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Why farm salmon outcompete fishery salmon

Josh Eagle[a,*], Rosamond Naylor[b], Whitney Smith[b]

[a] *Stanford Fisheries Policy Project, Stanford Law School, Crown Quandrangle 559 Nathan Abbott Way, Stanford, CA 94305 8610, USA*
[b] *Center for Environmental Science and Policy, Institute for International Studies, Stanford University, Stanford, CA 94305, USA*

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Abstract

Over the past quarter century, the salmon aquaculture industry has grown rapidly. Price declines caused by the resulting worldwide increase in salmon production have severely impacted the salmon fishing industry, particularly in Alaska. In this paper, we examine the reasons behind the success of farm salmon. In addition to its inherent market advantages, farm salmon has benefitted from a legal structure that limits the ability of the fishing industry to adjust to competition. We look at these fisheries laws and at the impacts of various policy options on the future economic, ecological, and political sustainability of the fishing industry.

Keywords: Salmon; Aquaculture; Fisheries policy; Fishing industry; Seafood markets; Sustainability

1. Introduction

Farm salmon has transformed world salmon markets [1]. In 1980, commercial fisheries produced more than 99 percent of salmon consumed worldwide. Today, only about 40 percent of the world's salmon is caught by commercial fisheries. The rest originates in net-pen farms installed along the coasts of Norway, Scotland, Chile, Canada, and other countries. Alaska, which allows no salmon farming, has seen its share of the market decline from more than 50 percent in 1980 to about 15 percent today. This decline has occurred despite the fact that Alaskan production has remained stable: the total amount of salmon produced by fishing and farming worldwide is now *more than double* what it was a decade ago. Farming has not only increased the overall size of the market, but also has changed the relative amounts of the kinds of salmon products on the market. While the fishing industry has always relied heavily on canning, salmon farmers sell almost exclusively fresh fillets and steaks. An industrial commodity since the first cannery opened in California in the 1860's, salmon is now a "super-commodity," a uniform product available fresh on demand around the globe.

The sharp increase in the production of fresh, farm salmon has rearranged the economic and political landscape of the fishing industry. While commercial landings have remained constant, salmon prices have declined dramatically. Low prices affect both farmers and fishermen, but they have thus far had a greater impact on the fishing industry. Faced with an economic crisis in Alaska, where salmon fishing is the state's largest employer, the United States and Alaskan governments have applied band-aid subsidies in the form of "disaster relief" and large-scale government purchases of canned salmon. This approach—treating the symptoms of the problem rather than the causes—has proven ineffective, and the fishing industry's problems continue to grow. The trend will likely continue until the legal landscape of the fishing industry, which has institutionalized a variety of inefficiencies, is significantly modified.

In our paper, we first describe the evidence that farm salmon is outcompeting fishery salmon, namely the sharp ascent of farm salmon and its economic impact on commercial fisheries.[1] We then attempt to explain the reasons behind the success of farming. In the last part of our paper, we examine the impact of various proposed

*Corresponding author. Tel.: +1-650-725-8415; fax: +1-650-725-8509.
E-mail address: jeagle@stanford.edu (J. Eagle).

[1] We use the term "fishery" salmon instead of "wild" salmon to refer to fish caught by commercial fisheries. The reason is that a large percentage of the fish caught in commercial fisheries (about 20 percent, for example, in Alaska fisheries) are "hatchery fish." Although hatchery fish spend their adult lives in the ocean, they (like farm salmon) spend the first part of their existence in incubators and concrete runways, and are thus not accurately described as "wild" salmon.

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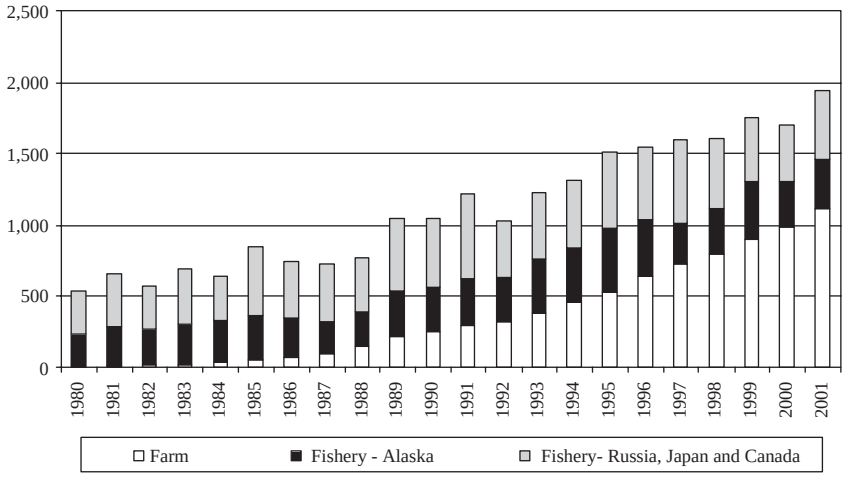

Fig. 1. World salmon supply, 1980–2001 [3].

policy changes on commercial fisheries. We look at how these policy options might impact market competition between fishermen and farmers as well as the ecological, economic, and political sustainability of the fishing industry. This analysis has relevance beyond salmon, in particular with respect to market competitions between other farmed and captured species, including shrimp [2].

