperski and Holland (2013) found a dome-shaped relationship between annual revenue variability and revenue diversification in the US Westcoast groundfish and Alaskan fisheries.

Here we use a metier analysis to define fisheries and determine whether diversity in fisheries participation affects variability in revenue. We are able to expand previous analyses of the US Westcoast groundfish fishery (Kasperski and Holland 2013) to all commercial fisheries on the US Westcoast by using a metier approach to define fisheries based on catch composition. We find that diversity of revenue decreases year-to-year variance across US Westcoast commercial fisheries.

# Data and Methods

## Catch Data

This work uses fish ticket data from the US Westcoast commercial fisheries from 2009-2013, a total of 501,386 trips and 5,982 vessels. PacFin records species by "market category". For most easily identifiable and highly marketable species this is equivalent to species name. However for a number of rockfish that are difficult to distinguish, their market category is some flavor of "unspecified rockfish". We keep the raw market categories in this analysis with the argument that the resolution of the market and the targeting behavior of fishermen are equivalent.

Catch by species was totaled for each trip. We drop species from consideration that are caught in fewer than 100 trips over 5 years and with a median catch off less than 100 lbs. This drops 121 trips (less than half of one percent of total trips) and 60 market categories (i.e. species). A list of these species, along with median catch and number of trips found in is in the Appendix. We also drop any trips with the grgroup of DRG (dredge) as there are fewer than 5 trips overall for this gear type.

## Fisheries definition

Previous work defines income diversity as an index which integrates both number of fisheries and proportion of trips a vessel partipates within annually (Kasperski and Holland 2013; Sethi, Reimer, and Knapp 2014). This metric therefore requires some definition of a "fishery". Fisheries are commonly defined as

A unit determined by an authority or other entity that isengaged in raising and/or harvesting fish. Typically, the unit is defined in terms of some or all of the following: people involved, species or type of fish, area of water or seabed, method of fishing, class of boats and purpose of the activities ([FA0](http://www.fao.org/fi/glossary/), Fletcher et al. (2005)).

Previous work in on the US West Coast and Alaska tends to make use of gear, area and type of fish to define fisheries (Kasperski and Holland 2013), or existing management jurisdictions (Sethi, Reimer, and Knapp 2014). Federally managed groundfish require vessels to submit logbooks which include permits. However for the state-managed fisheries we frequently only have the the fish ticket. This means our primary source of information about the fishery comes from the composition of catch. In order to use of the non-groundfish data we needed a way to classify to which fishery a trip belonged by composition of catch. To address these issues we used a metier analysis approach to define fisheries (gear-species target combinations) (Deporte et al. 2012). Thus in the following analysis we are considering a metier equivalent to a fishery.

### Metier analysis

A metier is defined as a gear-species target combination (Deporte et al. 2012). We first define species targets and then assign these targets to gear to make the final metier designation.

To find species target data we classify target species assemblages by first subsetting to all 2010 trips and searching for characteristic catch assemblages. To find these assemblages we first split trips by gear type (using PacFin grgroups designation) and calcluate a pairwise dissimiliarity index for each trip within a gear/year subset using the Bray-Curtis dissimilarity index. This metric has the advantage of avoiding the double-0 problem common in species count data. The Bray-Curtis dissimilarity index is defined as

where is the biomass of the lesser value for only those two species in common between both sites. and are the total number of individuals counted in both trips. This index ranges between 0 and 1, with 0 meaning the sites have the same composition and 1 meaning they share no species.

We transform the disimilarity index to be a measure of similarity

and build an undirected, weighted network in which nodes are trips, and edge widths are the similarity in species composition between trips. With this network we use the *infoMap* algorithm to find communities (clusters or subgraphs) within the network (using the implementation in the R package igraph)(Rosvall and Bergstrom 2008; Rosvall, Axelsson, and Bergstrom 2009).

