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1 Measuring Output for U.S. Commercial Fisheries From Theory to Practice

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Emily Markowitz[1] (Emily.Markowitz@noaa.gov)

Sun Ling Wang[2] (Sun-Ling.Wang@noaa.gov)

[1]Contractor, ECS Federal in support of NOAA Fisheries Office of Science and Technology Economics & Social Analysis Division; as of Sept. 28, 2020: Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98195

[2]On detail with the NOAA Fisheries Office of Science and Technology Economics & Social Analysis Division

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GitHub: https://github.com/emilyhmarkowitz/FisheriesEconomicProductivityIndex

R Package is forthcomming.

1.1 A quick message from our sponsors: NOAA README

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1.2 Study Purpose

- Develop alternative approaches to measure national and regional fishery outputs for productivity measurements.
- Evaluate the impacts of missing data and other issues on output estimates.

1.3 Theoretical Framework: Törnqvist index

1.3.1 A Flexible Function and Superlative Quantity Index (Diewert 1976)

Of course, we could calculate something as simple as the simple sum of fisheries quantity from species' quantities. There, you would simply sum all of the species from the entire commercial fishing sector.

$$CommericalFishing = \sum_{t=1}(Cod, Lobster, Seaweed, Flounder, ...)$$

When you have a dataset with missing data, different groups that require their own subsetted analysis (so we can recogize the difference between the economic stuff of finfish, shellfish, etc.), and other unqiue caveats as this one does, you will find that this method will likely provide a grossely incomplete image of what is actually happening.

Instead, we have adapted the **General Total Factor Productivity (TFP) Equation**

The equation for the 2 main models described here can be described by this theoretical Törnqvist index framework. It is a flexible function and superlative quantity index.

The general form of the TFP can be measured as aggregate output (Y) divided by real total inputs (X). Rates of TFP growth are constructed using the Törnqvist index approach. The TFP growth over two time periods is defined as:

$$ln(TFP_t/TFP_{t-1}) = \sum_{i=1}^{n}((\frac{R_{t,i} + R_{t-1,i}}{2}) * ln(\frac{Y_{t,i}}{Y_{t-1,i}}))) - \sum_{j=1}^{m}((\frac{W_{j,t} + W_{j,t-1}}{2}) * ln(\frac{X_{j,t}}{X_{j,t-1}})))$$

Such that:

- Output represents $\sum_{i=1}^{n}((\frac{R_{it}+R_{it-1}}{2}) * ln(\frac{Y_{it}}{Y_{it-1}}))$
- Input represents $\sum_{j=1}^{n}((\frac{W_{jt}+W_{jt-1}}{2}) * ln(\frac{X_{jt}}{X_{jt-1}}))$

The first part is the function is the output, which is composed of a 2 year average revenue shares and quantity change. Output, for our purposes, will represent National or Regional commercial fisheries landings.

The second part of this function represents (in a similar fashion to the first part of the equation) all the input (e.g., capital, labor, energy, materials, and services costs) that went into obtaining the output and follows a similar equation setup. Finding the data for this input side of the equation has proven to be a bit more difficult than anticipated, …so for this exercise we are simply going to attempt to solve the output side of the equation.

where:

- Y_i = individual outputs. This will later be referred to as Q_i in the following equations.
- X_j = individual inputs
- R_i = output revenue shares
- W_j = input cost shares
- t and $t-1$ = time, where 1 is the minimum year in the data set
- i = fishery category, e.g., Finfish (=1), Shellfish (=2)
- s = species, e.g., Salmon, Alewife, Surf Clams

1.4 Output Method: From Quantity to Quantity Measures

1.4.1 Variable Summary

Variables

- Q = individual quantity outputs in pounds (lbs).
- V = individual value outputs in dollars ($)
- QE and VE = simple sum of Quantity (Q) and Value (V)
- R = output revenue shares
- *baseyr* is the year to base all indices from

Subscript Indices

- t and $t-1$ are time subscripts, where 1 is the minimum year in the data set
- i is category, e.g., Finfish (=1), Shellfish (=2)
- s is species, e.g., Salmon, Alewife, Surf Clams

1.4.2 Data requirements and source

The Tornqvist quantity index requires data on quantity and revenue shares. We employ landings quantity (pounds) and landings value ($USD) data by year, state, and species.

- Data source: Fisheries One Stop Shop downloaded August 13 2020
- More information about the data: Commercial Fisheries Landings Data

Here is the original data:

	year	V1_1Salmon	Q1_1Salmon	V1_2Cod	Q1_2Cod	V2_1Shrimp	Q2_1Shrimp	V2_2Clam	Q2_2Clam	V1_3Flounder	Q1_3Flounder	V1_4SeaBass	Q1_4SeaBass
1	2007	NA	NA	2800	2000	800	100	1000	150	1000	NA	NA	1000
2	2008	NA	NA	2700	1900	1000	120	1200	160	1200	NA	120	1200
3	2009	NA	NA	2900	2000	900	110	900	140	900	NA	110	900
4	2010	100	20	3000	2500	700	90	NA	NA	NA	NA	90	NA
5	2011	100	10	3100	2400	900	80	NA	NA	NA	NA	80	NA
6	2012	150	12	2900	2300	1000	100	NA	NA	NA	NA	100	NA
7	2013	180	11	2800	2000	1200	100	1000	140	1000	NA	100	1000
8	2014	170	11	3200	2300	1100	110	900	110	900	NA	NA	900
9	2015	200	10	3500	2400	1000	90	1000	130	1000	NA	NA	1000
10	2016	180	15	3200	2200	1200	100	1100	160	1100	NA	NA	1100

1.4.2.1 In this data, we use these naming conventions for the column names.

For example, in "V1_0Finfish":

- "V"… refers to the variable represented in the column (here V = "Value")
- …"1"… refers to the category iteration (here, = Finfish)
- …"_"… is simply a separator in the title
- …"0".. refers to the total of the specific category.
- …"Finfish" is purely descriptive (here the name of the category), so you can follow along with what is happening!

Similarly for "Q2_2Clam":

- "Q"… refers to the variable represented in the column (here Q = "Quantity")
- …"2"… refers to the category iteration (here, = Shellfish)
- …"_"… is simply a separator in the title
- …"2".. refers to the iteration of the species, such that this organism happens to be the second species of this category.
- …"Clams" is purely descriptive (here the name of the species), so you can follow along with what is happening!

1.4.3 Lets get started

1.4.4 Calculate Category and Entire Fishery Sums of V and Q

1.5 Commercial fisheries data availability, issues, and mitigation

- How should we deal with missing data?
- How much of the time series should be assessed?
- How should species data be categorized?

1.5.1 Missing data

NA in the commercial fisheries data set does not mean 0, but rather that the data may be confidential (following the rule of 3) or simply be missing. This can be a serious issue here, as missing data could lead to artificially large price (PC_t) and quantity (QC_t) changes for years in the time series.

There are a lot of NAs in this data set. Some data columns are completely filled with NA and even those that are not – So first thing we did was to take care of columns that were mostly made of NAs. We instituted a % missing data threshold. Here, these columns have too few data according to a 40% threshold we've instituted, so we are simply going to remove that data. Honestly, what could data with that much missing really tell us and at what point are we just making the data up to make up for what is missing?

Now with those offending columns of missing data gone, we can go after the loose, infrequent, NAs. Here we impute the values from the closest value and hearkening back to our previous example, the fictitious code value data looks a lot more realistic!

When we apply these practices for missing data to real data examples, we see that the removal of nearly 400 species data results in a plot for quantity index (one of our targeted end products) almost the same to one where no data was removed. This provides evidence that those removed data weren't really contributing much to the results. This is also a large data set such that the impact of the data removed (35% of the original data) is cushioned by how much data is remaining.

On the other hand, the removal of 58 species (approximately 25% of the original data) radically changes this regional plot. The y-axis is displaying beyond-reasonable values and the spike in the "Other" category can't possibly be correct. With the percent missing threshold implemented, QI values appear to be in a much more sensible range.

1.5.2 Time Series Reporting Consistency

Consistent reporting throughout the time series. Looking simply at the summed quantity for each category and the entire fishery, there have been several periods of improved reporting, such that the increasing trend is so steep and is not indicative of real increases in the quantity of fish caught from 1950 (when data was first started to be collected) to today (2016). If we just take the last part of that timeline, the trend seems more level and reasonable.

If we look at the quantity index result, we see that much of our missing data is pre-1990 and our analysis inherently removes less data when we subset, giving us more species data to work with.

1.5.3 Defining Species Categories

The next question is something we are still thinking about: How to define our species categories. These can be specific or broad?

Theoretically, categories should group species with similar economic impact (e.g., fishing costs) which can be difficult to define.

It is possible that we might be able to use taxonomic group as a proxy for this since species in the same taxonomic group are more likely to be caught in similar ways (an idea that is very pleasing to the biologist in me!).

More specifically, we applied two methods:

1. We used the same species groupings as were used in Fisheries Economics of the US report. This could work because there is a precedent for using this species split up, but it is fairly over-generalized. "Shellfish" is not really the same as saying "all invertebrates", for example.

2. Alternatively, thanks to renewed data managing efforts done by ST1, we now have ITSN numbers associated with each species, and with some fancy footwork, can resort these species into a variety of taxonomically-relevant groups.

However, with the more categories we have, the less data we have for each category.

These plots were created using the same data, just by splitting the categories up differently. We can see that the QI is increasing in the first plot using the FEUS categories and that the second plot using the taxonomically defined species has species increasing and decreasing.

This may be a key to better seeing what is actually going on in the data.

1.6 Ways to work your analysis

1.7 QUANTITY METHOD

In most of the following examples, we will just focus on the finfish (i=1) side of the equation. Here *baseyr* is set to 2010 and the *pctmiss* (The percent of data in a column that we will allow to be missing for analysis; more on that later) is set to 0.5%.

This method works directly from the quantity data so it is good for when $Q_{t,i,s}$ is often available.

I won't get to deep in the math here – we can review these later if needed in the discussion – but the main takeaway is that this method simply uses the available quantity data at the species level to develop revenue-share weighed quantity changes.

1.7.1 At the species level:

1.7.1.1 Remove any V and Q data where V column has less data than the specifed *pctmiss*

No warning.

	Q1_1Salmon	Q1_2Cod	Q2_1Shrimp	Q2_2Clam	REMOVED_Q1_3Flounder	Q1_4SeaBass
2007	NA	2000	100	150	NA	1000
2008	NA	1900	120	160	NA	1200
2009	NA	2000	110	140	NA	900
2010	20	2500	90	NA	NA	NA
2011	10	2400	80	NA	NA	NA
2012	12	2300	100	NA	NA	NA
2013	11	2000	100	140	NA	1000
2014	11	2300	110	110	NA	900
2015	10	2400	90	130	NA	1000
2016	15	2200	100	160	NA	1100

1.7.1.2 Total Value of species with available Q and V data

For where $Q_(t,i,s)$ and $V_(t,i,s)$ is not available to a certain threshold (say 60% of the data is missing we call it "unavailable"), the data is simply removed from the analysis.

$$Q_{t,i} = \sum_{s=1}^{l} (Q_{t,i,s_{available}})$$

$$V_{t,i} = \sum_{s=1}^{l}(V_{t,i,s_{available}})$$

Because we removed some columns for not meeting a perecent missing threshold of 0.5% and those columns will not be used at all in any part of the further analysis, we need to re-calculate the totals of V and Q for the catagories and the fishery as a whole.

	QE1_0Finfish	VE1_0Finfish	Q1_0Finfish	V1_0Finfish
2007	3000	3800	3000	2800
2008	3100	4020	3100	2820
2009	2900	3910	2900	3010
2010	2520	3190	2520	3190
2011	2410	3280	2410	3280
2012	2312	3150	2312	3150
2013	3011	4080	3011	3080
2014	3211	4270	3211	3370
2015	3410	4700	3410	3700
2016	3315	4480	3315	3380

1.7.1.3 Address Infrequent Missing Data There may be instances where there are no or too few Q data for that species in a year or ever. The next goal will be to calculate the quantity change, so we need to have a value in there that won't show change. If we left an NA (which would be treated as a 0) in the cell, then the change from year to year would be very large and misrepresent the index trend. To avoid this, we do the following:

$$where \begin{cases} if: Q_{t,i=1} = 0, then: Q_{t,i=1} = Q_{t,i=1+1...} \\ if: Q_{t,i\neq 1} = 0, then: Q_{t,i} = Q_{t-1,i} \end{cases}$$

1.7.1.3.1 1. If there are instances for a species where there are too Q are completely missing from the timeseries or where a percent of data that is missing from the timeseries, we will remove the offending columns entierly, so they don't influence the downstream price change or price index calculations. Let's say here that if 50% of the data is missing in a given $Q_{t,i,s}$, don't use that to calculate that species $Q_{t,i}$

	Q1_1Salmon	Q1_2Cod	Q1_4SeaBass
2007	NA	2000	1000
2008	NA	1900	1200
2009	NA	2000	900
2010	20	2500	NA
2011	10	2400	NA
2012	12	2300	NA
2013	11	2000	1000
2014	11	2300	900
2015	10	2400	1000
2016	15	2200	1100

No warning.

1.7.1.3.2 2. If the first value of $Q_{t,i,s}$ is 0/NA in a timeseries, we (impute) let the next available non-zero/non-NA value of Q in the timeseries inform the past.

	Q1_1Salmon	Q1_2Cod	Q1_4SeaBass
2007	20	2000	1000
2008	NA	1900	1200
2009	NA	2000	900
2010	20	2500	NA
2011	10	2400	NA
2012	12	2300	NA
2013	11	2000	1000
2014	11	2300	900
2015	10	2400	1000
2016	15	2200	1100

1.7.1.3.3 3. If there is a value in the middle of $P_{t,i,s}$'s timeseries that is 0/NA, we (impute) let the most recent past available non-zero/non-NA of $P_{t,i,s}$ in the timeseries inform the future.

	Q1_1Salmon	Q1_2Cod	Q1_4SeaBass
2007	20	2000	1000
2008	20	1900	1200
2009	20	2000	900
2010	20	2500	900
2011	10	2400	900
2012	12	2300	900
2013	11	2000	1000
2014	11	2300	900
2015	10	2400	1000
2016	15	2200	1100

1.7.1.4 Impute values of $V_{t,i,s}$ where P was able to be calculated

To ensure that the price index does not rise or fall to quickly with changes (that are really because of NA values) we fill in the missing instances of $V_{t,i,s}$.

$$where \begin{cases} if : V_{t,i=1} = 0, then : V_{t,i=1} = V_{t,i=1+1...} \\ if : V_{t,i\neq 1} = 0, then : V_{t,i} = V_{t-1,i} \end{cases}$$

1.7.1.4.1 1. If the first value of $V_{t,i,s}$ is 0/NA in a timeseries, we let the next available non-zero value of $V_{t,i,s}$ in the timeseries inform the past.

	V1_1Salmon	V1_2Cod	V1_4SeaBass
2007	100	2800	120
2008	NA	2700	120
2009	NA	2900	110
2010	100	3000	90
2011	100	3100	80
2012	150	2900	100
2013	180	2800	100

	V1_1Salmon	V1_2Cod	V1_4SeaBass
2014	170	3200	NA
2015	200	3500	NA
2016	180	3200	NA

1.7.1.4.2 2. If there is a value in the middle of $V_{t,i,s}$'s timeseries that is 0/NA, we let the most recent past available non-zero of $V_{t,i,s}$ in the timeseries inform the future.

	V1_1Salmon	V1_2Cod	V1_4SeaBass
2007	100	2800	120
2008	100	2700	120
2009	100	2900	110
2010	100	3000	90
2011	100	3100	80
2012	150	2900	100
2013	180	2800	100
2014	170	3200	100
2015	200	3500	100
2016	180	3200	100

1.7.1.4.3 Analysis Warnings Checks Just so we can get a sense of the data, we want to see how many species are significantly increasing or decreasing over time for V and Q.

