

ANALYZING FACTORS AFFECTING ALASKA'S SALMON PERMIT VALUES:  
EVIDENCE FROM BRISTOL BAY DRIFT GILLNET PERMITS

By

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## Abstract

The effects of total earnings, total costs and mining exploration on permit prices in Alaska are investigated using an autoregressive distributed lag (ARDL) approach to cointegration. I take specific account of regional and gear specific salmon fisheries – that is, Bristol Bay drift gillnet permits – in our modelling. I find that there is a stable long-run relationship among permit prices, total earnings, and total costs. It is also found that, in both the short- and long-run, total earnings have a positive and significant relationship with permit prices, while total costs have a negative and significant relationship. Although the mining exploration in the region has a negative and significant effect on permit prices in the short-run, the effect does not seem to last in the long-run.



# Table of Contents

	Page
Title Page.....	i
Abstract .....	iii
Table of Contents.....	v
List of Figures.....	vii
List of Tables .....	ix
Dedication .....	xi
Acknowledgments.....	xiii
1 Introduction .....	1
2 Limited Entry Permit System in Alaska.....	5
3 Data Description .....	7
4 Model .....	9
5 Results .....	11
6 Discussion and Conclusion.....	17
References .....	19
Appendix .....	21



## List of Figures

	Page
Figure 1. Plots of CUSUM.....	15
Figure 2. Plots of CUSUMSQ.....	16
Figure 3. Average ex-vessel salmon prices.....	24
Figure 4. Average gasoline prices .....	25
Figure 5. Average permit price and average total earnings .....	26
Figure 6. Number of permits fished and permits renewed.....	27
Figure 7. Total pounds of salmon harvested .....	28



## List of Tables

	Page
Table 1. Data Description.....	8
Table 2. Estimated short-run coefficients of the price permit model of Bristol Bay .....	13
Table 3. Estimated long-run coefficients of the price permit model of Bristol Bay .....	14
Table 4. Results of real average permit price VARSOC lag selection.....	21
Table 5. Results of real average total earnings VARSOC lag selection .....	21
Table 6. Results of real average gas price VARSOC lag selection .....	21
Table 7. Results of Pebble Mine dummy VARSOC lag selection.....	22
Table 8. Results of real average permit price Augmented Dickey-Fuller unit root tests .....	22
Table 9. Results of real average total earnings Augmented Dickey-Fuller unit root tests.....	22
Table 10. Results of real average gas price Augmented Dickey-Fuller unit root tests .....	23
Table 11. Results of Pebble Mine dummy Augmented Dickey-Fuller unit root tests.....	23
Table 12. Results of Zivot-Andrews unit root test .....	24





## Dedication

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## 1 Introduction

Commercial salmon fisheries are not only a critical resource to Alaska's economy, but to the U.S. market as well. During the 2013-2014 period, for example, the Alaskan salmon fisheries provided an annual average of 59,539 jobs with total labor income of \$1.584 billion and accounted for almost 98% of U.S. salmon harvests with annual harvests averaging around 800 million pounds valued at over \$500 million (McDowell, 2015). To prevent economic rent dissipation in the salmon fisheries, the Alaska state legislature thus has adopted the so-called limited entry permit system for commercial salmon fisheries through the passage of the Limited Entry Act since 1975. The system issues tradeable permits for specific salmon fisheries corresponding to different types of gear and geographical areas, and requires the permit holders to be present on the vessel when fish are landed. However, Alaskan salmon fisheries have been subject to great volatility in permit values over the past four decades. For example, starting in 1978 the value of a permit in 2014 dollars was nearly \$152,000. They reached an all-time high of \$475,000 in 1989, but fell sharply to a low of \$26,000 in 2002. By 2014, the values of the permits had rebounded back to around \$150,000. Therefore, it is crucial to examine factors that contribute to the dynamic behavior of permit values appropriately in order to understand Alaska's commercial salmon fisheries accurately.

The focus of this article will be on the Bristol Bay drift gillnet fishery. As of 2016 the estimated number of participants in this fishery was 1,862 and the primary target species is Sockeye salmon, though Chinook, Chum, Coho and Pink salmon returns are also targeted (NOAA, 2016). The fishery operates from the middle of June through the end of August and approximately 80% of the salmon catch in Bristol Bay is caught with drift gillnets (NOAA, 2016). The Bristol Bay Management Area consists of five management districts including all

coastal and inland waters from Cape Newenham to Cape Menshikof which includes eight major river systems in the area that form the largest commercial sockeye salmon fishery in the world (NOAA, 2016).

Previous research has been done on permit price modeling at a statewide level for Alaskan salmon fisheries (Karpoff, 1982), the effects on the market price of an asset in relation to subsidized loans (Karpoff, 1984), non-pecuniary benefits derived from commercial fishing (Karpoff, 1985), permit price relationships to expected returns consistent with asset pricing theory (Huppert, Ellis, & Noble, 1996), and changes in local ownership of Alaskan salmon entry permits (Knapp, 2010).

Karpoff (1982) used statewide Commercial Fisheries Entrance Commission (CFEC) permit transfer data from 1978-1981 to look into the determination of limited entry permit prices dependent on supply and demand for permits. He failed to confirm any price variations in permits at any given time due to transaction costs or information effects. He was also unable to find any significant relationship between price changes and net incomes, but the permits did appear to reflect new information contained in fish run forecasts provided by the Alaska Department of Fish and Game (ADF&G) and the strength of the effect of these forecasts appeared to be weakly correlated with the accuracy of the previous year's forecast.

Karpoff (1984) used the same CFEC permit transfer data to test whether loan subsidies available for limited entry permits increased demand for the affected asset by an amount equal to the present value of the subsidy. He also looked into the effect of a 1976 ballot initiative that was defeated to repeal the Limited Entry Act and annual ADF&G fish run forecasts on permit prices. Empirical tests revealed that supply and demand shifts due to

subsidized loans resulted in an increase in permit prices of approximately 23% and in transfer volume of approximately 22%.

Again using the same data, Karpoff (1985) tested the hypothesis that fishermen receive significant non-pecuniary benefits in salmon fisheries statewide. It was found that limited entry permit prices appear to reflect primarily the monetary rent streams from the right to fish, but there were a number of low-income fishermen whose continued presence in the fisheries would be mysterious if there were not any non-pecuniary benefits and that the extent of those benefits did not depend on gear type or geographic area.

In an extension of Karpoff (1984), Huppert et al. (1996) examined permit values during the period 1977-1990 and interpreted relationships between permit prices and expected net earnings via a present value asset pricing model. The results generally confirmed that Alaska's limited entry permit price trends were consistent with simple asset pricing theories. Therefore, at the statewide level, these models tend to be accurate in the application of permit values. Much of this research is outdated and conclusions were derived from very small datasets in the early years of the limited entry program. There is no current research or modeling on regional specific salmon fisheries in the State of Alaska.