*InfoMap* is an information theoretic approach, which uses the probability flow of a random walker on a network as a proxy for the information flows in a real system. The objective of *infoMap* is to compress the description of the probability flow, and in doing so partitions the network into modules. *InfoMap* works by computing the fraction of time a node is visted by a random walker using a deterministically greedy search algorithm. Merges between modules that give the largest decrease in description length are made until further merging leads to increases of description length. Results are refined with a simulated annealing approach, starting at several different temperatures, with the run selected as the one that gives the shortest description of the network.

We found that other commonly used clustering algorithms (i.e. k-means, hierarchical clustering) did poorly with this data. Many clustering algorithms do best when clusters are spherical in n-dimensional space, and/or require the number of clusters decided *a priori*. In this data we have fisheries participation may vary by an order of magnitude (100s of trips to 100,000s of trips), and we wanted to avoid having to decide subjectively on the number of clusters.

After dropping any modules that have fewer than 5 trips, we use a knn classifier to assign all other trips of each gear subset to those possible metiers.[[1]](#footnote-1) The nearest neighbor to each trip was found using the Bray-Curtis dissimilarity index (transformed into a similarity) and all analyses were performed using R.

## Income diversity

We measure income diversity (or portfolio diversification) with the Simpson's diversity index[[2]](#footnote-2) (Kasperski and Holland 2013; Sethi, Reimer, and Knapp 2014). Simpson's diversity index is calculated per vessel; i.e. have an index of where is the number of vessels. Thus is defined as

for fisheries with as the proportion of total gross revenue from fishery . Here values of 0 indicate no diversity (a single fishery), where values close to 1 indicate high levels of diversity.

We calculate the diversity indices each year a vessel is active and averaged across years. Diversity indices are calculated using the vegan() package in R. Vessels had to be active for at least 2 years in order to be included in this analysis.

## Income variability

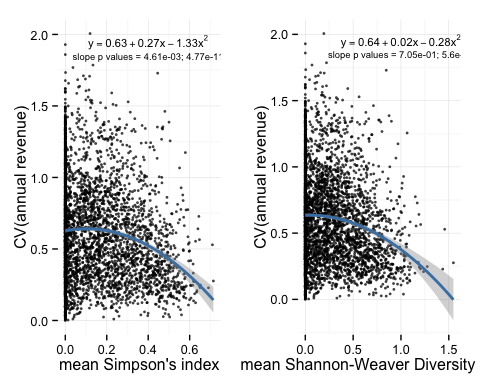
Income variability is calculated as the coefficient of variation in annual revenues. For a single vessel , the coefficient of variation () is calculated as

where is a vector of the annual revenues for vessel .

# Results

## Diversity and Risk

We find a negative relationship between income variability and diversity of fisheries. Shaded areas are 95% confidence interval. Kasperski and Holland (2013) suggest a quadratic relationship between revenue variability and diversity and we find support that this model improves fit to our data.



Using as a model selection tool, I find that the quadratic model improves the fit for both the Simpson and Shannon-Weaver diversity indices.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| model | k | Likelihood | AIC | delta |
| linear | 3 | -1277.31 | 2560.61 | -41.31 |
| quadratic | 4 | -1255.65 | 2519.31 | 0 |

Simpsons diversity

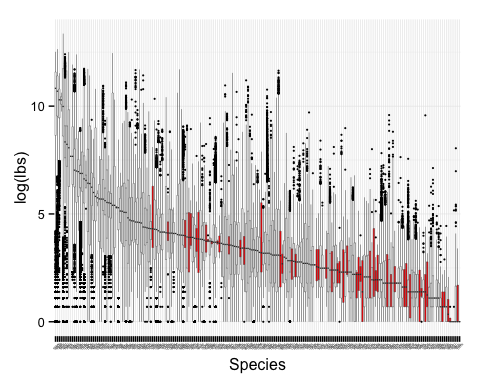
# Discussion

I find a negative relationship between diversity of fisheries and year-to-year variation in annual revenues. This is broadly predicted by portfolio theory that portfolios with more assets will tend to have lower variance, especially if assets (here fisheries) vary asynchronously. Further I have expanded previous work on the US Westcoast to demonstrate that this relationship holds broadly across all US Westcoast commercial fisheries.