We'll use the below function to collect our info:

```
## function (Columns, temp)
## {
##     lm_check <- data.frame(col = rep_len(x = NA, length.out = length(Columns)),
##         slope = rep_len(x = NA, length.out = length(Columns)),
##         intercept = rep_len(x = NA, length.out = length(Columns)),
##         R2 = rep_len(x = NA, length.out = length(Columns)), R2adj = rep_len(x = NA,
##             length.out = length(Columns)), Pr = rep_len(x = NA,
##             length.out = length(Columns)), Fstat = rep_len(x = NA,
##             length.out = length(Columns)))
##     for (c0 in 1:length(Columns)) {
##         if (sum(is.na(temp[, Columns[c0]])) == length(temp[,
##             Columns[c0]]) | length(temp[, Columns[c0]]) %in%
##             sum(temp[, Columns[c0]] %in% c(NA, 0))) {
##             lm_check$col[c0] <- NA
##             lm_check$slope[c0] <- NA
##             lm_check$intercept[c0] <- NA
##             lm_check$R2[c0] <- NA
##             lm_check$R2adj[c0] <- NA
##             lm_check$Pr[c0] <- NA
##             lm_check$Fstat[c0] <- NA
##         }
##         else {
##             temp0 <- summary(lm(rownames(temp) ~ temp[, Columns[c0]]))
##             lm_check$col[c0] <- Columns[c0]
##             lm_check$slope[c0] <- temp0$coefficients[2]
##             lm_check$intercept[c0] <- temp0$coefficients[1]
```

```
##             lm_check$R2[c0] <- temp0$r.squared
##             lm_check$R2adj[c0] <- temp0$adj.r.squared
##             lm_check$Pr[c0] <- temp0$coefficients[8]
##             lm_check$Fstat[c0] <- ifelse(is.null(temp0$fstatistic[1]),
##                 NA, as.numeric(temp0$fstatistic[1]))
##         }
##     }
##     lm_check$var <- substr(x = Columns, 1, 1)
##     lm_check$slopecheck <- "Insig"
##     lm_check$slopecheck <- ifelse(lm_check$slope >= 0 & lm_check$Pr <=
##         0.05, "Sig Pos", "Insig")
##     lm_check$slopecheck <- ifelse(lm_check$slope < 0 & lm_check$Pr <=
##         0.05, "Sig Neg", lm_check$slopecheck)
##     return(lm_check)
## }
```

	NameBasecategory		slope	intercept	R2	R2adj	Pr	Fstat	var	slopecheck
1	1_0Finfish	V1_1Salmon	0.0653553	2002.481	0.8159514	0.7929453	0.0003399	35.4667781	V	Sig Pos
2	1_0Finfish	V1_2Cod	0.0093573	1983.335	0.5614367	0.5066163	0.0126083	10.2413793	V	Sig Pos
3	1_0Finfish	V1_4SeaBass	-0.1176471	2023.500	0.2281640	0.1316845	0.1626498	2.3648961	V	Insig
4	1_0Finfish	Q1_1Salmon	-0.4845469	2018.720	0.5432798	0.4861898	0.0150066	9.5161963	Q	Sig Neg
5	1_0Finfish	Q1_2Cod	0.0065000	1997.200	0.2048485	0.1054545	0.1890352	2.0609756	Q	Insig
6	1_0Finfish	Q1_4SeaBass	-0.0010417	2012.521	0.0012626	-0.1235795	0.9223686	0.0101138	Q	Insig

How many slopes are significantly increaseing or decreaseing

	var	slopecheck	Freq
1	Q	Insig	2
3	Q	Sig Neg	1
5	Q	Sig Pos	0
2	V	Insig	1
4	V	Sig Neg	0
6	V	Sig Pos	2

1.7.1.5 Value of species $VV_{t,i}$ where Q available

$R_{t,i}$, as defined and discussed in the subsequent step, will need to sum to 1 across all species in a category. Therefore, you will need to sum a new total of $V_{t,i}$ available (called $VV_{t,i}$) for the category using only values for species that were used to calculate $Q_{t,i}$ (called $V_{t,i,s,available}$).

$$VV_{t,i} = \sum_{s=1}^{n}(V_{t,i,s,available})$$

where:

- $VV_{t,i}$ is the new total of $V_{t,i}$ (called $VV_{t,i}$) for the category using only values for species that were used to calculate $Q_{t,i}$

- $V_{t,i,s,available}$ are the $V_{t,i,s}$ where $Q_{t,i,s}$ were able to be calculated

	V1_1Salmon	V1_2Cod	V1_4SeaBass	VV1_0Finfish
2007	100	2800	120	3020
2008	100	2700	120	2920
2009	100	2900	110	3110
2010	100	3000	90	3190
2011	100	3100	80	3280
2012	150	2900	100	3150
2013	180	2800	100	3080
2014	170	3200	100	3470
2015	200	3500	100	3800
2016	180	3200	100	3480

1.7.1.6 Revenue-share

Revenue Share for each species ($R_{t,i,s}$; e.g., Salmon and Flounder)

$$R_{t,i,s} = V_{t,i,s}/VV_{t,i}$$

where:

- $R_{t,i,s}$ is the revenue share per individual species (s), category (i), for each year (t)
- $V_{t,i,s}$ is the value ($) per individual species (s), category (i), for each year (t)

Here we divide $V_{t,i,s}$ by $VV_{t,i}$ because $VV_{t,i}$ only includes species used to calculate $V_{t,i,s}$ as per the above price calculations.

	R1_1Salmon	R1_2Cod	R1_4SeaBass
1	0.0331126	0.9271523	0.0397351
2	0.0342466	0.9246575	0.0410959
3	0.0321543	0.9324759	0.0353698
4	0.0313480	0.9404389	0.0282132
5	0.0304878	0.9451220	0.0243902
6	0.0476190	0.9206349	0.0317460
7	0.0584416	0.9090909	0.0324675
8	0.0489914	0.9221902	0.0288184
9	0.0526316	0.9210526	0.0263158
10	0.0517241	0.9195402	0.0287356

####Analysis Warnings Checks

As an additional check, let's make sure that each row sums to 1.

	x
1	1
2	1
3	1
4	1
5	1

	x
6	1
7	1
8	1
9	1
10	1

Is there a warning?

No warning.

1.7.1.7 Revenue-share weighted quantity changes

Revenue Share-Weighted Qunatity Changes for each species ($QCW_{t,i,s}$; e.g., Salmon and Flounder)

$$QCW_{t,i,s} = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * ln(\frac{Q_{t,i,s}}{Q_{s,t-1,i}}) = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * [ln(Q_{t,i,s}) - ln(Q_{s,t-1,i})] = \frac{R_{t,i,s} + R_{t-1,i,s}}{Q_{t,i,s} + Q_{t-1,i,s}}$$

Where:

- $QCW_{t,i,s}$ = Revenue share-weighted quantity change for a species (s)

Such that:

- category's (i) Quantity Change for each species (s) = $\frac{R_{t,i,s}+R_{s,t-1,i}}{2}$
- category's (i) Revenue Share for each species (s) = $ln(\frac{Q_{t,i,s}}{Q_{s,t-1,i}} = [ln(Q_{t,i,s}) - ln(Q_{s,t-1,i})]$

1.7.2 At the fishery level:

Then we calculate the revenue share, QI, and revenue-share weighted quantity changes at the category level, which are used at the commercial fishery level to develop the annual quantity change and index.

1.7.2.1 Quantity change

Quantity Changes for the category ($QC_{t,i}$; e.g., Finfish). These, specifically the QC, are what go into the output equation.

$$QC_{t,i} = ln(\frac{Q_{t,i}}{Q_{t-1,i}}) = \sum_{s=1}^{n}(QCW_{t,i,s})$$

Where:

- $QC_{t,i}$ = Quantity change for a category (i)

	QCW1_1Salmon	QCW1_2Cod	QCW1_4SeaBass	QC1_0Finfish
2007	0.0000000	0.0000000	0.0000000	0.0000000
2008	0.0000000	-0.0474927	0.0073686	-0.0401241
2009	0.0000000	0.0476292	-0.0109989	0.0366303
2010	0.0000000	0.2089644	0.0000000	0.2089644

	QCW1_1Salmon	QCW1_2Cod	QCW1_4SeaBass	QC1_0Finfish
2011	-0.0214306	-0.0384862	0.0000000	-0.0599168
2012	0.0071203	-0.0397029	0.0000000	-0.0325827
2013	-0.0046142	-0.1278630	0.0033828	-0.1290945
2014	0.0000000	0.1279717	-0.0032286	0.1247431
2015	-0.0048429	0.0392239	0.0029045	0.0372855
2016	0.0211563	-0.0800763	0.0026235	-0.0562965

1.7.2.2 Implicit quantity index Quantity Index for the each category ($QI_{t,i}$)

We calculate the quantity index first by comparing by multiplying the previous years QI_{t-1} by that year's quantity change QC_t, where the QI of the first year $QI_{t=firstyear,i} = 1$

$$QI_{t,i} = QI_{t-1,i} * \exp(ln(\frac{Q_{t,i,s}}{Q_{t-1,i,s}})) = QI_{t-1,i} * \exp(QC_{t,i})$$

Where

$$QI_{i,t_{firstyear}} = 1$$

Note that the first row of this column is = 1

Then, to change the price index into base year dollars, we use the following equation:

$$QI_t = QI_t/QI_{t=baseyear}$$

	QI1_0Finfish
2007	0.8142640
2008	0.7822391
2009	0.8114241
2010	1.0000000
2011	0.9418429
2012	0.9116497
2013	0.8012406
2014	0.9076914
2015	0.9421740
2016	0.8905983

1.7.2.3 Redo Analysis for Other Categories Now lets redo that whole analysis up to this point (via function) for the two species of the shellfish group, as we will need them for the next steps of this analysis.

We use the *QuantityMethodOutput.Category* function to calculate everything we did above at category level.

What does the Shellfish data look like?

	R2_1Shrimp	R2_2Clam	QCW2_1Shrimp	QCW2_2Clam	QC2_0Shellfish	QI2_0Shellfish
2007	0.4444444	0.5555556	0.0000000	0.0000000	0.0000000	1.0918916
2008	0.4545455	0.5454545	0.0819526	0.0355288	0.1174814	1.2280076
2009	0.5000000	0.5000000	-0.0415282	-0.0698005	-0.1113287	1.0986305
2010	0.4375000	0.5625000	-0.0940644	0.0000000	-0.0940644	1.0000000
2011	0.5000000	0.5000000	-0.0552108	0.0000000	-0.0552108	0.9462857

	R2_1Shrimp	R2_2Clam	QCW2_1Shrimp	QCW2_2Clam	QC2_0Shellfish	QI2_0Shellfish
2012	0.5263158	0.4736842	0.1145079	0.0000000	0.1145079	1.0610904
2013	0.5454545	0.4545455	0.0000000	0.0000000	0.0000000	1.0610904
2014	0.5500000	0.4500000	0.0522040	-0.1090710	-0.0568670	1.0024330
2015	0.5000000	0.5000000	-0.1053521	0.0793507	-0.0260014	0.9767043
2016	0.5217391	0.4782609	0.0538255	0.1015627	0.1553882	1.1408993

1.7.2.4 Value of categories available

Value for all fisheries for species where Q was able to be calculated

$R_{t,i}$, defined and discussed in the subsequent step, will need to sum to 1 across all species in a category. Therefore, you will need to sum a new total of $V_{t,i}$ (called VV_t) for the category using only values for species that were used to calculate $QI_{t,i}$.

$$VV_t = \sum_{i=1}^{l} (V_{t,i_{available}} = \sum_{s=1}^{n} (VV_{t,i})$$

where:

- VV_t is the new total of $V_{t,i}$ for the entire fishery using only values for species that were used to calculate $P_{t,i}$

	R2_1Shrimp	R2_2Clam	QCW2_1Shrimp	QCW2_2Clam	QC2_0Shellfish	QI2_0Shellfish
2007	0.4444444	0.5555556	0.0000000	0.0000000	0.0000000	1.0918916
2008	0.4545455	0.5454545	0.0819526	0.0355288	0.1174814	1.2280076
2009	0.5000000	0.5000000	-0.0415282	-0.0698005	-0.1113287	1.0986305
2010	0.4375000	0.5625000	-0.0940644	0.0000000	-0.0940644	1.0000000
2011	0.5000000	0.5000000	-0.0552108	0.0000000	-0.0552108	0.9462857
2012	0.5263158	0.4736842	0.1145079	0.0000000	0.1145079	1.0610904
2013	0.5454545	0.4545455	0.0000000	0.0000000	0.0000000	1.0610904
2014	0.5500000	0.4500000	0.0522040	-0.1090710	-0.0568670	1.0024330
2015	0.5000000	0.5000000	-0.1053521	0.0793507	-0.0260014	0.9767043
2016	0.5217391	0.4782609	0.0538255	0.1015627	0.1553882	1.1408993

	V1_0Finfish	V2_0Shellfish
2007	2800	1800
2008	2820	2200
2009	3010	1800
2010	3190	700
2011	3280	900
2012	3150	1000
2013	3080	2200
2014	3370	2000
2015	3700	2000
2016	3380	2300

1.7.2.5 Revenue share

Revenue Share for the each category ($R_{t,i}$)

$$R_{t,i} = V_{t,i}/VV_t$$

TOLEDO - Which this wrong?

$$R_{t,i} = V_{t,i}/V_t$$

where:

- $R_{t,i}$ is the revenue share per individual species (s), category (i), for each year (t)
- $V_{t,i}$ is the value ($) per individual species (s), category (i), for each year (t)

Here, we don't use VV_t beacause we want to expand the proportion to include all of the species caught, regardless if they were used in the quantity calculations.

	R1_0Finfish	R2_0Shellfish	V1_0Finfish	V2_0Shellfish	V0_0Total
2007	0.6086957	0.3913043	2800	1800	4600
2008	0.5617530	0.4382470	2820	2200	5020
2009	0.6257796	0.3742204	3010	1800	4810
2010	0.8200514	0.1799486	3190	700	3890
2011	0.7846890	0.2153110	3280	900	4180
2012	0.7590361	0.2409639	3150	1000	4150
2013	0.5833333	0.4166667	3080	2200	5280
2014	0.6275605	0.3724395	3370	2000	5370
2015	0.6491228	0.3508772	3700	2000	5700
2016	0.5950704	0.4049296	3380	2300	5680

1.7.2.5.1 Analysis Warnings Checks As an additional check, let's make sure that each row sums to 1.

	x
2007	1
2008	1
2009	1
2010	1
2011	1
2012	1
2013	1
2014	1
2015	1
2016	1

Is there a warning?

No warning.

1.7.2.6 Revenue share weighted quantity changes Revenue Share-Weighted Qunatity Changes for each category ($QCW_{t,i}$; e.g., Finfish and Shellfish)

$$QCW_{t,i} = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * ln(\frac{QI_{t,i,s}}{QI_{s,t-1,i}}) = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * [ln(QI_{t,i,s}) - ln(QI_{s,t-1,i})] = \frac{R_{t,i} + R_{t-1,i}}{Q_{t,i} + Q_{t-1,i}}$$

Where:

- $QCW_{t,i}$ = Revenue share-weighted quantity change for each category (i)

Such that:

- category's (i) Quantity Change for each category (i) = $\frac{R_{t,i}+R_{t-1,i}}{2}$
- category's (i) Revenue Share for each category (i) = $ln(\frac{QI_{t,i}}{QI_{t-1,i}} = [ln(QI_{t,i}) - ln(QI_{t-1,i})]$

1.7.3 At the entire commercial fisheries sector level:

1.7.3.1 Quantity change Quantity Changes for the entire fishery (QC_t)

$$QC_t = ln(\frac{QI_{t,i}}{QI_{t-1,i}}) = \sum_{s=1}^{n}(QCW_{t,i})$$

Where:

- QC_t = Quantity change for the entire fishery

	QCW1_0Finfish	QCW2_0Shellfish	QC0_0Total
2007	0.0000000	0.0000000	0.0000000
2008	-0.0234816	0.0487284	0.0252468
2009	0.0217499	-0.0452255	-0.0234756
2010	0.1510636	-0.0260638	0.1249998
2011	-0.0480755	-0.0109113	-0.0589868
2012	-0.0251493	0.0261235	0.0009742
2013	-0.0866462	0.0000000	-0.0866462
2014	0.0755254	-0.0224371	0.0530883
2015	0.0238009	-0.0094036	0.0143972
2016	-0.0350218	0.0587217	0.0236999

1.7.3.2 Quantity index Quantity Index for the entier fishery (QI_t)

$$QI_t = QI_{t-1} * \exp(ln(\frac{Q_{t,i}}{Q_{t-1,i}})) = QI_{t-1} * \exp(QC_t)$$

where $QI_{t=1} = 1$ and then $QI_t = QI_t/QI_{t=baseyr}$

We calculate the quantity index first by comparing by multiplying the previous years QI_{t-1} by that year's quantity change QC_t, where the QI of the first year $QI_{t=firstyear,i} = 1$

Where

$$QI_{t_{firstyear}} = 1$$

Note that the first row of this column is = 1

Then, to change the price index into base year dollars, we use the following equation:

$$QI_t = QI_t/QI_{t=baseyear}$$

	QI0_0Total
2007	0.8809353
2008	0.9034593
2009	0.8824970
2010	1.0000000
2011	0.9427192
2012	0.9436381
2013	0.8653175
2014	0.9124970
2015	0.9257294
2016	0.9479312

1.7.3.2.1 Other Analysis Warnings Checks

To make sure our analyses worked as inteded, let's see if we can back calculate our numbers.