The main contribution of this article is to assess the effects of gross earnings, average fuel prices, and heavy mining exploration on the values of Bristol Bay drift gillnet permits with enhanced methods and an updated dataset. For the analysis I will estimate an asset pricing model utilizing an autoregressive distributed lag (ARDL) approach to cointegration developed by Pesaran, Shin and Smith (2001). The ARDL approach can be applicable to the level of variables without testing whether they are stationary or nonstationary and uses an error-correction format to estimate both the short- and long-run dynamics with a single step;



hence, it is well suited to deal with this line of research. Many permit holders depend on these permits for more than a source of summer income, but rather as an asset for retirement stability or as financial investment opportunities. Estimating an updated model with modern methods may help fishermen estimate their permit values in the short- and long-run and will help identify significant factors that impact permit values which could prove beneficial to long-time fishermen looking to sell their permits as well as new entrants to the industry deciding when to buy permits. I expect that earnings in previous years will have a positive impact on permit values in subsequent years, and that gas prices and heavy mining activity will negatively impact permit values. The remaining sections present an overview of Alaska's limited entry permit system, data description, methodology, empirical findings, and concluding remarks.

## 2 Limited Entry Permit System in Alaska

Alaska created the Commercial Fisheries Entry Commission (CFEC) in 1973 and adopted a limited entry management system for commercial salmon fisheries through the passage of the Limited Entry Act in 1975. Eight geographic areas (Southeast, Yakutat, Prince William Sound, Cook Inlet, Kodiak, Chignik, Alaska Peninsula, and Bristol Bay) are fished using five different types of gear (purse seine, beach seine, drift gill net, set gill net, and power troll) (Karpoff, 1984). These limited entry permits were originally issued for free to individuals based on “(1) the degree of economic dependence upon the fishery, including... the percentage of income derived from the fishery, reliance on alternative occupations, availability of alternative occupations, investment in vessels and gear; (and) (2) extent of past participation in the fishery, including ... the number of years of participation in the fishery, and the consistency of participation during each year” (Alaska Statutes, Sec. 16.43.250). Only individuals may own these permits, the owner must be present on the vessel while they are fishing, and permits may not be leased (Knapp, 2010).

The Limited Entry Act allows for two types of permit transfers: permanent and emergency. Permanent transfers occur when there is a change in the holder of the permit, and emergency transfers allow for the permit to be fished by someone other than the holder if the permit holder: “is prevented from fishing due to illness, death, disability, required military or government service, or other unavoidable hardship of a temporary, unexpected and unforeseen nature.” In order to permanently transfer a permit to someone else the permit holder must file a “Notice of Intent to Permanently Transfer” form and wait the 60 day waiting period; the permit holder and the transferee then must complete the “Request for Permanent Transfer of Entry Permit” form (CFEC, 2012b). This 60 day waiting period was

created by the legislature so that permit holders would have time to consider their long term needs before permanently transferring their permit. Limited entry permits must be renewed annually once issued, and failure to renew for a period of two years results in forfeiture (Weiss, 1992). Also, the Alaska Legislature has reserved the right to modify or revoke a limited entry permit without providing compensation or through buyback programs (Weiss, 1992). Permits that have been forfeited are removed from the fishery and are not reissued to other fishermen (CFEC, 2012a).

Permits are often advertised in fishing industry journals, newsletters, and local newspapers, along with being advertised through permit brokers who can assist with financing arrangements, escrow accounts, and paperwork advisement (CFEC, 2012b). There were a total of 11,047 transferable permits initially allocated in 1975, and between then and 2008 a total of 30,992 permit transfers occurred which includes 9,812 transfers of permits from initial issues (Knapp, 2010). Though these brokers may help with arranging financing, the Limited Entry Act has many caveats for financing. Permits may not be pledged, leased, mortgaged, encumbered or transferred with any retained right of repossession, and the permit may not be used as collateral for a loan. The two exceptions to the above are loans financed by the State of Alaska, Department of Commerce, Community and Economic Development, Division of Economic Development, and by the Alaska Commercial Fishing and Agriculture Bank (CFEC, 2012b).

### 3 Data Description

Annual data covering the period from 1978 to 2014 are used to estimate the model. The fishery related data has been acquired from ADF&G and the CFEC. Historical gasoline prices were gathered from the U.S. Energy Information Administration (EIA). Permit values were not recorded until 1978 so the model is conducted from that period forward. These permit values are estimated values for permanent permits in the fishery based on the average price of actual sales transactions. Total average earnings are based on the gross earnings for all permanent permit holders in the specific fishery. All monetary values have been adjusted to 2014 dollars using CPI as a deflator. Table 1 defines the variables contained in the analysis and reports basic summary statistics. The analysis uses the logged form of the values for a more intuitive interpretation. Pebble Mine is a mineral exploration project investigating a very large porphyry copper, gold, and molybdenum mineral deposit located about 200 air miles southwest of Anchorage, Alaska and roughly 230 river miles from Bristol Bay near Lake Illiamna. However, since the mine is located in some of the headwaters of the fishery, many local fisherman have voiced their concern over the mine and the possibility of the negative impacts it may have on the fishery in the future. The decision for  $DUM_t$  to take on the value of 1 for the years 2002-2013 was decided based upon Northern Dynasty Ltd. acquiring rights to Pebble in 2001, starting exploration in 2002, discovering Pebble East deposit in 2005, forming the Pebble Partnership with Anglo American plc in 2007, developers releasing preliminary assessment and environmental data in 2011, and the Pebble Partnership coming to an end in 2013 leaving Northern Dynasty Ltd. looking for new investors (Pebble Watch, 2015).

Table 1. Data Description

Variable	Definition	N	Mean	Std. Dev.	Median
P	Real average permit price	37	198,076	114,585	189,992
R	Real average earnings total	37	103,184	49,372	93,892
C	Real average gas price	37	2.466	0.662	2.389
DUM	Dummy variable representing Pebble Mine Exploration coded as 1 for years 2002-2013, 0 otherwise	37	0.300	0.464	0

Included in the Appendix are time-series plots of ex-vessel salmon prices (Figure 3), average gasoline prices (Figure 4), average permit prices corresponded with average total earnings (Figure 5), number of permits fished corresponded with permits renewed (Figure 6), and total pounds of salmon harvested (Figure 7).

