Property Rights and Natural Resource Curses:

Micro Evidence from a Tribal Fishery

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Abstract: We a study a U.S. federal court ruling that had major impacts on the structure of property rights in—and the distribution of revenue from—Washington state's commercial fisheries. Known as the "Boldt Decision", the 1974 ruling affirmed the right of Native American tribes to 50 percent of the fishery based on treaties signed in the 1850s. The ruling was an unexpected (but not undeserved) windfall for impoverished tribes because they had caught less than six percent of the salmon in the 25 years preceding 1974, and because half of the fishery revenues in 1973 amounted to $10,189 per tribal member. We find that the ruling conveyed limited long-run economic benefits to tribes, however, in part because it failed to re-create the efficient system of riparian property rights used by Pacific tribes at the time of the treaties. Instead, the post-1974 tribal fishery evolved to mimic the economically wasteful "rule of capture" and capital-intensive mobile fishing regime that is prevalent in non-tribal fisheries throughout the industrialized world. Our theory describes how individually rational decisions leads to rent dissipation and possibly a resource curse, and our empirical analysis identifies symptoms of a curse using data on fishing activity, schooling decisions, and income growth.

I. Introduction

After decades of courtroom battles over fishing rights, federal judge George Boldt issued a controversial and widely unexpected ruling in *U.S. v. Washington* that had major impacts on the distribution of revenue from Washington state's fisheries. The 1974 ruling, commonly referred to as the Boldt Decision, decreed that based on treaties signed in the 1850s, certain Native American tribes had the legal right to catch up to 50 percent of the harvestable salmon

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entering Washington State's waters each year. The victory was significant for the tribes because their salmon catch was only six percent of the annual harvest for the 25 years prior to 1974, and because 50 percent of the commercial fishery's wholesale revenue in 1973 was $124.3 million in today's dollars.[1] This amounted to $10,189 in revenue per capita for the members of the fourteen original plaintiff tribes based on their 1973 populations.[2] For perspective, consider that per capita income for Boldt tribes was $7,305 based on the 1970 census.[3] In short, the court victory was a large and unexpected (but not undeserved) economic windfall.

We exploit the Boldt Decision, and plausibly exogenous changes to salmon prices and stocks after 1974, to shed light on economic theories of the "natural resource curse."[4] A strand of this literature hypothesizes that resource windfalls – usually resource discoveries or positive price shocks - will have adverse long-run effects on income growth and other socio-economic outcomes if a key condition holds (see Mehlum et al. 2006, Torvik 2002). The condition is that property rights are weak at the time of the windfall; that is, there must be few barriers to the appropriation of resource rents. If property rights are weak, then wasteful competition for rents will ensue and this will eliminate windfall benefits. A true curse evolves over time because efforts to capture rents come at the expense of productive employment and human capital investments. This depresses output and retards long run growth.

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[1] This is the wholesale revenue of salmon based on the prices paid to fishermen from processors and dealers. The retail revenue from the fishery was much higher.

[2] Estimates of tribal members come from the *U.S. vs. Washington* ruling and are collaborated by Bureau of Indian Affairs estimates in its 1973 *Estimates of Resident Indian Population and Labor Force Status* report. Six additional tribes later became claimants to the 50 percent share. The 1973 membership of the original 14 plaintiffs was 12,199, and the membership of the six additional tribes was 2,544.

[3] This is the per capita income for the seven tribes for whom income data are reported in the 1970 census, in 2012 dollars.

[4] For comprehensive reviews of the resource curse literature, see van der Ploeg (2011) and Deacon (2011).