We want the calcuated V to equal this check:

When back calculated, growth rate?

$$ln(Q_t/Q_{t-1}) = \sum((\frac{R_{i,t} + R_{i,t-1}}{2}) * ln(\frac{Q_{t,i}}{Q_{t-1,i}}))$$

	part1	part2
2007	NA	NA
2008	-0.0252468	0.0252468
2009	0.0234756	-0.0234756
2010	-0.1249998	0.1249998
2011	0.0589868	-0.0589868
2012	-0.0009742	0.0009742
2013	0.0866462	-0.0866462
2014	-0.0530883	0.0530883
2015	-0.0143972	0.0143972
2016	-0.0236999	0.0236999

Is there a warning?

Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum(((R_{i, t} - R_{i, t-1})(2)) ln((Q_{t,i})(Q_{t-1,i}))*

1.7.3.3 Sum Total Simple Sum Quantity Output Index

$$QEI_t = QE_t/QE_{t=baseyr}$$

Where:

- QE_t is the sum of Q before these calculations; the simple sum
- QEI_t is the index of the sum of Q before these equations

	QE0_0Total	QEI0_0Total
2007	3250	1.2452107
2008	3380	1.2950192
2009	3150	1.2068966
2010	2610	1.0000000
2011	2490	0.9540230
2012	2412	0.9241379
2013	3251	1.2455939
2014	3431	1.3145594
2015	3630	1.3908046
2016	3575	1.3697318

1.7.3.4 View Total Outputs

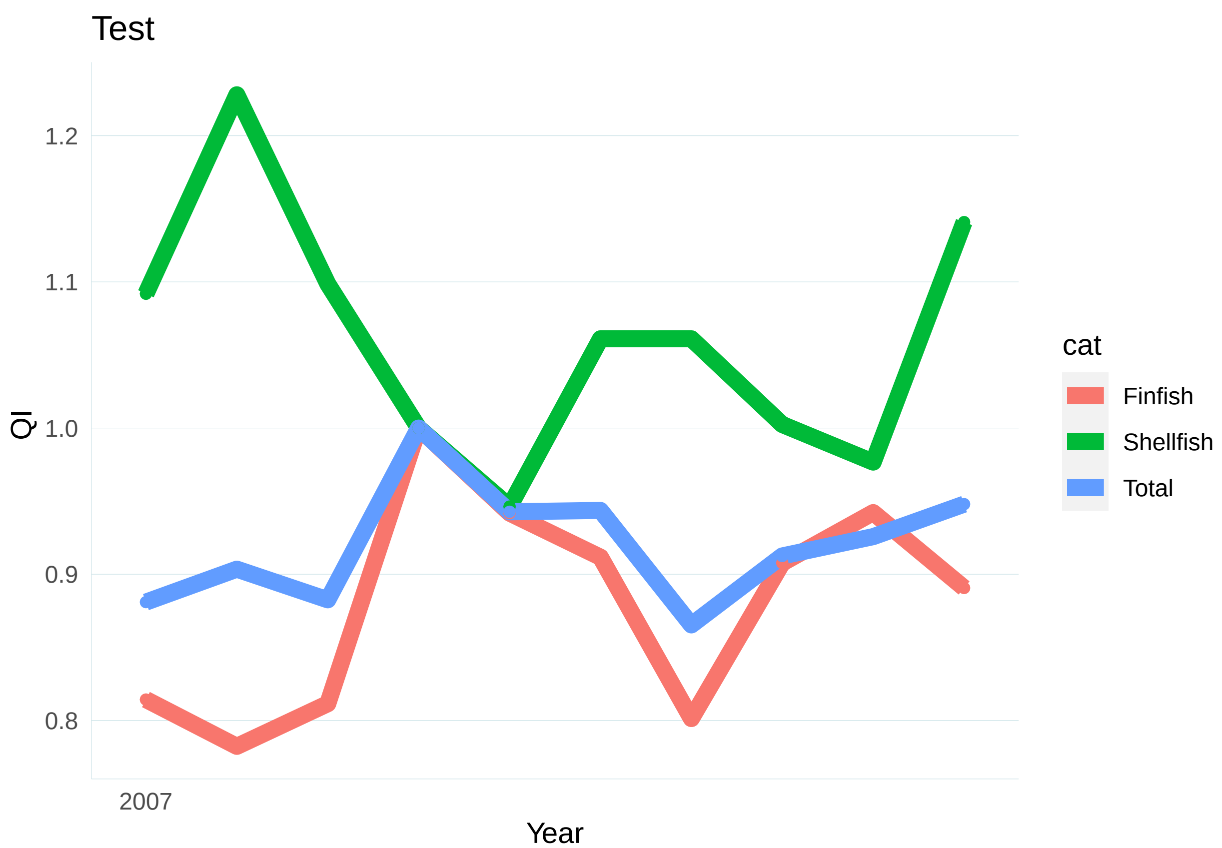
	QE0_0Total	VE0_0Total	VV0_0Total	V0_0Total	QC0_0Total	QI0_0Total	QEI0_0Total
2007	3250	5600	4820	4600	0.0000000	0.8809353	1.2452107
2008	3380	6220	5120	5020	0.0252468	0.9034593	1.2950192
2009	3150	5710	4910	4810	-0.0234756	0.8824970	1.2068966
2010	2610	3890	4790	3890	0.1249998	1.0000000	1.0000000
2011	2490	4180	5080	4180	-0.0589868	0.9427192	0.9540230
2012	2412	4150	5050	4150	0.0009742	0.9436381	0.9241379
2013	3251	6280	5280	5280	-0.0866462	0.8653175	1.2455939
2014	3431	6270	5470	5370	0.0530883	0.9124970	1.3145594
2015	3630	6700	5800	5700	0.0143972	0.9257294	1.3908046
2016	3575	6780	5780	5680	0.0236999	0.9479312	1.3697318

1.7.3.5 How many data were missing at the end of the analysis?

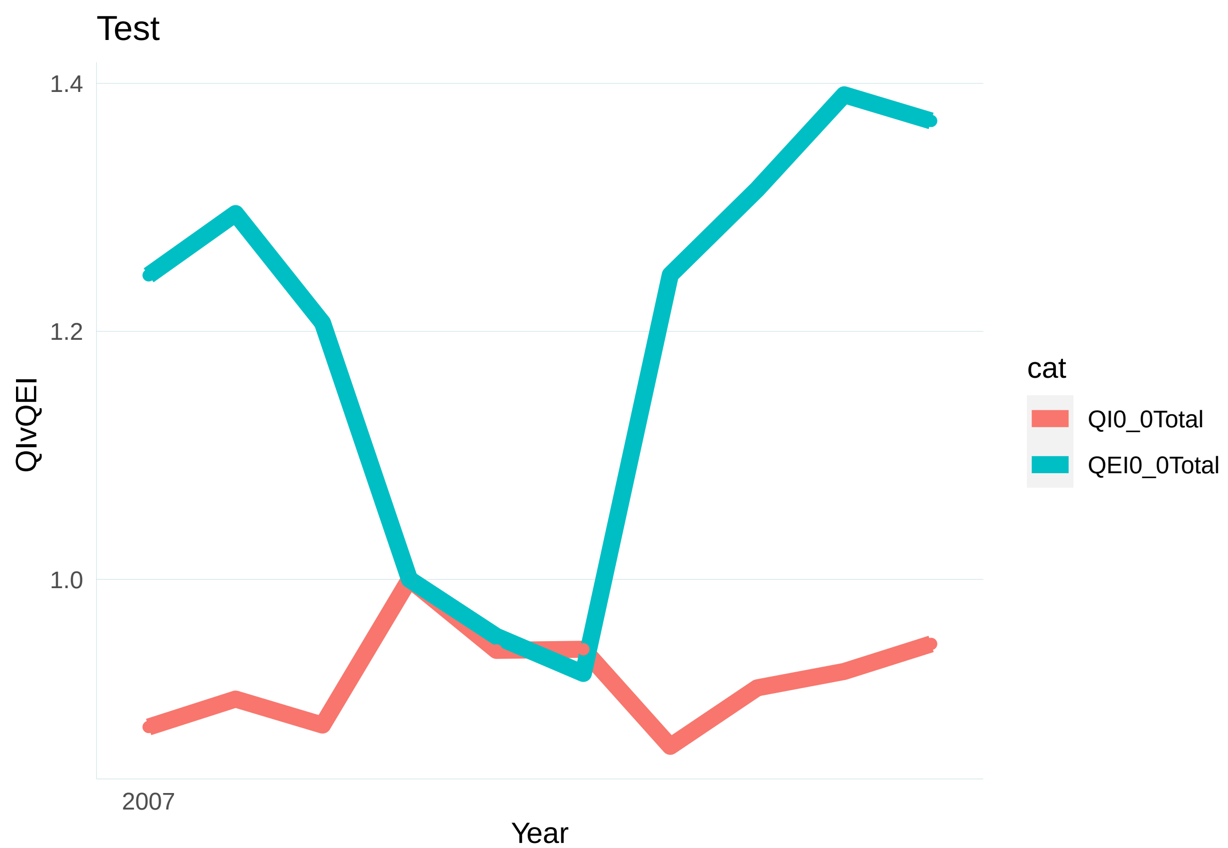
FYI: 0 of species V columns are completely empty, 1 of species Q columns are completely empty.

1.7.3.5.1 Graph 1: Quantity Index Categories

For comparison, let's recreate those graphs to make sure we are getting the same output:



1.7.3.5.2 Graph 2: Quantity Index Compare For comparison, let's recreate those graphs to make sure we are getting the same output:



1.7.4 Do same analysis via a function!

Now that we know the method, we can simplify most of it into a function and do this whole analysis in 4 easy steps:

- A. Import and Edit data
- B. Enter base year
- C. Run the function
- D. Obtain the implicit quantity estimates

1.7.4.1 Function We use the *QuantityMethodOutput* function to calculate the Quanity Output at Fishery Level

1.7.4.2 A. Import and Edit data

1.7.4.3 B. Enter base year

1.7.4.4 C. Run the function

1.7.4.5 D. Obtain the implicit quantity estimates

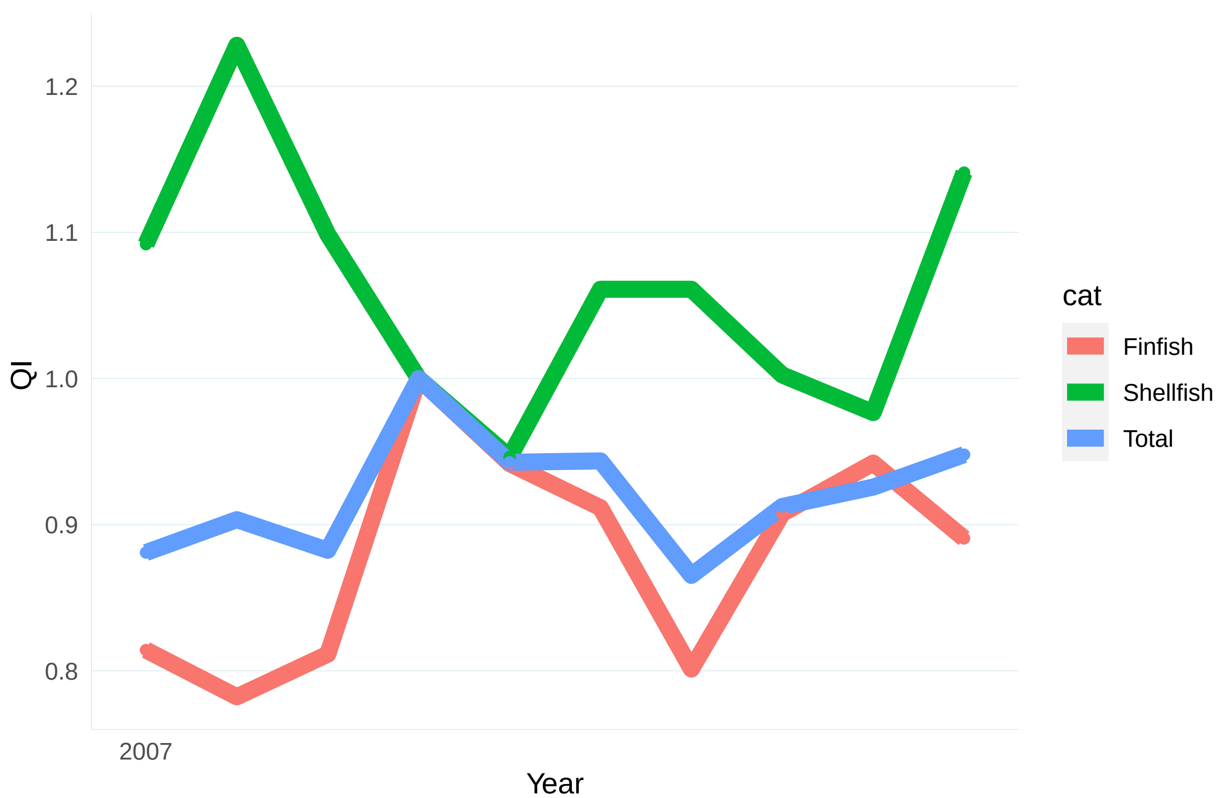
	QE0_0Total	VE0_0Total	VV0_0Total	V0_0Total	QC0_0Total	QI0_0Total	QEI0_0Total
2007	3250	5600	4820	4600	0.0000000	0.8809353	1.2452107
2008	3380	6220	5120	5020	0.0252468	0.9034593	1.2950192
2009	3150	5710	4910	4810	-0.0234756	0.8824970	1.2068966
2010	2610	3890	4790	3890	0.1249998	1.0000000	1.0000000
2011	2490	4180	5080	4180	-0.0589868	0.9427192	0.9540230
2012	2412	4150	5050	4150	0.0009742	0.9436381	0.9241379
2013	3251	6280	5280	5280	-0.0866462	0.8653175	1.2455939
2014	3431	6270	5470	5370	0.0530883	0.9124970	1.3145594
2015	3630	6700	5800	5700	0.0143972	0.9257294	1.3908046
2016	3575	6780	5780	5680	0.0236999	0.9479312	1.3697318

Did all of the analyses work as intended?

list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(2, 1, 0, 1, 0, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(2, 1, 0, 1, 0, 2))), list(list(var = c(1, 1, 2, 2), slopecheck = c(1, 2, 1, 2), Freq = c(2, 0, 1, 1))), Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum((R_{i, t} - R_{i, t-1}) / 2) x ln((Q_{i,t}) / (Q_{i,t-1})), FYI: 0 of species V columns are completely empty, 2 of species Q columns are completely empty.

