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Regulation and Policing of the Aquaculture Industry and its Effects on Domestic Aquaculture Production

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REGULATION AND POLICING OF THE AQUACULTURE INDUSTRY AND ITS EFFECTS ON DOMESTIC AQUACULTURE PRODUCTION

by

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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RESEARCH PAPER APPROVAL

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TITLE: REGULATION AND POLICING OF THE AQUACULTURE INDUSTRY AND ITS EFFECTS ON DOMESTIC AQUACULTURE PRODUCTION

MAJOR PROFESSOR: Dr. Jebaraj Asirvatham

Through the use of a multiple regression model and a Chow test, the purpose of this analytical research paper is to determine whether or not United States aquaculture production has decreased in gross production since the mid-1970's. A number of variables were used as possible influencers of the increase in aquacultural products produced between 1960-2013, including population, immigration numbers, median household income, United States consumption of freshwater and marine fish, and seafood commodity prices. A strong correlation was shown between some of the independent variables and the dependent variable, while the calculated F-value was just substantial enough to show a break point in the data that was gathered. While the variables used were not optimal for this regression analysis, this research could still prove useful to economists attempting to see if strict regulations and policing put in place in the mid-1970's greatly affected total production of the United States aquaculture industry.

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INTRODUCTION

From an economic perspective, many government regulations and restrictions can be harmful to the natural order of an industry. This can be especially true when concerning financial policies, such as banking regulations or mandating a minimum wage. One example of a financial policy that may have negative effects was the increase in the upper limit threshold of salary of workers that would receive compensation for overtime hours worked. While many applauded then President Barack Obama's decision to push for this policy, others questioned whether or not workers would see the benefits that would stem from this policy change (e.g. Sumner, Henderson, Calcagno, and Caplan, 2018; Boudreaux, 2016). Another example of poor regulation is the travel industry in the 1970's. Economists feared that regulation was keeping non-competitive businesses operating at the expense of the consumer, resulting in higher airfare or transportation costs. This, compounded with inflation, convinced the government to pass laws deregulating the airline industry in 1978. By the time the effects of the laws came to pass in 1983, "all airlines were free of domestic CAB regulation, which meant they could set their own prices and effectively compete with other carriers" (Ash, 2020). This article went even further to compare inflation adjusted ticket prices from the 1970's to airline tickets today. The article found that the prices were about same between 1970's prices and today but considering the increase in the costs of inputs for those airlines (fuel prices, wages/salaries, construction costs of airplanes, etc.) the deregulations of those airlines was a good thing for the industry. Today, you can find round-trip flights around the United States for less than $75.

Many studies have been done over the impact of regulations on consumers, including industry prices, consumer income equality, and even state-level poverty. A study that covered the

latter particularly was designed to cover the link between federal regulation and state-level poverty and who really caries the burden of those regulations. The creators of the study used the FRASE (Federal Regulation and State Enterprise) index to quantify the federal burden of regulations at the state level. The study was able to find that "…a 10% increase in the effective federal regulatory burden on a state is associated with an approximate 2.5% increase in the poverty rate" (Chambers, McLaughlin, and Stanley, 2018). To reiterate, this study shows that regulation, while implemented with good intentions, has the potential to indirectly, negatively impact part of the population that the regulation most likely aims to help. As a matter of fact, all these studies ended up showing that regulations can and does affect those that the regulations are intended to help. Many studies can be found showing the negative effects of regulations in certain regions, especially small ones.

There are also examples of beneficial regulations that succeed in what they set out to do; economists tend to agree that regulation can be good for issues such as societal health or protecting the environment. Mike Moffatt writes "The U.S. Food and Drug Administration bans harmful drugs, for example; the Occupational Safety and Health Administration protects workers from hazards they may encounter in their jobs; the Environmental Protection Agency seeks to control water and air pollution" (Moffatt, 2020). Most regulations are put in place by publicly elected leaders answering to their constituents, meaning that the policies are the result of good intentions, whether or not they are there to financially benefit the industry it is affecting. This is compounded by the fact that some politicians at the higher level may not truly understand the intricacies of the industries they represent in their home state. In some cases though, the environmental impact can actually have job creation as a side effect, rather than a reduction. One study over the ecological restoration sector found that 126,000 direct jobs are employed in this

sector and another 95,000 people are indirectly employed (BenDor, et al., 2015). There are also examples of legislation that helps societal health, such as regulations on the sale of nicotine products. In the 1980's and 90's, many lawsuits were being filed against tobacco companies because they knew about the negative health risks of smoking yet did nothing to warn consumers of it. Many lawsuits and settlements later, tobacco companies were required to dump billions of funds into public programs to help prevent the adverse health effects of smoking. They were also required to refrain from certain advertising practices and to dissolve some of the biggest tobacco industry organizations (Michon, 2015).

