Salmon Fish Traps in Alaska

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Economic History

Salmon cannery at Loring, Alaska in 1897. Reproduced from *The Salmon and Salmon Fisheries of Alaska* by Jefferson F. Moser, 1899

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Abstract

Salmon return faithfully to their stream of birth and can be efficiently caught by fixed gear. But since the introduction at the turn of the century of fish traps to the emerging Alaska commercial salmon fishery, most territorial residents fought for their abolition even while admitting to their technical efficiency. The new State of Alaska immediately banned traps in 1959. I estimate the economic rents generated by the Alaska salmon traps as they were actually deployed and find that they saved roughly $ 4 million 1967$ per year, or about 12% of the ex-vessel value of the catch. I also find strong evidence that the fishermen operating from boats earned zero profits throughout the 20th century. Thus the State's ban on fish traps did allow 6,000 additional people to enter the fishery, but did nothing to boost average earnings.

1. Introduction

> **"W**e Alaskans charge emphatically and can prove that the fish trap is a menace to a continued successful operation of fisheries in Alaska. By this measure you would legalize the destruction of the major industry of Alaska and jeopardize the livelihood of the many resident workers, of the many small businesses; in whole, the entire economic structure of Alaska. For what? The continued exploitation of Alaskan resources by an absentee monopoly that must have a profit far in excess of that of any other business."
>
> --RR Warren, a resident Alaska fisherman, testifying before the U.S. Senate on a bill to formally lease fish trap sites to persons, 1948[1]

> SENATOR MOORE: The claim is made -- and it looks rather a reasonable thing to us -- that if you eliminated the trap you would be eliminating the most efficient operation up there....
>
> DELEGATE BARTLETT: That, I think, Mr. Chairman, is the desire of the people of Alaska -- for the simple reason that they feel that the trap is too efficient. It is like other things in this world that are regulated and governed sometimes out of existence because they do away with employment.[2]

Pacific Salmon return unfailingly to the stream of their birth. The aboriginal Tlingit and Haida Indians had well-developed private property rights to Alaska Salmon that allowed them to

[1] U.S. Senate, *Hearings on S. 1446*, 1948, p. 246
[2] *Hearings on S. 1446*, p. 113

exploit this natural gift (Cooley 1963). The arrival of capitalist civilization caused the deterioration of the resource in an open-access free for all. The fish trap was at the center of the drama.

The Alaska commercial salmon fishery grew up with the new territory beginning in about 1900 and was its economic backbone until World War II. As new canneries were developed throughout coastal Alaska, entrepreneurs realized that they could catch huge amounts of fish in their own large stationary traps, rather using their own boats. Almost immediately, however, local Natives, pioneers, and boat fishermen decided that the commercial fish trap was too efficient for their own welfare. Thus an increasingly pitched political battle raged for 50 years between residents and nonresidents, between labor and capital, and between local fishermen and distant federal bureaucrats. Opposition to the hated fish trap provided the political fuel for the statehood movement, and the new State of Alaska banned the trap as part of its constitution.

The superior technical efficiency of the fish trap for Alaska salmon was unquestioned: Throughout the political debate,[3] no one attempted to figure out whether, and to what extent, the traps were actually generating economic rents from cost efficiencies. In this paper I make an initial attempt at this task. Lacking definitive data on production costs and profits, I draw on several historical sources to estimate the private and social cost savings from fish traps as they were actually deployed in the Alaska salmon fisheries.[4] I find that between their appearance in 1906 and their mandated demise in 1959, they saved roughly $ 4 million in real 1967$ per year, or about 12% of the ex-vessel[5] value of the catch.

The opponents of traps thought that banning them would create significant jobs, population, and economic growth in the infant territory of Alaska. Because the ban actually occurred, I can evaluate this argument. Trap opponents were correct about the volume of employment. I construct and use a relatively complete historical time series on entry into the salmon fishery by boat fishermen to show that the fishermen operating from boats earned zero profits throughout the 20th century. Thus the State's ban on fish traps did allow 6,000 additional

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[3] See, e.g., Karpoff (1982, p. 2) who writes that traps are "the clearly most efficient harvesting means" without providing any supporting evidence or citations. Rogers (1960) makes a similar unsupported assertion. Others with actual fishing experience, such as Asplund (1999) and Scudder (1970) have a more nuanced view of the costs and benefits of competing technologies.

[4] The *optimal* deployment of fish traps is completely hypothetical, since the obvious practices of damming salmon streams and placing traps in narrow bays were outlawed in 1889 and 1906 to avoid complete destruction of the resource.

people to enter the fishery, but did nothing to boost average earnings or stem the tide of new entrants whenever prices rose.

The paper proceeds as follows. Section 2 provides the initial conditions: some biological and historical background. Section 3 discusses fishing technology. Section 4 lays out the regulatory and political constraints within which the technologies and the parties competed. Section 5 develops my estimates of the rents generated by fish traps. Section 6 considers the effects of the trap ban on the employment and earnings of fishermen. Section 7 concludes.

2. Biology and History

Salmon Biology and Relative Value

Pacific Salmon are anadramous; they return to the stream of their birth after spending a fixed lifespan in the ocean. The annual "run" takes place during several weeks each summer. Some fish swim only a few hundred yards upstream; others travel 2,000 miles up the Yukon River at speeds of 50 miles a day against the current. Since each fish returns to the unique stream in which it was born, and many streams harbor multiple runs, there are about 10,000 different spawning populations that must be maintained separately. Stream-jumping only occurs in geologic time. It was not until well into the 20th century that biologists understood that each run is genetically unique and that successful long-term conservation of the aggregate fish stock requires adequate "escapement" of spawning fish into each and every stream (Cooley 1963).

Salmon begin to deteriorate physically when they leave salt water. They often school up before leaving the ocean for a freshwater bay. They like to swim very close to the beach while moving along the ocean shoreline.

There are five species of salmon, but only three are commercially important during the study period. The red (sometimes called "sockeye") salmon is most valuable. Canned, it commanded a price premium of about 50% over the far more abundant pink salmon. The low-value chum salmon is used by Natives to feed their dogs, but it too has been canned in abundance. Between 1896 and Alaska statehood in 1959, the salmon industry caught and sold almost 4 billion salmon. About 1.2 billion of these were reds, about 2 billion pinks.

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[5] the term ex-vessel refers to the price of the raw fish when transferred from catcher to canner.

The Aboriginal Fishery

The economy of the coastal Indians -- the Tlingits and Haidas -- was built on the pacific salmon. It was easy to catch and easy to store (by sun drying or smoking) with little loss of nutrition. One man could, in a few hours, easily catch several hundred fish -- more than enough to supply himself for a full year. This ease of capture supported a large amount of leisure-based activity: arts & crafts, ritual, and, in some cases, warfare and slave taking. Because of the immense river systems provided by the Yukon and Kuskokwim rivers, thousands of inland Natives were able to make salmon an integral part of their diet in areas as far as 1,500 miles from the ocean. Hewes estimated that 76,000 Alaska Natives were principally reliant on Salmon and the total aboriginal take was about 33 million pounds of fish (Hewes 1957). This amount represents about 25% of the commercial take in 1960.

The Indians had well-developed property rights to particular salmon streams and defended them from neighboring clans and from the Russians. The rights were vested with the nuclear family or clan, not the individual (Price 1990). In times of scarcity a clan could fish in a neighboring clan's stream by paying a royalty on the catch. (Rogers 1960)

Because they had well-developed rights, the Indians could concentrate on maximum efficiency in fishing technology. They used weirs, special woven baskets, and other direct in-stream methods to take salmon. Writing in 1838, Robert Campbell of the Hudson's Bay Company noted how the Tlingits would catch thousands of fish by a combination of a dam built across the great Stikine River and the use of spears. Price (1990) notes how the salmon fishing was a grand social ritual as well as a subsistence activity.

During the 1800s, the Russians occupied parts of Alaska territory. They too used nets and traps in streams, often taking as many as 1,000 fish per day directly out of one river. The historical record shows conflicting views of who was "in control" of the fishery and the territory of southeast Alaska during this period.

The Gold Rush and the Arrival of the Canneries

The Klondike gold rush caused a dramatic increase in the non-Native population: from 1,738 in 1890 to 8,707 in 1900. Diseases brought by these pioneers cut down the Native population from perhaps 12,000 Natives pre-contact to about 6,000 by 1900 (Rogers 1960).