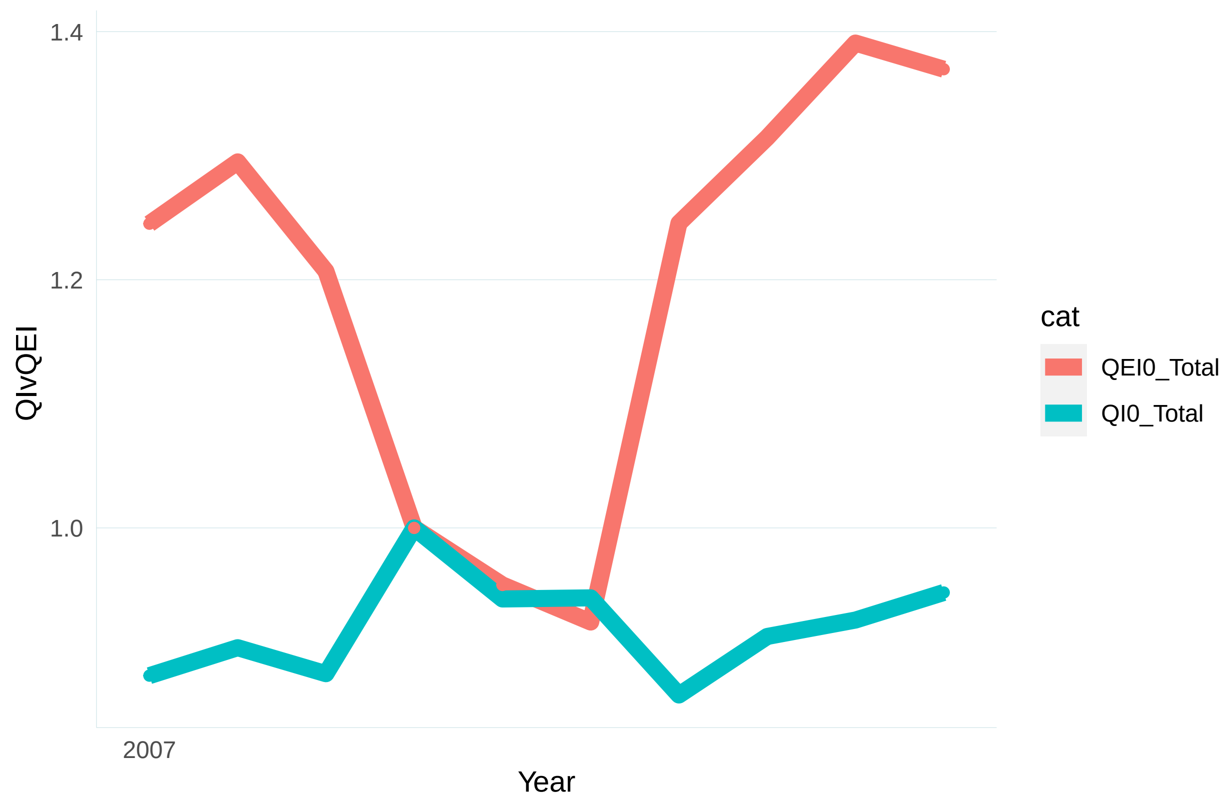
1.7.4.6 E. Graph

1.7.4.6.1 Graph 1: Quantity Index Categories For comparison, let's recreate those graphs to make sure we are getting the same output:



1.7.4.6.2 Graph 2: Quantity Index Compare

For comparison, let's recreate those graphs to make sure we are getting the same output:



1.7.5 Practice with real data (For National Data)

1.7.5.1 A. Import and Edit data

Load and subset Data

Edit/Restructure Data

	Q01__0002ALEWIFE	Q01__0003ALEWIFE.	Q01__0004ALFONSINO	Q01__0006AMBERJACK.GREATER	Q01__0007AMBERJACK.GREATER.
1950	NA	735961	NA	NA	NA
1951	NA	758873	NA	NA	NA
1952	NA	722115	NA	NA	NA
1953	NA	750022	NA	NA	NA
1954	NA	650472	NA	NA	NA

1.7.5.2 B. Enter base year

1.7.5.3 C. Run the function

1.7.5.4 D. Obtain the implicit quantity estimates

	VE_Total	VV_Total	V_Total	QC_Total	QI_Total
1950	2596863100	2794604681	2593845000	0.0000000	0.5833753
1951	2711142600	2900126381	2707189300	0.1808450	0.6990175
1952	2904551900	3094353181	2900834400	-0.0581459	0.6595316
1953	2945724500	3131700481	2943735500	0.0916487	0.7228333
1954	3131528000	3322992081	3129278700	0.0715284	0.7764304
1955	3208381300	3399979081	3206680100	0.0483422	0.8148868
1956	3413031000	3617472081	3411352200	0.0898360	0.8914820
1957	3065775700	3269932281	3064051500	-0.0817660	0.8214896
1958	3003831240	3192160321	3000058540	0.0066717	0.8269887
1959	3552786100	3742561181	3550436800	0.0862896	0.9015185
1960	3431488969	3621283050	3429038869	-0.1508356	0.7752960
1961	3545366800	3729969881	3537472400	0.0942802	0.8519477
1962	3740472904	3941834181	3734589304	0.0735513	0.9169715
1963	3436281347	3636121924	3428888647	-0.0241395	0.8951012
1964	3082842508	3284893585	3077660908	-0.0277494	0.8706042
1965	3312327541	3509281118	3306663741	0.1488608	1.0103461
1966	2883071824	3082537701	2877970424	-0.0601130	0.9514006
1967	2744821593	2941375070	2738756093	-0.1708434	0.8019865
1968	2859020482	3021220759	2838969682	0.0476535	0.8411292
1969	2995595955	3180276732	2976017755	0.1936074	1.0208110
1970	3289726569	3490531746	3284116169	0.2190917	1.2708540
1971	3657625234	3856485856	3654919813	0.0732409	1.3674258
1972	3420056087	3821528621	3417179485	0.0337448	1.4143567
1973	3323261015	3693691834	3320568292	0.5501115	2.4517114
1974	3501940970	3869173264	3496834422	-0.0500974	2.3319128
1975	3268937259	3637613906	3265136356	-0.1298601	2.0479285
1976	3550765040	3917851484	3545559881	0.2572091	2.6486176
1977	3456110039	3824752205	3452906402	0.0717087	2.8455220
1978	4293546946	4446059629	4289847393	0.2304973	3.5831554
1979	4415372581	4567973390	4411863460	0.1452215	4.1431871
1980	4413228333	4565856246	4410212249	0.0175105	4.2163753
1981	4208881700	4199769740	4195935855	-0.1134433	3.7641892
1982	4814459232	4786892219	4801533282	0.1436368	4.3456236
1983	4992086437	4957376601	4978087659	0.0760852	4.6891649
1984	4906589699	4890270598	4866852348	-0.0021455	4.6791151
1985	4678743893	4674097298	4649387420	-0.0831762	4.3056703
1986	4349847101	4330715720	4327978634	-0.0039701	4.2886103
1987	4788480254	4696479795	4763388776	0.1316480	4.8920464
1988	4041389595	3899842610	4004196923	-0.0837429	4.4990572
1989	4023369359	3842546597	3974910973	-0.0804014	4.1514865
1990	4021450928	3878674910	3979163122	0.0285336	4.2716495
1991	4032118379	3865661788	3995315782	0.0761421	4.6096048
1992	3725995400	3582777275	3687951116	-0.0380712	4.4374100
1993	4105010022	3942994707	4062059127	0.1099665	4.9532174
1994	4372163988	4217669145	4336688968	0.1186832	5.5773881
1995	3888584141	3711645486	3849488988	-0.0478938	5.3165617
1996	3876679172	3715532966	3836741499	-0.0489903	5.0623787
1997	4094095068	3936173876	4057326451	0.1098330	5.6500784
1998	3731867387	3582969082	3697377040	-0.0868527	5.1800604
1999	3990116584	3830900260	3962104908	0.0620856	5.5118611
2000	3793869254	3576918541	3733876374	0.0167412	5.6049132
2001	3765148707	3547935875	3688174498	-0.0834742	5.1560427

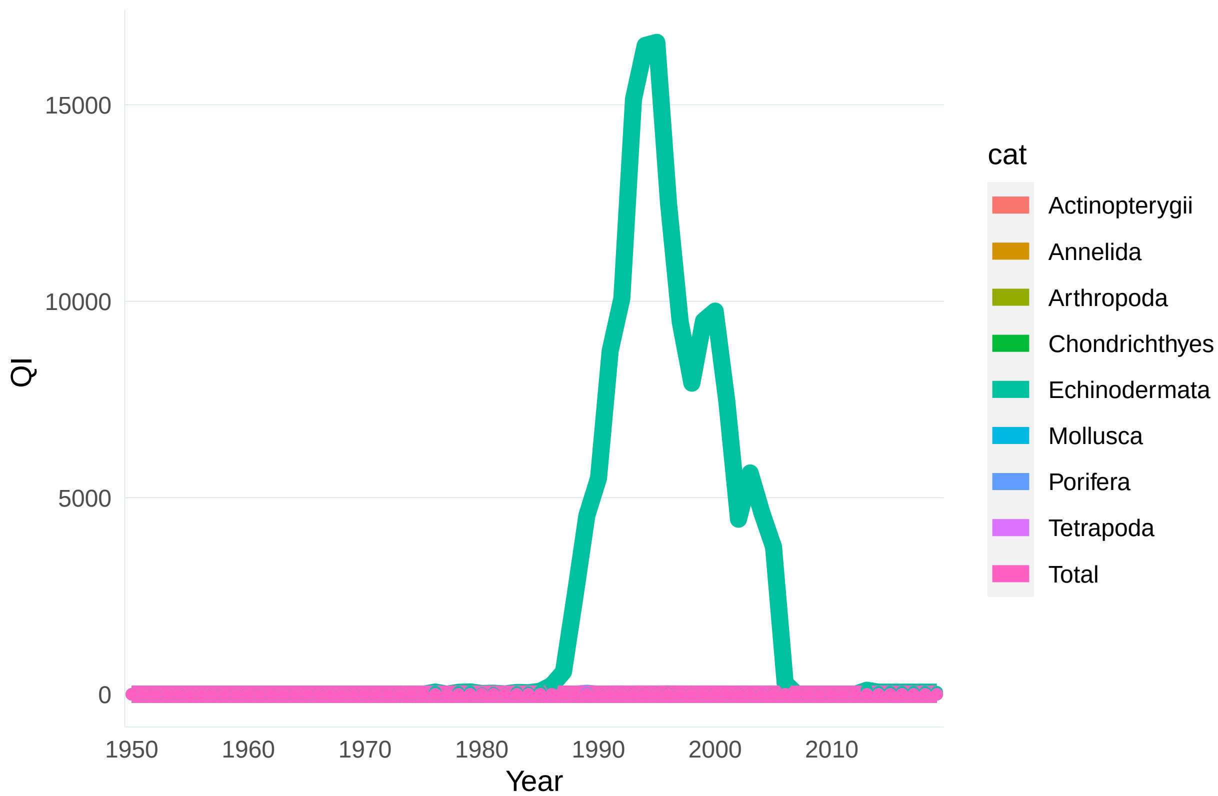
	VE_Total	VV_Total	V_Total	QC_Total	QI_Total
2002	3722911790	3474372249	3612665910	-0.1562316	4.4102783
2003	3704927643	3448902742	3606132813	-0.0195427	4.3249264
2004	1889813769	2016983232	1860167720	-0.4037095	2.8883506
2005	1741044062	1870255471	1705470703	0.0884218	3.1553751
2006	1753094099	1890964774	1726077750	0.2093299	3.8901093
2007	517159611	667070680	475161635	-1.3996532	0.9596219
2008	521159877	670125837	486480769	0.0043617	0.9638166
2009	534736167	677145565	494251216	-0.0363905	0.9293733
2010	605385696	714949228	551050632	0.0732448	1.0000000
2011	661229735	755626132	601024253	0.0834047	1.0869816
2012	655629951	772527014	602002953	0.0405896	1.1320094
2013	658197330	734787347	590869779	-0.0059572	1.1252858
2014	587575682	720097666	519339299	-0.0424983	1.0784650
2015	577149068	699010404	533666838	-0.0443819	1.0316473
2016	556835463	711262899	519781163	0.0820077	1.1198162
2017	525822797	668362521	488629852	-0.0481920	1.0671298
2018	490972000	671036323	439699415	0.0076003	1.0752712
2019	430592128	622763099	397062280	-0.0190156	1.0550175

Did all of the analyses work as intended?

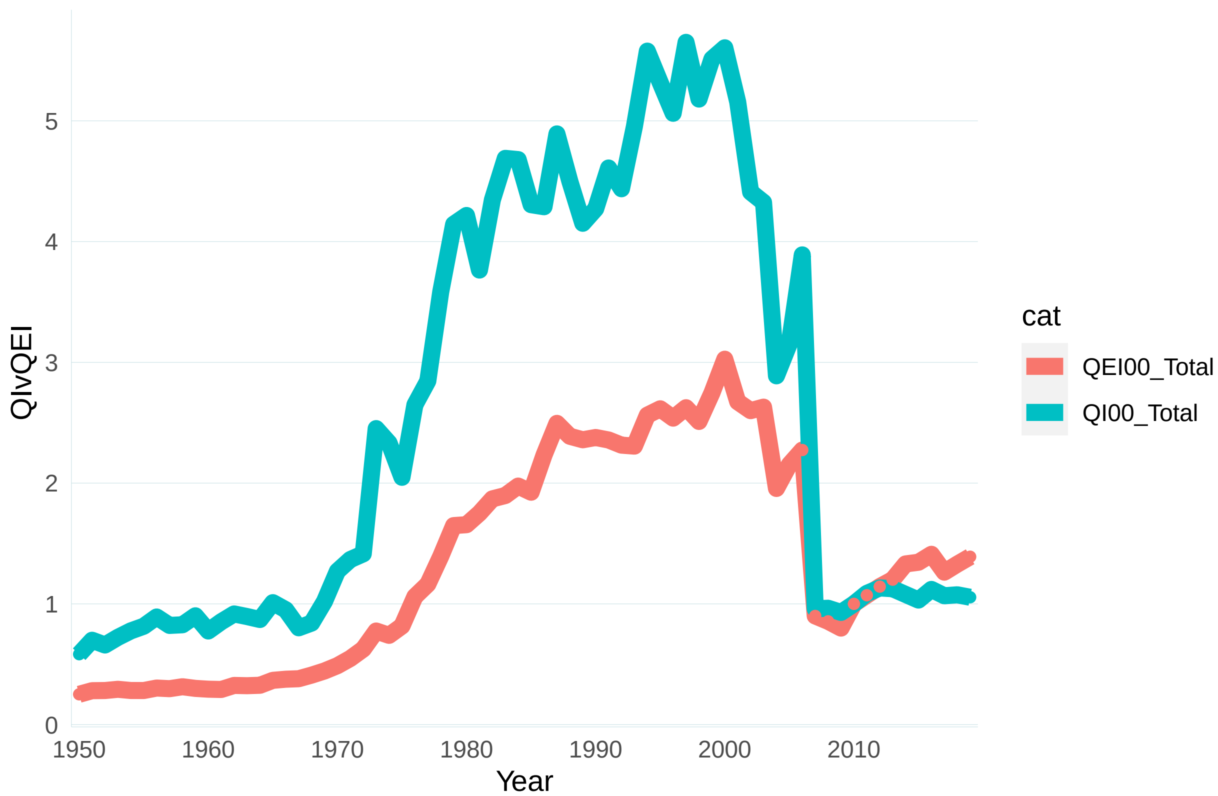
list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated *because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(8, 1, 18, 9, 8, 10))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(8, 1, 18, 9, 8, 10))), FYI: 10_0000Other is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(8, 1, 18, 9, 8, 10))), FYI: 10_0000Other is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, FYI: 11_0000Plantae is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista* *is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(8, 1, 18, 9, 8, 10))), FYI: 10_0000Other is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, FYI: 11_0000Plantae is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 2, 2), slopecheck = c(1, 2, 1, 2), Freq = c(1, 2, 0, 3))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(64, 21, 119, 57, 84, 63))), FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(0, 0, 2, 1, 1, 0))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(6, 1, 18, 8, 4, 13))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(5, 4, 5, 5, 4, 5))), FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, list(list(var = 1:2, slopecheck = c(1, 1), Freq = c(2, 2))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(8, 1, 18, 9, 8, 10))), FYI: 10_0000Other is no longer being calculated because there were no more available columns o P after data was removed for not meeting the pctmiss, FYI: 11_0000Plantae is no longer being calculated because there were less than 2 columns of P available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(list(var = c(1, 1, 2, 2), slopecheck = c(1, 2, 1, 2), Freq = c(1, 2, 0, 3))), list(list(var = c(1, 1, 1, 2, 2, 2), slopecheck = c(1, 2, 3, 1, 2, 3), Freq = c(1, 1, 1, 0, 3, 0))), Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum((R_{i, t} - R_{i, t-1}) / 2) x ln((Q_{i,t}) / (Q_{i,t-1})), FYI: 2 of species V columns are completely empty, 2 of species Q columns are completely empty.*