#### 4 Model

To investigate the factors determining the values of Bristol Bay drift gillnet permits, following previous studies (i.e., Karpoff, 1984; Huppert et al., 1996), I also rely on an asset pricing model developed by Hirschleifer (1980). In its simplest form this model can be stated as:

$$P = f(R, C, z) \quad (1)$$

where:

$P$  = price of a permit

$R$  = expected total earnings (revenue)

$C$  = expected total costs

$z$  = all other factors affecting the price of a permit

Equation (1) can be specified in a log linear form as follows:

$$\ln P_t = \beta_0 + \beta_1 \ln R_t + \beta_2 \ln C_t + \beta_3 DUM_{2002-2013} + u_t \quad (2)$$

where:

$DUM_t$  = a dummy variable capturing the effect of the 2002-2013 Pebble Mine exploration on permit prices

Since an increase in expected total earnings generally leads to an increase in permit prices, it is expected that  $\beta_1 > 0$ . To the extent that a rise in expected total costs results in a decrease in permit prices through reduction in fishing activities and hence demand for permits, it is expected that  $\beta_2 < 0$ . Finally, if the Pebble Mine exploration has a negative effect on the fishery and permit prices, it is expected that  $\beta_3 < 0$ .

Equation (2) is now reformulated as follows to illustrate the ARDL modeling approach:

$$\Delta \ln P_t = \beta'_0 + \sum_{i=1}^n \beta'_{i1} \Delta \ln P_{t-i} + \sum_{i=0}^n \beta'_{i2} \Delta \ln R_{t-i} + \sum_{i=0}^n \beta'_{i3} \Delta \ln C_{t-i} + \beta'_4 DUM_{2002-2013} + \theta_0 \ln P_{t-1} + \theta_1 \ln R_{t-1} + \theta_2 \ln C_{t-1} + \varepsilon_t \quad (3)$$

All variables here are as previously defined. Equation (3) is the basis of my empirical analysis. Unlike a standard error-correction model that includes the lagged error-correction term from Equation (3), the ARDL model includes the linear combination of lagged level variables ( $\ln P_{t-1}$ ,  $\ln R_{t-1}$ , and  $\ln C_{t-1}$ ) as the error-correction term. Pesaran et al. (2001) recommend using the  $F$ -test to evaluate whether or not the three lagged level variables in Equation (3) are jointly significant. For this, the upper and lower asymptotic critical values provided by Pesaran et al. (2001) can be utilized to test the null hypothesis that there is no cointegration (that is,  $H_0: \theta_0 = \theta_1 = \theta_2 = 0$ ) against the alternative that there is (that is,  $H_1: \theta_0 \neq \theta_1 \neq \theta_2 \neq 0$ ). Once the  $F$ -test provides a cointegrating relationship, the long-run coefficient estimates are derived by the estimates of  $\theta_1$  and  $\theta_2$  normalized on  $\theta_0$ . The short-run dynamic effects are represented by the estimates of coefficients following the sigma symbols.

Stationary processes follow a simple random walk around a fixed value while unit root ( $I(1)$ ) processes are those that have a stationary first-difference time series.  $I(2)$  processes are those that the second-difference of the process becomes stationary. Although the variables do not need to all be of the same order of integration, none can be  $I(2)$  or else the ARDL process crashes.

## 5 Results

With unit root tests being sensitive to lag order, I first conducted a series of tests using the VARSOC command in STATA that includes final prediction error, Akaike's information criterion, Schwarz's Bayesian information criterion, and the Hannan and Quinn information criterion lag-order selection statistics to determine each variables' optimal lag length. Permit price, gas price, and the dummy variable for Pebble Mine exploration all show to have optimal lags of one and earnings an optimal lag of two. Detailed results for these tests are in the Appendix in Tables 4-7.

After determining the optimal lag order I ran a series of Augmented Dickey-Fuller unit root tests in order to confirm that none of the variables are  $I(2)$  processes. I find strong evidence that all the levels of the variables of interest have a unit root and the first differences of each are stationary. Since the test statistics for the levels (first differences) are above (below) -2.972 (-2.618) at the 5% (10%) significance level, I cannot (can) reject the null hypothesis of a unit root for any of the three variables. This indicates that each series in Equation (3) is  $I(1)$  variable, ensuring that the ARLD method can be safely applied to the current research. The detailed results of the Dickey-Fuller tests can be found in the Appendix in Tables 8-11.

In the ARDL approach, the short- and long-run estimated coefficients of the individual series are statistically meaningful only if they are cointegrated. Therefore the model is tested to determine the existence of cointegration relationship among the three variables using the  $F$ -test. The computed  $F$ -statistic of 15.703 far exceeds the 5% upper bound critical value of 6.021 so I can reject the null hypothesis that the three variables are



not cointegrated. Therefore, it is likely that any deviation among the three variables is not expected to continue and will have a tendency to return to its trend path in the long-run.

The final test I performed before conducting the ARDL analysis was the Zivot-Andrews test to see if any of the variables are sensitive to structural break and I failed to reject the null of a unit root process that excludes exogenous structural change in permit prices, average earnings, and average gas prices. Detailed results of this test along with time series plots can be found in the Appendix in Table 12 and Figures 4 and 5. With all of these tests completed I concluded that Equation (3) could be estimated using the ARDL process.

With the positive and significant coefficient that I found on the earnings variable in both the short- and long-run relationships and the negative and significant coefficient on the fuel price variable I confirm that limited entry permit values in the Bristol Bay region for drift gillnetting are consistent with typical asset pricing theory. These results suggest that improved earnings result in higher permit prices, while increased costs tend to lower permit prices due to the profit margin decreasing which in turn reduces both demand for permits, and prices. There is a negative effect of Pebble Mine exploration dummy on permit values in the short-run, but the statistical significance of this relationship drops in the long-run relationship. It is important to mention that the error-correction term ( $ec_{t-1}$ ) obtained from the linear combination of lagged variables in Equation (3) is negative and highly significant, confirming that there is a significant long-run relationship among the variables (Kremers, Ericson & Dolado, 1992). The coefficient on the error-correction term being  $-.601$  indicates that when permit values in the previous year deviate from the equilibrium, the permit market tends to adjust by approximately 60.1% in the following year.

I performed a series of diagnostics tests on the ARDL model and there is no evidence of serial correlation, functional form specification, heteroscedasticity, or normality issues within the model. These results along with the short-run dynamics are shown in Table 2. In the short-run with a 1% increase in earnings we can expect to see an increase in permit prices by 0.516%. Also in the short-run, with a 1% increase in costs we can expect to see a decrease in permit prices by 0.346%.

Table 2. Estimated short-run coefficients of the price permit model of Bristol Bay

Variable	Coefficients
$\ln R_t$	0.516 (5.448)**
$\ln C_t$	-0.346 (-1.913)*
$DUM_{2002-2013}$	-0.32 (-1.995)**
$ec_{t-1}$	-0.601 (-4.783)**
Serial correlation	1.266 [0.261]
RESET	2.195 [0.138]
Normality	0.410 [0.815]
Heteroskedasticity	0.016 [.901]

Note: \*\* and \* denote significance at the 5% and 10% levels, respectively. Parentheses are  $t$ -statistics. Brackets in diagnostic tests are  $p$ -values. RESET indicates regression specification error test, which uses Ramsey's RESET test based on the square of the fitted values.