Overall, many people have realized that too much regulation can hinder growth and state governments have taken notice. In 2016, Kentucky unveiled the "Red Tape Reduction" initiative, which included the amending, updating, or eliminating of over 4,500 state regulations. Kevin Wheatley, a writer for Capital Solutions, explains that, "Bevin's [Kentucky's governor at that time] press release included praise from those working in Kentucky's business community, and Republican legislative leaders expressed their support as well" (Wheatley, 2016). This deregulation was meant to help stimulate job growth while making it easier for businesses to follow state guidelines and policies. Other states such as Rhode Island, Idaho, and Virginia have also taken efforts to "reduce red tape" with running a business in the 21st century.

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DOMESTIC AQUACULTURE IN THE UNITED STATES

Since the study is being done explicitly over fishery production in the United States, it is also important to quickly go over the different species that dominate the sector's production. Farmed species vary from nation to nation, with the climate also playing a central role on what can be farmed in that region. Species raised in Norway's fisheries are going to be different than the species raised in Indonesia. The variety of species can also be affected by how much coastal area the nation has access to. Regions such as the Bay of Bengal are constantly being fought over as countries try to claim the fishing rights for as much area as possible. If a country does not have as much access to coastal zones, they may be forced to have inland fisheries that raise a different species than if they had access to those coastal zones.

According to Jeffrey Malison and Christopher Hartleb from Wisconsin University, the United States could have a competitive advantage in "the production of cool- and cold-water species, particularly freshwater species that can be grown on a grain-based diet." They continue by explaining what types of fish are most popular among aquaculturists:

> "Currently, the most popular species for U.S. aquaculture are catfish, Atlantic salmon, rainbow trout, crawfish, hybrid striped bass, tilapia, shrimp, and a variety of shellfish. Beyond these, a wide range of food fish, game fish, baitfish and ornamental species are currently being raised. Additionally, a significant amount of research is being conducted on developing methods for the commercial production of even more species." (Malison, 2005)

There are plenty of other species being experimented with as well to determine which varieties have the best feed-to-product ratio, which varieties are the cleanest in their fisheries, and which

are the least susceptible to disease.

While Malison also mentions the potential for “yellow perch, bluegill, and walleye” as potentially profitable fish to raise, sablefish are also growing as an aquacultural product in Canada and the United States. Wild sablefish numbers dictate a lower and lower quota every year, making them a potential species to take over aquaculture in the Pacific Northwest region. Because of their low quota numbers and high-quality meat, it is a fish that is one of the more expensive aquacultural products per pound in that region. Many studies are currently being done, especially in the Pacific Northwest, to see their optimum diet, reproductive cycles, and what fishery system they acclimate best to. Another reason sablefish could be a desirable fish to raise is their potential ability to live off a majority plant-based diet. If these fish can be raised off a cheaper, plant-based diet rather than on a majority of fish oil or fishmeal, sablefish will be a profitable product for any new investors in this sector. Researchers have found that sablefish are preferable because of their reproductive habits as well. Matthew Cook, Tom Wade, and other researchers ran experiments with sablefish and realized that could recreate conditions that sablefish require to reproduce. They rely on certain temperatures and light to indicate their spawning season; these researchers were able to reproduce that in a fishery. They continue to work with sablefish today. While capture production still greatly outpaces fishery production in the United States, new studies are consistently being done to be as efficient as possible while complying with changing regulation.

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REGULATION IN AQUACULTURE

In the early 20th century, it was becoming apparent that American industries were not producing at a socially optimal level. Factories were producing both air and water pollutions at high levels and usage of farm chemicals was not regulated. Even the meat packing industry drew attention via Upton Sinclair's novel 'The Jungle". With Sinclair motivating the government to enact policy regulating the meat packing industry, it was only a matter of time before the government moved onto other industries and their effect on the environment. Laws affecting the quality of farm chemicals was passed in 1910 while laws protecting grazing land for livestock were passed in 1934. Finally, in 1963 the Clean Air Act was passed in an attempt to curb the production of air pollution and to monitor pollution levels. This was a start in regulating the previously unchecked emission of pollution into the environment.