1.7.5.5 E. Graph

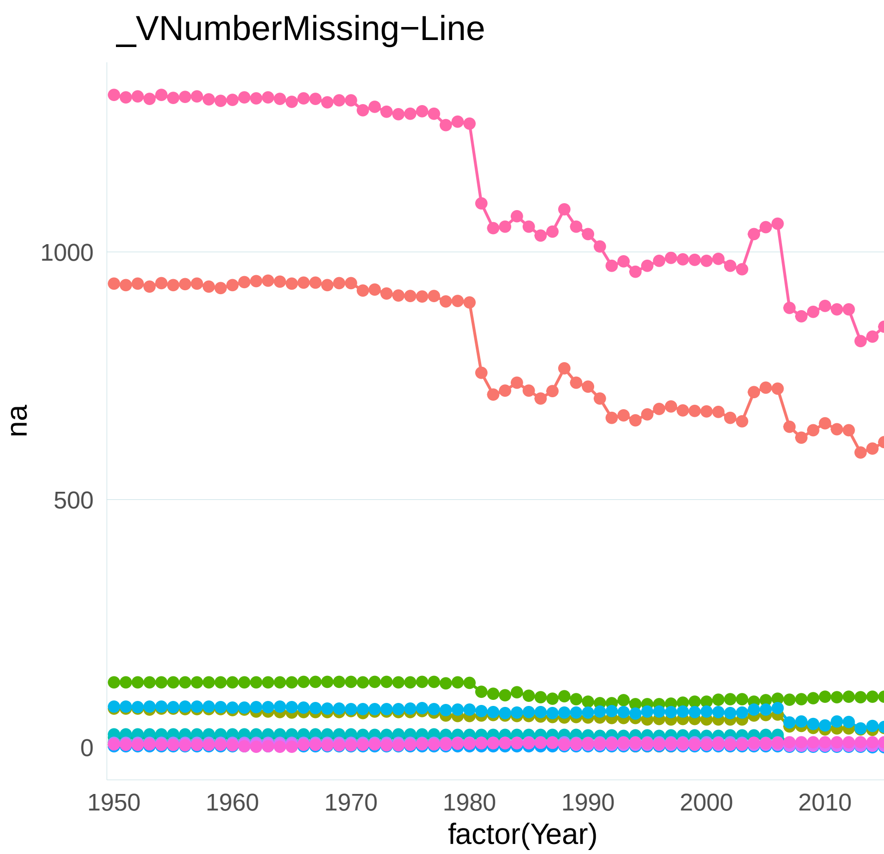
1.7.5.5.1 Graph 1: Quantity Index Categories For comparison, let's recreate those graphs to make sure we are getting the same output:



1.7.5.5.2 Graph 2: Quantity Index Compare For comparison, let's recreate those graphs to make sure we are getting the same output:



QIvQEI
5
4
3
2
1
0
1950
1960
1970
1980
1990
2000
2010
Year
cat
QEI00_Total
QI00_Total



1.7.5.5.3 Graph 3: Missing values of V

1.8 PRICE METHOD

In most of the following examples, we will just focus on the finfish (i=1) side of the equation. Here *baseyr* is set to 2010 and the *pctmiss* (The percent of data in a column that we will allow to be missing for analysis; more on that later) is set to 0.5%.

Alternatively, we have a price model method to calculate implicit quantity. Here, on top of all the work that is done for the Quantity-derived output, we also calculate price and use price to weigh the revenue share.

Essential by calculating price we are developing a deflator for the total landings values: We use the total value were $P_{t,i,s}$ was available ($VV_{t,i}$) to calculate $PI_{t,i}$ and extrapolate $Q_{t,i}$ by dividing the total value ($V_{t,i}$)

1.8.1 At the species level:

1.8.1.1 Remove any V and Q data where V column has less data than the specifed *pctmiss*

No warning.

	Q1_1Salmon	Q1_2Cod	Q2_1Shrimp	Q2_2Clam	REMOVED_Q1_3Flounder	Q1_4SeaBass
2007	NA	2000	100	150	NA	1000
2008	NA	1900	120	160	NA	1200
2009	NA	2000	110	140	NA	900
2010	20	2500	90	NA	NA	NA

	Q1_1Salmon	Q1_2Cod	Q2_1Shrimp	Q2_2Clam	REMOVED_Q1_3Flounder	Q1_4SeaBass
2011	10	2400	80	NA	NA	NA
2012	12	2300	100	NA	NA	NA
2013	11	2000	100	140	NA	1000
2014	11	2300	110	110	NA	900
2015	10	2400	90	130	NA	1000
2016	15	2200	100	160	NA	1100

1.8.1.2 Caluclate New Category Sums of V and Q

Because we removed some columns for not meeting a perecent missing threshold of 0.5% and those columns will not be used at all in any part of the further analysis, we need to re-calculate the totals of V and Q for the catagories and the fishery as a whole.

	QE1_0Finfish	VE1_0Finfish	Q1_0Finfish	V1_0Finfish
2007	3000	3800	3000	2800
2008	3100	4020	3100	2820
2009	2900	3910	2900	3010
2010	2520	3190	2520	3190
2011	2410	3280	2410	3280
2012	2312	3150	2312	3150
2013	3011	4080	3011	3080
2014	3211	4270	3211	3370
2015	3410	4700	3410	3700
2016	3315	4480	3315	3380

1.8.1.3 Price

We first measure output price for each species ($P_{t,i,s}$; e.g., Salmon and Flounder) in each of the categories (e.g., Finfish & Others and Shellfish) using detailed landings time series data on value ($) and pounds (lbs).

Price for a species (s) of category (i) in year (t) =

$$P_{t,i,s} = V_{t,i,s}/Q_{t,i,s}$$

where:

- $P_{t,i,s}$ is the price per individual species (s), category (i), for each year (t)
- $Q_{t,i,s}$ is the quantity (lb) per individual species (s), category (i), for each year (t)
- $V_{t,i}$ is the value ($) per category (i), for each year (t)

	P1_1Salmon	P1_2Cod	P1_4SeaBass
2007	NA	1.400000	NA
2008	NA	1.421053	0.1000000
2009	NA	1.450000	0.1222222
2010	5.00000	1.200000	NA
2011	10.00000	1.291667	NA
2012	12.50000	1.260870	NA
2013	16.36364	1.400000	0.1000000
2014	15.45455	1.391304	NA
2015	20.00000	1.458333	NA
2016	12.00000	1.454546	NA

1.8.1.3.1 Address Infrequent Missing Data There may be instances where there are no or too few Q data for that species in a year or ever. The next goal will be to calculate the quantity change, so we need to have a value in there that won't show change. If we left an NA (which would be treated as a 0) in the cell, then the change from year to year would be very large and misrepresent the index trend. To avoid this, we do the following:

$$where \begin{cases} if : P_{t,i=1} = 0, then : P_{t,i=1} = P_{t,i=1+1...} \\ if : P_{t,i\neq 1} = 0, then : P_{t,i} = P_{t-1,i} \end{cases}$$

1. If there are instances for a species where there are too few pairs of V and/or Q are completely missing from the timeseries or where a percent of V is missing from the timeseries, we will remove the offending price columns entierly, so they don't influence the downstream price change or price index calculations.

Let's say here that if 50% of the data is missing in a given $V_{t,i,s}$, don't calculate that species $P_{t,i,s}$

	P1_1Salmon	P1_2Cod
2007	NA	1.400000
2008	NA	1.421053
2009	NA	1.450000
2010	5.00000	1.200000
2011	10.00000	1.291667
2012	12.50000	1.260870
2013	16.36364	1.400000
2014	15.45455	1.391304
2015	20.00000	1.458333
2016	12.00000	1.454546

2. If the first value of $P_{t,i,s}$ is 0/NA in a timeseries, we (impute) let the next available non-zero/non-NA value of P in the timeseries inform the past.

	P1_1Salmon	P1_2Cod
2007	5.00000	1.400000
2008	NA	1.421053
2009	NA	1.450000
2010	5.00000	1.200000
2011	10.00000	1.291667
2012	12.50000	1.260870
2013	16.36364	1.400000
2014	15.45455	1.391304
2015	20.00000	1.458333
2016	12.00000	1.454546

3. If there is a value in the middle of $P_{t,i,s}$'s timeseries that is 0/NA, we (impute) let the most recent past available non-zero/non-NA of $P_{t,i,s}$ in the timeseries inform the future.

	P1_1Salmon	P1_2Cod
2007	5.00000	1.400000
2008	5.00000	1.421053
2009	5.00000	1.450000
2010	5.00000	1.200000

	P1_1Salmon	P1_2Cod
2011	10.00000	1.291667
2012	12.50000	1.260870
2013	16.36364	1.400000
2014	15.45455	1.391304
2015	20.00000	1.458333
2016	12.00000	1.454546

1.8.1.3.2 Impute values of $V_{t,i,s}$ where P was able to be calculated

To ensure that the price index does not rise or fall to quickly with changes (that are really because of NA values) we fill in the missing instances of $V_{t,i,s}$.

$$where \begin{cases} if: V_{t,i=1} = 0, then: V_{t,i=1} = V_{t,i=1+1...} \\ if: V_{t,i\neq 1} = 0, then: V_{t,i} = V_{t-1,i} \end{cases}$$

1. If the first value of $V_{t,i,s}$ is 0/NA in a timeseries, we let the next available non-zero value of $V_{t,i,s}$ in the timeseries inform the past.

	V1_1Salmon	V1_2Cod
2007	100	2800
2008	NA	2700
2009	NA	2900
2010	100	3000
2011	100	3100
2012	150	2900
2013	180	2800
2014	170	3200
2015	200	3500
2016	180	3200

2. If there is a value in the middle of $V_{t,i,s}$'s timeseries that is 0/NA, we let the most recent past available non-zero of $V_{t,i,s}$ in the timeseries inform the future.

	V1_1Salmon	V1_2Cod
2007	100	2800
2008	100	2700
2009	100	2900
2010	100	3000
2011	100	3100
2012	150	2900
2013	180	2800
2014	170	3200
2015	200	3500
2016	180	3200

1.8.1.4 Total value of species (V)

And then I follow similar steps or the category and national level.

$$V_{t,i} = \sum_{s=1}^{l}(V_{t,i,s})$$

1.8.1.5 Total value of species where P is available (VV)

A.K.A.: Value of species $VV_{t,i}$ where P was able to be calculated

$R_{t,i}$, as defined and discussed in the subsequent step, will need to sum to 1 across all species in a category. Therefore, you will need to sum a new total of $V_{t,i}$ available (called $VV_{t,i}$) for the category using only values for species that were used to calculate $P_{t,i}$ (called $V_{t,i,s,available}$).

When I say "available" here, I am asking how many values of P were we able to calculate. As you can see here, even though there were plenty of Q and V, they didn't amount to many P. Even if a value of P for a species doesn't make the cut, that gets applied to the total value of the category.

$$VV_{t,i} = \sum_{s=1}^{l}(V_{t,i,s_{available}})$$

where:

- $VV_{t,i}$ is the new total of $V_{t,i}$ (called $VV_{t,i}$) for the category using only values for species that were used to calculate $P_{t,i}$
- $V_{t,i,s,available}$ are the $V_{t,i,s}$ where P were able to be calculated

	V1_1Salmon	V1_2Cod	VV1_0Finfish
2007	100	2800	2900
2008	100	2700	2800
2009	100	2900	3000
2010	100	3000	3100
2011	100	3100	3200
2012	150	2900	3050
2013	180	2800	2980
2014	170	3200	3370
2015	200	3500	3700
2016	180	3200	3380

1.8.1.5.1 Analysis Warnings Checks

Just so we can get a sense of the data, we want to see how many species are significantly increasing or decreasing over time for V and Q.

We'll use the below function to collect our info:

```
## function (Columns, temp)
## {
##     lm_check <- data.frame(col = rep_len(x = NA, length.out = length(Columns)),
##         slope = rep_len(x = NA, length.out = length(Columns)),
##         intercept = rep_len(x = NA, length.out = length(Columns)),
##         R2 = rep_len(x = NA, length.out = length(Columns)), R2adj = rep_len(x = NA,
##             length.out = length(Columns)), Pr = rep_len(x = NA,
##             length.out = length(Columns)), Fstat = rep_len(x = NA,
##             length.out = length(Columns)))
```

```
##     for (c0 in 1:length(Columns)) {
##         if (sum(is.na(temp[, Columns[c0]])) == length(temp[,
##             Columns[c0]]) | length(temp[, Columns[c0]]) %in%
##             sum(temp[, Columns[c0]] %in% c(NA, 0))) {
##             lm_check$col[c0] <- NA
##             lm_check$slope[c0] <- NA
##             lm_check$intercept[c0] <- NA
##             lm_check$R2[c0] <- NA
##             lm_check$R2adj[c0] <- NA
##             lm_check$Pr[c0] <- NA
##             lm_check$Fstat[c0] <- NA
##         }
##         else {
##             temp0 <- summary(lm(rownames(temp) ~ temp[, Columns[c0]]))
##             lm_check$col[c0] <- Columns[c0]
##             lm_check$slope[c0] <- temp0$coefficients[2]
##             lm_check$intercept[c0] <- temp0$coefficients[1]
##             lm_check$R2[c0] <- temp0$r.squared
##             lm_check$R2adj[c0] <- temp0$adj.r.squared
##             lm_check$Pr[c0] <- temp0$coefficients[8]
##             lm_check$Fstat[c0] <- ifelse(is.null(temp0$fstatistic[1]),
##                 NA, as.numeric(temp0$fstatistic[1]))
##         }
##     }
##     lm_check$var <- substr(x = Columns, 1, 1)
##     lm_check$slopecheck <- "Insig"
##     lm_check$slopecheck <- ifelse(lm_check$slope >= 0 & lm_check$Pr <=
##         0.05, "Sig Pos", "Insig")
##     lm_check$slopecheck <- ifelse(lm_check$slope < 0 & lm_check$Pr <=
##         0.05, "Sig Neg", lm_check$slopecheck)
##     return(lm_check)
## }
## <bytecode: 0x0000000023987750>
```

	NameBasecategory	col	slope	intercept	R2	R2adj	Pr	Fstat	var	slopecheck
1	1_0Finfish	P1_1Salmon	0.4644811	2006.562	0.7230807	0.6884658	0.0018246	20.8892823	P	Sig Pos
2	1_0Finfish	P1_2Cod	7.0307005	2001.848	0.0437863	-0.0757404	0.5617834	0.3663306	P	Insig
3	1_0Finfish	V1_1Salmon	0.0653553	2002.481	0.8159514	0.7929453	0.0003399	35.4667781	V	Sig Pos
4	1_0Finfish	V1_2Cod	0.0093573	1983.335	0.5614367	0.5066163	0.0126083	10.2413793	V	Sig Pos
5	1_0Finfish	Q1_1Salmon	-0.2014388	2015.561	0.1151079	-0.0618705	0.4565969	0.6504065	Q	Insig
6	1_0Finfish	Q1_2Cod	0.0065000	1997.200	0.2048485	0.1054545	0.1890352	2.0609756	Q	Insig

How many slopes are significantly increaseing or decreaseing

	var	slopecheck	Freq
1	P	Insig	1
4	P	Sig Pos	1
2	Q	Insig	2
5	Q	Sig Pos	0

	var	slopecheck	Freq
3	V	Insig	0
6	V	Sig Pos	2

1.8.1.6 Value of species $VV_{t,i}$ where Q available

$R_{t,i}$, as defined and discussed in the subsequent step, will need to sum to 1 across all species in a category. Therefore, you will need to sum a new total of $V_{t,i}$ available (called $VV_{t,i}$) for the category using only values for species that were used to calculate $Q_{t,i}$ (called $V_{t,i,s,available}$).

$$VV_{t,i} = \sum_{s=1}^{n}(V_{t,i,s,available})$$

where:

- $VV_{t,i}$ is the new total of $V_{t,i}$ (called $VV_{t,i}$) for the category using only values for species that were used to calculate $Q_{t,i}$
- $V_{t,i,s,available}$ are the $V_{t,i,s}$ where $Q_{t,i,s}$ were able to be calculated

	V1_1Salmon	V1_2Cod	VV1_0Finfish
2007	100	2800	2900
2008	100	2700	2800
2009	100	2900	3000
2010	100	3000	3100
2011	100	3100	3200
2012	150	2900	3050
2013	180	2800	2980
2014	170	3200	3370
2015	200	3500	3700
2016	180	3200	3380

1.8.1.7 Revenue-share A.K.A.: Revenue Share for each species ($R_{t,i,s}$; e.g., Salmon and Flounder). Here we divide $V_{t,i,s}$ by $VV_{t,i}$ because $VV_{t,i}$ only includes species used to calculate $V_{t,i,s}$ as per the above price calculations.

$$R_{t,i,s} = V_{t,i,s}/VV_{t,i}$$

where:

- $R_{t,i,s}$ is the revenue share per individual species (s), category (i), for each year (t)
- $V_{t,i,s}$ is the value ($) per individual species (s), category (i), for each year (t)

	R1_1Salmon	R1_2Cod	R1_4SeaBass
2007	0.0344828	0.9655172	NA
2008	0.0357143	0.9642857	0.0428571
2009	0.0333333	0.9666667	0.0366667

	R1_1Salmon	R1_2Cod	R1_4SeaBass
2010	0.0322581	0.9677419	0.0290323
2011	0.0312500	0.9687500	0.0250000
2012	0.0491803	0.9508197	0.0327869
2013	0.0604027	0.9395973	0.0335570
2014	0.0504451	0.9495549	NA
2015	0.0540541	0.9459459	NA
2016	0.0532544	0.9467456	NA

1.8.1.7.1 Analysis Warnings Checks

As an additional check, let's make sure that each row sums to 1.

	x
2007	1.000000
2008	1.042857
2009	1.036667
2010	1.029032
2011	1.025000
2012	1.032787
2013	1.033557
2014	1.000000
2015	1.000000
2016	1.000000

Is there a warning?