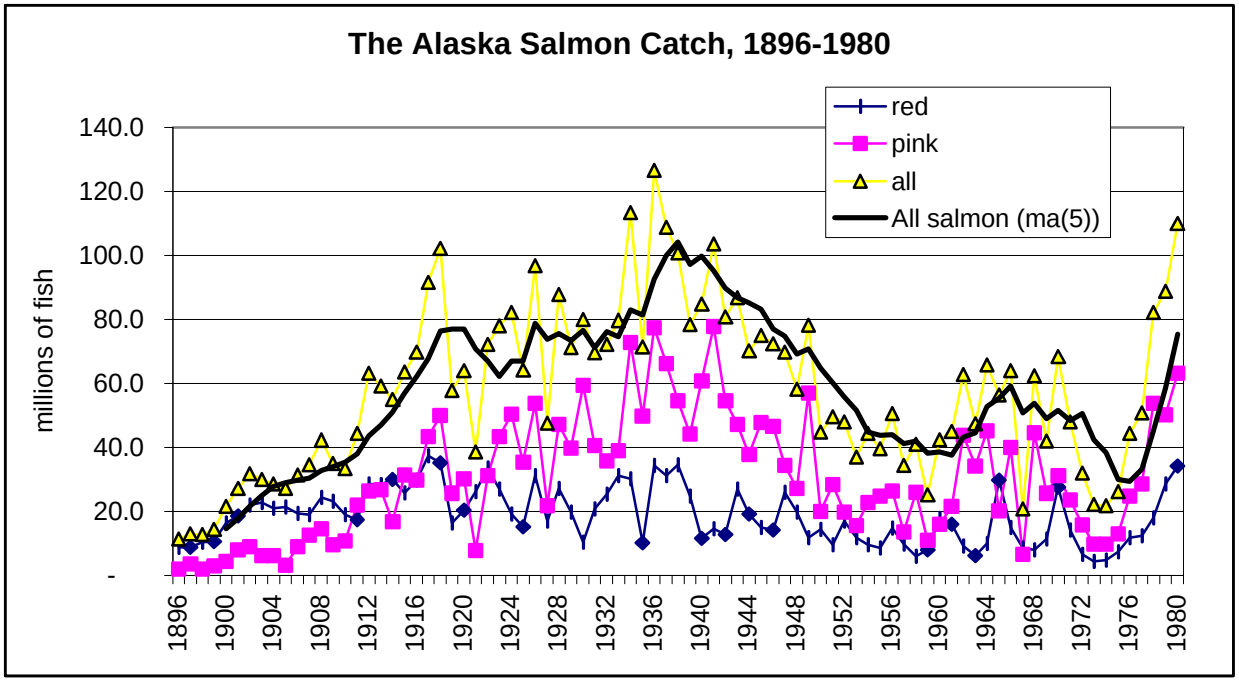
The first salmon canneries were built in 1878 in Sitka and Klawock. From the start, Canners used imported Chinese labor, but these initial canneries, at least, made peace with the Indians by purchasing salmon from them or paying them to catch it. (Price 1990 p 51).

The number of Canneries grew rapidly between 1878 and 1920. By 1920 there were more than 100 operating mostly in the protected waterways of the Southeast region, but several operations had been set up all along the coast. The area of Southwest Alaska known as Bristol Bay was discovered to have the world's largest run of red salmon and canneries were established there despite the high cost of getting to and from the area.

The Commercial Salmon Catch

The total commercial catch over the past century is shown in Figure 1. The catch grew rapidly with the expansion of the cannery capacity through 1920. Originally the higher-valued red salmon were the major species taken. As the red supply was locally depleted in various streams, the industry turned to pink salmon; this lower grade species fueled the growth in total catch. The marked low levels of red salmon catch for the years 1920, 1925, 1930, 1935, and 1940 illustrate how the depletion of a particular cohort of red salmon can be perpetuated through successive breeding cycles (the red has a 5-year lifespan).

FIGURE 1: THE ALASKA COMMERCIAL SALMON CATCH: 1896-1980



A long-run decline in the catch began after the peak year of 1939. It was temporarily arrested after Alaska became a state and instituted new conservation measures, including the banning of fish traps. An aggressive hatchery program was also commenced. But the inexorable entry of more gear coincided with further decline to record low levels in 1972. This decline helped promote the "enclosure" of the salmon fishery in 1973 under a limited entry permit system. Since then the catch has rebounded to near-record levels.

Salmon Industry Structure and Conduct

The canning industry had to concentrate capital, labor, and materials in remote locations for the intense but very short salmon runs. They used imported (usually Chinese) labor in the canneries and often hired fishermen off the docks in San Francisco and Seattle. In 1919 the FTC reported that 5 companies controlled 53% of the pack; by 1939 it was 9 companies that controlled 58%, in 1959 the 6 largest concerns produced 53%. (Cooley 1963).

As the local Alaska labor supply gradually increased, nonresident unions worked hard to retain their jobs and preferential status. This made Alaskans furious not only with capital but with nonresident labor. Faced with this labor turmoil, the canneries were always amenable to more substitution of capital for labor.

3. Fishing Technology

There were three competitive methods of catching salmon commercially: gill nets, purse seines, and traps. The term "mobile gear" applies to gill nets and purse seines towed by boats. The term "fixed gear" applies to traps and gill nets or seines secured to the shore.

Mobile Gear

The drift gillnet is towed by a boat into or across the path of a group of salmon. It seems to have an advantage in shallower water and is (still) widely used in Bristol Bay. It requires a smaller boat to maneuver and only 2 people to operate.

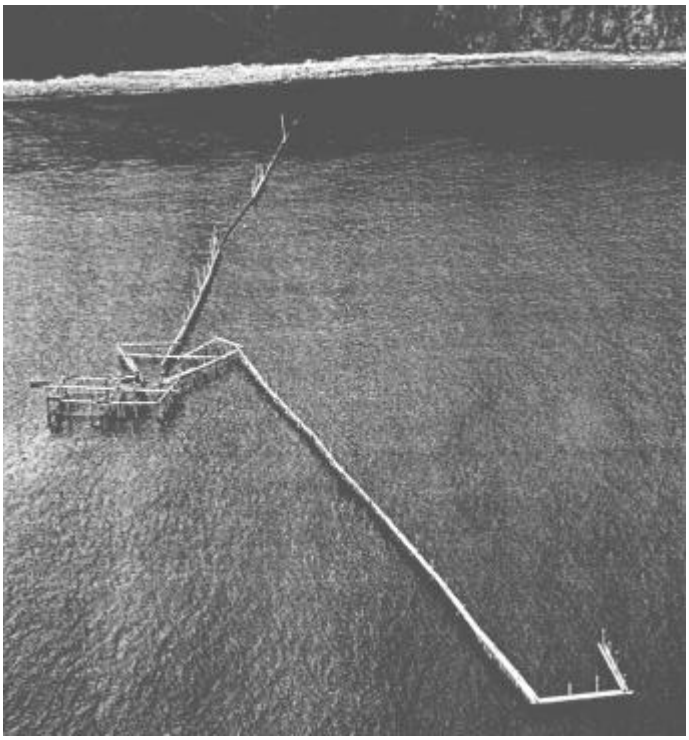
The purse seine is a large net maneuvered around a congregation of fish in deeper water by two boats. It operates, like an upside-down purse, with a drawstring on the bottom. The net is anchored to the main vessel while a smaller skiff encircles the fish. The efficiency of purse seine gear increased dramatically in 1910 when the first gasoline-powered special purpose purse seiner

was deployed. The purse seine requires a much larger capital investment than the gillnet boat -- about $15,000 in 1948 -- and takes 6 men to operate. (Price 1990, Asplund 1998). However, the technology had an efficiency that could rival that of the trap, sometimes catching as much as 55,000 fish in a single day (Scudder 1970.)

Fixed Gear: The Fish Trap

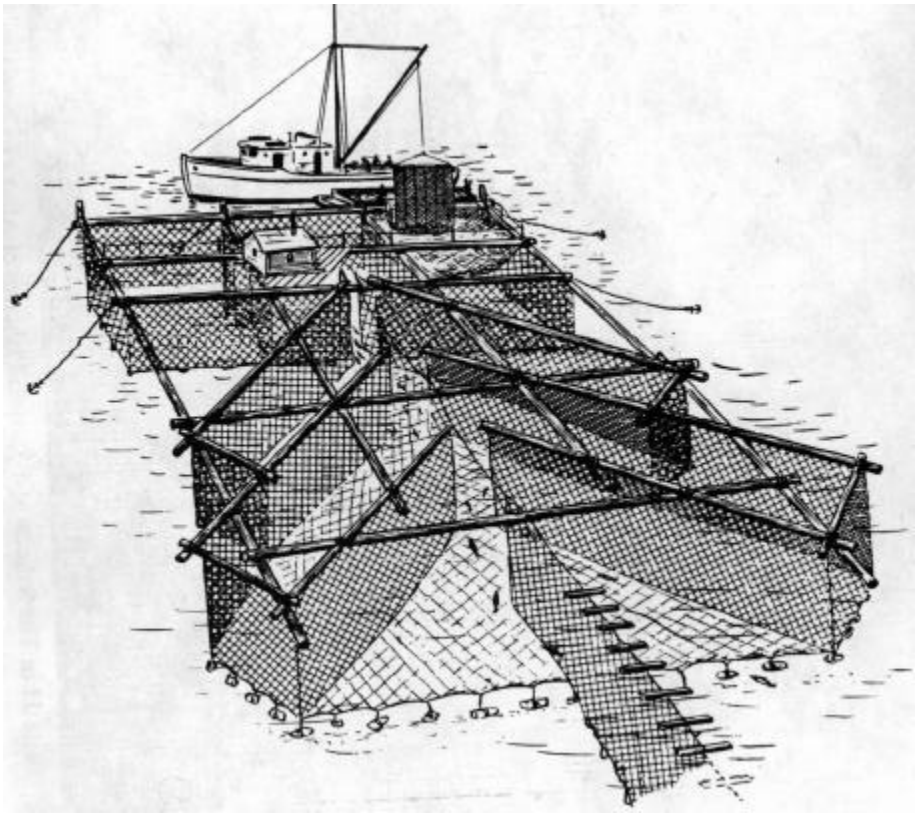
The fencing off of entire streams was banned in 1889. By 1906 no fixed gear was allowed in rivers or narrow bays. Thus the commercial fish trap evolved to take advantage of the Salmon's tendency to migrate along the main ocean shore and to congregate at the mouths of bays. An early enthusiast writing in 1909 described the trap operations thus:

> It is most simple in its construction, and consists of a long arm of piling and netting reaching out at an angle into the sea. The fish are stopped by the net, which is fastened to the piles and extends to the very bottom of the water. Continuing their way up against the trend of the water they pass through a narrow funnel which opens into the trap proper. The trap is completely covered on the bottom with a great net and the fish, crowding through the opening, find themselves in a trap from which there is no escape...This immense net is lifted from the inside of the trap at stated periods and the catch is dumped unceremoniously into waiting scows. The capacity of the scows used in Alaska is about twenty thousand fish, and it is not uncommon to see two of these coming from one trap completely filled with flapping, gasping salmon. (Kirkwood 1909, p. 35)



Pile-driven fish trap. The allowable length of the "jigger" extending seaward from the heart of the trap was a contentious issue with fishery regulators

There are two types of traps. The pile-driven trap, shown in the photograph above, was the original technology that evolved from smaller collections of hand-driven stakes. It was expensive to set up, as the piles had to be re-driven every year. The only major technical innovation in traps occurred in 1907 when the floating trap was introduced. The "floater" featured floating logs that were anchored to the seafloor. Wire was hung from this frame, which could be towed into a protected bay for the winter. The illustration below shows the central part of a floating trap. Although the floater was much cheaper to construct and install, it could not withstand the harsher weather and exposure to the open sea found in many western Alaska fishing locations. Floaters dominated the protected waters of Southeast.



Floating salmon trap. The lead extends from the bottom of the drawing to the shore. This trap has no jigger. Illustration by G.T. Sundstrom in *Commercial Gear of the United States,* Fish and Wildlife Circular 109.

Reasons why Traps May not Have Been Economically Efficient

Although the traps were undoubtedly impressive in their catching power, it does not follow that they were economically efficient in widespread use, just as supposedly "free" hydroelectric energy can be very costly to harness. The fish traps were substantial construction projects, and they needed to be largely rebuilt each year. They also had to be placed in the proper location, much as an oil well must be drilled in the right location. Scudder noted that "a matter of a few feet in the location of the tailhold could mean the difference between success and failure."[6] Fishing industry lobbyists were quick to point out that these scouting and "dry hole" costs were substantial. One asserted that $400,000 was spent in locating and perfecting the sites of 11 productive traps.[7]

[6] Scudder (1970) p.6
[7] Philip MacBride, *Hearings on S. 1446*, p. 27

The traps were immobile, so the product still needed transportation to the cannery if the trap could not be sited close to it. Also, if a run were somehow altered after the trap had been set up it was too late to do anything about it.

Traps also piled the risk of a bad run on to the owners instead of sharing it with the catchers -- a significant problem in an industry that had to commit itself to large purchases of inputs "before a single fish showed up."

Reasons why Traps may Have Been Very Efficient

Countering these potential economic drawbacks were the more obvious advantages of the traps. Most obvious were their low labor requirements, a particularly important feature in areas with no local labor force and a generally attractive feature to cannery management that had to deal with an increasingly diverse and powerful set of unions. (A fishermen's strike in 1912 revealed the cooperative nature of the trap as a fish-catching servant).

Another important benefit before the advent of ice-carrying tenders was the ability of traps to store the fish live. This allowed the canneries to smooth their flow of raw fish to the production lines during periods when the fisheries were closed for conservation or during natural swings in the runs. Prior to the 1889 law banning the practice, many traps were located right in rivers next to a cannery. One long-time cannery worker from Chignik was quoted as saying "When I want 15,000 salmon, I say, 'Joe, go up to the trap and get me 15,000 salmon.' "[8]

Finally, the traps provided the closest thing to an exclusive fishing zone that could be gotten because boats were prohibited within 300 feet of a trap. By regulation, they kept out other traps for a mile and boats for 300 feet in any direction from the trap, although as the packers' lobbyist W.C. Arnold put it, "In practice, they are right there." (Hearings1, p. 58)

4. Politics and Regulation

Federal Regulation and the White Act

Other territories (such as Hawaii) controlled their own fisheries. But the salmon industry was able to prevent this transfer of power to the territory of Alaska in 1912. One reason they

[8] Scudder (1970) p. 6

opposed the transfer was because the people of Alaska were already hostile to traps as a result of a fisherman's strike that year. As a result various federal agencies -- the Treasury Department, the Commerce Department, and ultimately the Interior Department -- ran the salmon fishery.

The Treasury Department attempted to control the initial depletion of entire salmon runs by gradually prohibiting fishing and especially traps in streams, then rivers, and then bays. By 1906 it was using closures of specific areas and for specific times in a sometimes-vain effort to preserve the resource. In an extraordinary but short-lived effort to rationalize the fishery, Commerce Secretary Herbert Hoover persuaded President Harding to create several Fishery Reserves in 1922. The reserves were closed to entry unless a permit was obtained, allowing Hoover's Bureau of Fisheries to regulate fishing effort directly. The initial effects of this policy were almost revolutionary. In the Karluk River, for example all fishing was prohibited except by two canners, who were able to take all the fish they needed directly from the river using a simple weir!

The attempt to "enclose" the fisheries by executive order met with fierce legal and political resistance from Alaskans. The White Act of 1924 was the result of the ensuing political battle and remained the foundation of all further federal regulation through 1959. The act prescribed an escapement goal of 50% of all Salmon and allowed the Secretary of Commerce to regulate all aspects of Alaska salmon fishing *except* for access to the fishery. No "exclusive right of fishery shall be granted.[9]" The House version of the bill abolished fish traps, but the Senators from Washington blocked that provision.

Fish Traps and Indians

The noted anthropologist George Emmons noted that the Salmon industry in 1905 provided employment (much within the canneries) for 2,371 natives out of a total Tlingit and Haida population of 6,000. (Price p. 75). Besides appropriating their major food source, the fish trap replaced purchases from Native fishermen and made Natives the first group to join a growing chorus of protest against the brutal efficiency of the trap. As one unidentified Haida Indian put it,

> The cannery owners do not hire as many natives as they did a few years ago, but instead they are putting in what they call fish traps, and these traps require very few laborers...(Price p. 64)

[9] Cooley (1963) p. 119

Recognizing the singular importance of the salmon to their participation in the cash economy, as well as their continued needs for subsistence fishing, the Alaska Native Brotherhood had an interesting, and generally "assimilationist," platform in 1921:

Equality of Natives before the law
Equal rights and privileges
Equal schools
Abolition of fish traps
A political convention
Use of one language (English)
One COUNTRY, ONE FLAG.[10]

The White Act further hurt Natives by prohibiting subsistence fishing within streams. The Indians were conflicted about asking for full-blown reservations but worked with the Interior Department and pressed claims for aboriginal fishing rights. Eventually, the courts ruled that they had abandoned those rights when they went to work in the canneries for cash. Eventually, the Indians asked for reservations including fishing rights, but were rejected in that request by the Interior Department.

Up until about 1930 most of the people using seine boats were Natives, but after the onset of the depression whites began to enter the fishery: For example, Price cites federal statistics showing that in 1929, "practically all" seiners were Natives. In 1934, "eight percent" of the Ketchikan district's seiners were Natives. But by the 1940s, the percentage in the Wrangell district was only 20% all Native plus 60% mixed race crews. Price asserts based on these data that Natives -- the most immobile part of the labor force -- suffered the brunt of the displacement effects of traps.

Fish Traps as a Political Lightning Rod

Opposition to the traps developed quickly among territorial residents. Traps displaced local seiners' labor and reduced their purchases of inputs from local business. The initial stories about phenomenal catches spread by word of mouth and were, no doubt, amplified beyond the actual values involved. The concentration of trap ownership in the hands of a handful of nonresident corporations was particularly galling. According to Alaska economist George Rogers (1960), the trap represented the "very quintessence of absenteeism" -- absentee private

[10] The 1920-21 Alaska Native Brotherhood platform, quoted in Price (1990), p. 91

capital in cahoots with absentee federal regulation. Pondering the political landscape shortly after traps were banned by the new State of Alaska, Rogers suggested that

> the traps have long been the principal *bete noire* of Alaskan political demonology. The anti-trap case has been emotionally distorted to the point where even Alaskans who have never seen one would readily brand them as "fish killers" and look upon them as the very embodiment of evil in this world....It could also be said that as long as traps continued in operation, they could serve a number of useful political purposes. The local candidate for public office could always resort to taking a staunch stand against traps and count on the other issues being drowned out by ringing applause.....[11]

Economist James Crutchfield, writing ten years later, agrees with this general assessment:

> The years of discrimination and political frustration led Alaskans to articulate the question of control of the fisheries on a straight "we-they" basis that left little room for rational discussion of the biological and economic complexities of the resource and the industry.[12]

Alaska political entrepreneurs used the trap issue to rally the citizens of the territory around the quest for statehood. Eventually they wrested control of the territorial legislature from the cannery interests, who had long controlled what they once called "a toy for Alaskans to play politics with."[13] When in 1948 the cannery interests saw a new state with full control over its fisheries looming on the horizon, they launched an all-out effort to have the federal government issue formal 15-year leases to their currently occupied trap sites. The Alaska territorial government countered with a 1948 statewide referendum that drew the largest voter turnout on record to support the abolition of fish traps by an eight to one margin. The leasing measure failed, as similar measures had failed for years.