These regulations were implemented around the time that the "Blue Revolution" began. Beginning in the mid-20th century for some countries, the Blue Revolution saw impressive growth in the aquaculture industry for many countries as they started to commit resources to their domestic fisheries. The Blue Revolution continues today, as countries continue to expand their aquacultural production sectors, especially coastal nations such as Norway, India, and the Republic of Korea.

After the Clean Air Act, the government stepped in to regulate the use of America's freshwater sources and oceanic resources in the 1970's. Starting in 1969, the government imposed regulations that policed how federal agencies can act when the environment is in question. For instance, highway construction that was originally only meant to go the shortest distance from point A to point B would now require an environmental inquiry into the damage

the constructions might cause. In 1972, regulations were enacted that protect and provide stewardship for the coastal zones belonging to the United States. Starting with the introduction of the Coastal Zone Management Progarm, this federal program would help states develop and protect coastal zones through grants following approval at the federal level. This program is completely voluntary, as it only provides funding to develop the coast, rather than demand regulations be put in place to restrict development. After concern grew about privatized use of the shoreline, this act was put in place to help coastal zones be, “developed in the context of increased development of marine and coastal areas, need for more coordinated and consistent governmental efforts, an increase in general environmental consciousness and public recreation demands, and a focus on land-use control nationally” ("Coastal Zone Management Act (1972)”, 2021).

Doubling down in 1972, two more coastal regulations were implemented, including the Marine Mammal Protection Act and National Marine Sanctuary Act, covering specifically ocean habitats and marine mammals. In 1973, the Endangered Species Act was passed to both protect and attempt to increase local populations of endangered animals. This act was very important, as endangered species were now protected with multi-pronged legislation, including fines on individuals threatening endangered species, conservation agreements, experimental populations, and environment consultations, among other facets. Finally, the regulation spree ended in 1976 with the Magnuson-Stevens Fishery Conservation and Management Act (“Regulating Aquaculture”, 2020).

The Magnuson-Stevens Act undoubtedly has the most impact on offshore fisheries, especially underwater marine habitats. This act has the ability to help reduce or completely prevent damage done to these habitats and “provides fishery managers with the tools to mitigate

one of these threats: harms from fishing, specifically destructive commercial fishing practices like bottom trawling—by which large, weighted fishing gear is towed along the ocean floor, physically damaging marine habitats" (Masterson, 2021). While the Magnuson-Stevens Act is wide reaching and allows agencies to place limits on the amount of fish caught or to change management plans, some environmentalists, such as Masterson, believes that the Magnuson-Stevens Act doesn't do enough to reduce damage done to the marine environment.

Unfortunately, with all regulation, while some reap the benefits, others have them reduced or removed entirely. For instance, new laws were introduced in the Fall of 2020 that were put in place to protect endangered marine life, specifically the Dungeness crab. These laws, intended to prevent entanglement in nets from trawling, will restrict the depth at which fishermen/fisheries can reach while allowing an acting director to prematurely close a fishing season, postpone starting the fishing season, close the season altogether, and restrict the amount of fishing gear a vessel can use (Cabral, 2020). This was obviously met with outcry from fisherman who believe they already go to great lengths to prevent the entanglement of endangered species in their nets. Cabral also quotes the President of the California Coast Crab Association, Ben Platt, as opposing the newly introduced regulations. "Although they might sound good on paper, [these regulations] represent a lot of potential closures of this fishery that are completely unnecessary based on the fact that we've already successfully mitigated this issue to what it is today where we're only having a rare interaction."

Another less recent encroachment of regulation on United States fisherman is a lawsuit filed in 2010 by an animal rights group in the hopes to eliminate gillnet fishing. The Karen Beasley Sea Turtle Rescue and Rehabilitation Center filed the lawsuit to protect sea turtles from being snared in commercial fishing nets (Pletl, 2010). Unfortunately, as mentioned earlier, as one

side gains benefits from government regulation, another party has their benefits taken away. In this case, Pletl quotes Jim Nozak, a local fisherman who worked with a businessman whose business was forced to shut down. “The business closed down Jan. 1 and Nozak blames it on increased regulations and the closure of some fisheries.” In 20 years of fishing, Nozak claims to have never even caught a sea turtle. He also says that grouper, snapper, and bass fishing have also been affected by regulation.