2. Evidence that farm salmon is outcompeting fishery salmon

2.1. The growth of farm salmon production

For more than a century, commercial fisheries were the sole source of salmon for the world market. The Big Four salmon fisheries—Alaska, Japan, the USSR, and Canada—produced a combined 800,000 metric tons of salmon in 1985. The late 1980s and early 1990s saw record high catches and profits, particularly in Alaska (Fig. 1). Driven by a favorable climate regime and a successful hatchery program, catches in Alaska peaked at an all-time high of 450,000 tons in 1995, pushing world catches to almost 1,000,000 tons.[2] By the late 1990s, catches in Alaska had returned to more typical levels in the range of 200,000–300,000 tons, and world catches to the neighborhood of 800,000 tons [3].

Commercial salmon farming began in Norway, Washington, Scotland, and British Columbia in the 1970s, but was not a factor in world markets until the mid-1980s, when production reached 50,000 tons [4]. By 1990, farm production had quintupled to more than 250,000 tons. In 1999, world farm salmon production for the first time surpassed salmon fishery production. In 2001, world farm salmon production totaled more than 1,000,000 tons [3].[3]

In the 15 years between 1985 and 2000, farm salmon grew from 6 percent of world salmon production to 58 percent, while fishery salmon saw its percentage of the market decline from 94 to 42 percent. Today, commercial fisheries account for less than 40 percent of total salmon production. The market has so far shown an ability to absorb as much salmon as can be produced. Overall, world production of farm and fishery salmon has increased from 850,000 tons in 1985 to over 1,800,000 tons in 2001 [3].

2.2. The growth in hatchery production

While farm production has increased, so too has the use of hatcheries in commercial fisheries. Hatcheries—in which salmon eggs are fertilized and fish are raised to smolts before being released into the ocean—are used in the lower 48 states and British Columbia with the aim of aiding in the recovery of low or endangered wild populations. In Alaska, Japan, and Russia, hatcheries are used for a different purpose, that is, to increase commercial fishery catches. The past 20 years have seen a sharp increase in the use of hatcheries for this purpose. In Alaska, for example, hatchery fish made up less than 2 percent of commercial landings in 1985. In 2002, hatchery fish accounted for more than 20 percent of Alaska's commercial salmon landings [5]. See Fig. 2.

2.3. Decline of salmon prices and associated economic impacts

Prices for both farm and fishery salmon have fallen in line with the growth in salmon supplies fueled by farms

[2] We use "tons" to mean metric tons. Each metric ton is 1000 kg or 2200 pounds.

[3] For help in visualization, this is equivalent to 2.2 billion pounds or more than 300 million seven-pound salmon.

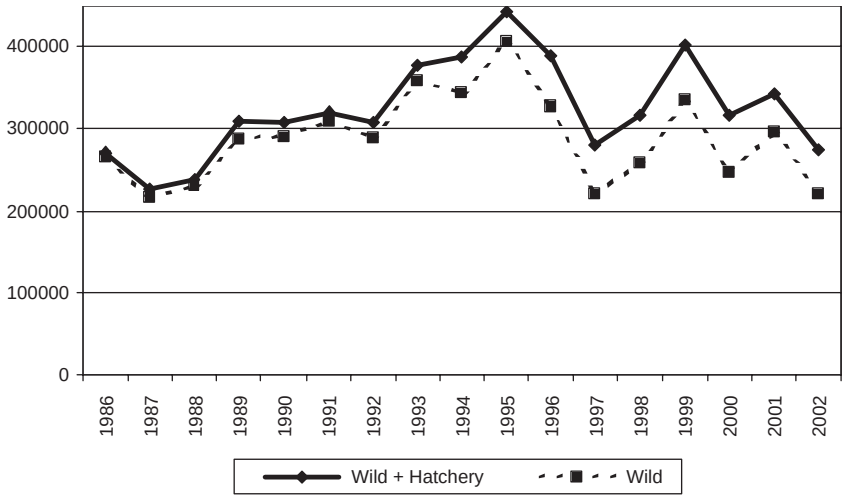

Fig. 2. Wild and hatchery salmon landings in Alaska, 1986–2002.

Table 1
Changes in the prices of salmon since the late 1980s

Species	1988 ex-vessel price per pound[a]	1984–1992 average ex-vessel price per pound	2002 ex-vessel price per pound	Percent change in price from 1984–1992 average (from 1988)
Chinook	2.69	1.93	1.23	−36 (−54)
Chum	0.86	0.45	0.16	−64 (−81)
Coho	1.72	1.02	0.37	−64 (−78)
Pink	0.79	0.34	0.06	−82 (−92)
Sockeye	2.37	1.33	0.55	−59 (−77)
Farm Atlantic[b]	3.11	—	1.21	−61

[a] All prices are in nominal US dollars. Prices for farm Atlantic salmon are wholesale (not ex-vessel).
[b] Prices for farm Atlantic salmon are from 1989 and 2001.

and hatcheries (Table 1). Prices of Atlantic farm salmon have dropped by 61 percent since 1989. From their 1984–1992 average prices, prices of the five species of salmon caught in Alaska's commercial fisheries have dropped by 36–82 percent. From their recent high-water mark in 1988, prices have fallen by 54–92 percent [6]. As a result of these price declines, the ex-vessel value of the Alaska salmon fisheries has declined from more than $700 million in 1988 (242,000 tons landed) to about $160 million (283,000 tons) in 2002.