The resource curse idea, even in the conditioned form described above, has critics, and it is difficult to precisely test.[5] One approach has been to interact cross-country measures of institutional quality with measures of resource abundance, usually oil and minerals, in cross-sectional regressions. Alexeev and Conrad (2009), for example, use this approach to conclude that added resource abundance boosts output in countries with strong institutions, but has no significant effect in countries with weak institutions. A second approach exploits the timing of windfalls, by creating country-level temporal measures of resource discoveries and/or commodity price indices.[6] Collier and Goderis (2009), for example, use time-series data to conclude that increases in commodity prices for metals and fuels reduce long-run GDP per capita in countries with weak institutions, but have insignificant positive effects in countries with strong institutions. In all countries, there are generally positive short-run GDP effects that last a couple of years.[7]

We approach our test of the resource curse hypothesis using the windfall approach and proceed in the following way. First, we develop a simple, stylized theoretical model that fits our empirical setting. Our theory is similar in spirit to Mehlum et al. (2006) and Torvik (2002), but it incorporates ideas from economic models of common pool fisheries (Gordon 1954, Scott 1955, Johnson and Libecap 1982), especially from models that are specific to migratory salmon (Higgs 1982, Deacon et al. forthcoming). Our theory focuses on the decision of individual tribal members to enter an open-access, capital-intensive fishery and on the economic implications of

[5] Some recent criticisms are found in Brunnschweiler and Bulte (2009) and Haber and Menaldo (2011).

[6] Tsui (2010), for example, creates a country-level panel of major oil discoveries.

[7] A third approach exploits within-country variation in resource windfalls. Caselli and Michaels (2013), for example, regard off-shore oil revenues in Brazil as a resource windfall and study their impacts on municipality incomes among other outcomes. (Municipalities receive oil revenue to varying degrees based on their proximity to oil fields and other factors). They find that oil revenue has no effect on local GDP, so the windfall is neither a blessing nor a curse on economic grounds. By contrast, Aragón and Rud (2013) find that the expansion of a Peruvian mine in a city generated significant economic benefits to residents in the surrounding areas.

doing so. Exogenous increases in the value of salmon induce entry when no barriers exist, rent dissipation ensues, and alternative investments in non-fishing human capital are lost. When barriers to rent appropriation exist, resource windfalls are beneficial because rents are captured and fewer resources are lost on the investment of rent-appropriating capital.

Next, we test the theory using individual and tribal level panel data spanning 1970 through 2009. Our most extensive data come from Washington fish tickets. The fish tickets provide detailed information on every fishing trip made by every commercial fisherman in the Washington fishery going back to 1970. They provide a rare opportunity to carefully examine the competitive process by which economic rents from sudden access to a natural resource are dissipated (or captured) by participants. The other data we use come from Bureau of Indian Affairs reports on student enrollment, and from U.S. census decadal data on tribal incomes on reservations. We use these data sources to study how fishery behavior, human capital investments, and incomes responded to the Boldt Decision, and to changes in world salmon prices and Washington salmon stocks over time.

Our tests also exploit stark and plausibly exogenous variation in property rights to salmon across tribes. The variation was created by the Boldt Decision itself. Each tribe was assigned different fishing zones based on assessments of where its ancestors had fished prior to extensive contact with whites, in the mid-19th century (Boxberger 1989). Some tribes were assigned zones at terminal sites, in and around the mouth of rivers, while other tribes were assigned zones that also included marine waters. These are important differences because salmon are migratory, and they annually return to rivers to spawn. Terminal zones constrain fishermen to catch fish where it is most cost-effective; at the mouths of rivers where salmon are densely concentrated and easy to catch with inexpensive and efficient stationary gear (i.e., nets affixed to river banks). By contrast, fishermen in marine zones have incentives to engage in socially wasteful efforts to capture rents – by leapfrogging other fishermen in order to intercept salmon further out at sea. Hence, we predict that the tribes which were assigned marine zones were the ones most susceptible to the resource curse.

Terminal tribes were necessarily affected by the actions of marine tribes, however, because the Boldt Decision provided no mechanism for allocating the 50 percent among the 14 (and later 20) treaty tribes. Instead, the allocation was governed by the rule-of-capture and, as we will see, tribes with marine zones eventually caught the vast majority of fish by intercepting migrating salmon on their way to terminal zones. For this reason, qualitative accounts of the Boldt Decision view the marine tribes as the lucky beneficiaries of strategically placed zones. Indeed, several tribes litigated against one another in attempts to expand their own zone or to restrict the zones of other tribes.[8] If the resource curse is present, however, the tribes who were assigned the marine zones were the unlucky ones.