For people who know how gillnet fishing works, this regulation makes even less sense in terms of what the laws are trying to do. Gillnets are designed to catch on the targeted fish they are laid out to catch, consisting of a hole that is a specific size to get caught around the gills of a specific fish. According to author Sonia Strobel at Skipper Otto:

> “Each net targets a specific fish, based on the size of the holes. Fish that are too big for a specific net will bounce off and have to go around, while fish that are too small will pass through the nets with no problems. Gillnetting can even discriminate between specific species of salmon. For example, a 5-inch mesh net is good for sockeye salmon in the Nass, as most other species of salmon will not become ensnared when using that mesh size. The mesh size varies depending on the run; anywhere from 4 ½-inch in Barkley Sound up to 5 ⅛-inch in the Skeena.” (Strobel, 2020)

While there is most likely sound research behind the damaging nature of gillnets, it may be overblown in the face of fisherman that use these nets for their livelihood.

Adherence to federal and state regulations is only part of the battle for small fisheries and fishing vessels. Proving your adherence to these regulations most likely includes education in the form of courses or the purchase (and renewal) of a yearly certificate. In Florida, you even need extra licensing if you would like to produce shellfish as an aquacultural product. For first time

applicants of this licensing, business owners must also provide, “a construction plan and associated timeline, species production plan and associated timeline, and a description detailing the implementation of appropriate Aquaculture Best Management Practices” (Rocco, 2021). After completing all of these, plus an in-person inspection of your facility and an annual payment to Florida’s Department of Agriculture and Consumer Services, you need to wait three to four weeks just to see if you get the license.

HEADING 4

THE NEED FOR SUSTAINABLE AQUACULTURE

Without spending too much time on it, it is important to discuss the importance of aquaculture in our modern society and, of course, the motivation for this research paper. The inspiration behind this research paper lies within a TED talk that was posted in February of 2016. Mike Velings, the co-founder of the organization Aqua-Spark, spoke for only 15 minutes in front of a small audience, yet successfully explained societies need for an improved, expanded source of protein and the capacity of our oceans to get us there. “There's great technologies popping up all over the globe.” Velings says “From alternatives to battle disease so we don't need antibiotics and chemicals anymore, to automated feeders that feel when the fish are hungry, so we can save on feed and create less pollution. Software systems that gather data across farms, so we can improve farm practices. There's really cool stuff happening all over the globe” (Velings, 2016).

Velings hit on topics that have been known for years: that the human population is growing at an exponential rate that needs an exponentially productive food supply to support it, especially proteins. He explains that not only are our ocean resources being tapped to feed the human population, but it is also being used to provide feed (fish meal, fish oil, etc.) for more fish raised through aquaculture. Through his investment fund Aqua-Spark, based in the Netherlands, Velings supports businesses along the aquaculture production chain that help develop a sustainable future for aquaculture. Their company helps promote sustainable business practices and the development of breathtaking technology that further increases the efficiency of our fisheries.