Finally, Alaska became a state and after a last ditch attempt by the cannery interests to keep the fisheries under federal control failed, all fish traps were abolished in 1960. The total salmon catch for 1959 had hit an all-time low. A new state Department of Fish and Game initiated research and conservation efforts, but these did little to improve the salmon runs in the face of a large influx of new entrants into the seine and drift gillnet fisheries. By 1972, with runs again at an all-time low, Alaskans were ready to abandon the concept of open access to the salmon fishery. They approved a constitutional amendment legalizing the issuance of a fixed

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[11] Rogers (1960) p. 13
[12] Crutchfield & Ponetcorvo (1969) p. 55
[13] Cooley (1963) p. 183

number of tradable limited entry permits. Under this management regime, the salmon catch has increased dramatically, as shown in Figure 1.

5. The Relative Efficiency of Traps

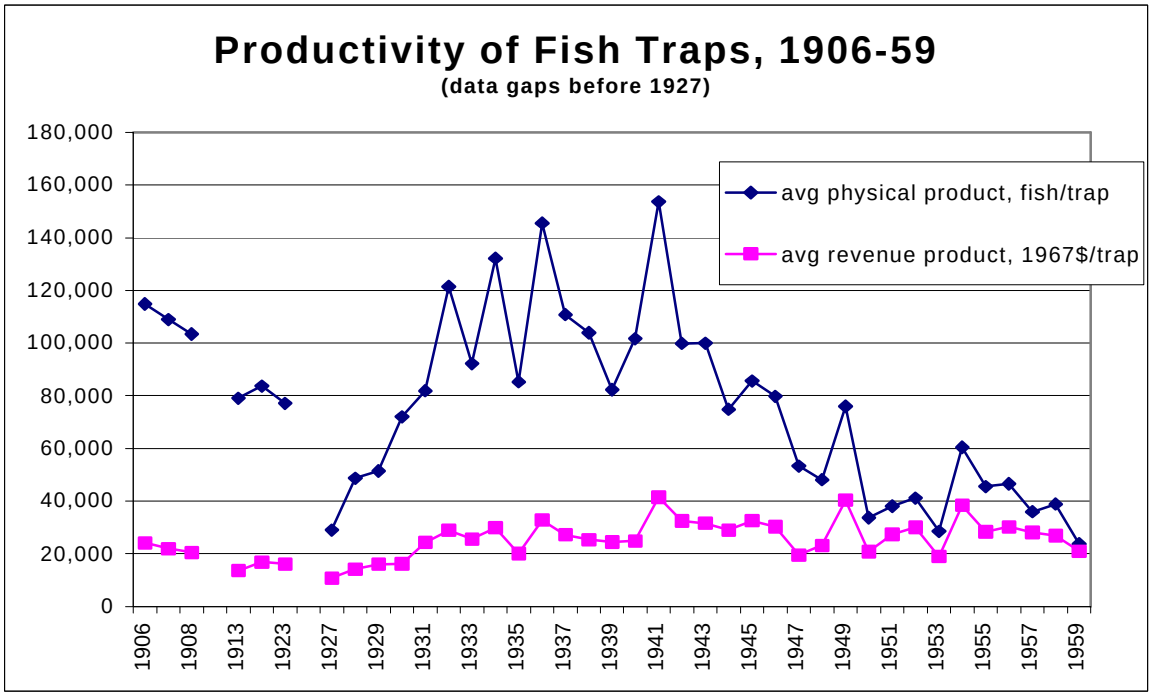
Output of Traps

Throughout the political debates, It was common for some to make astounding claims about the productivity of the fish traps. The Alaska Supreme court uncritically accepted the assertion that a catch of 600,000 fish per year was "not unusual".[14] In fact such a catch was very unusual. But as with tales of the gold on the beaches of Nome, the fantastic early successes of a few traps became a part of Alaskans' political mythology.

The average physical productivity of traps was *initially* quite high, due to their placement in favorable locations. In 1906 there were only 60 traps, most located in Southeast, with an average annual catch of 114,000 fish per trap. Physical production began to drop between 1910 and 1920, in part because so many additional traps were being added at less attractive sites. Prior to 1930 the averages also contain numerous so-called "dummy traps" in the denominator. Dummy traps were non-working traps that were set up to pre-empt others from occupying part of a shoreline and to be used as trading stock when negotiating with federal regulators over reductions in total trap numbers. The number of traps peaked in 1927 and undoubtedly included many dummy traps, although I can find no hard evidence of how many. After a very low run in 1928, the federal Bureau of Fisheries (then under the Department of Commerce) began to reduce the allowed number of traps down to a level of about 425, which was maintained throughout the next two decades.

[14] *Metlakatla Indian Community v. Egan*, Supreme Court of Alaska, June 2, 1961. 362 Pacific Reporter, 2d series.

FIGURE 2: PRODUCTIVITY OF FISH TRAPS, 1906-1959

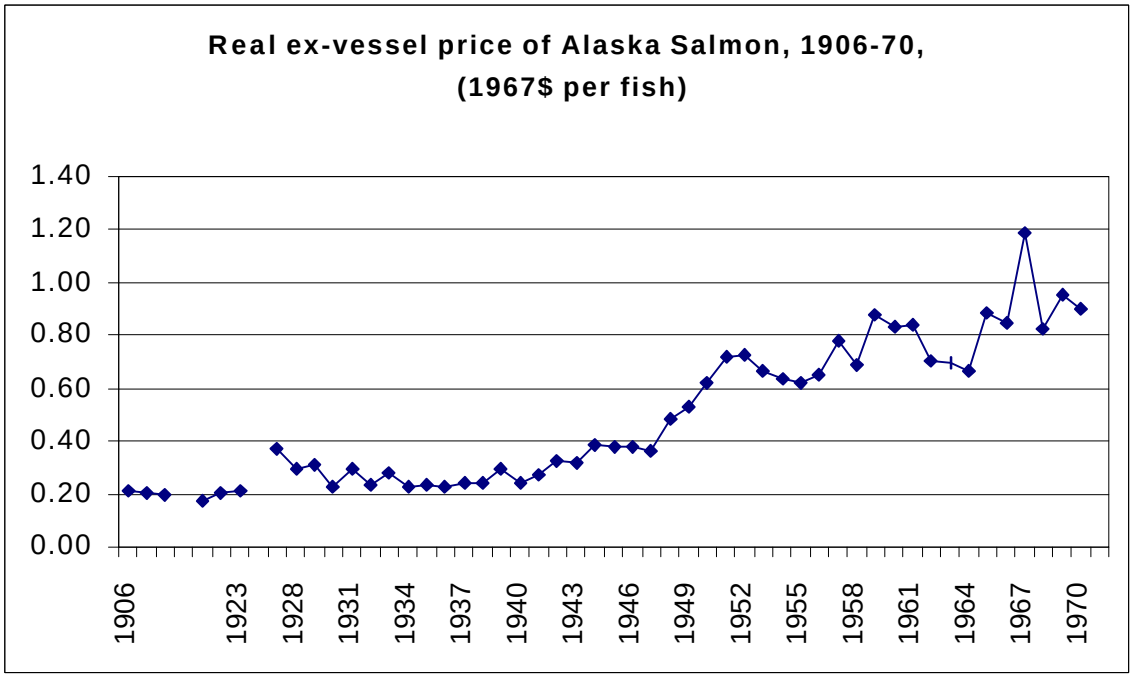


note: First data segment is 1906-1908. Second data segment covers 1913,1918, and 1923. Third data segment covers 1927-1959.

The average revenue product continued to increase even as physical efficiency dropped due to a substantial and sustained increase in real wholesale prices of final product, which led in turn to higher "ex-vessel"[15] values for the raw fish produced by the trap:

[15] The ex-vessel value is the market value of the fish when it passes from the catching boat (or trap) to the cannery's tender boat or dock.

FIGURE 3: REAL EX-VESSEL PRICE OF ALASKA SALMON, 1906-1970



note: First data segment is 1906-1908. Second data segment covers 1913,1918, and 1923.
Third data segment covers 1927-1959.

Capital Cost of Traps

The economic efficiency of the fish traps depended critically on their capital costs. The early trap designs were based on piles driven into the ocean floor just off the shore. This technology was costly to implement as the pilings had to be replaced every year and were themselves hard to come by in areas such as southwest Alaska that had no trees. But a technological innovation in anchoring technology produced the floating trap. The floater which eliminated the need for the costly pile-driving operation in many areas.

Because of the critical importance of the traps' capital cost to its effectiveness, the issue was brought up repeatedly in public discussion and (implicitly) debated. I now review some of the available data on this cost. Unless otherwise noted, the estimates were made in 1948.