Our empirical tests also attempt to exploit temporal variation in property rights, which comes from the delay in the full enforcement of the Boldt Decision, and from uncertainty over whether or not the U.S. Supreme Court would uphold the ruling (it did in 1979). Because of the delay, even members of tribes with marine zones were initially constrained in their ability to enter the marine fishery, largely because the uncertainty kept them from borrowing to get the necessary capital (e.g., Cohen 1986, Boxberger 1989, Wold 1989, Kersteter 2000). We exploit these delays empirically to test our prediction that the constraints on rent dissipation will make windfalls a blessing rather than a curse in this early period of the data.

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[8] Examples include *US and Tulalip Tribe v. Lummi Indian Tribe*, *US, Tulalip, Muckleshoot and Upper Skagit v. Suquamish Indian Tribe v. State of Washington*, *Muckleshoot Tribe v. Lummi Indian Tribe,* and *Lower Elwha Band of S. Klallams v. Lummi Indian Tribe.*

To preview our preliminary evidence, it suggests that some tribes accrued large benefits from the Boldt Decision, but primarily during the early period from 1974 to around 1978 or so. During this period, we find that the tribal fishery relied primarily on traditional – and efficient - fishing methods using set nets close to river mouths. We find a positive relationship between fishery revenues and tribal per capita and median incomes for the census decadal period between 1969 and 1979.

The period after the late 1970s was fundamentally different. We find that the tribal fishery became heavily capitalized, especially by the early and mid-1980s, and a much larger percentage of the catch occurred in outside zones further away from river mouths. We also find that increases in salmon prices induced entry into the marine fisheries. We interpret this result as being consistent with rent dissipation on the external margin. Effort also appears to have been diverted away from non-fishing human capital investments as we find a negative relationship between the annual number of students on Indian reservations and annual tribal fishery revenues. We also find some weak indications of a negative relationship between tribal incomes and fishery revenues during the 1979-1989, even as the fishery expanded and salmon prices rose.

We tentatively conclude that the Boldt Decision conveyed few long-run economic benefits to tribes and that the higher salmon prices and stocks of the 1980s were more of a curse than a blessing. Our evidence is consistent with Barsh's (1977) prescient assessment. He argued that the incentive structure created by the Boldt Decision would ultimately cause the tribal fishery to mimic the economically wasteful and over-capitalized non-tribal salmon fishery in Washington. One of the key errors of the Boldt Decision, according to Barsh, is that it assigned tribes fishing zones in marine areas thereby encouraging wasteful competition for rents. The Boldt Decision did so despite historical evidence that tribal salmon fishing at the time of the

1850s treaties relied on an intricate system of spatial property rights that centered on the use of stationary gear (see Higgs 1982, Johnsen 2006, Crutchfield and Pontecorvo 1969).

II. Rent Dissipation in the non-Tribal Fishery Prior to *U.S. vs. Washington*

The waters of the Pacific Northwest have historically been prolific producers of salmon but the state has a history of uprooting rational systems of property rights and replacing them with systems enabling rent dissipation. Before non-Indians entered the fishery the annual runs of Pacific salmon to what is now Washington State were in excess of 50 million fish in even numbered years and possibly as large as 100 million in odd numbered years.[9] Although early Spanish and Russian ships occasionally visited the coasts of the region, the journey of Lewis and Clark up the Missouri and down the Columbia river in 1805-06 was the beginning of the non-Indian's migration to the far west. Though growth in the region was considerable through the Civil War period, commercial use of the fishery was nearly non-existent and the fishery remained in the domain of the Native Americans.

During this early period, Native Americans relied upon a system of clan and family-owned fishing sites near river mouths to husband salmon and live off their abundance (see Higgs 1982, Boxberger 1989, Johnsen 2006). They primarily caught salmon with stationary gear affixed to rivers – for example, with fishing weirs - and managed populations by letting some salmon escape to allow spawning and reproduction. There is evidence of tribal investment in habitat, and no evidence of salmon depletion under this system. In fact, salmon were so abundant that they were often given away in elaborate potlatch ceremonies (see Johnsen 2006).

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[9] Pink salmon, the major source of canned salmon today, return to their native waters and are catchable primarily in odd numbered years.