With the diagnostics tests completed and the error correction model estimated I moved on to estimate the long-run relationships among the variables. The coefficient on the earnings variable is positive and significant. With a 1% increase in earnings we can expect to see an increase in permit prices by 1.352%. This is statistically significant at the 1% confidence level which gives us empirical evidence that earnings are directly and positively

related to permit prices. The coefficient on the gas price variable is negative and significant which is expected since it is our proxy for costs and as costs increase the profit margin decreases which in turn negatively impacts the value of the permits following traditional asset pricing theory. With a 1% increase in gas prices we can expect to see a decrease in permit prices by .576% and this is significant at the 5% level giving us empirical evidence that input costs have a direct negative impact on permit prices. The dummy variable representing mining exploration is negative but not statistically significant which gives us evidence that the years in which heavy mining exploration occurred in the region did not significantly affect permit prices in the long-run. The long-run relationship results can be found below in Table 3.

Table 3. Estimated long-run coefficients of the price permit model of Bristol Bay

Variable	Coefficient
$\ln R_t$	1.352 (7.725)**
$\ln C_t$	-0.576 (-1.968)**
$DUM_{2002-2013}$	-0.101 (-0.455)
Constant	-2.966 (-1.520)

Note: \*\* and \* denote significance at the 5% and 10% levels, respectively. Parentheses are t-statistics.

Lastly, I performed two hypothesis tests to see if there are any recursive residuals due to a structural break because the ARDL process is sensitive to this. In Figures 1 and 2 below, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) are plotted. These tests show that the plots lie between the 5% critical bounds at all points so therefore there is no issue of recursive residuals in terms

of mean and in terms of variance so the ARDL model is well specified and it is shown that there is stability of the short- and long-run coefficient estimates for the period 1978-2014. Although the Zivot-Andrews test performed was unable to reject the null hypothesis of a unit root process excluding exogenous structural change in average permit price, average earnings, and average gas prices, given that the post regression diagnostic tests including the Ramsey RESET test and cumulative sum of recursive residuals show no issues the fact that there may be a structural break is not creating a problem in the regression.