# Appendix

## Filtered species

To focus on species commonly caught, we remove species that were caught in fewer than 100 trips with a median catch weight of less than 100 lbs. Boxplots showing distribution of catch by species is shown, red boxes are species that were dropped from the analysis.

 Species excluded are shown below with the number of trips they were found in and their median catch in pounds.

|  |  |  |  |
| --- | --- | --- | --- |
| spid | common name | number of trips | median catch (lbs) |
| EELS | unsp. eels | 96 | 46.5 |
| CWCD | cowcod rockfish | 94 | 4 |
| RSTN | rosethorn rockfish | 86 | 6 |
| BSOL | butter sole | 84 | 6 |
| DRDO | dorado/dolphinfish | 83 | 54 |
| OGRN | other groundfish | 80 | 61.5 |
| UTCR | unsp. tanner crab | 71 | 4 |
| WEEL | wolf eel | 71 | 9 |
| SQR1 | nom. squarespot | 69 | 4 |
| GBLC | greenblotched rockfish | 61 | 11 |
| ISRK | bigeye thresher shark | 60 | 170 |
| HNYC | honeycomb rockfish | 57 | 2 |
| MSHP | plainfin midshipman | 55 | 10 |
| STLH | steelhead | 54 | 12.5 |
| YTNA | yellowfin tuna | 54 | 108 |
| RCK6 | unsp. rosefish rckfsh | 44 | 8 |
| BSRK | blue shark | 41 | 35 |
| STNA | skipjack tuna | 32 | 75 |
| RCK2 | unsp. bolina rckfsh | 31 | 12 |
| USRM | unsp. ocean shrimp | 29 | 5 |
| ETNA | bigeye tuna | 27 | 1057 |
| OBAS | other bass | 25 | 6 |
| UCLM | unsp. clam | 24 | 25 |
| NUSR | nor. unsp. near-shore rockfish | 22 | 7 |
| WSTG | white sturgeon | 22 | 30.5 |
| CSKT | california skate | 21 | 47 |
| MXRF | mexican rockfish | 16 | 3.5 |
| USHR | unsp. near-shore rockfish | 16 | 5 |
| RCK7 | unsp. gopher rckfsh | 15 | 10 |
| FNTS | fantail sole | 14 | 7 |
| KSTR | kumamoto oyster | 14 | 13 |
| RCK5 | unsp. small reds rckfsh | 14 | 9 |
| BMSL | blue or bay mussel | 13 | 16 |
| EULC | eulachon | 13 | 1 |
| CMSL | california mussel | 12 | 21.5 |
| QFSH | queenfish | 12 | 42.5 |
| GSTG | green sturgeon | 11 | 38 |
| PSRK | pelagic thresher shark | 11 | 50 |
| PRRK | pinkrose rockfish | 9 | 7 |
| RCKG | rock greenling | 9 | 2 |
| UDNR | unsp. deep near-shore rf | 9 | 41 |
| SLNS | slender sole | 7 | 1 |
| STRK | stripetail rockfish | 6 | 4 |
| USMN | unsp. salmon | 5 | 11 |
| BMOL | bigmouth sole | 4 | 1 |
| ESTR | eastern oyster | 4 | 29484 |
| GDUK | geoduck | 4 | 316.5 |
| LCLM | native littleneck | 4 | 31 |
| LDAB | longfin sanddab | 4 | 1.5 |
| PNKR | pink rockfish | 4 | 8.5 |
| SSDB | speckled sanddab | 4 | 42.5 |
| UTNA | unsp. tuna | 4 | 703 |
| KFSH | giant kelpfish | 3 | 50 |
| PROW | prowfish | 3 | 9 |
| SCLM | soft-shelled clam | 3 | 10 |
| TCOD | pacific tomcod | 3 | 17 |
| BRNZ | bronzespotted rockfish | 2 | 21 |
| CLCO | calico rockfish | 2 | 1 |
| CMEL | chameleon rockfish | 2 | 202 |
| OCRK | other croaker | 2 | 40 |
| CEEL | spotted cusk-eel | 1 | 2151 |
| CHLB | california halibut | 1 | 12 |
| ORCK | other rockfish | 1 | 14 |
| RCK1 | bocaccio+chilipepper rckfsh | 1 | 60 |
| RCK8 | canary+vermilion rckfsh | 1 | 3 |
| RZCL | rosy razor clam | 1 | 6 |
| UHLB | unsp. halibut | 1 | 64 |
| USTR | unsp. oyster | 1 | 1 |