In 1855 the territorial Governor, Isaac Stevens, negotiated and signed six treaties with fourteen Washington tribes and family groups.[10] Through these treaties the Natives gave up rights to certain lands in return for money but retained access to the fishery. Each of the treaties specified that "...the right of taking fish at usual and accustomed grounds and stations is further secured to said Indians in common with all of the citizens of the Territory..."[11]

At the time these treaties were signed, few anticipated that salmon fishing would become the second largest industry in the state. Twenty years after the signing of the treaties, however, only the timber industry employed more men and generated more revenue. The rise of the fishing industry was due to the advent of the canning process, which allowed salmon to be preserved and shipped long distances. The first cannery in the territory was constructed in 1866. Ten years later there were over seventy. The commercial fishery shipped over 150 million pounds of canned salmon out of the Puget Sound alone in the peak year of 1913. The growth of this industry was characterized by large scale entry of all types of fishermen.

Fish traps were developed here on a scale never seen elsewhere in the world. In 1913, 61 percent of the fish were caught by these stationary devices, with the remainder harvested using purse-seine and gill nets (Higgs 1982, p. 70). Fish traps were stationary devices, like Native American weirs, but they tended to be larger and protruded further out above river mouths and other locations along the migration path of salmon. In 1910, the first gasoline powered purse seine was deployed and soon after purse seine fishing became a major force in open marine waters. Purse seines are large nets, deployed by large boats, capable of intercepting migrating

[10] See Treaty with the Makahs, 12 Stat 939, Treaty of Medicine Creek, 10 Stat 1132, Treaty of Olympia, 12 Stat 971, Treaty of Point Elliot, 12 Stat 927, Treaty of Point No Point, 12 Stat 933, and Treaty with Yakimas, 12 Stat 951.

[11] Treaty of Point Elliot, Article 5.

salmon before they reached fish traps on their way to spawn in rivers. Because of the traps, purse seines, and gill netters, salmon were intercepted before they reached tribal fishing grounds and the Native American catch become an inconsequential part of the fishery as early as 1900.

Like the weirs, the stationary fish traps were also highly efficient at catching salmon, but only if the state were willing to preclude marine fishing from purse seines and other boats. Fish traps eliminated search costs and the unit cost of trapping fish was significantly lower than that of mobile gear which required more labor inputs and marine fuel - cost savings were perhaps as high as 90 to 95 percent (Barsh 1977). There is also some anecdotal evidence that salmon caught with traps tended to be larger, and of higher quality (Higgs 1982).[12]

In spite of their efficiency advantages, fish traps were banned from Washington waters in 1934. Higgs (1982) estimates the economic losses. He concludes that the traps could have saved a minimum of 66 percent of the harvest costs incurred by the mobile fleet. These findings are in line with those of Deacon et al. (forthcoming), who find that the net-value of a salmon fishery in Alaska was increased by 26 to 83 percent when a government policy in the 2000s discouraged mobile fishing in open water.

The other source of rent loss prior to 1974 was the lack of constraints on entry into the mobile fishery. At least as early as Crutchfield (1961), economists were espousing limits on entry to address the overcapitalization problem of "too many boats chasing too few fish". The idea was to cap the number of vessels permitted to compete for a fishery-wide quota. The licenses would be transferable so that the right to enter could be sold to other fishermen. Economists advocated this approach as a way to keep fishermen profits above the open access

[12] Additionally, harvest with fish traps allows for a high degree of control over the escapement necessary to regenerate stocks of specific populations and species because salmon segregate themselves as they migrate upriver but are mixed in open water (Barsh 1977).

zero-profit equilibrium that might otherwise result in a fishery of homogeneous fisheries. The first limited entry programs were introduced with pioneer programs of Australia, British Columbia and Alaska, but they were not introduced in Washington State salmon fisheries until after the Boldt Decision and these limits only apply to the non-tribal fishery. Empirical evidence suggests that the early limited entry programs, where applied, generated significant rents.[13]

The long-run trend in Washington has been the depletion of the resource in terms of the size of annual salmon runs. After 1913 fish runs, natural stocks began to decline and only the construction of a large hatchery system in the state has allowed the fishery to continue as a viable industry. Population growth, development, pollution and timber harvesting have exacerbated the over-fishing problems by destroying fish spawning habitat. Many previously productive watersheds now have no viable wild runs of salmon, although it is notable that salmon populations have rebounded impressively in the past couple years.