Rows of R_{t,i,s} for 1_0Finfish did not sum to 1

1.8.1.8 Revenue-share weighted price changes

$$PCW_{t,i,s} = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * ln(\frac{P_{t,i,s}}{P_{s,t-1,i}}) = \frac{R_{t,i,s} + R_{s,t-1,i}}{2} * [ln(P_{t,i,s}) - ln(P_{s,t-1,i})] = \frac{R_{t,i,s} + R_{t-1,i,s}}{2 * ln(P_{t,i,s}/P_{t-1,i,s})}$$

Where:

- $PCW_{t,i,s}$ = Revenue share-weighted price change for a species (s)

Such that:

- category's (i) Price Change for each species (s) = $\frac{R_{t,i,s}+R_{s,t-1,i}}{2}$
- category's (i) Revenue Share for each species (s) = $ln(\frac{P_{t,i,s}}{P_{s,t-1,i}} = [ln(P_{t,i,s}) - ln(P_{s,t-1,i})]$

1.8.2 At the fishery level:

1.8.2.1 Value of categories available

$$VV_t = \sum_{i=1}^{l}(V_{t,i_{available}})$$

1.8.2.2 Price change

A.K.A., Price Changes for the category ($PC_{t,i}$; e.g., Finfish)

$$PC_{t,i} = ln(\frac{P_{t,i}}{P_{t-1,i}}) = \sum_{s=1}^{n}(PCW_{t,i,s})$$

Where:

- $PC_{t,i}$ = Price change for a category (i)

	PCW1_1Salmon	PCW1_2Cod	PC1_0Finfish
2007	0.0000000	0.0000000	0.0000000
2008	0.0000000	0.0144018	0.0144018
2009	0.0000000	0.0194695	0.0194695
2010	0.0000000	-0.1830357	-0.1830357
2011	0.0220102	0.0712743	0.0932846
2012	0.0089738	-0.0231613	-0.0141875
2013	0.0147572	0.0989356	0.1136927
2014	-0.0031679	-0.0058852	-0.0090532
2015	0.0134715	0.0445941	0.0580655
2016	-0.0274080	-0.0024612	-0.0298692

1.8.2.3 Price index

A.K.A.: Price Index for the each category (PI_t)

$$PI_{t,i} = PI_{t-1,i} * exp(PC_{t,i})$$

We calculate the price index first by comparing by multiplying the previous years PI_{t-1} by that year's price change PC_t, where the PI of the first year $PI_{t=firstyear} = 1$

$$PI_{t,i} = PI_{t-1,i} * \exp(ln(\frac{PC_{t,i}}{PC_{t-1,i}})) = PI_{t-1,i} * \exp(PC_{t,i})$$

Where

$$PI_{i,t=firstyear} = 1$$

Then, to change the price index into base year dollars, we use the following equation:

$$PI_t = PI_t/PI_{t=baseyear}$$

In this example, our base year is 2010. Notice that the $PI_{t,i=baseyr} = 1$

And we add the PI to the data

	tempPI_yr1	tempPI_yrb	PI1_0Finfish
2007	1.0000000	1.160864	1.160864
2008	1.0145060	1.177703	1.177703
2009	1.0344514	1.200857	1.200857
2010	0.8614275	1.000000	1.000000
2011	0.9456527	1.097774	1.097774

	tempPI_yr1	tempPI_yrb	PI1_0Finfish
2012	0.9323310	1.082309	1.082309
2013	1.0445909	1.212628	1.212628
2014	1.0351767	1.201699	1.201699
2015	1.0970642	1.273542	1.273542
2016	1.0647803	1.236065	1.236065

where $PI_{t=1,i} = 1$ and then $PI_{t,i} = PI_{t,i}/PI_{t=baseyr,i}$

1.8.2.4 Implicit quantity Note here that all columns of VE are being used, despite having been removed earlier in the analysis when PI could not be calculated and PI columns have functionally been removed from the analysis.

$$Q_{t,i} = VE_{t,i}/PI_{t,i}$$

	temp...ncol.temp..
2007	3273.424
2008	3413.423
2009	3256.007
2010	3190.000
2011	2987.864
2012	2910.443
2013	3364.594
2014	3553.302
2015	3690.494
2016	3624.405

1.8.2.5 Implicit quantity index

$$QI_{t,i} = QI_{t,i}/QI_{t=baseyr,i}$$

	QI1_0Finfish
2007	1.0261518
2008	1.0700387
2009	1.0206920
2010	1.0000000
2011	0.9366346
2012	0.9123647
2013	1.0547316
2014	1.1138877
2015	1.1568948
2016	1.1361771

1.8.2.5.1 Analysis Warnings Checks

1. When back calculated, V_t should equal $PI_t * Q_t$

$$V_{t,i} = PI_{t,i} * Q_{t,i}$$

	V1_0Finfish	PI1_0Finfish	Q1_0Finfish	V1_0Finfish_Check
2007	2800	1.160864	3273.424	3800
2008	2820	1.177703	3413.423	4020
2009	3010	1.200857	3256.007	3910
2010	3190	1.000000	3190.000	3190
2011	3280	1.097774	2987.864	3280
2012	3150	1.082309	2910.443	3150
2013	3080	1.212628	3364.594	4080
2014	3370	1.201699	3553.302	4270
2015	3700	1.273542	3690.494	4700
2016	3380	1.236065	3624.405	4480

Is there a warning?

Warning: When back calculated, V_{t,i} did not equal PI_{t,i} Q_{t,i}*

2. When back calculated, $Q_{t,i}$ should equal $V_{t,i}/PI_{t,i}$

$$Q_{t,i} = V_{t,i}/PI_{t,i}$$

	V1_0Finfish	PI1_0Finfish	Q1_0Finfish	V1_0Finfish_Check	Q1_0Finfish_Check
2007	2800	1.160864	3273.424	3800	2411.997
2008	2820	1.177703	3413.423	4020	2394.491
2009	3010	1.200857	3256.007	3910	2506.543
2010	3190	1.000000	3190.000	3190	3190.000
2011	3280	1.097774	2987.864	3280	2987.864
2012	3150	1.082309	2910.443	3150	2910.443
2013	3080	1.212628	3364.594	4080	2539.938
2014	3370	1.201699	3553.302	4270	2804.362
2015	3700	1.273542	3690.494	4700	2905.283
2016	3380	1.236065	3624.405	4480	2734.484

Is there a warning?

Warning: When back calculated, Q_{t,i} did not equal V_{t,i}/PI_{t,i}

1.8.2.6 Redo Analysis for Other Categories Now lets redo that whole analysis up to this point (via function) for the two species of the shellfish group, as we will need them for the next steps of this analysis.

We use the *PriceMethodOutput.Category* function to calculate everything we did above at category level.

What does the Shellfish data look like?

	PCW2_1Shrimp	PCW2_2Clam	PC2_0Shellfish	PI2_0Shellfish	Q2_0Shellfish	QI2_0Shellfish
2007	0.0000000	0.0000000	0.0000000	1.030337	1747.0009	2.495716
2008	0.0183493	0.0648402	0.0831894	1.119717	1964.7830	2.806833

	PCW2_1Shrimp	PCW2_2Clam	PC2_0Shellfish	PI2_0Shellfish	Q2_0Shellfish	QI2_0Shellfish
2009	-0.0087575	-0.0805788	-0.0893363	1.024023	1757.7726	2.511104
2010	-0.0237392	0.0000000	-0.0237392	1.000000	700.0000	1.000000
2011	0.1730144	0.0000000	0.1730144	1.188883	757.0129	1.081447
2012	-0.0604413	0.0000000	-0.0604413	1.119154	893.5320	1.276474
2013	0.0977034	0.0488994	0.1466028	1.295862	1697.7119	2.425303
2014	-0.0998625	0.0614193	-0.0384432	1.246990	1603.8619	2.291231
2015	0.0553143	-0.0293044	0.0260098	1.279850	1562.6836	2.232405
2016	0.0393171	-0.0549436	-0.0156266	1.260005	1825.3889	2.607699

1.8.2.7 Value for all fisheries for species where P was able to be calculated $R_{t,i}$, defined and discussed in the subsequent step, will need to sum to 1 across all species in a category. Therefore, you will need to sum a new total of $V_{t,i}$ (called VV_t) for the category using only values for species that were used to calculate $PI_{t,i}$.

$$VV_t = \sum_{s=1}^{n}(VV_{t,i})$$

where:

- VV_t is the new total of $V_{t,i}$ for the entire fishery using only values for species that were used to calculate $P_{t,i}$

1.8.2.8 Revenue share Revenue Share for the each category ($R_{t,i}$)

$$R_{t,i} = V_{t,i}/V_t$$

where:

- $R_{t,i}$ is the revenue share per individual species (s), category (i), for each year (t)
- $V_{t,i}$ is the value ($) per individual species (s), category (i), for each year (t)

Here, we don't use VV_t beacause we want to expand the proportion to include all of the species caught, regardless if they were used in the price calculations.

	R1_0Finfish	R2_0Shellfish	V1_0Finfish	V2_0Shellfish	V0_0Total
2007	0.6086957	0.3913043	2800	1800	4600
2008	0.5617530	0.4382470	2820	2200	5020
2009	0.6257796	0.3742204	3010	1800	4810
2010	0.8200514	0.1799486	3190	700	3890
2011	0.7846890	0.2153110	3280	900	4180
2012	0.7590361	0.2409639	3150	1000	4150
2013	0.5833333	0.4166667	3080	2200	5280
2014	0.6275605	0.3724395	3370	2000	5370
2015	0.6491228	0.3508772	3700	2000	5700
2016	0.5950704	0.4049296	3380	2300	5680

1.8.2.8.1 Analysis Warnings Checks

As an additional check, let's make sure that each row sums to 1.

	x
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1

Is there a warning?

No warning.

1.8.2.9 Revenue share weighted price changes

Revenue Share-Weighted Price Changes for each category ($PCW_{t,i}$; e.g., Salmon and Flounder)

$$PCW_{t,i} = \frac{R_{t,i} + R_{t-1,i}}{2} * ln(\frac{PI_{t,i}}{PI_{t-1,i}}) = \frac{R_{t,i} + R_{t-1,i}}{2} * [ln(PI_{t,i}) - ln(PI_{t-1,i})]$$

Where:

- $PCW_{t,i}$ = Revenue share-weighted price change for a category (i)

Such that:

- Price Change for each category (i) = $\frac{R_{t,i}+R_{t-1,i}}{2}$
- Revenue Share for each category (i) = $ln(\frac{PI_{t,i}}{PI_{t-1,i}} = [ln(PI_{t,i}) - ln(PI_{t-1,i})]$

1.8.3 At the entire commercial fisheries sector level:

1.8.3.1 Price change

Price Changes for the entire fishery ($PC_{t,i}$; e.g., Finfish)

$$PC_t = ln(\frac{P_t}{P_{t-1}}) = \sum_{s=1}^{n}(PCW_{t,i})$$

Where:

- PC_t = Price change for the entire fishery

	PCW1_0Finfish	PCW2_0Shellfish	PC0_0Total
2007	0.0000000	0.0000000	0.0000000
2008	0.0084283	0.0345050	0.0429332

	PCW1_0Finfish	PCW2_0Shellfish	PC0_0Total
2009	0.0115603	-0.0362914	-0.0247311
2010	-0.1323193	-0.0065778	-0.1388971
2011	0.0748488	0.0341928	0.1090416
2012	-0.0109508	-0.0137889	-0.0247398
2013	0.0763088	0.0482052	0.1245141
2014	-0.0054812	-0.0151679	-0.0206491
2015	0.0370656	0.0094067	0.0464723
2016	-0.0185815	-0.0059053	-0.0244869

1.8.3.2 Price index

We calculate the price index first by comparing by multiplying the previous years PI_{t-1} by that year's price change PC_t, where the PI of the first year $PI_{t=firstyear} = 1$

$$PI_t = PI_{t-1} * \exp(ln(\frac{P_{t,i}}{P_{t-1,i}})) = PI_{t-1} * \exp(PC_t)$$

Where

$$PI_{t_{firstyear},i} = 1$$

	PI0_0Total
2007	1.128281
2008	1.177776
2009	1.149006
2010	1.000000
2011	1.115209
2012	1.087957
2013	1.232218
2014	1.207035
2015	1.264452
2016	1.233866

1.8.3.3 Implicit quantity

$$QI_t = VE_t / PI_{t=baseyr}$$

	Q0_0Total
2007	4963.304
2008	5281.138
2009	4969.513
2010	3890.000
2011	3748.177
2012	3814.488
2013	5096.500
2014	5194.548
2015	5298.737
2016	5494.925

1.8.3.4 Implicit quantity index

$$QI_t = QI_{t-1} * exp(QC_t)$$

where $QI_{t=1} = 1$ and then $QI_t = QI_t / QI_{t=baseyr}$

1.8.3.5 Simple Sum Quantity Output Index

$$QEI_t = QE_t / QE_{t=baseyr}$$

Where:

- QE_t is the sum of Q before these calculations; the simple sum
- QEI_t is the index of the sum of Q before these equations

	temp...paste0..QEI...NameBaseTotal..
2007	1.2452107
2008	1.2950192
2009	1.2068966
2010	1.0000000
2011	0.9540230
2012	0.9241379
2013	1.2455939
2014	1.3145594
2015	1.3908046
2016	1.3697318

1.8.3.6 Quantity change Same as before, these are the values that would go into the output portion of the output equation. This method is good for data that are missing many of the quantity values.

$$QC_t = ln(QI_t / QI_{t-1})$$

Solve Output portion of the equation for the Output Changes:

$$QC_t = \sum_{i=1}^{n} ((\frac{R_{it} + R_{it-1}}{2}) * ln(\frac{Q_{it}}{Q_{it-1}}))$$

	Q0_0Total	QI0_0Total	QC0_0Total
2007	4963.304	1.2759136	0.0000000
2008	5281.138	1.3576191	0.0732370
2009	4969.513	1.2775099	-0.0732619
2010	3890.000	1.0000000	-0.2699238
2011	3748.177	0.9635417	-0.0370504
2012	3814.488	0.9805883	0.0175616
2013	5096.500	1.3101544	0.3083746
2014	5194.548	1.3353593	0.0106022
2015	5298.737	1.3621431	0.0147757
2016	5494.925	1.4125770	0.0474804

1.8.3.6.1 Analysis Warnings Checks To make sure our analyses worked as inteded, let's see if we can back calculate our numbers.

We want the calcuated V to equal this check:

1. When back calculated, V_t should equal $PI_t * Q_t$?

$$V_t = P_t * Q_t$$

	V0_0Total	PI0_0Total	Q0_0Total	V0_0Total_Check
2007	4600	1.128281	4963.304	5600
2008	5020	1.177776	5281.138	6220
2009	4810	1.149006	4969.513	5710
2010	3890	1.000000	3890.000	3890
2011	4180	1.115209	3748.177	4180
2012	4150	1.087957	3814.488	4150
2013	5280	1.232218	5096.500	6280
2014	5370	1.207035	5194.548	6270
2015	5700	1.264452	5298.737	6700
2016	5680	1.233866	5494.925	6780

Is there a warning?