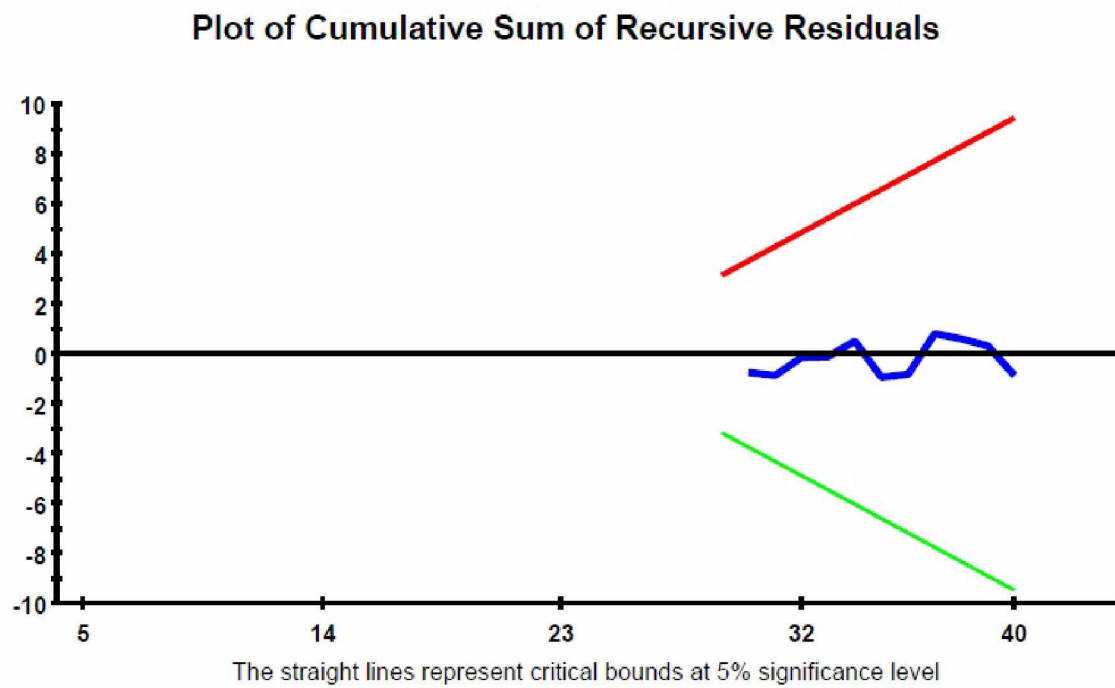


Figure 1. Plots of CUSUM

### Plot of Cumulative Sum of Squares of Recursive Residuals

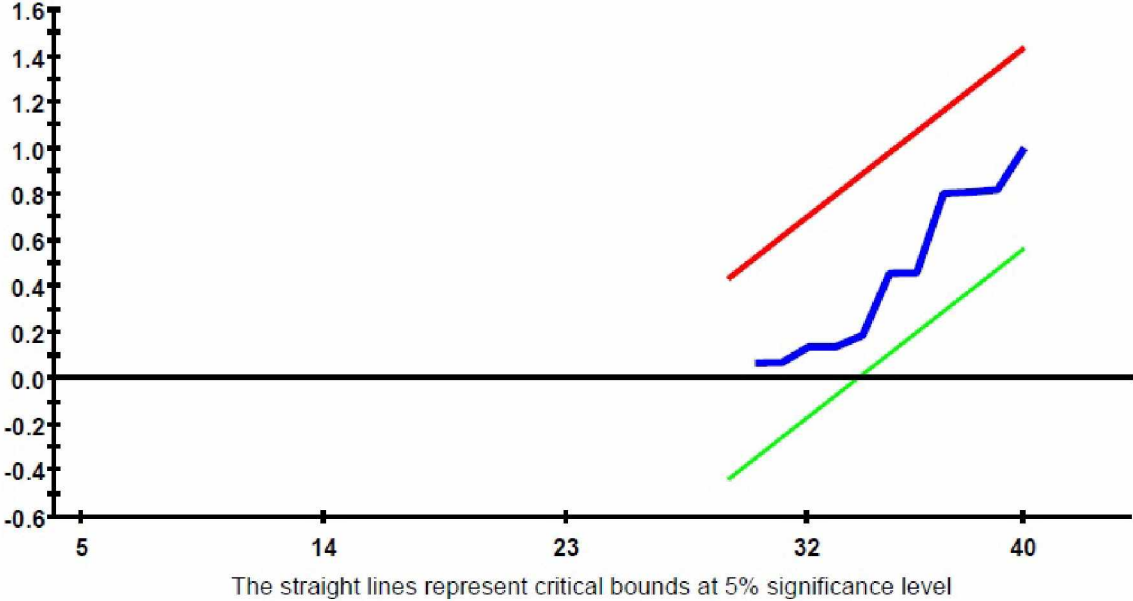


Figure 2. Plots of CUSUMSQ

## 6 Discussion and Conclusion

Alaska adopted a limited entry permit system for commercial salmon fishing in 1975. These permits have been subject to great volatility in price over the last four decades. In this article, therefore, I aim to empirically examine the factors that contribute to the dynamic behavior of the permit values. The primary contribution of the paper is to address the issue in the context of regional and gear specific salmon fisheries in Alaska – that is, Bristol Bay drift gillnet permits - using an enhanced method – that is, an autoregressive distributed lag (ARDL) approach to cointegration. Evidence is found that there is a stable cointegration relationship among the variables of interest which points to a long-run relationship between permit prices, total earnings, and total costs. It is also found that total earnings have a positive and significant relationship with permit prices, and total costs have a negative and significant relationship in both the short- and long-run. Finally, it is found that the dummy variable accounting for years in which mining exploration in the area has a negative and significant effect in the short-run but not in the long-run. This final result must be taken with extreme caution as mining in the region is only one factor that is occurring during the dummy period and the mining activity only coincides with the years where a structural break was observed, but may not be the actual reason for the break.

I must acknowledge that using average gas prices as the sole input price in the model vastly oversimplifies the asset pricing model as there are a number of inputs that contribute to total costs with wages paid to the deckhands, food prices, maintenance costs, and insurance rates all being examples. Rather than simply using average gas prices as a proxy for input prices in the model, it would be beneficial to collect aggregated cost data from the ADF&G Fish Ticket system in order to more accurately estimate the asset pricing model. If

that is not possible due to confidentiality reasons the input prices could still be expanded upon by including a food price index and other production indices in addition to the gas price values to more accurately represent a proxy of inputs.

More research also needs to be conducted in order to pinpoint any causality of the effect of Pebble Mine exploration on permit values. Since the dummy variable was assigned a value of 1 over a large date range from 2002-2013 some investigation into what else was going on in those years that could also influence permit values needs to be conducted.

It would also be interesting to investigate how the buildup of the farmed fish market in the early 1990s affected permit values and to see if there has been a long term impact on the values due to this. Other factors that may have an effect on permit values could be explored as well such as shifts in government leadership, proposed changes to the limited entry system, and how the Exxon Valdez oil spill affected permit values in specific regions. Data is available for fisheries in several other regions of the state and it may be beneficial to examine these fisheries as well in order to see if the findings of this research are sensitive to fishery type and region.

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## Appendix

Table 4. Results of real average permit price VARSOC lag selection

Selection-order criteria

Sample: 1982 - 2014

Number of obs

=

33

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-431.738				1.4e+10	26.2266	26.2418	26.2719
1	-398.042	67.393*	1	0.000	2.0e+09*	24.2449*	24.2755*	24.3356*
2	-397.699	.68478	1	0.408	2.1e+09	24.2848	24.3306	24.4208
3	-397.681	.03547	1	0.851	2.2e+09	24.3443	24.4054	24.5257
4	-397.56	.24322	1	0.622	2.3e+09	24.3976	24.4739	24.6243

Table 5. Results of real average total earnings VARSOC lag selection

Selection-order criteria

Sample: 1979 - 2014

Number of obs

=

36

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-440.017				2.6e+09	24.501	24.5163	24.5449
1	-431.371	17.293	1	0.000	1.7e+09	24.0761	24.1068	24.1641
2	-428.961	4.8184*	1	0.028	1.5e+09*	23.9979*	24.0439*	24.1298*
3	-428.515	.8937	1	0.344	1.6e+09	24.0286	24.09	24.2045
4	-428.294	.44082	1	0.507	1.7e+09	24.0719	24.1487	24.2918

Table 6. Results of real average gas price VARSOC lag selection

Selection-order criteria

Sample: 1979 - 2014

Number of obs

=

36

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-37.625				.50056	2.14583	2.16119	2.18982
1	-10.7075	53.835*	1	0.000	.118625*	.705971*	.736676*	.793944*
2	-10.2253	.9643	1	0.326	.12212	.734741	.780798	.866701
3	-9.78069	.88929	1	0.346	.126014	.765594	.827004	.94154
4	-9.72616	.10906	1	0.741	.132928	.81812	.894882	1.03805

Table 7. Results of Pebble Mine dummy VARSOC lag selection

Selection-order criteria

Sample: 1979 - 2014

Number of obs

=

36

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-24.0084				.234921	1.38936	1.40471	1.43334
1	2.1066	52.23*	1	0.000	.058211*	-.005922*	.024783*	.082051*
2	2.17947	.14575	1	0.703	.061304	.045585	.091642	.177545
3	2.26731	.17568	1	0.675	.064525	.09626	.15767	.272207
4	2.37526	.21589	1	0.642	.067864	.145819	.222581	.365752

Table 8. Results of real average permit price Augmented Dickey-Fuller unit root tests

RAPP ADF				
Lag	T-Statistic	1%	5%	10%
0	-1.554	-3.675	-2.969	-2.617
1*	-1.142	-3.682	-2.972	-2.618
2	-1.157	-3.689	-2.975	-2.619
3	-1.209	-3.696	-2.978	-2.62
* denoting optimal lag				

d.RAPP ADF				
Lag	T-Statistic	1%	5%	10%
0	-9.082	-3.682	-2.972	-2.618
1*	-3.808	-3.689	-2.975	-2.619
2	-2.959	-3.696	-2.978	-2.62
3	-2.266	-3.702	-2.98	-2.622
* denoting optimal lag				

Table 9. Results of real average total earnings Augmented Dickey-Fuller unit root tests

RAET ADF				
Lags	T-Statistic	1%	5%	10%
0	-3.09	-3.655	-2.961	-2.613
1	-1.996	-3.662	-2.964	-2.614
2*	-2.121	-3.668	-2.966	-2.616
3	-1.632	-3.675	-2.969	-2.617
* denoting optimal lag				

d.RAET ADF				
Lags	T-Statistic	1%	5%	10%
0	-9.853	-3.662	-2.964	-2.614
1	-4.565	-3.668	-2.966	-2.616
2*	-4.408	-3.675	-2.969	-2.617
3	-5.708	-3.682	-2.972	-2.618
* denoting optimal lag				

Table 10. Results of real average gas price Augmented Dickey-Fuller unit root tests