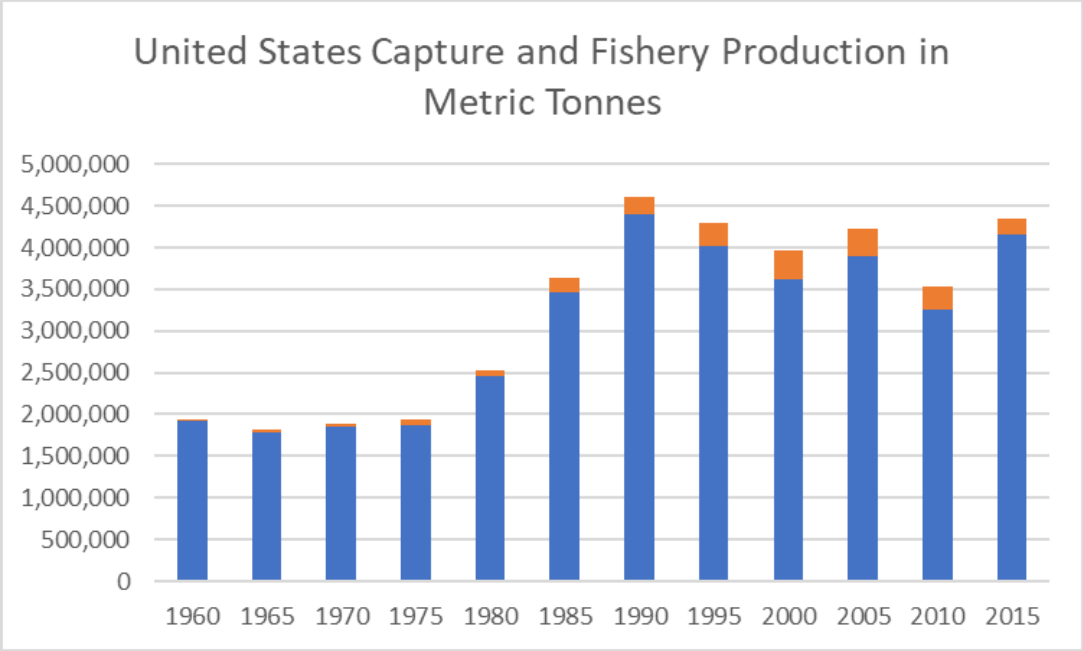

Figure 1. United States Capture and Fishery Production in Metric Tonnes

Figure 1 incorporates data from the Food and Agricultural Organization's website and compares both capture production and fishery/aquaculture production over a fifty-five-year span. The blue sections represent wild caught marine and freshwater fish in metric tonnes and the orange section represents domestically produced marine and freshwater fish in fisheries. The graph shows that, while fishery production has increased over this period, capture production dominates the domestic seafood market and fisheries need sustained, prolonged growth to catch up.

Aqua-Spark's website further explains the need for large-scale, sustainable aquaculture, as global fish consumption is expected to grow to 20% more than it was in 2016. This doesn't include the hope that fishery-produced proteins will start to replace proteins from livestock such as beef, goat, or poultry. Wild-caught populations cannot sustain this increase, so we must turn to the aquaculture industry instead. Velings expands on this thought, explaining that in terms of

resource input, fish are a resource that require very little. “You can farm one pound of fish with just one pound of feed, and depending on species, even less. And why is that? Well, that's because fish, first of all, float. They don't need to stand around all day resisting gravity like we do.”

HEADING 5

PREVIOUS STUDIES

Since intensive aquaculture is relatively new (especially to the United States), previous studies that include solid data/statistics are hard to find. There were a few studies to analyze for an idea on what to expect from my proposed regression model, but nothing that seemed to be a thorough calculation on the effects of regulation. It would have been preferable if there was a study that correlated regulations of a certain government level and a corresponding loss in production or decrease in the number of operations.

A paper that was published through the University of Alaska provided insight on the complexity of regulation affecting aquaculture and why it can be inefficient and biased against private aquaculture enterprises. The paper gave five reasons why domestic aquacultural production has been stunted since its major growth in the 1970's and 1980's (Knapp, 2010). The fifth one mentions the "governance system for leasing and regulating" as a problem that inhibits growth in the aquacultural sector. To paraphrase, Knapp explains that laws and regulations at the federal, state, and local levels combine to form a difficult path to walk. With multiple major government agencies at the federal level, failure to comply with even one agency's rules will prevent the business from opening its doors, regardless of the stance of the rest of the agencies. Knapp further explains that each agency, regardless of what level of government, has narrow-minded vision when it comes to their interests or goals. One agency may focus solely on water usage while another agency intends to promote economic growth, but if one of them is unhappy with the situation, the development may become delayed or not happen at all. After that, there may be problem with local zoning laws; many offshore fisheries not only need coastal zones for their facility, but they may also need land along the coast for their operations.

One study that proved useful, though slightly outdated, was part of a proceeding from an aquacultural symposium in Texas. Though the paper did not cover the impacts of the regulation themselves, it did go over some inefficiencies and complications that was found among the legislation surrounding it. One of the findings was that "as many as 11 federal agencies are directly involved in regulating aquaculture and another 10 are indirectly involved" (DeVoe, 1995). A quick search through certain websites, such as the Food and Agriculture Organization, show that the estimation of twenty agencies directly and indirectly affecting aquaculture in the United States has not changed since 1995. Another point that DeVoe makes is the number of statutes, both binding and nonbinding, that exist at the federal level. The study found that more than 120 statutory programs substantially affect the development of domestic aquaculture, yet only around half of the programs "require a direct compliance response from the fish farmer." Though the federal level may be inefficient in handling legislation, the vast majority of regulation does come from the state level.

As mentioned in an earlier paragraph, licensing can also be an issue with existing operations, but DeVoe explains that licensing to begin an aquaculture operation can be expensive and time consuming. He had found instances of businesses waiting four years or more for permits allowing them to establish their operations. He also explained that some businesses may spend over $100,000 in consultant and legal fees while stating that the first applicant for a National Pollutant Discharge Elimination System permit "spent $150,000 for environmental assessments and legal fees relating to the processing of his permit."