Warning: When back calculated, V_t did not equal PI_t x Q_t

2. When back calculated, Q_t should V_t/PI_t?

$$Q_{t,i} = V_t/PI_{t,i}$$

	V0_0Total	PI0_0Total	Q0_0Total	Q0_0Total_Check
2007	4600	1.128281	4963.304	4077.000
2008	5020	1.177776	5281.138	4262.269
2009	4810	1.149006	4969.513	4186.228
2010	3890	1.000000	3890.000	3890.000
2011	4180	1.115209	3748.177	3748.177
2012	4150	1.087957	3814.488	3814.488
2013	5280	1.232218	5096.500	4284.956
2014	5370	1.207035	5194.548	4448.919
2015	5700	1.264452	5298.737	4507.880
2016	5680	1.233866	5494.925	4603.418

Is there a warning?

Warning: When back calculated, Q_t did not equal V_t/PI_t

3. When back calculated, growth rate?

$$ln(Q_t/Q_{t-1}) = \sum((\frac{R_{i,t} + R_{i,t-1}}{2}) * ln(\frac{Q_{t,i}}{Q_{t-1,i}}))$$

	Q0__0Total	Q1__0Finfish	R1__0Finfish	Q2__0Shellfish	R2__0Shellfish	part1	part2
2007	4963.304	3273.424	0.6086957	1747.0009	0.3913043	NA	NA
2008	5281.138	3413.423	0.5617530	1964.7830	0.4382470	-0.0620701	0.0732370
2009	4969.513	3256.007	0.6257796	1757.7726	0.3742204	0.0608198	-0.0732619
2010	3890.000	3190.000	0.8200514	700.0000	0.1799486	0.2449128	-0.2699238
2011	3748.177	2987.864	0.7846890	757.0129	0.2153110	0.0371395	-0.0370504
2012	3814.488	2910.443	0.7590361	893.5320	0.2409639	-0.0175368	0.0175616
2013	5096.500	3364.594	0.5833333	1697.7119	0.4166667	-0.2897476	0.3083746
2014	5194.548	3553.302	0.6275605	1603.8619	0.3724395	-0.0190555	0.0106022
2015	5298.737	3690.494	0.6491228	1562.6836	0.3508772	-0.0198589	0.0147757
2016	5494.925	3624.405	0.5950704	1825.3889	0.4049296	-0.0363564	0.0474804

Is there a warning?

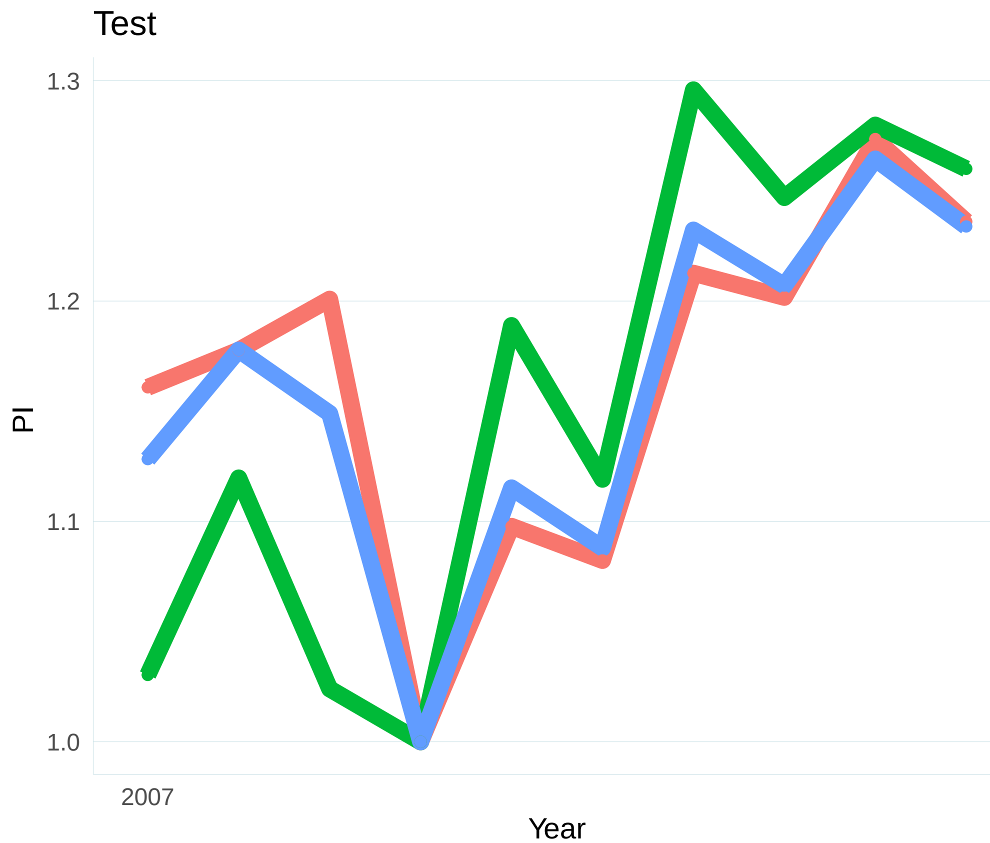
Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum(((R_{i, t} - R_{i, t-1})(2)) ln((Q_{t,i})(Q_{t-1,i}))*

1.8.3.7 View Total Outputs

	QE0__0Total	VE0__0Total	VV0__0Total	V0__0Total	PC0__0Total	PI0__0Total	Q0__0Total	QI0__0Total	QEI0__0Total	QC0__0Total
2007	3250	5600	4700	4600	0.0000000	1.128281	4963.304	1.2759136	1.2452107	0.0000000
2008	3380	6220	5000	5020	0.0429332	1.177776	5281.138	1.3576191	1.2950192	0.0732370
2009	3150	5710	4800	4810	-0.0247311	1.149006	4969.513	1.2775099	1.2068966	-0.0732619
2010	2610	3890	4700	3890	-0.1388971	1.000000	3890.000	1.0000000	1.0000000	-0.2699238
2011	2490	4180	5000	4180	0.1090416	1.115209	3748.177	0.9635417	0.9540230	-0.0370504
2012	2412	4150	4950	4150	-0.0247398	1.087957	3814.488	0.9805883	0.9241379	0.0175616
2013	3251	6280	5180	5280	0.1245141	1.232218	5096.500	1.3101544	1.2455939	0.3083746
2014	3431	6270	5370	5370	-0.0206491	1.207035	5194.548	1.3353593	1.3145594	0.0106022
2015	3630	6700	5700	5700	0.0464723	1.264452	5298.737	1.3621431	1.3908046	0.0147757
2016	3575	6780	5680	5680	-0.0244869	1.233866	5494.925	1.4125770	1.3697318	0.0474804

1.8.3.8 How many data were missing at the end of the analysis?

FYI: 0 of species V columns are completely empty, 1 of species Q columns are completely empty. #### Plots



1.8.3.8.1 Graph 1: Price Index

1.8.3.8.2 Graph 2: Quantity Index Compare

1.8.3.8.3 Graph 3: Quantity Compare

1.8.4 Do same analysis via a function!

Now that we know the method, we can simplify most of it into a function and do this whole analysis in 4 easy steps:

- A. Import and Edit data
- B. Enter base year
- C. Run the function
- D. Obtain the implicit quantity estimates

1.8.4.1 Function

We use the *PriceMethodOutput* function to calculate the Implicit Quanity Output at Fishery Level

1.8.4.2 A. Import and Edit data

1.8.4.3 B. Enter base year

1.8.4.4 C. Run the function

1.8.4.5 D. Obtain the implicit quantity estimates

	QE0_0Total	VE0_0Total	VV0_0Total	V0_0Total	PC0_0Total	PI0_0Total	Q0_0Total	QI0_0Total	QEI0_0Total	QC0_0Total
2007	3250	5600	4700	4600	0.0000000	1.128281	4963.304	1.2759136	1.2452107	0.0000000
2008	3380	6220	5000	5020	0.0429332	1.177776	5281.138	1.3576191	1.2950192	0.0732370
2009	3150	5710	4800	4810	-0.0247311	1.149006	4969.513	1.2775099	1.2068966	-0.0732619
2010	2610	3890	4700	3890	-0.1388971	1.000000	3890.000	1.0000000	1.0000000	-0.2699238
2011	2490	4180	5000	4180	0.1090416	1.115209	3748.177	0.9635417	0.9540230	-0.0370504
2012	2412	4150	4950	4150	-0.0247398	1.087957	3814.488	0.9805883	0.9241379	0.0175616
2013	3251	6280	5180	5280	0.1245141	1.232218	5096.500	1.3101544	1.2455939	0.3083746
2014	3431	6270	5370	5370	-0.0206491	1.207035	5194.548	1.3353593	1.3145594	0.0106022
2015	3630	6700	5700	5700	0.0464723	1.264452	5298.737	1.3621431	1.3908046	0.0147757
2016	3575	6780	5680	5680	-0.0244869	1.233866	5494.925	1.4125770	1.3697318	0.0474804

Did all of the analyses work as intended?

, list(var = c(1, 1, 2, 2, 3, 3), slopecheck = c(1, 2, 1, 2, 1, 2), Freq = c(1, 1, 2, 0, 0, 2)), FYI: Rows of R_{s,i,t} for 1_0Finfish did not sum to 1, Warning: When back calculated, V_{i,t} did not equal PI_{i,t} Q_{i,t}, Warning: When back calculated, Q_{i,t} did not equal V_{i,t}/PI_{i,t}, list(var = c(1, 1, 2, 2, 3, 3), slopecheck = c(1, 2, 1, 2, 1, 2), Freq = c(1, 1, 2, 0, 1, 1)), Warning: When back calculated, V_t did not equal PI_t * Q_t, Warning: When back calculated, Q_t did not equal V_t/PI_t, Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum((R_{i, t} - R_{i, t-1}) / 2) x ln((Q_{i,t}) / (Q_{i,t-1})), FYI: 0 of species V columns are completely empty, 2 of species Q columns are completely empty, and 0 of 5 species P columns are completely empty. *

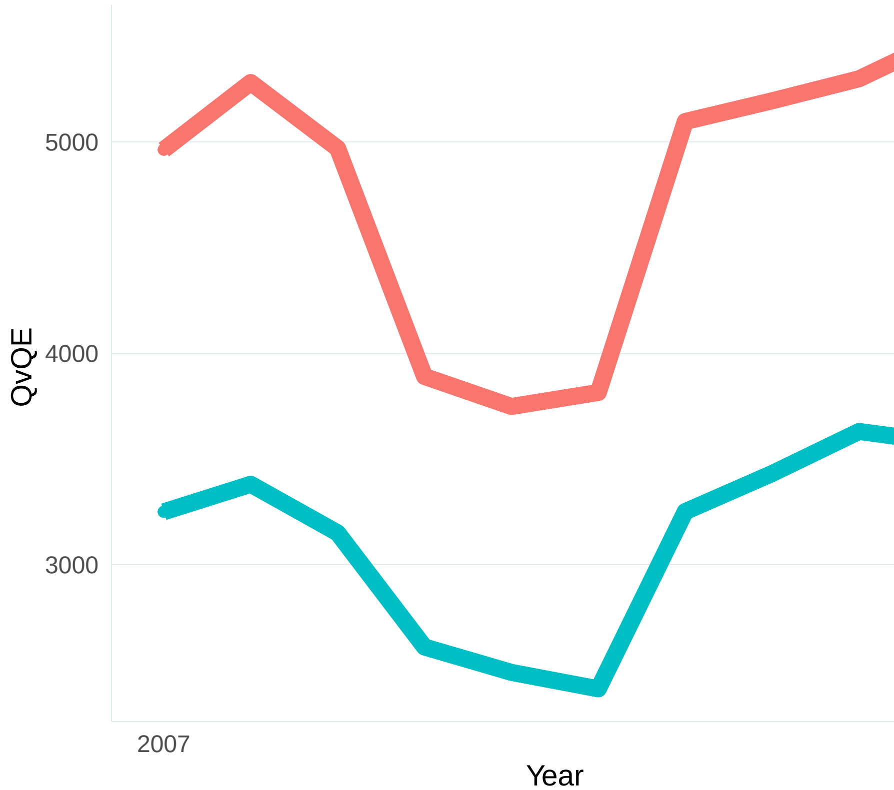
1.8.4.6 E. Graph

1.8.4.6.1 Graph 1: Price Index

For comparison, let's recreate those graphs to make sure we are getting the same output:

1.8.4.6.2 Graph 2: Quantity Index Compare For comparison, let's recreate those graphs to make sure we are getting the same output:


1.4
1.3
1.2
1.1
1.0
0.9
QIvQEI
2007
Year
cat
QEI0_Total
QI0_Total



1.8.4.6.3 Graph 3: Quantity Compare

1.8.5 Practice with real data (For National Data)

1.8.5.1 A. Import and Edit data

Load and subset Data

Edit/Restructure Data

	Q01__0002ALEWIFE	Q01__0003ALEWIFE.	Q01__0004ALFONSINO	Q01__0006AMBERJACK.GREATER	Q01__0007AMBERJACK.GREATER.
1950	NA	735961	NA	NA	NA
1951	NA	758873	NA	NA	NA
1952	NA	722115	NA	NA	NA
1953	NA	750022	NA	NA	NA
1954	NA	650472	NA	NA	NA

1.8.5.2 B. Enter base year

1.8.5.3 C. Run the function

1.8.5.4 D. Obtain the implicit quantity estimates

	VE_Total	VV_Total	V_Total	PC_Total	PI_Total	Q_Total	QI_Total	QC_Total
1950	2596863100	2794604681	2593845000	0.0000000	9.9675236	260532424	0.4303577	0.0000000
1951	2711142600	2900126381	2707189300	-0.1212391	8.8294531	307056684	0.5072084	0.1640520
1952	2904551900	3094353181	2900834400	0.0907005	9.6677301	300437835	0.4962751	-0.0216501
1953	2945724500	3131700481	2943735500	-0.0487177	9.2080293	319908247	0.5284371	0.0633851
1954	3131528000	3322992081	3129278700	-0.0559950	8.7065957	359673067	0.5941222	0.1170278
1955	3208381300	3399979081	3206680100	0.0003453	8.7096024	368372877	0.6084929	0.0240459
1956	3413031000	3617472081	3411352200	-0.0337031	8.4209534	405302205	0.6694942	0.0955397
1957	3065775700	3269932281	3064051500	-0.0060364	8.3702742	366269448	0.6050183	-0.1013776
1958	3003831240	3192160321	3000058540	-0.0558103	7.9159237	379466926	0.6268185	0.0349491
1959	3552786100	3742561181	3550436800	0.0828581	8.5997620	413126095	0.6824180	0.0852974
1960	3431488969	3621283050	3429038869	0.1023245	9.5263249	360211203	0.5950111	-0.1370718
1961	3545366800	3729969881	3537472400	-0.0576920	8.9922854	394267602	0.6512668	0.0888076
1962	3740472904	3941834181	3734589304	-0.0119179	8.8857525	420951733	0.6953447	0.0660684
1963	3436281347	3636121924	3428888647	-0.0379607	8.5547651	401680387	0.6635115	-0.0473576
1964	3082842508	3284893585	3077660908	-0.0960807	7.7710688	396707661	0.6552974	-0.0118619
1965	3312327541	3509281118	3306663741	-0.0792721	7.1788242	461402516	0.7621629	0.1511255
1966	2883071824	3082537701	2877970424	-0.0751205	6.6593048	432938857	0.7151455	-0.0636703
1967	2744821593	2941375070	2738756093	0.1348783	7.6208918	360170656	0.5949441	-0.1844403
1968	2859020482	3021220759	2838969682	-0.0471637	7.2698068	393273242	0.6496243	0.0871465
1969	2995595955	3180276732	2976017755	-0.1312197	6.3758026	469838251	0.7760974	0.1787788
1970	3289726569	3490531746	3284116169	-0.1262266	5.6197287	585388862	0.9669684	0.2203496
1971	3657625234	3856485856	3654919813	0.0512353	5.9151609	618347548	1.0214109	0.0554043
1972	3420056087	3821528621	3417179485	-0.0667839	5.5330258	618116777	1.0210297	-0.0004601
1973	3323261015	3693691834	3320568292	-0.5744829	3.1150711	1066833123	1.7622371	0.5458324
1974	3501940970	3869173264	3496834422	0.0893255	3.4061325	1028128240	1.6983028	-0.0377426
1975	3268937259	3637613906	3265136356	0.0761651	3.6756964	889338203	1.4690440	-0.1447468
1976	3550765040	3917851484	3545559881	-0.1824311	3.0627449	1159340783	1.9150449	0.2653499
1977	3456110039	3824752205	3452906402	-0.0995799	2.7724507	1246590272	2.0591670	0.0729531