RAGP ADF					d.RAGP ADF				
Lags	T-Statistic	1%	5%	10%	Lags	T-Statistic	1%	5%	10%
0	-1.22	-3.655	-2.961	-2.613	0	-5.45	-3.662	-2.964	-2.614
1*	-1.461	-3.662	-2.964	-2.614	1*	-4.928	-3.668	-2.966	-2.616
2	-0.966	-3.668	-2.966	-2.616	2	-3.709	-3.675	-2.969	-2.617
3	-0.975	-3.675	-2.969	-2.617	3	-3.026	-3.682	-2.972	-2.618
* denoting optimal lag					* denoting optimal lag				

Table 11. Results of Pebble Mine dummy Augmented Dickey-Fuller unit root tests

PEBEXP ADF					d.PEBEXP ADF				
Lags	T-Statistic	1%	5%	10%	Lags	T-Statistic	1%	5%	10%
0	-1.22	-3.655	-2.961	-2.613	0	-5.45	-3.662	-2.964	-2.614
1*	-1.461	-3.662	-2.964	-2.614	1*	-4.928	-3.668	-2.966	-2.616
2	-0.966	-3.668	-2.966	-2.616	2	-3.709	-3.675	-2.969	-2.617
3	-0.975	-3.675	-2.969	-2.617	3	-3.026	-3.682	-2.972	-2.618
* denoting optimal lag					* denoting optimal lag				

Table 12. Results of Zivot-Andrews unit root test

Zivot-Andrews Unit Root			
Variable	T-Statistic	1%	5%
RAPP	-4.179	-5.34	-4.80
RAET	-4.601	-5.34	-4.80
RAGP	-3.108	-5.34	-4.80
PEBEXP	-6.289	-5.34	-4.80