## Sensitivity of classifying year

To check whether our metier designations were sensitive to the year used to train the k-nearest-neighbors classifier we trained the knn classifier on years before (2010) and after (2012) ITQ implementation. To check agreement between partition results, we used the adjusted Rand index (ARI) (Rand 1971). The Rand index measures the accuracy of the partitions, and weights equally false positives and false negatives. The Rand index is calculated as

where can be considered as the number of agreements between the two partititions, and as the number of disagreements between the partitions. The Rand index can take a value between 0 and 1, with a Rand index = 1 indicating the partitions are identical. The Rand index does not take into account the possibility that agreements happen between the two partitions due to chance (i.e. the expected of a randomly partitioned dataset is not 0), and as the number of clusters increases approaches 1. The adjusted Rand index (ARI) has been proposed to address these limitations (Hubert and Arabie 1985) and is calculated as

$$ \text{ARI} = \frac{ {n \choose 2}(a + d) - [(a+b)(a+c) + (c+d)(b+d)] }{ {n\choose 2}^2 - [(a+b)(a+c) + (c+d)(b+d)]}.$$

I calculated the adjusted Rand Index () using the R library e1071, function classAgreement() for each gear group and each year that wasn't trained (2009, 2011, 2013). Results are as follows. Agreement between training sets are high, with only the gear group NET in 2013 with a value .[[3]](#footnote-3)[[4]](#footnote-4)

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2009 | 2011 | 2013 |
| **TLS** | 0.9971 | 0.9917 | 0.9862 |
| **TWS** | 0.9716 | 0.9738 | 0.9809 |
| **TWL** | 0.9132 | 0.9464 | 0.9531 |
| **NET** | 0.9293 | 0.9474 | 0.8632 |
| **HKL** | 0.9263 | 0.9269 | 0.9129 |
| **MSC** | 0.9937 | 0.9931 | 0.9946 |

## Metier analysis details

There were between 104 and 112 metiers represented each year. These metiers, along with the most commonly caught species, number of vessels, and number of trips made, as well as their spatial distribution are listed in the Appendix The table is structred to record the metier, the major species, major gear types used, the percentage of trips falling in California (CA), Oregon (OR), and Washington (WA), the number of trips, and the number of vessels. The table is ordered from metiers with most trips to fewest. Major species are defined in one of two ways:

1. More than 50% of the trips have a majority of this species by weight
2. No species is present in more than 50% of the trips, the species listed are present in at least 19% of the trips

If there is no species present as a majority catch in more than 50% of the trips it's considered a multispecies fishery, this is noted in the table.

Familiar structure emerges from these metiers, which is reassuring. In particular well known fisheries are all present: dungeness crab pot fishery (POT\_12), red sea urchin diving fishery (MSC\_12), albacore trolling (TLS\_22), salmon trolling (TLS\_12), sablefish fixed gear (longline HKL\_12, pot POT\_42), pacific whiting midwater trawl (TWL\_32), pink shrimp (TWS\_12), among others.