Under Alaska's limited-entry regulatory system, commercial salmon fishing is divided into 27 permit "areas".[4] A person must hold a specific permit in order to fish in any one of these fisheries. Only a limited number of permits for each fishery exists. As a result of the price declines over the past decade, the values of permits have decreased dramatically (Table 2). The average salmon permit in Alaska lost 79 percent of its value between 1993 and 2002 [7]. The combined asset value of all salmon permits in Alaska dropped by more than $700 million during that time.

[4] There are 15 geographic areas. In most of these, more than one kind of salmon fishing (seine, gillnet, troll, etc.) takes place.

Salmon price changes have also severely impacted incomes in Alaska. It has been estimated that commercial fisheries provide about 20,000 jobs in fishing and processing, and another 15,000 related jobs [8]. Salmon fisheries represent about 50 percent of total direct and indirect statewide employment in the commercial fishing industry [9]. These jobs represent employment for one of every 10 working Alaskans and produce annual income to individuals of more than $1 billion [8]. At current levels of production, each 10 cent per pound decline in salmon prices translates to $66 million in lost income for Alaskan fishermen.

In rural parts of the state, such as the Yukon-Kuskokwim area, commercial salmon fishing has represented the sole or major source of cash income for participants over recent decades. In these remote areas, fishermen depend heavily on income from commercial fishing to purchase necessities. They also use income from commercial fishing to finance their subsistence activities of hunting and fishing. Subsistence provides most of the protein consumed by rural Alaskans—375 pounds per person annually. The estimated replacement cost of this protein is about $2000 per person and almost $300 million statewide [10].

Table 2
Changes in permit prices in the five most valuable Alaska salmon fisheries since 1993

Permit	1993 average sale price[a]	2002 average sale price	Percent change in price from 1993 to 2002
Bristol Bay drift gillnet	199,600	19,700	−90
Southeast drift gillnet	82,200	27,900	−66
Bristol Bay set gillnet	49,100	11,900	−76
Kodiak set gillnet	111,900	56,800	−49
Lower Yukon set gillnet	31,400	12,700	−60

[a] Prices are in nominal US dollars.

Although it is clear that the increased supply of salmon is responsible for the price decline, it is unclear how much of the change is due to farm salmon and how much to hatchery salmon. Although both farms and hatcheries increase the overall supply of salmon, the products of each compete with different sectors of the commercial fishery. Pink and chum fishermen, for example, are probably the most affected by hatcheries, which mainly produce pinks and chums [11]. Sockeye and coho fisheries, on the other hand, are in more direct competition with farm salmon (and trout). Overall, the increase in farm production has a greater effect on the market, because the amount produced by farms annually is about 20 times that produced by hatcheries.

3. Why are farm salmon outcompeting fishery salmon in the marketplace?

The situation in which only a few firms compete to sell identical or differentiated goods is an oligopoly [12]. Firms competing in an oligopoly engage in price and non-price competition. Non-price competition is based on real differences between competing products, on differentiation created in the mind of the consumer via advertising, or on some combination of the two [13].

The world salmon market can be thought of as an oligopoly where farming and fishing function as firms. While both of these "firms" produce salmon, the salmon produced by each industry has different qualities. The most important characteristic of an oligopoly, for purposes of our paper, is that firms have a far more difficult time matching their competitors' advances in product innovation than they do matching price decreases [13]. As discussed below, farm salmon embodies several important innovations in salmon production. Some of these innovations cannot be matched by fishermen; however, current laws make innovation in fishing production more difficult than it should be.

In this section, we look at the market advantages inherent in farm salmon products and salmon farming production methods. We then examine the ways in which current laws impair the fishing industry's ability to compete. Existing salmon fishing laws were enacted in a world where the important competition in the salmon business was among groups of fishermen. While these laws harmed consumers by artificially raising prices, and injured certain sectors of the fishing industry by forcing them out of the fisheries, they did create high employment and profitability within politically favored sectors [14–16]. In the new context of competition with salmon farmers, these same fisheries laws have new, deleterious effects on *all* sectors of the fishing industry.

3.1. The inherent competitive advantages of salmon farming

Salmon farming, like other kinds of livestock operations, has several decided market advantages over the commercial hunting of wild animals. From price declines in the world market for salmon since the advent of farming it can be inferred that salmon farmers are able to produce salmon more cheaply than fishermen can. Farmers also engage in non-price competition with fishermen. "Innovations" in salmon created by farmers include supply and product advantages. *Supply advantages* are features of the farming process that allow that process to conform more closely than the fishing process to market demands. This would include, for example, the ability to control and thus predict supply. *Product advantages* are features of the salmon produced by the farming process that make it more desirable to the market. For example, a more aesthetically pleasing salmon will have a market advantage over a salmon that is less pleasing to the eye.

3.1.1. Supply advantages

The processes of salmon farming are well-suited to meeting market demand, especially in the changing context of global markets [17]. Gunnar Knapp points out that "[w]ith globalization, markets will care more and more about consistency and predictability of production" [18]. Salmon farmers have far greater control over the timing, consistency and quantity of production than do fishermen. Salmon farmers could, for example, produce one ton of 8-pound, light pink Atlantic salmon for a supermarket chain to be delivered on each day of 2004.