From 1950 through 1973, total catch and distribution of catch between non-Indians and tribal fishermen was relatively stable. Except for modest license fees, entry was free and participation varied less than 20 percent from the mean in any year.[14] Most of this limited variation was due to entry and exit of pink salmon fishermen in odd numbered years. American Indians averaged about six percent of the commercial catch over this period.

[13] Evidence of rent generation is found in license prices, which have been positive and substantial in many limited entry fisheries (Wilen 1988). Positive license prices are an indication of positive rents because the market value of a license should reflect the expected present value profit that a fisherman can earn in a fishery.

[14] Washington State Department of Fisheries, "1991 Fisheries Statistical Report," 1992.

III. U.S. vs. Washington

Though Native Americans were always recognized as having some treaty-based access to the fishery, the extent of their rights had been an issue of litigation since the turn of the century.[15] In 1970, after a series of arrests by state officials of Indians fishing off of reservations, the U.S. government decided to pursue litigation that would clarify fishing rights. *U.S. v. Washington* was filed in Federal District Court by the U.S. Department of Justice on behalf of seven Washington tribes.[16] The purpose of the suit was to force the State of Washington to recognize the tribes as a group having rights distinct from those of other fishing groups. In February of 1974, after three and a half years of litigation, Judge Boldt ruled that as signatories to these treaties, the Indians had reserved a fair share of the resource for themselves. This fair share, Judge Boldt determined, was equal to up to half of the harvestable fish.[17]

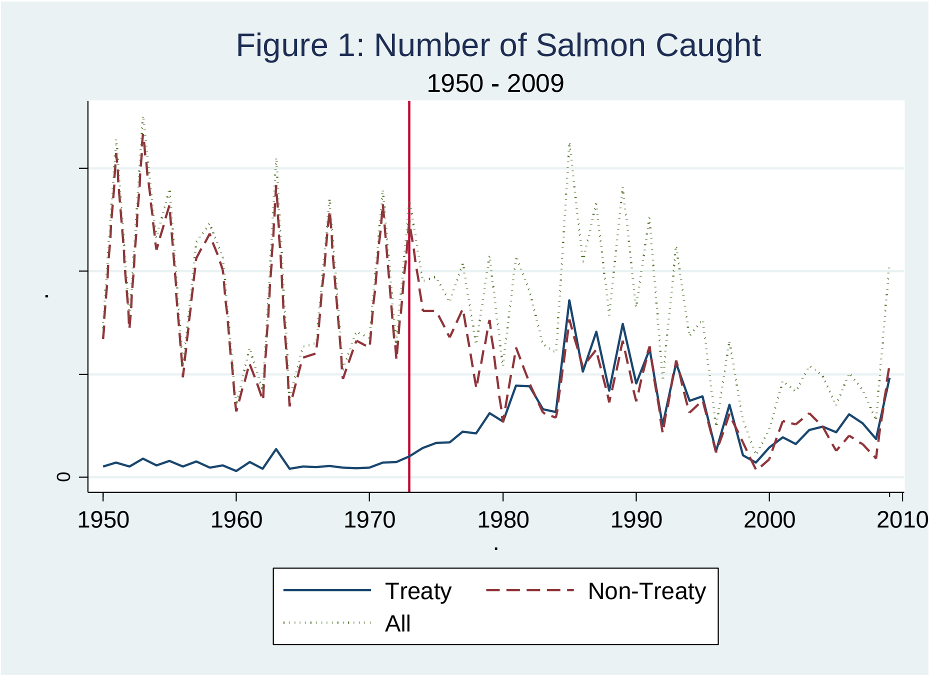
Although these initial rulings became the cornerstone of the "Boldt Decisions", litigation continued. In 1978, the State Supreme Court ordered the Department of Fisheries not to enforce the Boldt decision because it violated the equal protection provision of the U.S. Constitution. In response, the federal court took over management of the fishery and appointed a Special Master and a Fisheries Technical Advisor to provide final approval for fishery management and regulation decisions. In 1979 the U.S. Supreme Court denied the state's appeal on the central issue of a 50 percent share, but agreed that tribal catches for subsistence and ceremonial fish would be counted toward the tribal allocation (see timeline in appendix). In 1982 the state lost its attempt to keep fish of hatchery origin out of the total to be divided. Tribal catch reached the 50