Another study I found useful to guide research was another paper presented at a meeting, this one in 2010 at the International Institute of Fisheries Economics and Trade (IIFET). Jingjie Chu presented data that showed a massive growth in aquacultural production from the late

1970's to the late 1980's. This growth rate was actually higher than the rest of the world's growth rate at that time, but it eventually slowed to a more modest 3.4% from 1998 to 2007. This study, combined with a previous one, found that "a strict regulatory environment, cost uncertainties, weak government advocacy, strong local decision-making authority, large number of coastal landowners' opposition, environmental constraints, and poor marketing" were most likely to blame for the slowed, stunted growth of the aquacultural industry in the United States. The paper goes on to explain that it is not hard to imagine many American businesses investing elsewhere due to "globalization and economic integration" causing a "significant decrease of transportation cost". Though the introduction was very informative and provided insight into the aquaculture industry from different points of view, the rest of the scientific paper, which consisted of a survey of domestic aquaculturists, was extremely helpful as well. The survey found that many large-scale, marine aquaculturists expect to expand their business overseas. More specifically, the survey found that around 25% of the aquaculturists surveyed planned on explicitly expanding their operations in other countries. Since smaller aquacultural businesses do not have the resources to expand overseas, it would make sense that mostly larger businesses would be the ones intent on moving their operations elsewhere. This is compounded by the statistic that the 25% of business that plan on expanding overseas, rather than domestically, employ around 80% of the workforce amongst the surveyed companies. One of Chu's closing remarks in their conclusion is that the United States needs to "further develop aquaculture, retain entrepreneurs, or benefit from the economic returns, then the government needs to improve the regulatory environment so that aquaculturists will have confidence to expand their operations domestically."

HEADING 6

REGRESSION MODEL

Aquacultural data is very hard to gather, especially when looking for historical data that reaches beyond 1980. The Food and Agriculture Organization of the United Nations though was able to provide data detailing aquacultural production per country, species, or year. The United Nations being an international organization, any variables that were measured by their weight were counted in metric tons, rather than the American or British Imperial "ton". The term "tonne" is used throughout this paper as a unit of measurement weighing 1000kg or 2,204.6 pounds.

Although import numbers would have been preferable as a dependent variable, aquacultural production in the United States by volume had historical data that reached to 1950. This data, measured in tonnes, includes all species of freshwater and marine fish produced via fisheries that the FAO records data over ("Global Aquaculture Production", 2020). Again, though import numbers/data would be a much more practical and direct way of seeing if the United States began importing more than producing, aquacultural production data covered many more years of data and could still show a shift away from agricultural production. Simply put, you could still see if growth in this sector keeps up with a growing population that needs a protein source.

There are many variables that could influence the volume of aquaculture products produced in the United States. Two of the most obvious variables with the biggest impact on the dependent variable would be population and household income. Population data from 1950 to 2021 was found through Macrotrends.net ("U.S. Population 1950-2021") and median household income was gathered using the census bureau. The population data was especially important, as

the regression model needed to see if aquacultural production grew at the same rate as the population. There could be multiple reasons that it does not, such as Americans refusing to move away from beef and poultry or simply a preference for wild caught seafood. The median household income chart retrieved from the Census Bureau only reached as far back as 1967 and archived documents were used to fill in the blanks from 1960-1966 (Semega, 2017). The median household data, when retrieved, was not adjusted for 2013 values, so the historical Consumer Price Index was used to account for this. For this calculation (and later, commodity seafood prices), the past value was multiplied by 2013's Consumer Price Index and then divided by the Consumer Price Index of the year in question:

$19.28 (1960 seafood commodity price) x 232.957 (2013 CPI) / 29.6 (1960 CPI)

Immigration data was also used as a possible variable that would affect the amount of aquaculture products demanded and produced in the United States. This data was available through the Migration Policy Institute running from 1820 to the present. The Migration Policy Institute defines this as "persons admitted for lawful permanent residence during the 12-month fiscal year ending September 30 of the year designated."