As Knapp has also noted, all commercial fisheries face "three fundamental constraints… production is variable, production is uncertain and, production cannot be increased" [18]. Salmon fisheries are no exception. Fishermen are limited to catching the fish that are migrating between June and September into rivers in their districts. They can only catch these fish during an "openings"—a short periods during which fishing is open to permit holders. Some years many salmon return and some years many salmon do not. Climatic shifts,

such as the Pacific Decadal Oscillation, create long-term unpredictability in the size of fish stocks; for example, annual catches of salmon in Alaska have varied five-fold (30–150 million fish) during the last 25 years [19]. When all the fishing boats have filled their holds, or the opening ends, fishermen transfer their catches into a larger boat—a tender—which then takes the fish to the nearest processing facility. These fish are not always treated with care. The exigencies of the situation call for rapid transport and unloading of fish. Fishermen are anxious to get back out on the water for the beginning of the next opening. Fish on the dock must be processed as quickly as possible—"sell it or smell it" goes the expression. Once the fish are in the processing plant, the rush is on to process them as quickly as possible before the next load arrives. Only two processing methods are viable in the busiest plants. The bulk of Alaska salmon are canned, a process than has remained virtually unchanged for more than 100 years.[5] Some of the fish are headed and gutted and then frozen. These will later be sold whole or will be shipped to distant processing plants for further processing into fillets and steaks.

By contrast, a salmon farming company puts a calculated number of smolts into net-pens based on an estimate of market conditions in 2 years when the fish will be ready for market. The number of fish that will be available in 2 years is fairly well certain, given the fact that the company can, for the most part, control the growing conditions on the salmon farm. Although actual production at a given location may be affected by a variety of intervening factors such as disease, storms and marine mammal predation [20–22], the farming industry has thus far proven able to prevent problems at individual sites from disrupting the even and predictable flow of production worldwide. The industry has been able to do this by using a large number of sites spread across the globe. Most of the hundreds of fish farms worldwide (in Norway, Scotland, Chile, and British Columbia) are owned by four large companies. Each of these companies owns facilities in more than one location.

3.1.2. Product advantages

Globalization not only demands a consistent supply of product but also a consistent product. Large retail distributors (supermarket chains and super-discounters such as Price Club) prefer aesthetically pleasing, easy to prepare, repeatable products. As Knapp notes, "[g]lobalization is expanding opportunities for suppliers who can [produce] …appealing and convenient product forms [that are of] consistent quality, traceable" and inexpensive [18]. Because of the constraints imposed by the methods, timing, and location of fishing, the most consistent product salmon fisheries can produce is canned salmon. Cans always look the same. Fisheries have a more difficult time than farm producing steaks and fillets that are consistent in color, taste, and size. Fish are, after all, wild animals.

Farmers gain product advantages for several reasons. First, like other livestock growers, they can control the genetic makeup and diet of the fish they raise, using both to create a product in line with market preferences. Salmon farmers can even produce different hues of flesh for different markets, depending on the amount of synthetic carotenoid added to feed. Second, farmers can harvest their fish at a controlled pace. This allows for shorter times between the ocean and the processing plant. It also allows for more careful handling of fish and more intensive processing, such as filleting and pin-bone removal. Unlike in commercial fisheries, there is no need to rush processing; fish can be kept alive in net-pens until the processing plant is ready to handle them. Finally, the regular size and shape of farm salmon allows for lower cost processing, because they allow for increased mechanization of the process.

3.2. Competitive disadvantages for fisheries created by legislation

Alaska's current salmon fishing laws are the result of a complex, dynamic political economy that has at various times spawned legislative struggles between indigenous peoples and Europeans, Alaskans and lower-48ers, fishermen and fish processors, commercial fishermen and recreational fishermen, Southeasterners and Westerners, urbanites and rural residents, business and conservation, and more [14,15,23]. A complete genealogy of these laws is beyond the scope of this paper. It is sufficient for our purposes to note that the outcome of these conflicts, in Alaska and in other salmon fishing areas, frequently was legislated inefficiency. Conservation was often achieved, for example, not by reducing the number of fishermen, but by requiring the use of less efficient fishing gear. This approach was epitomized by the now-repealed legal mandate that only sail-powered vessels could be used in the Bristol Bay drift gillnet fishery [14,15,24].

The current rules governing salmon fishing in Alaska are fairly simple. Since 1974, permits have been required in order to participate in the state's 27 commercial salmon fisheries.[6] In 1974, permits were issued to those who qualified based on a point system.[7] A permit

[5] Canning developed in the mid-1800s as a necessity, as the only way that salmon could be transformed into a commodity. A short, intense fishing season, a very perishable product, and an extremely remote processing location meant that canning was the only way to profit from salmon.

[6] Alaska Statutes § 16.43.140.

[7] Alaska Statutes § 16.43.250.

entitles its holder to catch as many salmon as possible, using legal fishing gear, within the time limits of an opening. During salmon season, the Alaska Department of Fish and Game periodically "opens" salmon fisheries in each of the 27 fishing districts. Openings can be as short as 24 h.

The permit-holder must be physically present on a fishing vessel in order for that vessel to participate in a fishery.[8,9] A person may not hold more than two permits for any one fishery, although s/he may own permits in more than one fishery.[8] The number of permits per district ranges from 2 to 1878, with a median of 188 [7]. Although permits may be bought and sold, the permit-holder cannot lease nor temporarily transfer the permit to another.[8] Depending on the fishery, legal gear includes hand and power troll lines, drift and set gillnets, and beach and purse seines.