One of the more interesting angles is the non-whiting trawl fisheries. Trips using trawls are managed in aggregate in accordance to what they're not (i.e. "non-whiting groundfish"). However there seems to be some structure to this unifomly managed population.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Metier | Major species | Major gear types | CA | OR | WA | trips | multisp. | vessels |
| TWL\_4 | unsp. bait shrimp | beam trawl | 100 | NA | NA | 2386 | no | 10 |
| TWL\_8 | chilipepper, unsp. sanddabs | dnsh seine, gftrawl<8 | 93 | NA | 7 | 584 | yes | 31 |
| TWL\_6 | unsp. sea cucumbers | gfsh-trawl | 100 | NA | NA | 2118 | no | 49 |
| TWL\_11 | other crab, other shrimp | gfsh-trawl | 100 | NA | NA | 163 | yes | 14 |
| TWL\_2 | calif halibut | gftrawl<8 | 90 | 5 | 5 | 4813 | no | 63 |
| TWL\_3 | pacific whiting | mid-trawl | 38 | 38 | 25 | 4154 | no | 68 |
| TWL\_5 | chinook salmon, spiny dogfish | mid-trawl | 46 | 23 | 31 | 1976 | yes | 85 |
| TWL\_7 | yellowtail rockfish | mid-trawl | NA | 29 | 71 | 623 | no | 62 |
| TWL\_12 | canary rockfish | mid-trawl | NA | 60 | 40 | 61 | no | 31 |
| TWL\_14 | nor. unsp. shelf rockfish | mid-trawl | NA | 40 | 60 | 52 | no | 5 |
| TWL\_16 | darkblotched rockfish | mid-trawl, rlr-trawl | 29 | 57 | 14 | 54 | no | 29 |
| TWL\_13 | nor. unsp. slope rockfish | mid-trawl, rlr-trawl | NA | 100 | NA | 41 | no | 26 |
| TWL\_1 | dover sole, dover sole | rlr-trawl | 48 | 24 | 29 | 8338 | yes | 168 |
| TWL\_10 | pop | rlr-trawl | NA | 100 | NA | 40 | no | 19 |
| TWL\_15 | lingcod | sel ff twl | NA | 60 | 40 | 158 | no | 35 |
| TWL\_9 | petrale sole | sel ff twl, gftrawl<8, rlr-trawl | NA | 56 | 44 | 83 | no | 42 |

It should also be noted that major species is not necessarily the same as targeted species. Because this is a reflection of only the catch data, I only list the majority in the catch.[[5]](#footnote-5) This probably examples TWL\_12. With at least 40% of trips coming back with a majority of dover sole, the other species are likely sablefish and thornyheads. However they are caught in lower abundances, despite being targeted.