	VE_Total	VV_Total	V_Total	PC_Total	PI_Total	Q_Total	QI_Total	QC_Total
1978	4293546946	4446059629	4289847393	-0.0962753	2.5179784	1705156357	2.8166446	0.3137631
1979	4415372581	4567973390	4411863460	-0.1027958	2.2720001	1943385720	3.2101613	-Inf
1980	4413228333	4565856246	4410212249	-0.0330457	2.1981473	2007703641	3.3164042	0.0325190
1981	4208881700	4199769740	4195935855	0.0541069	2.3203588	1813892644	2.9962595	-0.1012606
1982	4814459232	4786892219	4801533282	-0.0267555	2.2590996	2131140736	3.5203024	0.1610999
1983	4992086437	4957376601	4978087659	-0.0342712	2.1829893	2286812133	3.7774466	0.0705808
1984	4906589699	4890270598	4866852348	-0.0199458	2.1398792	2292928318	3.7875495	-0.0007077
1985	4678743893	4674097298	4649387420	0.0567295	2.2647829	2065868564	3.4124833	-0.1025628
1986	4349847101	4330715720	4327978634	-0.0929672	2.0637231	2107766829	3.4816925	0.0221690
1987	4788480254	4696479795	4763388776	-0.0376986	1.9873719	2409453514	3.9800305	0.1337413
1988	4041389595	3899842610	4004196923	-0.1810645	1.6582265	2437175838	4.0258233	Inf
1989	4023369359	3842546597	3974910973	0.0826819	1.8011595	2233766303	3.6898234	-0.0886921
1990	4021450928	3878674910	3979163122	-0.0168059	1.7711423	2270540820	3.7505690	0.0167143
1991	4032118379	3865661788	3995315782	-0.0661084	1.6578412	2432149884	4.0175212	0.0679031
1992	3725995400	3582777275	3687951116	-0.0473732	1.5811352	2356531753	3.8926122	-0.0297158
1993	4105010022	3942994707	4062059127	-0.0068959	1.5702694	2614207525	4.3182512	0.1036201
1994	4372163988	4217669145	4336688968	-0.0599662	1.4788740	2956414140	4.8835216	0.1225581
1995	3888584141	3711645486	3849488988	-0.0696921	1.3793176	2819208737	4.6568803	-0.0474868
1996	3876679172	3715532966	3836741499	0.0296516	1.4208289	2728463068	4.5069830	-0.0330153
1997	4094095068	3936173876	4057326451	-0.0450450	1.3582477	3014247800	4.9790535	0.0999581
1998	3731867387	3582969082	3697377040	-0.0115640	1.3426313	2779517616	4.5913170	-0.0818072
1999	3990116584	3830900260	3962104908	0.0022699	1.3456824	2965125023	4.8979106	0.0645914
2000	3793869254	3576918541	3733876374	-0.0898368	1.2300619	3084291359	5.0947543	0.0392347
2001	3765148707	3547935875	3688174498	0.0751249	1.3260298	2839414822	4.6902575	-0.0829086
2002	3722911790	3474372249	3612665910	0.1341718	1.5164335	2455044518	4.0553395	-0.1459950
2003	3704927643	3448902742	3606132813	0.0169653	1.5423797	2402085389	3.9678595	-0.0203527

	VE_Total	VV_Total	V_Total	PC_Total	PI_Total	Q_Total	QI_Total	QC_Total
2004	1889813769	2016983232	1860167720	-0.1544429	1.3216534	1429886040	2.3619422	-0.5222809
2005	1741044062	1870255471	1705470703	-0.1648763	1.1207602	1553449201	2.5660487	0.0833327
2006	1753094099	1890964774	1726077750	-0.2086514	0.9096966	1927119579	3.1832922	0.2199644
2007	517159611	667070680	475161635	0.0902594	0.9956248	519432220	0.8580187	-1.3289472
2008	521159877	670125837	486480769	0.0017992	0.9974178	522509115	0.8631012	0.0211240
2009	534736167	677145565	494251216	0.0368727	1.0348817	516712348	0.8535259	-0.0265683
2010	605385696	714949228	551050632	-0.0342871	1.0000000	605385696	1.0000000	0.1494147
2011	661229735	755626132	601024253	-0.0125710	0.9875077	669594504	1.1060626	0.0939191
2012	655629951	772527014	602002953	-0.0204319	0.9675357	677628658	1.1193338	0.0143946
2013	658197330	734787347	590869779	-0.0386691	0.9308362	707103280	1.1680211	0.0225857
2014	587575682	720097666	519339299	-0.0602186	0.8764369	670414131	1.1074165	-0.0552013
2015	577149068	699010404	533666838	0.0029147	0.8789951	656600975	1.0845994	0.0112312
2016	556835463	711262899	519781163	-0.0637685	0.8246928	675203523	1.1153278	0.0335641
2017	525822797	668362521	488629852	-0.0055386	0.8201378	641139586	1.0590597	-0.0504760
2018	490972000	671036323	439699415	-0.0069958	0.8144203	602848422	0.9958088	-0.0970116
2019	430592128	622763099	397062280	-0.0627348	0.7648975	562940974	0.9298881	-Inf

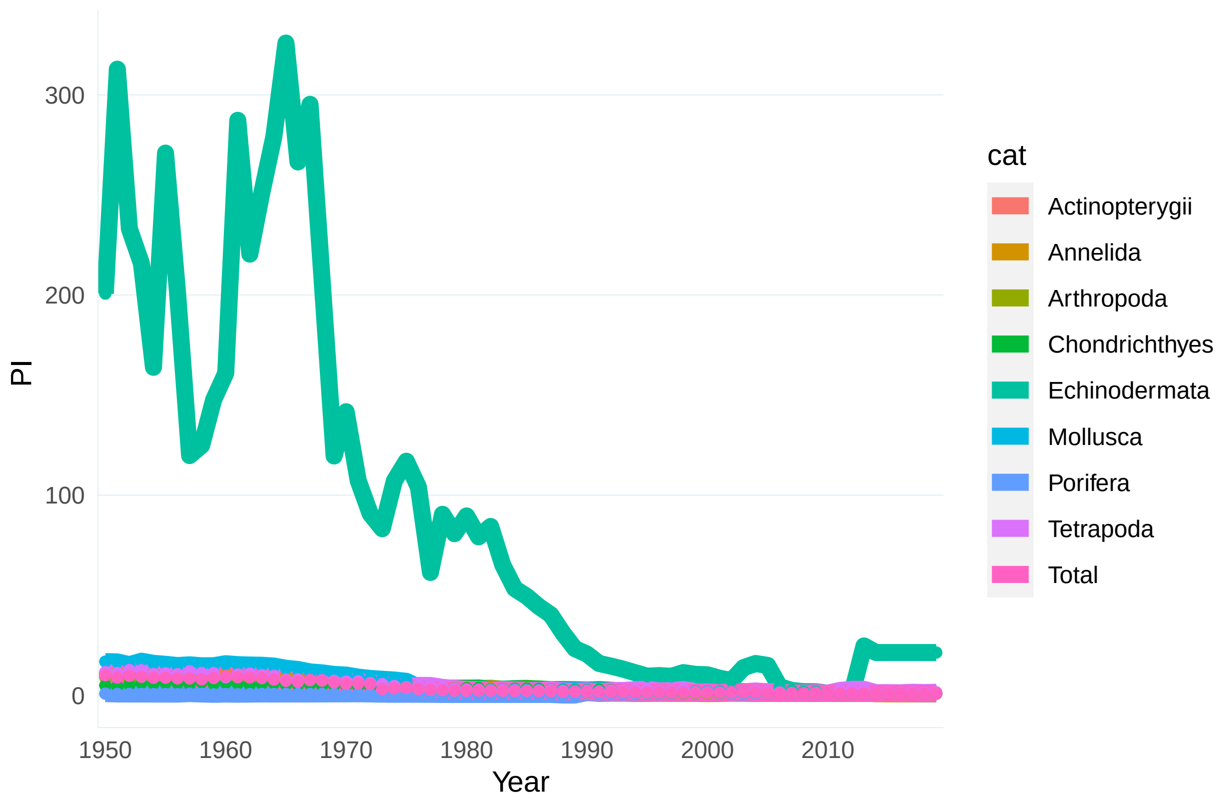
Did all of the analyses work as intended?

, list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(8, 192, 4, 76, 31, 97, 57, 84, 63)), FYI: Rows of R_{s,i,t} for 01_0000Actinopterygii did not sum to 1, Warning: When back calculated, V_{i,t} did not equal PI_{i,t} Q_{i,t}, Warning: When back calculated, Q_{i,t} did not equal V_{i,t}/PI_{i,t}, FYI: 02_0000Agnatha is no longer being calculated because there were less than 2 columns of Q available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(0, 2, 0, 0, 0, 2, 1, 1, 0)), list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(0, 25, 0, 10, 2, 13, 8, 4, 13)), list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(3, 8, 3, 5, 6, 3, 5, 4, 5)), FYI: Rows of R_{s,i,t} for 05_0000Chondrichthyes did not sum to 1, FYI: 06_0000Chromista is no longer being calculated because there were less than 2 columns of Q available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, FYI: 07_0000Cnidaria is no longer being calculated because there were no more available columns of V after data was removed for not meeting the pctmiss, list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(0, 2, 0, 1, 0, 1, 0, 0, 2)), list(var = c(1, 1, 1, 2, 2, 2, 3, 3, 3), slopecheck = c(1, 2, 3, 1, 2, 3, 1, 2, 3), Freq = c(1, 26, 0, 11, 1, 15, 9, 8, 10)), FYI: 10_0000Other is no longer being calculated because there were no more available columns of V after data was removed for not meeting the pctmiss, FYI: 11_0000Plantae is no longer being calculated because there were less than 2 columns of Q available (according to 'MinimumNumberOfSpecies') after data was removed for not meeting the pctmiss, list(var = c(1, 1, 2, 2, 3, 3), slopecheck = c(1, 2, 1, 2, 1, 2), Freq = c(0, 3, 1, 2, 0, 3)), list(var = c(1, 1, 2,

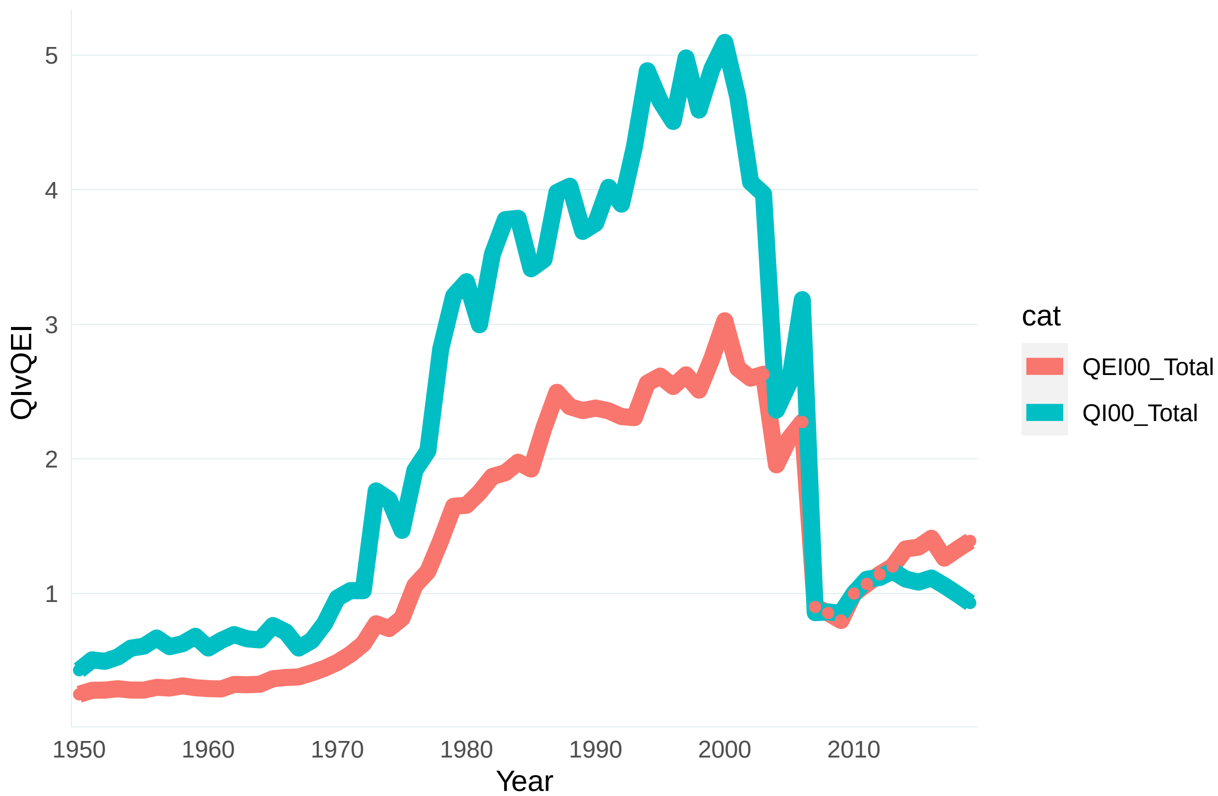
2, 3, 3), slopecheck = c(1, 2, 1, 2, 1, 2), Freq = c(3, 0, 1, 2, 3, 0)), Warning: When back calculated, V_t did not equal PI_t * Q_t, Warning: When back calculated, Q_t did not equal V_t/PI_t, Warning: When back calculated, ln(Q_t/Q_{t-1}) = did not equal sum((R_{i, t} - R_{i, t-1}) / 2) x ln((Q_{i,t}) / (Q_{i,t-1})), FYI: 2 of species V columns are completely empty, 2 of species Q columns are completely empty, and 0 of 6 species P columns are completely empty. *

1.8.5.5 E. Graph

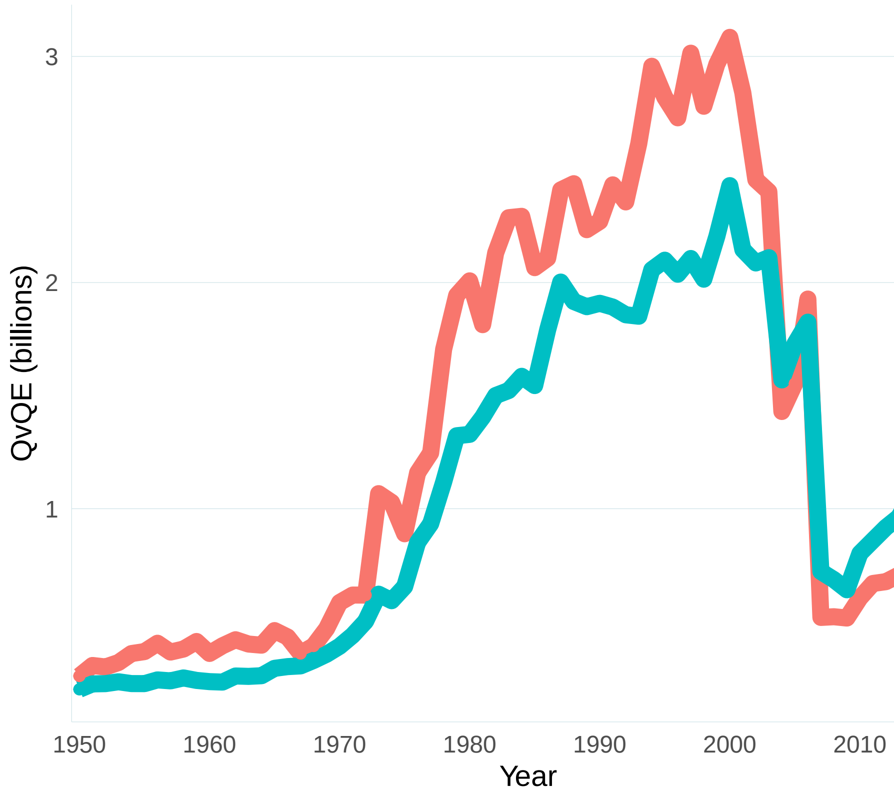
1.8.5.5.1 Graph 1: Price Index For comparison, let's recreate those graphs to make sure we are getting the same output:



1.8.5.5.2 Graph 2: Quantity Index Compare For comparison, let's recreate those graphs to make sure we are getting the same output:



QIvQEI
5
4
3
2
1
1950
1960
1970
1980
1990
2000
2010
Year
cat
QEI00_Total
QI00_Total



1.8.5.5.3 Graph 3: Quantity Compare