There is one fishery (on the upper Yukon) in which the use of fish wheels is allowed, but generally speaking fish traps and wheels are prohibited in Alaska's commercial salmon fisheries.[10,11,12]

3.2.1. Price disadvantages

Although perhaps not so obviously as the sail-power requirement, this simple set of rules results in fishing costs significantly higher than what they would be under an optimal system. These costs translate directly to higher consumer prices for fishery salmon and smaller profits for fishermen.

The main cause of high costs is the derby system created by Alaska's limited-entry laws. Under a derby system, all permit holders for a given fishery are given the chance to catch as many fish as possible (using legal gear) within the time limits of an opening. A derby approach results in fishing costs that are higher than necessary. First, a derby system contains no mechanism for reducing fishing effort to an economically optimal level. In Alaska's fisheries, the amount of fishing effort expended is not determined by how much effort is needed to catch the fish. Instead, it is determined by how many fishermen qualified for permits in 1974. Thus, in a fishery with 1878 permits, such as the Bristol Bay drift gillnet fishery, there will be 1878 boats trying to catch fish, even if those same fish could be caught with 1000 boats, as estimated by a recent study [25].

Even worse, the derby provides those 1878 permit-holders with every incentive to increase their fishing costs. Because it is a race, a derby fishery rewards those who invest in faster boats with higher storage capacity. In Bristol Bay, boats are equipped with bigger and more fuel-hungry engines. Boats continue to expand in height and width, even though their length has been capped at 32′. In the Bristol Bay study, the authors estimate that excess capacity raised costs by more than $13 million in a fishery where the total gross revenue was only $39 million and net revenue was less than $4 million.

Another estimate of the impact of law on costs comes from a study of salmon wheels and traps. Traps and wheels have the potential to immensely increase fishing efficiency because salmon return to the streams where they were born. Boats are mostly unnecessary in salmon fishing, although more than 6600 were used in 2002 [7]. Colt has estimated that switching from current fishing gear back to fish wheels in Alaska would reduce fishing employment by 6000 jobs—or nearly half the salmon fishing workforce [23].

The inference that salmon fishing labor costs are about 100 percent higher than necessary is corroborated by evidence from the 2002 Chignik salmon cooperative. Under this experiment, the Alaska Board of Fisheries allowed salmon permit holders to form a fishing cooperative for the summer of 2002 if more than 50 percent of the permit holders in the Chignik area voted in favor of doing so.[13] Seventy-seven percent approved the experiment, and the state allocated the cooperative just over 69 percent of the total harvest [26,27]. Preliminary data show that, under the cooperative structure (where profits are distributed among all permits holders, even those who do not actually fish), only about a third to half as many boats were needed in 2002 to catch the same amount of fish as in 2001 [26,27].

One final piece of evidence regarding the impact of laws on production costs can be gleaned from subsidies. Alaska salmon fisheries have been suffering financial distress despite the fact that the state and US governments have poured tens of millions of dollars in subsidies into the fisheries over the past decade. The fishing industry receives subsidies in the form of, among other things, direct payments, loan guarantees, fuel tax credits, enhanced unemployment benefits, and management services [28]. At the urging of Alaska's congressional delegation, for example, the US Department of Agriculture recently purchased $15 million of canned salmon for its food programs [29]. Even the fish are subsidized. Although the US government charges fees or royalties for private access to publicly owned natural

[8] Alaska Statutes § 16.43.150.

[9] 5 Alaska Administrative Code § 39.107(b).

[10] Alaska Statutes § 16.10.070.

[11] Alaska Statutes § 16.10.100.

[12] The fish trap is a floating or fixed device positioned across the migratory path of spawning salmon. It is designed to lead salmon into a holding section from which escape is virtually impossible. The trap can be opened to permit escapement as desired, and can be used to hold fish for a short period of time before processing. Fish wheels consist of two large baskets that turn on an axle. They are rotated by the river current and scoop up passing fish as they turn. Captured fish slide down a chute into a holding box that is emptied several times a day [14,23].

[13] 5 Alaska Administrative Code § 15.359.

resources such as timber, oil, and minerals, fishermen are not required to pay for the salmon they catch.

3.2.2. Production and product disadvantages

As discussed above, salmon fisheries are naturally at a disadvantage to the farming industry in terms of the pace of production. While farmers can collect their fish at a measured tempo over the full year, fishermen catch fish in pulses over a short period of time. The pace advantages of farming create benefits to farmers in the form of better prices (or more price leverage with respect to processors), more processing options, and higher quality.

The current regulatory structure of salmon fishing contributes to fishing's production disadvantages in several ways. First, by creating a derby fishery, in which permit holders begin fishing *en masse* at the commencement of an opening and continue at a rapid pace until the opening ends, legislation exacerbates the industry's inability to provide fresh and carefully processed products. Under the current system, fishermen's only objective is to catch fish as quickly as possible, and then transfer them from boat to tender as quickly as possible. There is very little incentive to treat catches with care. In the holds of tenders, fish from many boats are mixed together. This system creates a quality "tragedy of the commons," in which no one fisherman will be rewarded for treating his catch well. Quality incentives are further diminished because of the price impact of the derby structure, which lowers prices paid to fishermen due to the fact that all of the fish come to the dock at the same time. Finally, processors must shape their processing approach to suit the derby. Only those methods which are capable of preserving large amounts of fish quickly are viable. Until prices for carefully processed products rise significantly higher, so that processors can make a greater overall profit from many fewer fish, processors will continue to use traditional processing methods such as canning.