## 

## Metier results

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Metier | Major Species | Major gear types | CA | OR | WA | trips | multispecies | vessels |
| POT\_12 | dungeness crab | crab pot | 46 | 22 | 31 | 109108 | no | 1409 |
| MSC\_12 | red sea urchin | diving gr | 77 | 23 | NA | 59014 | no | 250 |
| TLS\_12 | chinook salmon | troll | 49 | 25 | 26 | 45119 | no | 1835 |
| POT\_22 | california spiny lobster | c&l pot | 100 | NA | NA | 28308 | no | 257 |
| HKL\_22 | black rockfish | oth hk&ln | 55 | 31 | 14 | 21489 | no | 504 |
| HKL\_12 | sablefish | longline | 65 | 13 | 22 | 20680 | no | 714 |
| NET\_12 | market squid | seine | 100 | NA | NA | 20316 | no | 156 |
| HKL\_32 | brown rockfish, gopher rockfish, lingcod | pole(com) | 88 | 12 | NA | 17807 | yes | 498 |
| MSC\_22 | razor clam | oth-known | NA | 40 | 60 | 16451 | no | 308 |
| TLS\_22 | albacore | troll | 49 | 23 | 28 | 14159 | no | 1693 |
| POT\_32 | rock crab | c&l pot | 97 | 3 | NA | 13078 | no | 228 |
| NET\_22 | pacific sardine | seine | 77 | 12 | 12 | 9797 | no | 184 |
| HKL\_42 | calif halibut | pole(com) | 100 | NA | NA | 9254 | no | 641 |
| TWL\_12 | dover sole, dover sole | rlr-trawl | 48 | 24 | 29 | 8315 | yes | 168 |
| TWS\_12 | pacific pink shrimp | dbl-shrimp | 38 | 38 | 23 | 6238 | no | 143 |
| MSC\_32 | ghost shrimp | oth-known | 18 | 82 | NA | 6116 | no | 146 |
| HKL\_52 | shortspine thornyhead | longline | 81 | 10 | 10 | 5855 | no | 112 |
| POT\_62 | unsp. hagfish | fish pot | 51 | 17 | 31 | 5649 | no | 149 |
| POT\_52 | spotted prawn | prwn trap | 81 | NA | 19 | 5632 | no | 38 |
| POT\_42 | sablefish | fish pot | 61 | 22 | 17 | 5627 | no | 345 |
| NET\_32 | calif halibut | gill net | 100 | NA | NA | 5495 | no | 71 |
| TWL\_22 | calif halibut | gftrawl<8 | 90 | 5 | 5 | 4813 | no | 63 |
| MSC\_42 | unsp. sea cucumbers | diving gr | 95 | 5 | NA | 4444 | no | 95 |
| TWL\_32 | pacific whiting | mid-trawl | 38 | 38 | 25 | 4154 | no | 68 |
| MSC\_52 | basket cockle | oth-known | 49 | 13 | 38 | 3854 | no | 241 |
| HKL\_62 | white seabass | pole(com) | 100 | NA | NA | 3530 | no | 408 |
| NET\_42 | white seabass | gill net | 100 | NA | NA | 3447 | no | 62 |
| TWL\_42 | unsp. bait shrimp | beam trawl | 100 | NA | NA | 2386 | no | 10 |
| TWS\_22 | ridgeback prawn | sgl-shrimp | 92 | NA | 8 | 2275 | no | 29 |
| TWL\_62 | unsp. sea cucumbers | gfsh-trawl | 100 | NA | NA | 2118 | no | 49 |
| TWL\_52 | chinook salmon, spiny dogfish | mid-trawl | 46 | 23 | 31 | 2001 | yes | 86 |
| HKL\_172 | surfperch spp. | pole(com) | 100 | NA | NA | 1873 | no | 35 |
| HKL\_82 | vermillion rockfish | pole(com) | 80 | 18 | 2 | 1778 | no | 286 |
| NET\_182 | unsp. smelt | dip net | 94 | 6 | NA | 1747 | no | 11 |
| NET\_52 | unsp. shad | dip net | 100 | NA | NA | 1368 | no | 12 |
| HKL\_72 | unsp. sanddabs | pole(com) | 100 | NA | NA | 1329 | no | 106 |
| NET\_82 | northern anchovy | seine | 81 | 6 | 12 | 1306 | no | 68 |
| TWS\_32 | calif halibut, hornyhead turbot | sgl-shrimp | 100 | NA | NA | 1274 | yes | 38 |
| POT\_72 | other shrimp | prwn trap | 67 | 33 | NA | 1204 | no | 33 |
| MSC\_72 | dungeness crab | oth-known | 21 | 79 | NA | 1110 | no | 100 |
| NET\_72 | chub mackerel | dip net | 100 | NA | NA | 1047 | no | 33 |
| POT\_92 | cabezon, gopher rockfish | fish pot | 100 | NA | NA | 1037 | yes | 77 |