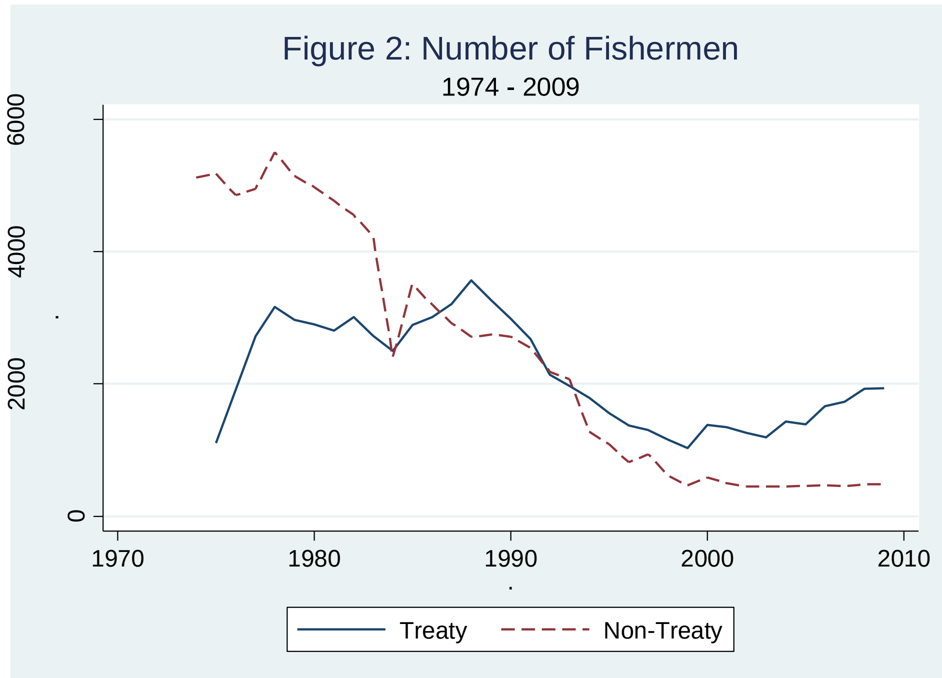
[15] See, for example, United States v. Winans, 198 US 371, 1905; Duwamish, et al., Indians v. United States, 79 Ct.Cl. 530, 1935; State v. Moses, 70 Wash. 2d 282, 1967; and Sohappy v. Smith, 302 F. Supp, 899, 1969.

[16] Seven additional tribes later joined in the lawsuit as intervenor plaintiffs (U.S. v Washington 384 F. Supp. 31 (1974): p. 327.

[17] An early legal history of the Boldt decision is contained in Barsh (1977).

percent level of harvest in 1980 and effectively stayed there after 1982 (see figure 1). The 1970s especially were characterized by large-scale entry of tribal fishermen (see figure 2).