Second, because of the incentives of the derby, and because of gear bans, laws encourage the use of efficient fishing gear that is harmful to fish quality. Some gear, such as purse seines, is useful for catching fish quickly, but can result in the bruising of fish. These gear types are also not very selective, which means that fishermen and processors waste time dealing with fish that span the quality spectrum. Only a small percentage of Alaska fishery salmon (less than 1 percent by weight) are produced using gear such as trolls (hooks and lines) that is highly protective of fish quality [30].

4. The impact of policy options on sustainability

Because of the economic changes that are occurring in the salmon industry, significant political attention has been focused on fishing and farming. The Alaskan and US governments have begun to take steps aimed at lessening the economic impacts of farming on the fishing industry. Thus far, these steps have consisted mainly of subsidies, as mentioned above, although some funds have also been invested in marketing Alaska salmon.

A number of other policy options have been suggested. These suggestions range from changing laws to permit industry restructuring to increasing government subsidies [31]. In this section, we discuss the probable impact of the proposed policy changes on the fishing industry. In assessing these policies, we choose to use a metric of sustainability despite the fact that some believe it to be an "ill-defined concept" and that perhaps "the effectiveness of policies towards a goal of sustainability cannot be assessed" [32,33]. Specifically, we describe policy options in terms of their impact on the economic, ecological and political sustainability of the industry, beyond their impact on competitiveness. These interlinked concepts represent a way of thinking about business, competition, government, and the environment that transcends traditional theories of competition.

In our analysis, an industry is *economically sustainable* when it is profitable in the long run without input from the public in the form of monetary, environmental, or other subsidies. In other words, such an industry can be successful without imposing costs on the public [34]. An industry is *ecologically sustainable* if it maintains, or is part of a management system that maintains, the natural capital upon which it and other industries depend. In the case of potentially renewable resources such as fish stocks or coastal environments, maintenance means not impairing the ability of the resource to provide services from generation to generation [35]. *Political sustainability* is measured by the extent to which an industry is dependent on, or vulnerable to, political intervention [36]. An industry that is subject to substantial public criticism is less likely to persist over the long term than the one that is not. Similarly, an industry that requires repeated political interventions, e.g., disaster relief appropriations, in order to prosper is less likely to persist than the one that does not. Note that each of the three forms of unsustainability has, at its root, external costs [34].

These three forms of sustainability are often interlinked. For example, industries that impose costs on society through pollution (economically unsustainable) are likely to attract the unwanted attention of the political process (politically unsustainable). Industries that destroy resources they need in order to persist in the course of their operations (ecologically unsustainable) will almost certainly need political intervention in order to remain profitable (politically unsustainable). Industries that destroy their resource base in the course of operations (ecologically unsustainable) impose costs on society by diminishing public capital (economically unsustainable).

4.1. Fisheries policy options

There are at least four categories of possible government responses to the predicament of the fishing industry. First, laws regulating the horizontal structure of the industry can be changed. Such changes would allow for more widespread use of fishing cooperatives, such as the Chignik experiment. Second, the derby system could be modified through a system of fishing rights such as individual fishing quotas. Third, the use of currently barred gear types such as fish wheels and traps could be legalized. Finally, the government might provide various forms of financial assistance to the industry. While each of these possibilities has the potential to both decrease production costs and increase the prices received by fishermen, each also has different implications for sustainability.

4.1.1. Industry restructuring

Which measures are most likely to lead to sustainability? Generally speaking, reforms that would allow or encourage the industry to produce and sell higher-quality, cheaper fish without continual government intervention and without imposing environmental costs on society have the highest "sustainability quotient." Such changes would allow the industry to reduce the current product and production advantages enjoyed by the salmon farming industry.

Cooperatives, individual quotas, and the legalization of fish wheels and traps, all have potential double benefits for the fishing industry. First, these measures will lower production costs, and thus increase competitiveness. As the Chignik experiment showed, cooperatives have great potential for reducing the amount of fishing effort expended [37,38]. Individual quotas, if tradeable, would similarly create a mechanism for reducing effort and cost [39,40]. Wheels and traps have the potential to immensely reduce labor costs in salmon fishing [7]. Second, all of these reforms will slow the pace of fishing. Slowing the pace of fishing can help fishermen compete with the farming industry in several ways. Slower fishing leads to higher prices for fishermen because the delivery of fish to the docks is spread out over time. Slower fishing also leads to higher quality fish because fishermen can take the time to treat each fish with greater care and are rewarded for doing so. One-hundred percent of Chignik cooperative members felt that fish quality had improved as a result of the cooperative strategy [26]. Slower fishing also leads to easier, more customized processing because processors do not have to accommodate extreme pulses in delivery. Use of fish wheels and traps would likely lead to enhanced fish quality because fish remain alive in wheels and traps until they are removed by the fisherman. Furthermore, fishermen can select fish from traps that meet certain standards, and release others alive. It seems clear that more cooperatives, individual quotas, and better gear will decrease costs and the pace of fishing.