| NET\_102 | misc. fish, swordfish | drf gl net | 87 | NA | 13 | 986 | yes | 81 |
| MSC\_62 | unsp. bait shrimp | oth-known | 33 | NA | 67 | 940 | no | 13 |
| NET\_62 | common thresher shark | drf gl net | 93 | NA | 7 | 841 | no | 82 |
| HKL\_92 | albacore | pole(com) | 88 | 3 | 9 | 834 | no | 301 |
| POT\_82 | california sheephead | fish pot | 100 | NA | NA | 829 | no | 47 |
| MSC\_112 | gaper clam | oth-known | NA | 75 | 25 | 693 | no | 49 |
| HKL\_152 | pacific halibut | longline | 5 | 50 | 45 | 684 | no | 203 |
| TWL\_72 | yellowtail rockfish | mid-trawl | NA | 29 | 71 | 617 | no | 62 |
| TWL\_82 | chilipepper, petrale sole, unsp. sanddabs | dnsh seine, gftrawl<8 | 93 | NA | 7 | 588 | yes | 31 |
| HKL\_132 | blackgill rockfish | longline | 96 | NA | 4 | 566 | no | 98 |
| MSC\_82 | swordfish | oth-known | 100 | NA | NA | 542 | no | 40 |
| MSC\_102 | other sea urchins | diving gr | 73 | 27 | NA | 505 | no | 54 |
| MSC\_92 | unsp. mollusks | diving gr | 78 | 22 | NA | 494 | no | 12 |
| POT\_102 | other crab | c&l pot | 89 | 11 | NA | 480 | no | 104 |
| HKL\_142 | california sheephead | pole(com) | 88 | 12 | NA | 420 | no | 57 |
| TWS\_52 | unsp. bait shrimp | sgl-shrimp | 100 | NA | NA | 403 | no | 3 |
| NET\_152 | chub mackerel | seine | 86 | 14 | NA | 384 | no | 46 |
| HKL\_212 | chinook salmon | pole(com) | 89 | NA | 11 | 337 | no | 150 |
| TWS\_42 | unsp. sea cucumbers | sgl-shrimp | 100 | NA | NA | 326 | no | 21 |
| HKL\_102 | california scorpionfish | pole(com) | 100 | NA | NA | 316 | no | 16 |
| POT\_122 | other mollusks | c&l pot | 100 | NA | NA | 293 | no | 70 |
| HKL\_162 | yellowtail | pole(com) | 100 | NA | NA | 276 | no | 78 |
| MSC\_132 | butter clam | oth-known | NA | 67 | 33 | 267 | no | 26 |
| TLS\_32 | calif halibut | troll | 100 | NA | NA | 251 | no | 65 |
| HKL\_112 | common thresher shark | pole(com) | 95 | NA | 5 | 251 | no | 70 |
| NET\_132 | pacific barracuda | drf gl net | 100 | NA | NA | 228 | no | 17 |
| NET\_142 | other crab | gill net | 100 | NA | NA | 227 | no | 19 |
| HKL\_122 | unsp. smelt | pole(com) | 100 | NA | NA | 218 | no | 15 |
| POT\_132 | unsp. octopus | c&l pot, crab pot | 63 | 32 | 5 | 179 | no | 83 |
| NET\_222 | rock crab | gill net | 100 | NA | NA | 177 | no | 16 |
| TWL\_112 | other crab, other shrimp | gfsh-trawl | 100 | NA | NA | 163 | yes | 14 |
| NET\_92 | sockeye salmon | gill net | NA | NA | 100 | 160 | no | 26 |
| TWL\_152 | lingcod | sel ff twl | NA | 60 | 40 | 158 | no | 35 |
| HKL\_202 | shortfin mako shark | pole(com) | 100 | NA | NA | 158 | no | 41 |
| POT\_112 | cabezon | fish pot | 29 | 57 | 14 | 155 | no | 9 |
| MSC\_122 | blue mud shrimp | oth-known | NA | 100 | NA | 153 | no | 22 |
| HKL\_182 | chub mackerel | longline | 100 | NA | NA | 137 | no | 30 |
| NET\_122 | pacific sardine | seine | 83 | 8 | 8 | 120 | no | 24 |
| MSC\_142 | rock crab | diving gr, oth-known, c&l pot | 67 | 33 | NA | 112 | no | 19 |
| NET\_112 | chinook salmon | set net | 29 | NA | 71 | 106 | no | 29 |
| HKL\_252 | unsp. shelf rockfish | pole(com) | 100 | NA | NA | 106 | no | 6 |
| HKL\_232 | pacific barracuda | pole(com) | 100 | NA | NA | 90 | no | 54 |
| TWL\_92 | petrale sole | sel ff twl, gftrawl<8, rlr-trawl | NA | 56 | 44 | 83 | no | 42 |