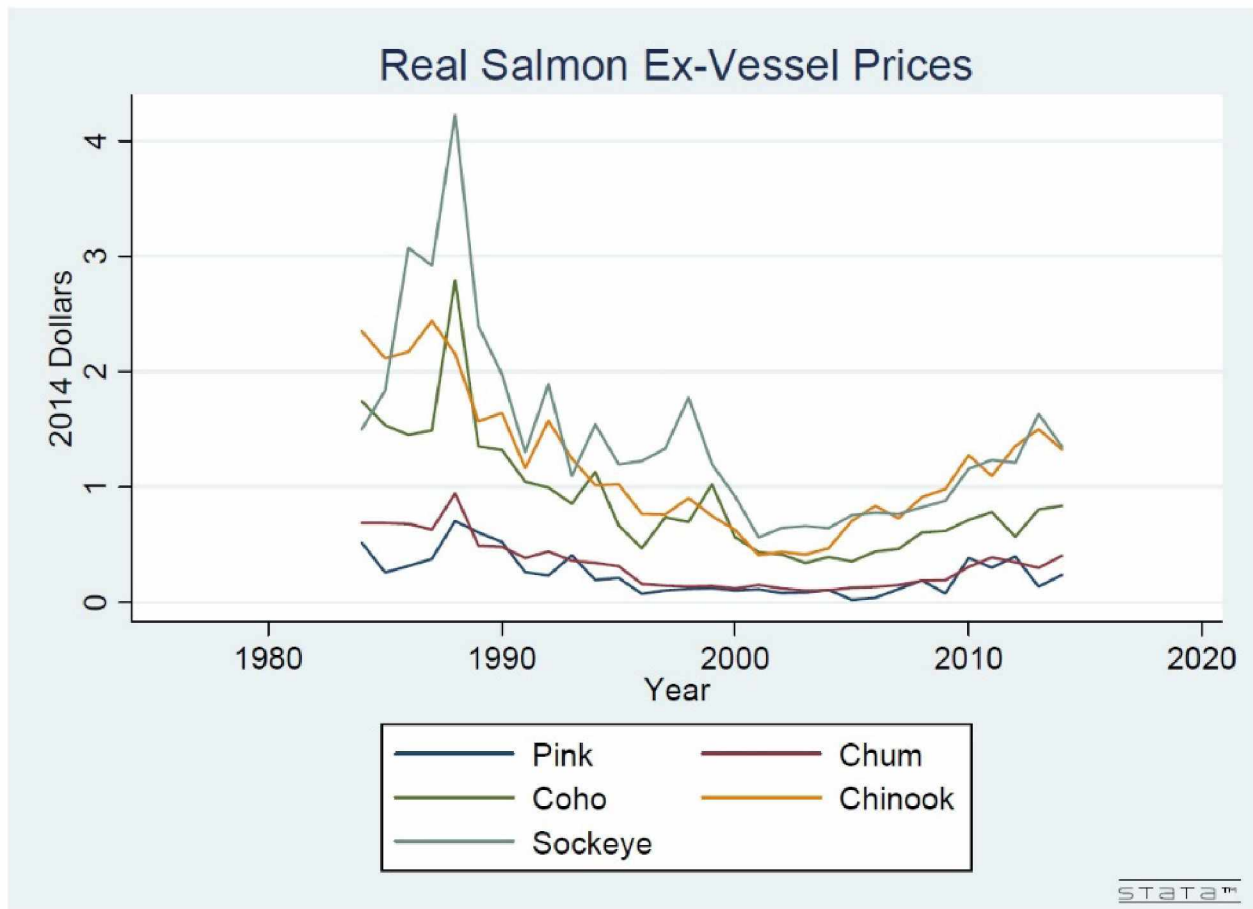


Figure 3. Average ex-vessel salmon prices

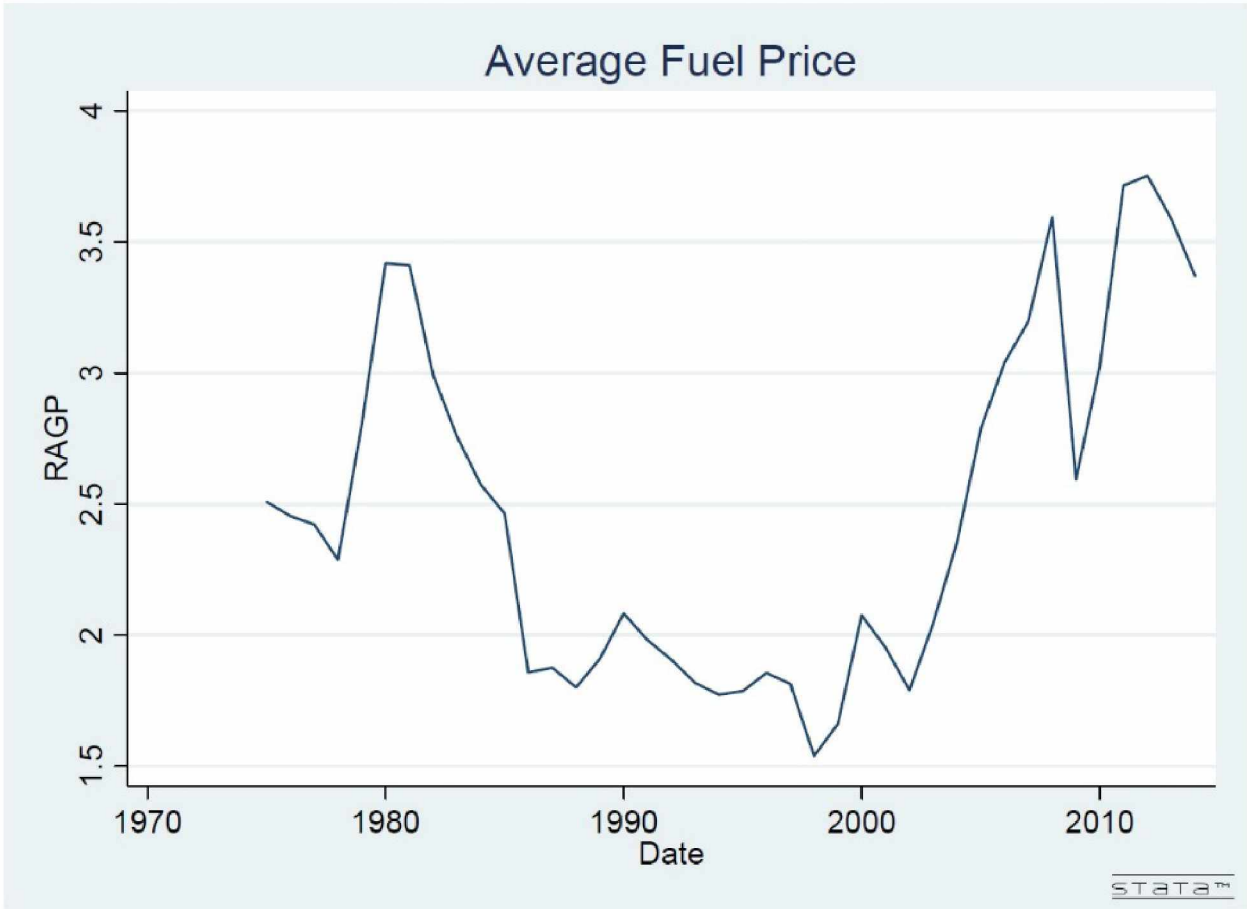


Figure 4. Average gasoline prices

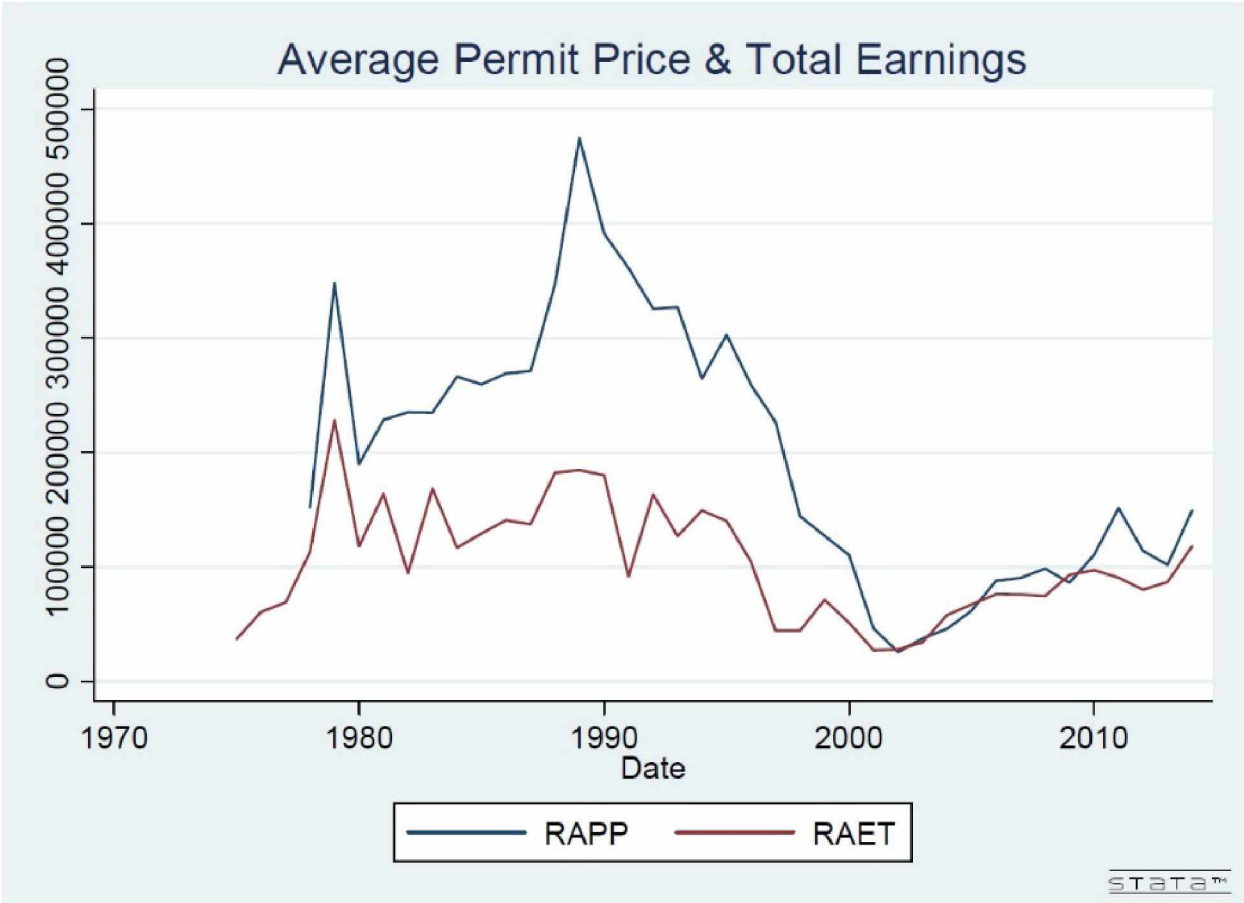