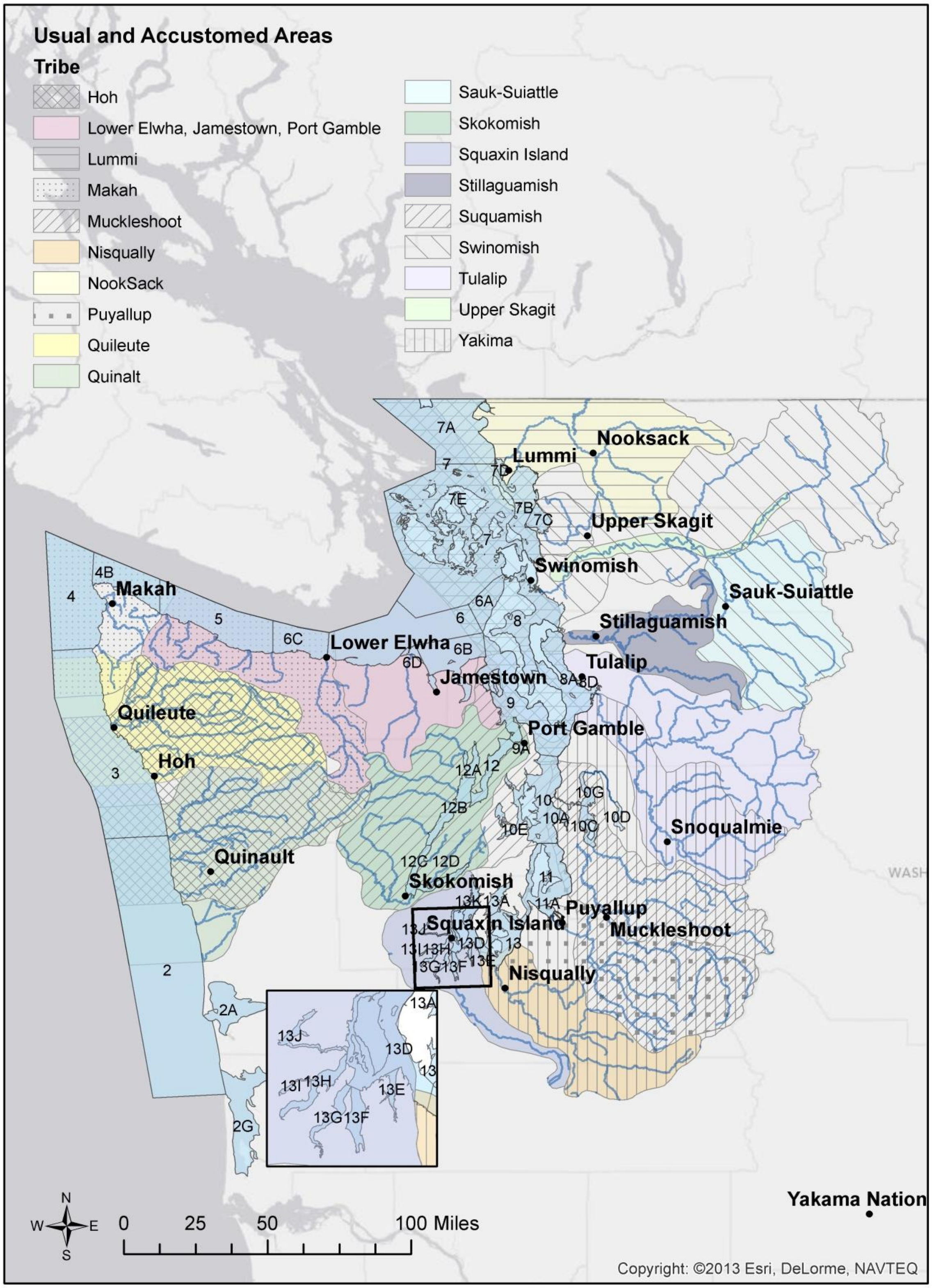


The Boldt decision did not define means by which the treaty tribes would share the 50 percent allocation, but it did set up a system of fishing territories based on historical fishing patterns. The U.S. District Court was given this difficult task. Beyond the problems of documenting where fishing took place in the 19th century, the concept of a "tribe" does a poor job of linking current Indian people to the families and subdivisions of tribal units that actually controlled specific fishing sites (Wold 1989). The court ultimately determined U&As for 20 modern Indian tribes having federally recognized reservations. The location of the reservations and the U&As are shown in the map below. The labeled points represent reservation locations and the colored and patterned shapes represent U&As. The interior lines are major river systems (that salmon spawn in) and the numbers (e.g, 4, 6A, 7C, etc.) denote salmon catch reporting areas in the Washington regulatory scheme.

Most of the U&As have significant areas of overlap, with as many as eight tribes sharing portions of a U&A (see map).[18] For example, U&As for the Lummi, Suquamish, Swinomish, Tulalip, Skokomish, and the three Klallam tribes (Lower Elwha, Port Gamble, and Jamestown) all overlap. But spatial overlap is only one dimension of the issue. In a temporal sense, nearly all of the U&As overlap. As Wold (1989, p. 40) points out, "salmon from, for example, the Squaxin Island's U&A, pass through Makah, Lower Elwha, Jamestown, Port Gamble, Lummi, Skokomish, Swinomish, Suquamish, Tulalip, Muckleshoot, Puyallup, and Nisqually U&As on their way to the spawning grounds." The salmon migration offers a sequence of opportunities to catch fish, with the Makah having the first opportunity and the Squaxin Island having the terminal opportunity.