| MSC\_162 | other mollusks | diving gr | 100 | NA | NA | 70 | no | 25 |
| TLS\_52 | yellowtail rockfish | troll | 30 | 40 | 30 | 64 | no | 40 |
| TWL\_122 | canary rockfish | mid-trawl | NA | 60 | 40 | 61 | no | 31 |
| HKL\_222 | leopard shark | pole(com) | 100 | NA | NA | 61 | no | 27 |
| TWL\_162 | darkblotched rockfish | mid-trawl, rlr-trawl | 29 | 57 | 14 | 54 | no | 29 |
| TWL\_142 | nor. unsp. shelf rockfish | mid-trawl | NA | 40 | 60 | 52 | no | 5 |
| HKL\_192 | swordfish | longline | 100 | NA | NA | 50 | no | 10 |
| NET\_162 | other shark | gill net | 100 | NA | NA | 46 | no | 12 |
| NET\_192 | soupfin shark | gill net | 88 | NA | 12 | 46 | no | 10 |
| MSC\_182 | california sheephead | diving gr | 100 | NA | NA | 43 | no | 9 |
| TLS\_62 | lingcod, vermillion rockfish | troll | 85 | 8 | 8 | 42 | yes | 29 |
| TWL\_132 | nor. unsp. slope rockfish | mid-trawl, rlr-trawl | NA | 100 | NA | 41 | no | 26 |
| TWL\_102 | pop | rlr-trawl | NA | 100 | NA | 40 | no | 19 |
| NET\_172 | chum salmon | gill net | NA | NA | 100 | 36 | no | 13 |
| HKL\_312 | unsp. slope rockfish | longline | 100 | NA | NA | 31 | no | 15 |
| TLS\_42 | white seabass | troll | 100 | NA | NA | 31 | no | 20 |
| HKL\_262 | unsp. squid | pole(com) | 67 | 33 | NA | 30 | no | 12 |
| HKL\_242 | northern anchovy | longline | 100 | NA | NA | 27 | no | 3 |
| TWS\_72 | other skates | sgl-shrimp | 100 | NA | NA | 26 | no | 6 |
| MSC\_152 | black-and-yellow rockfish | diving gr | 100 | NA | NA | 25 | no | 9 |
| NET\_212 | california scorpionfish | gill net | 100 | NA | NA | 25 | no | 8 |
| TWS\_62 | other shrimp | sgl-shrimp | 100 | NA | NA | 22 | no | 3 |
| HKL\_282 | thornyheads (mixed) | longline | 100 | NA | NA | 21 | no | 11 |
| HKL\_272 | bat ray | pole(com) | 100 | NA | NA | 16 | no | 8 |
| TWS\_82 | unsp. skate | sgl-shrimp | 75 | NA | 25 | 11 | no | 5 |
| MSC\_172 | unsp. shad | unkn-gear | 100 | NA | NA | 10 | no | 2 |

### Alternative diversity measure: Shannon Weaver index

The Shannon-Weaver index is defined as

for fisheries, and is the proportion of total gross revenue from fishery . As diversity increases, increases from 0.

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1. In 2011 ITQs went in to a subset of the fisheries, namely the trawl groundfish fisheries. This change in management may change the assemblage of species caught together. To check for sensitivity based on year chosen as training year, we trained the knn classifier on both pre- (2010) and post- (2012) catch share implementation. We found no significant difference in how trips were assigned to metiers. But see the appendix for futher details. [↑](#footnote-ref-1)
2. But see the Appendix for an equivalent analysis using the Shannon-Weaver index. [↑](#footnote-ref-2)
3. Should I also show the results of 2010 trained 2010 and 2012 trained 2012 to each other? Is that circular? [↑](#footnote-ref-3)
4. Haven't yet found any reference to what an acceptably high value of the is. [↑](#footnote-ref-4)
5. But this is something I think might be useful for better characterizing these metiers. I would expect target species would have a high relative abundance within a catch (i.e. be a majority species) and/or have a high relative price. I could imagine some targetting index for species in trip like [↑](#footnote-ref-5)