These measures all receive high marks for economic and political sustainability once put into place because, by increasing profitability and competitiveness, they will lessen the need for repeated government intervention in the future. They also increase the likelihood that ecological sustainability can be achieved, as higher profit margins combined with limited entry should result in decreased pressure on the resource.

There are, of course, political obstacles that must be overcome at the outset of these programs [41]. The implementation of a system of individual quotas or more efficient gear requires some difficult initial allocation decisions. The question of who is entitled to receive what amount of the reduced supply of fishing privileges is not an easy one, although it has been answered in other fisheries. Both individual quotas and a shift to traps or wheels would also result in fewer fishing jobs and fishing-related jobs. The loss of these jobs would have economic impacts on both individuals and communities, and especially on small and remote communities [42]. It is possible that the economic impacts on these communities would be mitigated by the greater amounts of disposable income created by enhancing efficiency and profitability.

Fishing cooperatives present a different set of problems. For those who opt in to the cooperative, but do not participate in fishing, income will continue, but employment in the fishery will not. What will these idled fishermen do with their time? Will they continue to live in their communities, or will they move elsewhere, taking their incomes out of local economies? Will they attempt to move into other over-capitalized fisheries? Although it is too early to answer these questions with respect to Chignik, a 2002 survey suggests that most non-fishing cooperative members did not attempt to participate in other fisheries [27].

4.1.2. Subsidies to the fishing industry

4.1.2.1. Subsidizing unsustainability: disaster relief, hatcheries, and regulatory subsidies. Among the measures least likely to take fisheries in the proper direction are measures such as "disaster relief" or disguised payments to the industry in the form of government purchases of fishery salmon. These approaches might be useful where the industry involved faced short-term problems such as natural disasters. In the context of long-term changes, though, these kinds of subsidies are not likely to lead to economic sustainability because they encourage marginal operations to remain in business. They allow the industry to ignore fundamental reforms that could increase efficiency and create fishing businesses that are more resilient over the long term.

Delays in necessary restructuring allow farmers to gain hard-to-recapture market share.

Marginal businesses will not fully support ecologically sustainable fishing. As profit margins become smaller, or evaporate, common sense dictates that pressure on managers to increase catch levels will increase, and the industry will fight further environmental regulation. The chances that managers will succumb to industry pressure under this scenario are high because raising quotas is "free" for fisheries managers, and securing annual disaster appropriations is unlikely over long time periods.

Unfortunately, "disaster relief" has so far been the option of choice for federal and state policymakers. In 2001, the Governor of Alaska granted relief with the following declaration:

> WHEREAS, changes in the world salmon market are due to factors beyond these communities' control, including the rapid growth in production of farm salmon in foreign nations such as Chile and Norway that has displaced traditional markets for Alaska wild salmon; and,
>
> WHEREAS, as a result, prices paid for salmon in Bristol Bay, $0.40 a pound this season, is a third of what it was three years ago, and down from a peak of $2.11 in 1988, and prices paid for other salmon species have similarly declined… [43].

These subsidies have prevented one potential ecological benefit of lower prices—lower catches–from materializing in Alaska.

Another common form of subsidy in the salmon industry is the underwriting of hatcheries meant to supplement commercial catches. Hatchery catches now account for 20 percent of commercial landings in Alaska. The increased use of hatcheries is unlikely to lead to economically sustainable fisheries. Hatcheries place more fish on the market, which reduces prices [11]. Hatcheries also impose costs on the environment in the form of both genetic impacts and competition with wild fish for food resources [21,44].

The most ecologically unsustainable form of subsidy is that produced by lax environmental regulations, rules that allow production costs to be externalized function as a subsidy to private producers [45]. Although not well-publicized, salmon fishing has significant environmental externalities. The processing of fishery salmon in Alaska creates huge quantities of effluent—offal and other fish parts [46]. Several coastal areas in Alaska have been listed as impaired under the Clean Water Act due to the large quantities of untreated waste (over 1.5 million tons in Alaska each year) dumped by fish processors directly into the marine environment [46,47]. Under EPA regulations, fish processing plants in Alaska are required only to minimize "[t]he number and quantity of wastes and pollutants …to the extent feasible by managing each effluent waste stream in the most appropriate manner".[14] And, even where stocks are managed so that the number of returning spawners remains high, fishing greatly reduces the amount of salmon potentially available to supply terrestrial systems with nutrients [48]. Dead salmon are critical to the functioning of these nutrient-poor systems, and provide a primary food source for a large number of vertebrate species.

4.1.2.2. Subsidizing sustainability: buybacks and marketing assistance. Other kinds of expenditures are more likely to lead to sustainable fisheries. Under buyout programs (also known as "buyback" or "tie-up" programs), governments purchase licenses, gear, or vessels from fishermen. Both Canada and Washington State have begun to use these programs to address problems of the salmon fishing industry [49,50]. Although implementation of these programs is not without challenges, buyouts have the potential lead to fisheries that are economically, ecologically, and politically more sustainable. By decreasing the amount of capital invested in a fishery, increasing *per capita* rent, and reducing the number of marginal operations, buyouts may enable remaining fishermen to better weather the inevitable up-and-down cycles of the ocean and the market over the long run [51].