Other data variables that could help explain the variation in aquaculture production is domestic aquaculture consumption and seafood commodity pricing. Domestic aquaculture consumption, encompassing both freshwater and marine fish (not including mollusks, crustaceans, or cephalopods), was also found through the Food and Agriculture Organization of the United Nations. This food supply consumption (Code lines 2761 and 2764) was listed as volume in tonnes and includes all species of fish that the FAO documents as an aquacultural product. Seafood commodity pricing was available via FRED, the Federal Reserve Bank of St. Louis through the Producer Price Index and the U.S. Bureau of Labor Statistics. As stated above,

it would be best suited for this model if pricing was adjusted for inflation. Because of this, the Consumer Price Index was retrieved and used to account for this:

$5,620 (1960 Median Household Income) x 232.957 (2013 CPI) / 29.6 (1960 CPI)

The regression model, with these five independent variables, should help try to explain the changes in the dependent variable: domestically produced aquacultural products. The FAO had multiple options for downloading this data, including units in protein values, values in terms of currency, or the total weight in tonnes, among other units. Since the dollar value of these products would have too much variability to it (different prices per species, inflation, different taxes/import restrictions, etc.), it was determined that volume would be best used as a sturdy variable that wouldn't fluctuate in value over that time span. The protein value of the data was considered, since it would still span across all countries and much of my sustainability research had to do with protein consumption, but ultimately decided against it since the variety of species that are raised in fisheries fluctuates.

After the regression model is complete, a Chow test, which helps determine if there is a break point in the data provided, was run afterwards. This test was run to see if there is significant difference in aquaculture production before and after 1976; 1976 was the year decided upon since the vast majority of major aquaculture regulations took part from 1970-1976. The Error Sums of Squares was found for the entirety of the data, the first half of the data from 1960-1976, and the second half of the data from 1977-2013. These were then used to determine whether there was a break point in the production of aquaculture in 1976. Unfortunately, enough data was not present to be able to track the production numbers back to 1950, but sixteen years before the last of the major "Blue Revolution" regulations would still provide a good insight into the growth of this sector.

HEADING 7

RESULTS

The first findings of the regression analysis were the relationship between the independent and dependent variables. Understandably, the independent variables that had the most direct relationship to the dependent variable were Median Household Income and Commodity Seafood Prices. For every dollar that Median Household Income went up, domestic aquaculture production went up nearly half a tonne, indicating a positive correlation. Commodity Seafood Prices (as was expected) had a negative correlation; for every dollar that the commodity price of unprocessed and prepared seafood went up, the demand for domestically produced aquaculture products went down by about 1,140 tonnes.

Table 1. Coefficient Values of the Independent Variables

Independent Variable	Value of Coefficient
United States Population	0.006945331
Immigration Numbers	-0.001824407
Inflation Adj. Seafood Commodity	-1141.22558
Inflation Adj. Median Household	0.481309447
Fresh/Marine Fish Consumption	-0.241059146
Intercept	-1004086.615

The other three independent variables were not as viable as the first two variables, as the coefficients did not make nearly as much of an impact. As a matter of fact, it would be expected that the remaining three variables (seafood consumption, population, immigration number) would have positive correlations with the dependent variable. Instead, two of these three variables had negative coefficients of -0.24106, 0.006945, and -0.00182, respectively. Of these

three, demand for aquacultural products was impacted most by consumption of both marine and freshwater fish but showed a negative correlation of interesting value. For every tonne of consumed marine and freshwater fish, demand for domestically produced aquaculture products went down nearly a quarter of a tonne.

Though they are smaller coefficients, these three variables do still show substantial impact. For instance, for every one thousand people added to the United States population (either through birth or immigration), domestic aquaculture production increases by nearly seven tonnes. While immigration does not quite have the impact that the general population increase does, for every one thousand people that legally migrate to the United States, aquaculture production seems to decrease by nearly two tonnes. Likewise, the higher the freshwater and marine fish consumption, the lower the general demand for aquaculture products. This could be explained by the public opinion of farm-raised aquacultural products, especially since wild-caught seafood plays a much bigger role in seafood production.

Though three independent variables did not quite show the relationship I expected them to have with aquaculture production, the R-square value of 0.91 is promising. This shows that the 91% of the data that was collected as the dependent variable can be explained by the independent variables present in the multiple regression analysis. This is confirmed with an adjusted R-square of 0.904, showing that the R-square is an accurate value. I also tested the R-square value by removing some variables and running the regression again. The R-square value fluctuated about as much as the coefficients would in relation to the dependent variable. The standard error for each variable were on par with the coefficients found for each independent variable.