Estimate 1: Senator Warren Magnuson states a high-side estimate of an annual "yearly cost of developing and maintaining a trap site" at $20,000 per site for a pile-driven trap and $10,000 per year for floating traps. For comparison, a large cannery at the time cost more than $1 million as a capital investment. The senator's apparent confusion between fixed and variable cost is understandable since the depreciation time on many components of the trap was only one

year.[16] For the floating trap the timbers could be re-used but not many of the hanging wires, etc. For the pile-driven trap the piles could be cut down and re-used for shorter lengths the following year (MacBride testimony in Hearings1, p. 26)

Estimate 2: Secretary of the Interior Julius Krug in a letter to the Senate in 1948 estimates the "annual cost of installation" is between $4,000 and $8,000 per trap as of 1948. There is no mention of whether the high cost is for pile traps or is supposed to be the range for floaters.[17]

Estimate 3: Philip MacBride, an Industry lobbyist, testified in 1948 that the cost was about $20,000 to $25,000 per year to install the trap, with very little salvageable. Floating traps are useable in the sheltered waters of Southeast Alaska, while pile traps are necessary in the more exposed waters of Cook Inlet and Kodiak. But MacBride also points out the discovery cost aspect -- he estimates that his company has $900,000 of unamortized discovery costs, of which $400,000 can be attached to a particular 11 sites (Hearings1 p. 29). So this initial finding cost can be $40,000 per trap for remote areas. It was probably less in the more familiar and close-by waters of Southeast.

Somewhat later MacBride gives an estimate of $150,000-200,000 in 1912 to locate 20 sites that were later winnowed (either by federal regulation or by economics) to 7 sites. That works out to about $25,000 per site in discovery cost.[18]

Estimate 4: Mr. Ira Rothwell of the Alaska Territorial Department of Fisheries testified in 1948 that the initial cost of a trap is between $7,000 and $15,000. Of that, about 1/3 of the value requires replacement every year, (fully depreciates) while the other 2/3 of the investment depreciates over 5 years.[19]

Estimate 5: In a personal interview, long-time cannery manager Carl Asplund stated that a floating trap required an initial outlay of $5,000 to construct the frame, which lasted for 5 years. In addition, there was a recurring annual cost of $8,000 to reinstall & maintain the trap. Although the floating traps' main timbers could be towed to shore for the winter, they required new wire and netting every year. The anchors were re-useable.

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[16] Statement of H.L. Lannen, *Hearings on HR 1515*, 1948, p. 76
[17] *Hearings on S. 1446*, p. 248
[18] *Hearings on S. 1446*, p 29-34
[19] *Hearings on HR 1515*, p. 96

Labor Cost

According to Carl Asplund (1998), there were always two watchmen per trap, at an annual 1948 cost of $1,200.

Total Trap Cost Scenarios

Based primarily on the evidence reviewed above, I have adopted the following set of capital costs:

TABLE 1: FISH TRAP COST ESTIMATES
(IN 1948$, EXCLUDES $1,200/YR LABOR IN ALL SCENARIOS)

	# Units	One-Time Up-Front			Annual Setup & Maint.		
Gear	in 1948	Low	Mid	High	Low	Mid	High
Pile Traps	110	5,000	10000	40,000	10,000	15000	20,000
Floaters	261	5,000	10000	20,000	5,000	10000	10,000
Total all trap	371	1,855,000	3,710,000	9,620,000	2,405,000	4,260,000	4,810,000
Average per trap		**5,000**	**10,000**	**25,930**	**6,482**	**11,482**	**12,965**

Rents from Fish Traps Calculated from Costs

The private cost savings to canners from using trap-caught fish instead of boat-caught fish can be calculated by subtracting the average cost of a trap caught fish from the average ex-vessel value of that fish. The ex-vessel value data is precisely the price paid to mobile gear operators (as well as those few independent trap operators who sold at arms length to canners). I assume that since the mobile gear fishery is open to all, a zero profit condition generally applies there. Under this assumption the difference between ex-vessel value of a fish and the average cost of producing that fish from a trap also represents social resource savings.

Table 2 shows the pattern of rents generated by traps under the middle case or "best-guess" assumptions about cost. All dollars are converted to 1967 purchasing power. The one-time initial cost of finding and choosing the productive sites is amortized at 8% (real) to yield an annualized prospecting cost of only about $1,000. The annual installation cost is about $14,000, and labor runs about $1,500 per season. The total annualized cost of deploying an average trap is therefore about $16,300 in this scenario. When this average cost is subtracted from the actual product value generated by the traps, a total of $114 million in rent remains. This represents about 10% of the ex-vessel value of the catch, and about 3% of the wholesale value of the canned product.

TABLE 2: RENTS GENERATED WITH MID-CASE TRAP COSTS

Assumptions: **Trap costs in real 1967$ per trap:**

One-time Discovery Capital Cost:	12,077		
annualized at:	8%	(real)	966
Annualized Installation cost:			13,868
Annual operating labor cost:			1,449
Annualized total cost per trap:			16,283

Results:

Year	Average Revenue Product 1967$ per trap	Annualized Total Cost per trap 1967$	Rents per Trap 1967$	Total Rents million 1967$	Wholesale Value million 1967$	Ex-Vessel Value million 1967$	Rents as % of Wholesale Value	Rents as % of ex-vessel Value
1906	24,154	16,283	7,870	0.5	24.7	6.6	2%	7%
1907	21,927	16,283	5,644	0.4	26.1	7.0	2%	6%
1908	20,514	16,283	4,231	0.4	31.4	8.4	1%	5%
1913	13,558	16,283	(2,725)	(0.7)	38.1	10.2	-2%	-6%
1918	16,826	16,283	543	0.3	76.9	20.5	0%	1%
1923	16,096	16,283	(187)	(0.1)	61.0	16.3	0%	-1%
1927	10,760	16,283	(5,524)	(4.4)	65.2	17.7	-7%	-25%
1928	14,173	16,283	(2,110)	(1.5)	91.8	25.6	-2%	-6%
1929	15,959	16,283	(324)	(0.2)	84.0	22.1	0%	-1%
1930	16,210	16,283	(74)	(0.1)	68.5	18.0	0%	0%
1931	24,262	16,283	7,979	3.8	78.5	20.6	5%	18%
1932	28,844	16,283	12,561	4.3	61.8	17.2	7%	25%
1933	25,509	16,283	9,226	3.7	88.4	22.1	4%	17%
1934	29,821	16,283	13,538	6.2	95.6	25.6	6%	24%
1935	20,112	16,283	3,829	1.7	62.3	16.9	3%	10%
1936	32,741	16,283	16,458	7.5	110.5	28.4	7%	26%
1937	27,204	16,283	10,921	4.9	100.3	26.7	5%	19%
1938	25,333	16,283	9,050	4.1	88.9	24.6	5%	17%
1939	24,418	16,283	8,135	3.6	86.5	23.3	4%	15%
1940	24,905	16,283	8,622	3.7	78.5	20.8	5%	18%
1941	41,447	16,283	25,164	9.6	130.8	28.0	7%	34%
1942	32,495	16,283	16,212	6.8	96.7	26.3	7%	26%
1943	31,537	16,283	15,253	5.8	110.1	27.4	5%	21%
1944	28,906	16,283	12,623	5.0	95.4	27.1	5%	18%
1945	32,581	16,283	16,298	6.7	83.6	28.5	8%	23%
1946	30,212	16,283	13,928	5.8	94.9	27.4	6%	21%
1947	19,507	16,283	3,224	1.4	116.6	25.6	1%	5%
1948	23,129	16,283	6,846	2.7	124.1	28.0	2%	10%
1949	40,349	16,283	24,066	8.7	101.9	41.5	9%	21%
1950	20,755	16,283	4,472	1.8	99.1	27.7	2%	6%
1951	27,331	16,283	11,048	4.3	86.0	35.5	5%	12%
1952	30,010	16,283	13,726	4.8	86.4	35.0	6%	14%
1953	18,921	16,283	2,638	1.0	131.4	24.6	1%	4%
1954	38,289	16,283	22,006	4.8	76.0	28.1	6%	17%
1955	28,311	16,283	12,028	2.4	66.5	24.6	4%	10%
1956	30,178	16,283	13,895	3.5	87.6	32.8	4%	11%
1957	28,054	16,283	11,770	2.6	105.6	26.8	2%	10%
1958	26,861	16,283	10,578	2.6	68.3	28.4	4%	9%
1959	20,923	16,283	4,640	1.1	59.3	22.1	2%	5%
Total				**114.0**	**4,071.2**	**1,146.0**	**3%**	**10%**

See text for explanations.

Because of gaps in the data for early years, the totals at the bottom of the table include replications of the 1913, 1918, and 1923 values and do represent an estimate of the total rents accrued over the entire 53-year period. (The total is not discounted.)

These calculations suggest that trap operation was very attractive when the new technology was first introduced, the best locations were used, and average yields exceeded 100,000 fish per trap. Beginning in the 1910s, however, it appears that because of declining physical productivity, the traps were actually not the low-cost technology. Only when the number of traps was reduced from the all-time high level of 799 (in 1927) to about 420 (throughout the 1930s and 1940s) did the traps show cost savings.

Of course a simple calculation such as this ignores the tremendous variability in individual costs and productivity. In particular, it does not discount the total cost for the presence of the dummy traps, which undoubtedly had a much lower cost of installation since they had no actual wiring.

Nonetheless, even these crude numbers show that the trap was not a hands-down low-cost winner when placed in the locations to which it was restricted by the government. Its economics were improved in the 1930s by reducing the number of traps and boosting the average physical productivity. In the 1940s, with the total pack declining, the trap benefited from steadily rising real prices. And overall, these calculations suggest that its cost advantage over boats was rather modest -- only about 10% of the ex-vessel value of the fish.

Using the low and high scenarios for the cost of traps leads to broadly similar conclusions (Table 3, full tables in Appendix). Between 1906 and 1959, the salmon fishery generated about $1 billion in real raw fish (ex-vessel) value. The fish traps enabled the canners to retain between 4% and 22% of this value as economic rent. Assuming that the seine boats were operating with zero profits, these rents represent the total rent obtained from the salmon resource.