Figure 5. Average permit price and average total earnings

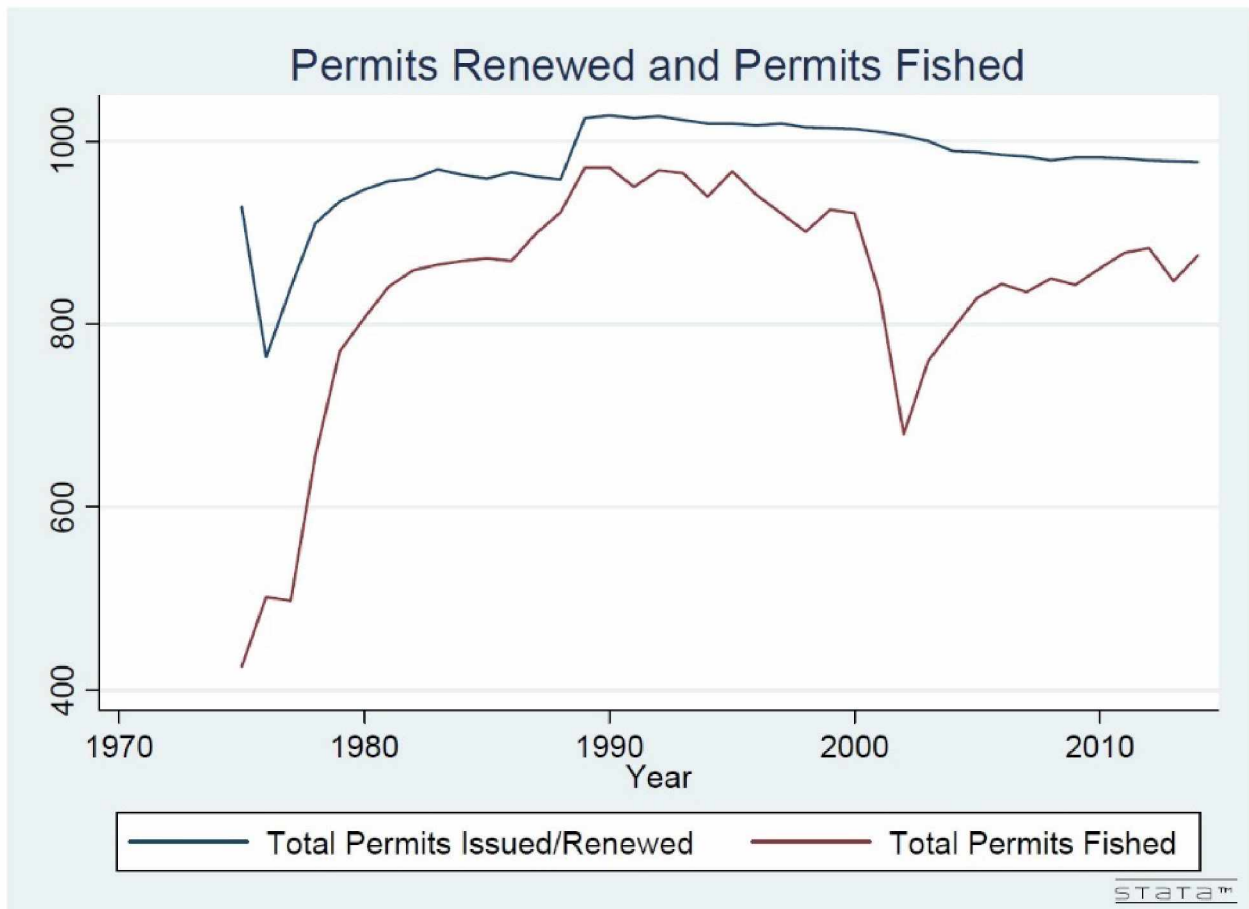


Figure 6. Number of permits fished and permits renewed



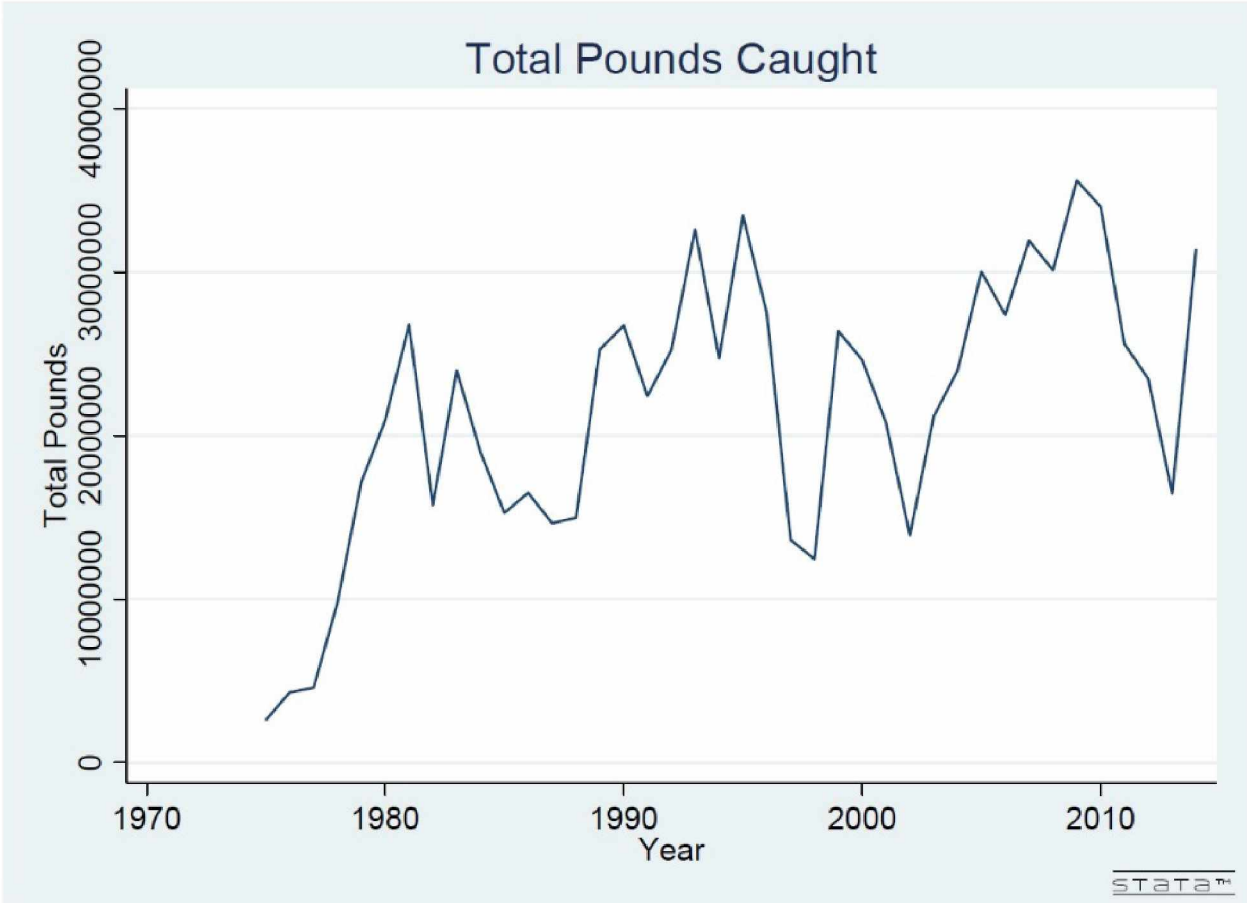


Figure 7. Total pounds of salmon harvested