There are significant obstacles to the implementation of buyout programs that should not be overlooked. Buyout programs present a number of tricky issues, such as who ought to pay (the government, i.e., taxpayers, or those who remain in the fishery), what ought to be purchased (vessels or permits), and the possibility that vessels remaining in the fleet may be retooled for greater fishing power [52]. And, as with all efficiency-increasing measures, these programs will, by definition, result in unemployment for some fishermen. In addition to the economic impacts to individuals and communities, there is the possibility that fishermen may move to other fisheries, creating capacity problems there.

Finally, marketing assistance is a relatively more sustainable form of subsidy. Unlike disaster relief, marketing subsidies can provide long-term help to the industry even if applied for only a short period of time. Marketing investments may allow the fishing industry to change demand patterns. This is important because the long-term prosperity of fishing industry lies not simply in selling more fish, but in selling more expensive, differentiated fish.

What kind of "innovations" can the fishing industry market in order to distinguish its product from farm salmon? There are at least three possibilities: taste, nutritional value and the positive connotations

[14] 60 Federal Register 34991, 1995.

associated with "wild" fish. To date, data on whether fishery salmon taste better than farm salmon are mixed [53]. With regard to health, some studies have shown that farm salmon have higher fat content and different, less beneficial fatty acid composition than wild salmon [54,55]. Limited tests have also shown that farm salmon contain more dangerous chemical substances than fish that feed in the wild [56–58]. On the other hand, some in the aquaculture industry are of the view that health qualities will eventually be an advantage to the farming industry due to the fact that, unlike fishermen, farmers can control the fish throughout their lives and purify feed contents [59].

Another potential marketing advantage lies in the sociocultural or environmental context of fishery salmon. It is possible that the fishing industry could differentiate its product on its "wild" character, or on the fact that it comes from places such as Alaska that are perceived by the consumer to have certain charismatic or pristine qualities (e.g., [60,61]).[15] Arce and Marsden have described such qualities as the "symbolic meaning of food" [62]. Toward this end, the Alaska Seafood Marketing Institute has been heavily emphasizing the words "Alaska" and "wild" in its marketing promotions [63].[16] The State of Alaska also had its salmon fisheries certified as sustainable by the Marine Stewardship Council.[17] Alaska has also pushed to having its salmon certified by the US Department of Agriculture as "organic." This effort ended unsuccessfully, as the USDA ultimately found that fishermen lacked the necessary control over salmon throughout their life cycles.[18]

If the fishing industry is to eventually prevail on such contextual grounds, it will need to extract itself from a hole dug by fishery managers and politicians in Washington, Oregon and California. Salmon in these states have been listed as endangered or threatened under the Endangered Species Act since the 1980s. These listings have created negative connotations for fishery salmon. Despite the fact that Alaska has no endangered or threatened salmon populations, many consumers are confused. In a 2000 survey performed by ASMI, nearly 40 percent of consumers said they were more likely to buy salmon after being informed that Alaska salmon were not, in fact, endangered [64].

[15] Fortunately for Alaska salmon marketers, the social history of industrial salmon on the Pacific Coast—including severe impacts on native residents and abuse of immigrant workers—is now somewhat distant.

[16] ASMI does not distinguish Alaska hatchery salmon from Alaska wild salmon in its promotions.

[17] This process looked at the health of fish populations, and did not focus on other environmental issues associated with salmon fishing in Alaska.

[18] This ruling is likely to be reversed in the near future. In April of 2003, Senator Ted Stevens of Alaska led a successful push to change the legal definition of "organic".

5. Conclusion

While there is some factual support for the view that Alaska's salmon fisheries are ecologically sustainable, it is clear that they are neither economically nor politically sustainable. This lack of economic and political sustainability will ultimately diminish the ecological sustainability of commercial fishing. As prices have dropped, catches have remained high. Further, the use of hatcheries to supplement commercial catches has increased during this period, and it is foreseeable that future economic downturns will lead to even greater reliance on hatcheries. Finally, marginal businesses are less likely to improve environmental performance than profitable businesses. As fishing becomes less and less economically viable, it is almost certain that environmental regulations will be more and more contested.

Doing nothing does not appear to be a viable option, given the fact that farm salmon is not a temporary phenomenon. Although the needed changes will be painful, they cannot be weighed against the unlikelihood that a pain-free state will magically reappear. As one halibut fisherman told us about his fishery's difficult and painful transition to individual quotas: "it was a choice between a lot of pain now followed by some peace, or lesser amounts of pain forever."

The fishing industry should push for significant legal restructuring aimed at lowering costs and improving quality. Along these same lines, governments should respond to distress not with disaster relief, but with legislative changes. Subsidies, if used, should be aimed at taking the industry as quickly as possible to a more sustainable state. These funds should be used to offset the economic dislocation caused by reforms, not to prop up the industry in its current form. They should also be used to raise the market demand for fishery salmon through advertising.

A differentiated oligopoly allows for the success of a variety of similar but not identical products. Just as US automakers may never be able to outcompete Japanese manufacturers in the small car sector, fishery salmon will probably never be able to outcompete farm salmon on consistency and availability. However, fishery salmon should be able to thrive as the sport utility vehicle of the seafood aisle: a different, though more expensive and slightly less reliable product. This difference has to be created by processing and marketing; it will be more easily exploited after the regulatory changes allowing cheaper and higher quality salmon to be caught have been made.

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