TABLE 3: SUMMARY OF ESTIMATED RENTS FROM FISH TRAPS, 1906-1959

Trap Cost	Average Revenue Product 1967$ per trap	Annualized Total Cost per trap 1967$	average Rents per Trap 1967$	cumulative Total Rents million 1967$	cumulative Whole-sale Value million 1967$	cumulative Ex-vessel Value million 1967$	Rents as % of wholesale Value	Rents as % of ex-vessel Value
Low	22,608	9,761	12,847	250.3	4,071	1,146	6%	22%
Mid	22,608	16,283	6,325	114.0	4,071	1,146	3%	10%
High	22,608	19,613	2,995	44.4	4,071	1,146	1%	4%

Estimated Rents from Traps Based on the Market Value of Trap Sites

Although there were no legally enforceable property rights to trap sites, the industry developed and respected an extra-legal system of rights. These rights to trap sites were leased and sold, and there is very limited anecdotal evidence about their market value. In congressional testimony, an anti-trap witnesses quoted Department of the Interior estimates that the "average" value of "perpetual" rights to a site was about $10,000 as of 1946, and the same rights could be leased for $3,500 per year.[20] The witness suggested that the market value of a trap site could easily double to $20,000 if the rights were validated by an official U.S. government lease.

The estimate of $3,500 per year in 1948 translates to $4,227 in 1967 dollars. This market rental value of the average trap site in 1948 is remarkably close to the values of $3,224 and $6,846 shown for 1947 and 1948 in Table 2 above. The agreement between these two estimates provides some reassurance that the cost-based estimates are in the right ballpark.

Comparison of Rents from Traps with Rents Dissipated by the Bristol Bay Seine Fleet

Because of shallow water and other natural factors, fish traps are not feasible and were almost never used in the huge red salmon fishery of Bristol Bay in southwestern Alaska. The technology of choice in Bristol Bay is the drift gillnet. In an attempt to conserve the fish resource, only sailboats were allowed to fish in Bristol Bay until 1951. Crutchfield and Pontecorvo (1969) noticed that the amount of mobile gear in Bristol Bay doubled between 1959 and 1969. They made a crude estimate of the amount of rent dissipated by the excessive numbers

[20] Frances Lopinsky, *Hearings S. 1446 (1948),* p. 191

of boats. They used the World War II wartime level of boats as the presumed-efficient amount of capital and found high levels of presumed-excessive gear, especially in the 1950s. For example, they suggested that 83% of the gear operating in Bristol Bay in 1955 was redundant; hence $2.4 million of potential rent was wasted in catching $2.9 million worth of raw fish.

Numbers of this size compare in order of magnitude with my estimates of rents preserved by traps during the same period -- e.g., $2.4 million in total rents from traps generated in 1955. Since the Bristol Bay fishery generates about 20% of the total Alaska salmon catch, this very crude comparison suggests that, circa 1955-59, the lost rents from excessive mobile gear throughout the fishery probably exceeded the rents preserved by traps. Of course, the two are not unrelated. Each form of gear makes the other less efficient on average.

Comparison of Rents from Alaska Traps with Rents from Washington Traps

Higgs (1982) estimated the resource cost of banning fish traps in the state of Washington. He concluded that traps in 1937 could have caught for $732,000 what mobile gear caught for $2 million. Thus the traps could have generated annual rents of about $1.3 million in 1937$ on a total catch of 7.6 million fish. The rents have a value in 1967$ of $2.9 million -- roughly equivalent in absolute terms with the annual rents in Table 2 above. However, since the average Alaska catch was about 60 million fish, and since I did not consider using traps and fixed gear for 100% catch as Higgs did, the *relative* loss of rents that I estimate for the Alaska trap ban is much lower -- roughly 10-15% of the catching cost using mobile gear (Table 3 above).

Limited Entry and Marketable Fishing Rights

After banning fish traps in 1959, the new State of Alaska struggled with a continuing increase in mobile gear, as discussed below. In 1973 a limited entry system was put in place with freely transferable rights to enter the various salmon fisheries. Shortly after the program was introduced, the total market value of all limited entry permits was $36 million in 1967$.[21]This can be compared to a total market value of trap rights of about $10 million (1967$) that results from the stated (potential) market value of $20,000 per trap site (1948$) that was suggested by the congressional witnesses in 1948 hearings. The market value of limited entry permits soared to almost $1 *billion* current dollars in 1990, but has since dropped with falling salmon prices.

[21] Alaska Commercial Fisheries Entry Commission 1992.

6. Changes After Fish Traps Were Banned

The State of Alaska banned fish traps in 1959. The ban took effect in 1960, with the exception of about 11 traps used by Alaska Natives with the encouragement of the Bureau of Indian Affairs. By 1963 all but two of these traps had been shut down after the Alaska ban was upheld by the U.S. Supreme Court. The "natural experiment" of banning the traps allows us to examine whether, and to what extent, the opposing views about traps were valid.

Predictions About the Effects of a Ban

The industry warned that without traps they were doomed:

> There can be no question but that the overall catch would fall....There are very basic reasons why the industry cannot exist in its present economic condition without the stabilizing factor raw supply which comes from the use of fish traps.[22]

Alaska's congressional delegate Bob Bartlett saw more people, more fishing, *and* more fish on the horizon:

> ...no prospective new industry...will result directly in a greater population increase and resulting permanent economic development than would be contributed by the elimination of traps...The abolition of fish traps and the rebuilding of the salmon runs will eventually provide employment for 7,500 additional independent fishermen, supporting 22,000 or more persons directly and as many more indirectly.[23]

Secretary of the Interior Julius Krug understood rent dissipation under open access:

> However, the elimination of fish traps will unquestionably mean that the use of other forms of gear will be intensified and eventually will nullify any benefit that might accrue from trap elimination.[24]

Changes in Fishing Effort and Productivity

In 1959 at the time traps were banned, they were catching about 25% of all salmon -- a mixture of perhaps 50% of the Southeast catch and none of the Bristol Bay red salmon catch. This trap catch dropped essentially to zero. Assessing the resulting substitution of fishing effort by mobile gear is not straightforward because there is no common metric for fish-catching power. Actual catch cannot be used because there is no way to control for the variation in the

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[22] W.C. Arnold, chief industry lobbyist, in *Hearings on S. 1446*, p. 85
[23] Statement of Bob Bartlett, *Hearings on HR 1515*, 1949, p. 108
[24] Statement of Julius Krug, Secretary of the Interior, in *Hearings on HR 1515*, p. 2

size of the run. To get around this problem I compute the hypothetical catch that would have resulted from the additional boats fishing at the pre-ban average productivity levels. Table 4 shows this comparison using 5-year periods before and after the ban.

While the number of traps dropped to essentially zero, the number of purse seine boats increased by 45%. The total catching power of the drift gillnet fleet (measured in fathoms of netting) remained stable. At pre-ban average productivity, the increased boats were just sufficient to replicate the 1955-59 catch of 38 million fish. Thus there was an almost perfect substitution of mobile gear physical fishing effort when traps were banned. Total catch increased substantially because average catch per boat increased.

TABLE 4: FISHING EFFORT AND CATCH BEFORE AND AFTER THE BAN ON TRAPS

	Traps (number)	Seines (boats)	Drift Gillnet (fathoms)	Total
Before Ban (1955-59)				
gear units	231	1,536	719,636	
average product (fish per unit)	37,950	11,670	16	
total product (000 fish)	8,774	17,930	11,444	38,148
After Ban (1961-65)				
amount of gear	10	2,228	715,959	
average product from 1955-59	37,950	11,670	16	
hypothetical catch (000 fish) (equals index of fishing effort)	380	26,002	11,386	37,767
actual average product (fish/unit)	43,780	15,977	22	
actual total product (000 fish)	438	35,597	15,443	51,478
Percent change in:				
amount of gear		45%	-1%	
actual average product		37%	36%	
Total product		99%	35%	35%

The number of fishermen increased with the number of seine boats. As Table 5 shows, the number of fishermen increased by 55%. Both physical productivity and price also increased, causing the average gross earnings per fisherman to increase by 20%.