Table 2. Standard Error Value of the Independent Variables

Independent Variable	Standard Error of Variable
United States Population	141158.972565
Immigration Numbers	0.000828
Inflation Adj. Seafood Commodity	0.030541
Inflation Adj. Median Household	312.227084
Fresh/Marine Fish Consumption	2.922215
Intercept	0.052575

After the multiple regression analysis was complete, a Chow test was run to determine whether there was a statistical difference between aquaculture production up until 1976 and after 1976. A Chow test is very useful in determining if there is a change in the slope of the graph after a certain date. This "change" in the slope is known as the breakpoint (if one is proven) and the test is run to see if a "breakpoint" does exist in the data. It is especially useful since this calculation relies on the error of the values, rather than the values themselves. After gathering the Error Sums of Squares for both the restricted and unrestricted model, the calculated F-value for the Chow test was 2.64. Since the regression model has fifty-four observations, you find a critical F-value of 2.32. This Chow test does show a break in the data, even though the test value is not much larger than the critical one. Therefore, with the specific data gathered and the Chow test that was run, it is possible to assume that regulations have made an impact on the production of domestic agricultural products in the United States.

HEADING 8

CONCLUSION

With the results of this regression model and Chow test showing an indication that regulation in the 1970's made a lasting impact on domestic aquaculture production in the United States, you can look at claims of fisherman that regulation is unnecessarily restricting the livelihood of their business. With animal rights groups consistently campaigning for new legislation over protection of our environment and wildlife, it is becoming harder and harder for people who work in those environments to follow them. It is possible that eventually someone who has access to better data (such as fishery numbers, historical import numbers reaching back to 1950's, etc) to run another regression analysis with a Chow test and see if there are breaks in those dependent variables.

While doing research, a couple possible reasons for the break point in the data came to light. One possible reason would be the trend in American industries shifting their production overseas. Demand for seafood could be pushed overseas simply because it is cheaper to produce in other countries. While regulations could be a factor in why production is being pushed overseas, there are a multitude of reasons as to why overseas production is cheaper, such as globalization driving down transportation costs. Another possible reason aquacultural production could be pushed overseas is tariffs. Tariffs could affect demand for products imported from other nations, especially if the tariffs are relatively low. Tariffs do affect trade limitations and prices, but a large portion of aquacultural imports come from ASEAN nations, such as Thailand, Indonesia, and Vietnam. After further research, tariffs on these nations seem to be of negligible value when considering a major impact to demand. Finally, it could also be assumed that demand for certain species of fish has shifted. If demand for certain freshwater fish, such as catfish, had

fallen out of favor with the American consumer and marine fish had taken its place, this study would not be able to account for that. This study simply shows a move away from domestically produced aquaculture products.

If this regression analysis were to be done again with different data, there is numerous hypothetical data that would be best. If it were possible to obtain historical data on the number of fisheries in the United States, obviously that would function as a preferable dependent variable. It would also be desirable to establish a value system to quantify the impact each regulation has on the aquaculture industry. It would also be helpful to have historical import data covering aquacultural products from prominent trade partners, including China and the European Union. Another possibility to directly research the direct impact of legislation would be to identify a recently implemented regulation that is restrictive over its affected region and closely follow any statistical changes in that region's aquacultural sector. This could be difficult to do, since it is difficult to determine which regulations would have an impact that is noticeable through the data that would be gathered over the next ten-to-fifteen-year period. You could also hypothetically do the opposite: locate a law or regulation that has been recently lifted/repealed and gather data that supports the growth of that region's aquacultural sector.

Although further research should be done to determine whether policy does truly substantially affect domestic aquaculture production (and possibly capture production, as well), you could use this relationship in convincing state and federal governments to reevaluate their stance on regulations over the private sector. Responsibilities of imposing federal regulations could be passed down onto smaller governments, such as state governments or county boards. At more local levels, it would also be possible to hire specialists or agencies to suggest what regulations and legislation could be most effective/helpful in reducing negative effects on the

environment and its wildlife.

What possible solutions could be implemented to solve problems with restrictive regulations? The first step would be to consolidate regulating power to a few agencies, preferably ones that have more connections at the state level. The needs of fisheries and the environment vary from region to region and can be better cared for by local agencies and personnel that are better equipped to understand the unique needs of that region. Another possibility is to review any existing laws that may be unnecessary and survey local aquaculturists to see if it is a necessary regulation to enforce. One article that was used for previous studies stated that many fisheries have problems with regulations that are constantly changing. It may be helpful to slowly enact these regulations or to announce the implementation a certain period before it is enforced.

Economists also looking for data over demand for aquacultural products may also find the relationship between aquaculture products and household income and commodity seafood prices useful for other research questions. You could possibly see more specific relationships between aquaculture production and specific commodity pricing, such as shellfish, catfish, or tuna. You could also use adjusted median household income to predict expenditures on certain commodities. The results of this study showing a strong correlative relationship between those independent variables and the dependent variable can be used to plan further research over the impacts of regulations.

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