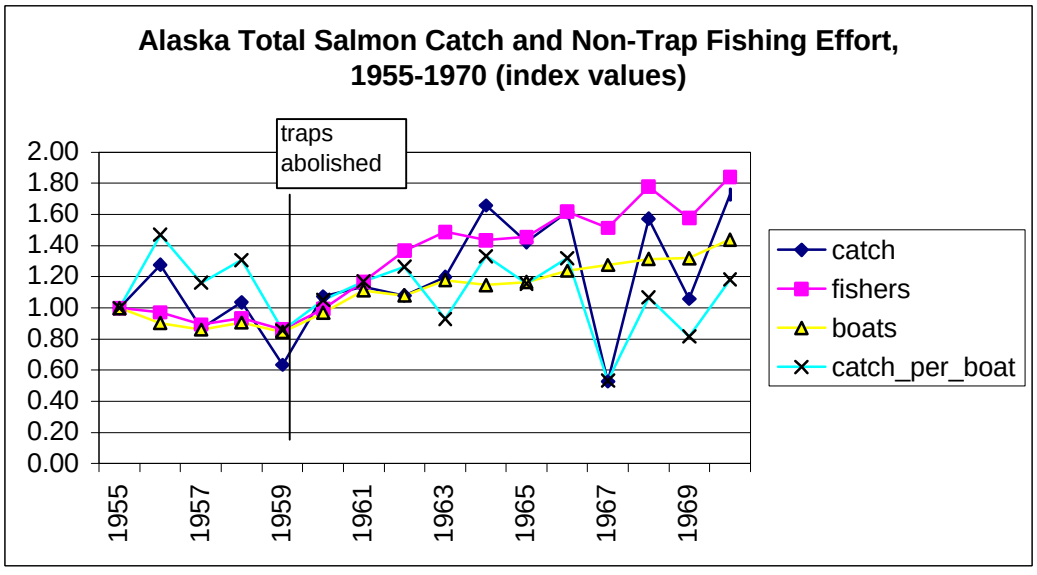
TABLE 5: MOBILE GEAR LABOR AND AVERAGE REVENUE PER FISHERMAN

	Before ban 1955-59	After ban 1961-65	% change
# of mobile gear fishermen	10,725	16,590	55%
average physical product (fish per man)	2,739	3,077	12%
average real price (1967$ per fish)	0.71	0.76	7%
average revenue product (1967$ per man)	1,935	2,329	20%

Thus Interior Secretary Julius Krug right when he predicted full crowding out of the traps catching power by the expanding purse seine fleet. But Delegate Bartlett could claim that he was right, too. In the minds of Alaskans, the additional employment of 6,000 fishermen was a clear benefit. And it is possible that these immediate victories did help the State implement a meaningful conservation program that lead to temporary increases in catch during the 1960s.

Ultimately, however, the surge in fishing employment was part of a continuous trend toward maximum employment consistent with the opportunity cost of fishing. As Figure 4 shows, the surge in mobile gear and fishermen continued through 1970 while the physical catch per boat declined slightly.

FIGURE 4: CATCH AND EFFORT AFTER THE TRAP BAN



These short-run data surrounding the trap ban suggest that actions such as abolishing traps had little effect on long-run resource depletion and rent dissipation because the fishery was always open to entry by new fishermen. The economic theory of open access resources makes a

strong prediction that additional entry will occur whenever the average *revenue* product of output is positive for an individual. The long-run data on the salmon fishery provide an opportunity to test this hypothesis and confirm the existence of zero profits in the mobile gear sector that I used above when estimating the rents from fish traps.

Testing the Rent Dissipation Hypothesis

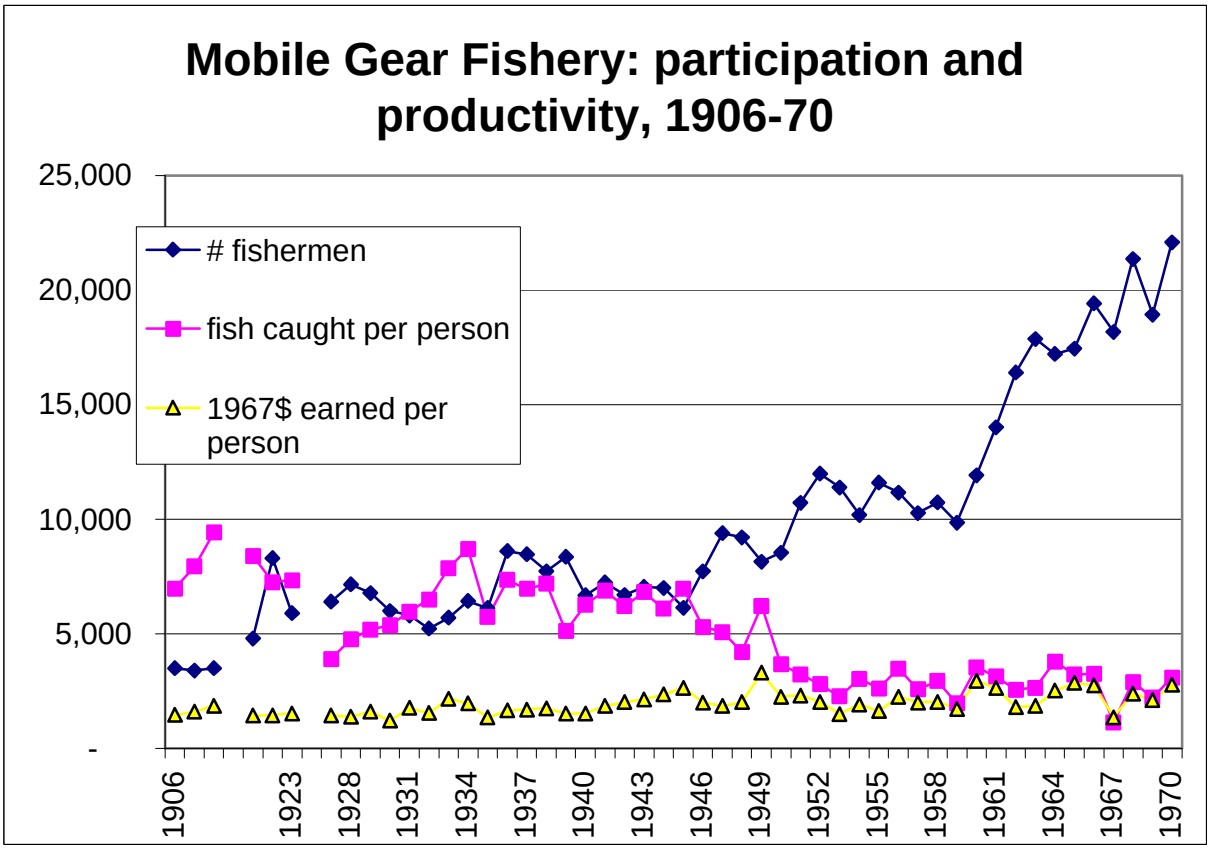
Theory predicts that fishermen will enter (or leave) the industry so as to maintain a constant average economic profit level of zero. This means that the number of fishermen should be very responsive to changes in product prices and their own alternative wages and more slowly responsive to changes in their cost functions.

I test for zero profits by looking for evidence of a constant or slightly rising average revenue product measured in real dollars per fisherman. The zero-profit ARP should remain constant (in the face of price changes or resource depletion) or increase because of rising alternative real wages and rising real boat costs that must be covered out of the ARP. It should not be falling; this would be evidence of previous period economic profits being dissipated.

Figure 5 shows the number of fishermen participating in the mobile gear fishery over the entire history of the open-access Alaska commercial salmon fishery. The figure also shows the average physical product measured in fish per person[25] and the average revenue product measured in 1967$ per person. The figure shows how fishermen surged into the fishery more or less continuously and maintained a remarkably constant real average revenue product of labor. During the earliest years (1906-08) the ARP surged with increasing physical productivity.

[25] The fish caught figure excludes trap-caught fish, of course.

FIGURE 5: MOBILE GEAR EFFORT AND PRODUCTIVITY, 1906-1970



note: First data segment is 1906-1908. Second data segment covers 1913,1918, and 1923. Third data segment covers 1927-1959.

During the depression output price was falling but after an initial contraction new entrants responded to another surge in physical productivity. Then, when physical productivity began its long secular decline at the end of the 1930s, new entrants continued to rush in as the output price continued rising. The dramatic increase in fishermen after statehood occurred exactly as forecast by the advocates of the trap ban, as discussed above. Throughout the entire period, the average revenue product is remarkably stable considering the swings in output price and physical productivity.

A simple regression of the log of average revenue product (LNARP) on time, alternative wages, and dummies for the "post-trap" period and World War II confirms this pattern:

Variable	*Coefficient*	*Std Error*	*t Stat*
Intercept	5.7304	0.9685	5.92
TIME	0.0007	0.0042	0.18
NOTRAP	0.0706	0.0864	0.82
WAR	0.1356	0.1127	1.20
lnOPPWAGE	0.2474	0.1561	1.58

where

NOTRAP = 0 for 1906-1959, 1 for 1960-70

WAR = 1 for 1942-45

lnOPPWAGE = log of average annual earnings per employee in the agriculture/forestry/fisheries sector

In this regression the ARP trends upward with the opportunity wage but has no independent drift. The equation suggests that there was a slight but insignificant permanent increase in average earnings after statehood. Overall, however, both the regression and the graph are consistent with a long-run zero-profit equilibrium in the mobile gear sector of the Alaska salmon fishery. Consistent with economic theory, banning traps without restricting access did increase employment but did nothing to improve fishermen's earnings.

7. Conclusions

In this paper I have considered a fundamental question that was barely asked and never answered during half a century of political debate about the costs and benefits of fish traps in Alaska. How much more efficient are the traps relative to the best alternative competing gear, the purse seine? It is impossible to get an accurate answer to this question because all fishing technology was operating in an overcapitalized and haphazardly managed fishery. Nonetheless, I estimate that traps, *as actually deployed* in Alaska between 1906 and 1959, generated between $50 million and $250 million in real 1967$ cost savings relative to a boats-only open access fishery. These rents amount to between 4 and 22% of the ex-vessel value of the raw fish, or between 1 and 6% of the wholesale value of the canned product.

By looking at data on participation in the mobile gear fishery, I have also shown that the evidence is strongly consistent with the hypothesis of a continuous zero-profit equilibrium in the number of fisherman competing with the traps. This means that when traps were banned, more than 6,000 additional fishermen could enter the industry, but all the rents from traps were lost.

Only when Alaska instituted a limited entry system in 1972 did society begin to reap substantial rents from the world's most productive salmon fishery.

The long-term data also show that Alaska salmon fishermen have been consistently rescued from their own declining physical productivity by rising real prices. The periodic need to exit the industry has been minimized, but only by luck. Recent price pressure from ever-increasing supplies of farmed salmon has changed this picture. The ex-vessel value of salmon declined from a 1988 peak of $781 million to $362 million in 1996 despite a 50% increase in harvest volume (Knapp 1998). Starting from a zero-profit equilibrium, these downward price shocks have induced full-blown "natural disasters" in coastal Alaska, complete with federal aid.

It may be time for Alaskans to reconsider the fish trap.

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Appendix

Low and High case estimates of rents generated by traps follow on the next two pages.

Rents from Fish Traps: LOW Capital Cost of Traps

Assumptions: **Trap costs in real 1967$ per trap:**

One-time Discovery Capital Cost:		6,039	
annualized at:	8%	(real)	483
Annualized Installation cost:			7,829
Annual operating labor cost:			1,449
Annualized total cost per trap:			9,761

Results:

Year	Average Revenue Product 1967$ per trap	Annualized Total Cost per trap 1967$	Rents per Trap 1967$	Total Rents million 1967$	Wholesale Value million 1967$	Ex-Vessel Value million 1967$	Rents as % of Wholesale Value	Rents as % of ex-vessel Value
1906	24,154	9,761	14,392	0.9	24.7	6.6	3.5%	13.1%
1907	21,927	9,761	12,166	0.9	26.1	7.0	3.3%	12.2%
1908	20,514	9,761	10,753	1.0	31.4	8.4	3.1%	11.5%
1913	13,558	9,761	3,796	0.9	38.1	10.2	2.4%	9.0%
1918	16,826	9,761	7,065	3.5	76.9	20.5	4.6%	17.2%
1923	16,096	9,761	6,335	2.8	61.0	16.3	4.6%	17.2%
1927	10,760	9,761	998	0.8	65.2	17.7	1.2%	4.5%
1928	14,173	9,761	4,411	3.2	91.8	25.6	3.5%	12.6%
1929	15,959	9,761	6,198	4.4	84.0	22.1	5.3%	20.0%
1930	16,210	9,761	6,448	4.5	68.5	18.0	6.6%	25.1%
1931	24,262	9,761	14,500	6.9	78.5	20.6	8.8%	33.6%
1932	28,844	9,761	19,083	6.5	61.8	17.2	10.6%	38.1%
1933	25,509	9,761	15,748	6.3	88.4	22.1	7.1%	28.6%
1934	29,821	9,761	20,060	9.2	95.6	25.6	9.6%	36.0%
1935	20,112	9,761	10,351	4.6	62.3	16.9	7.4%	27.4%
1936	32,741	9,761	22,980	10.4	110.5	28.4	9.4%	36.6%
1937	27,204	9,761	17,443	7.9	100.3	26.7	7.9%	29.6%
1938	25,333	9,761	15,571	7.1	88.9	24.6	8.0%	28.9%
1939	24,418	9,761	14,656	6.5	86.5	23.3	7.5%	27.9%
1940	24,905	9,761	15,144	6.5	78.5	20.8	8.3%	31.4%
1941	41,447	9,761	31,686	12.1	130.8	28.0	9.2%	43.2%
1942	32,495	9,761	22,733	9.5	96.7	26.3	9.8%	36.0%
1943	31,537	9,761	21,775	8.2	110.1	27.4	7.5%	30.1%
1944	28,906	9,761	19,145	7.6	95.4	27.1	8.0%	28.0%
1945	32,581	9,761	22,820	9.4	83.6	28.5	11.2%	32.8%
1946	30,212	9,761	20,450	8.6	94.9	27.4	9.0%	31.3%
1947	19,507	9,761	9,745	4.1	116.6	25.6	3.5%	16.1%
1948	23,129	9,761	13,367	5.4	124.1	28.0	4.3%	19.2%
1949	40,349	9,761	30,588	11.0	101.9	41.5	10.8%	26.5%
1950	20,755	9,761	10,994	4.4	99.1	27.7	4.4%	15.9%
1951	27,331	9,761	17,569	6.9	86.0	35.5	8.0%	19.3%
1952	30,010	9,761	20,248	7.1	86.4	35.0	8.2%	20.2%
1953	18,921	9,761	9,160	3.6	131.4	24.6	2.7%	14.5%
1954	38,289	9,761	28,528	6.3	76.0	28.1	8.3%	22.4%
1955	28,311	9,761	18,550	3.7	66.5	24.6	5.6%	15.1%
1956	30,178	9,761	20,417	5.1	87.6	32.8	5.8%	15.6%
1957	28,054	9,761	18,292	4.0	105.6	26.8	3.8%	15.0%
1958	26,861	9,761	17,100	4.2	68.3	28.4	6.1%	14.6%
1959	20,923	9,761	11,161	2.7	59.3	22.1	4.6%	12.3%
Total				**250.3**	**4,071.2**	**1,146.0**	**6.1%**	**21.8%**

Rents from Fish Traps: HIGH Capital Cost of Traps

Assumptions: **Trap costs in real 1967$ per trap:**

One-time Discovery Capital Cost:	31,316		
annualized at:	8%	(real)	2,505
Annualized Installation cost:			15,658
Annual operating labor cost:			1,449
Annualized total cost per trap:			19,613

Results:

Year	Average Revenue Product 1967$ per trap	Annualized Total Cost per trap 1967$	Rents per Trap 1967$	Total Rents million 1967$	Wholesale Value million 1967$	Ex-Vessel Value million 1967$	Rents as % of Wholesale Value	Rents as % of ex-vessel Value
1906	24,154	19,613	4,541	0.3	24.7	6.6	1.1%	4.1%
1907	21,927	19,613	2,314	0.2	26.1	7.0	0.6%	2.3%
1908	20,514	19,613	901	0.1	31.4	8.4	0.3%	1.0%
1913	13,558	19,613	(6,055)	(1.5)	38.1	10.2	-3.8%	-14.3%
1918	16,826	19,613	(2,786)	(1.4)	76.9	20.5	-1.8%	-6.8%
1923	16,096	19,613	(3,517)	(1.6)	61.0	16.3	-2.5%	-9.5%
1927	10,760	19,613	(8,853)	(7.1)	65.2	17.7	-10.9%	-40.1%
1928	14,173	19,613	(5,440)	(4.0)	91.8	25.6	-4.3%	-15.5%
1929	15,959	19,613	(3,654)	(2.6)	84.0	22.1	-3.1%	-11.8%
1930	16,210	19,613	(3,403)	(2.4)	68.5	18.0	-3.5%	-13.2%
1931	24,262	19,613	4,649	2.2	78.5	20.6	2.8%	10.8%
1932	28,844	19,613	9,231	3.2	61.8	17.2	5.1%	18.5%
1933	25,509	19,613	5,896	2.4	88.4	22.1	2.7%	10.7%
1934	29,821	19,613	10,209	4.7	95.6	25.6	4.9%	18.3%
1935	20,112	19,613	500	0.2	62.3	16.9	0.4%	1.3%
1936	32,741	19,613	13,128	5.9	110.5	28.4	5.4%	20.9%
1937	27,204	19,613	7,592	3.4	100.3	26.7	3.4%	12.9%
1938	25,333	19,613	5,720	2.6	88.9	24.6	2.9%	10.6%
1939	24,418	19,613	4,805	2.1	86.5	23.3	2.5%	9.2%
1940	24,905	19,613	5,292	2.3	78.5	20.8	2.9%	11.0%
1941	41,447	19,613	21,834	8.3	130.8	28.0	6.4%	29.8%
1942	32,495	19,613	12,882	5.4	96.7	26.3	5.6%	20.4%
1943	31,537	19,613	11,924	4.5	110.1	27.4	4.1%	16.5%
1944	28,906	19,613	9,294	3.7	95.4	27.1	3.9%	13.6%
1945	32,581	19,613	12,969	5.3	83.6	28.5	6.4%	18.7%
1946	30,212	19,613	10,599	4.5	94.9	27.4	4.7%	16.2%
1947	19,507	19,613	(106)	(0.0)	116.6	25.6	0.0%	-0.2%
1948	23,129	19,613	3,516	1.4	124.1	28.0	1.1%	5.0%
1949	40,349	19,613	20,736	7.5	101.9	41.5	7.3%	18.0%
1950	20,755	19,613	1,142	0.5	99.1	27.7	0.5%	1.7%
1951	27,331	19,613	7,718	3.0	86.0	35.5	3.5%	8.5%
1952	30,010	19,613	10,397	3.6	86.4	35.0	4.2%	10.4%
1953	18,921	19,613	(692)	(0.3)	131.4	24.6	-0.2%	-1.1%
1954	38,289	19,613	18,676	4.1	76.0	28.1	5.4%	14.6%
1955	28,311	19,613	8,698	1.7	66.5	24.6	2.6%	7.1%
1956	30,178	19,613	10,566	2.6	87.6	32.8	3.0%	8.1%
1957	28,054	19,613	8,441	1.9	105.6	26.8	1.8%	6.9%
1958	26,861	19,613	7,249	1.8	68.3	28.4	2.6%	6.2%
1959	20,923	19,613	1,310	0.3	59.3	22.1	0.5%	1.4%
Total				**44.4**	**4,071.2**	**1,146.0**	**1.1%**	**3.9%**