[18] As Wold (1989) points out, the district court decisions did not distinguish between parts of overlapping U&As that should be controlled by a particular tribe and those that were open to others. Instead, the decisions demarcated areas in which tribes could fish without being subject to state regulations.

Map: Reservation Location of Treaty Tribes and Usual and Accustomed Areas



IV. Theoretical Framework

Our model builds from Deacon et al.'s (forthcoming) model of a salmon fishery. A fishery-wide total allowable catch (TAC), determined by the regulator, is divided into two portions that are separable across time and space. Fifty percent of the TAC is for the non-tribal fishery and the other 50 percent is for the tribal fishery. Each fishery is closed when its TAC is reached. The model takes as given the regulator's TAC and focuses on the within-season activities of tribal fishermen. Each year there are N available tribal fishermen who are members of tribes with marine U&As. They chose between joining the capital intensive "outside" fishery or remaining at "inside" locations to fish with nets as fish return to rivers to spawn.

A. Model Preliminaries

The cost per unit effort of fishing salmon declines as salmon migrate toward a terminal location where stationary gear can be placed and processing facilities are located. We parameterize this by dividing the fishing grounds into two zones and regarding the distance to each as a single value, 0 or $\bar{d}$. These zones are called 'inside' and 'outside', respectively, and distance is normalized so that fishing at an additional unit of distance increases the cost per unit effort by 1 unit. We assume the stock spends time $\bar{T}$ in each zone.

Individuals who fish outside are the first to apply effort and therefore achieve a higher catch per unit effort than those who fish inside. All those fishing in a given distance zone are assumed to experience the same catch per unit effort. We can allow for heterogeneity, however, by allowing fishermen to apply effort at different rates.

Figure 3 illustrates the importance of salmon migration. Total catch, Q, is a linearly homogeneous function of aggregate fishing, E, and the stock, Z. The fishing technology is represented by Q = ZF(E/Z), where $F' > 0$, $F'' < 0$, $F(0) = 0$ and $F(E/Z) < 1$. Given an available stock, *Z*, applying E_T units of effort will yield a catch of Q_T. If that effort is applied sequentially, with E_0 units applied first and $E_T - E_0$ units subsequently, the first 'batch' of effort yields a catch of $ZF(E_0/Z)$ and the second yields a residual catch of $Q_T - Q_0 = Z(F(E_T/Z) - F(E_0/Z))$. Concavity of $F(\cdot)$ implies that catch per unit effort for the first application of effort (slope of line *ab*) is greater than for the second (slope of line *bc*).

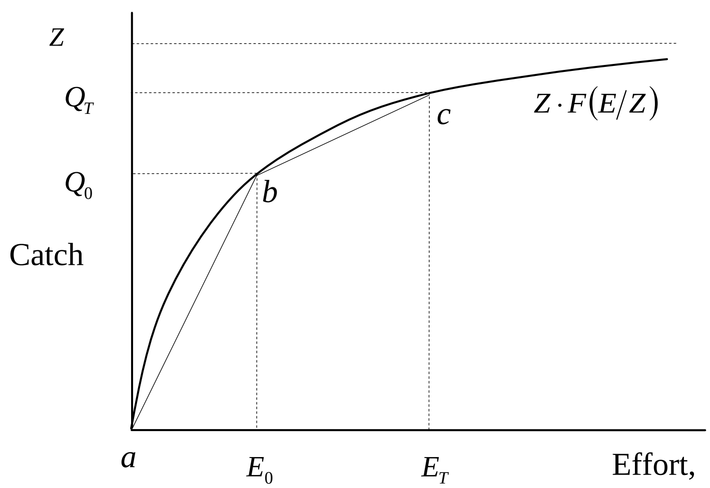


Figure 3. Catch effort function

The regulator's goal is an escapement target of $(1-\beta)Z$, implying that the TAC equals $\beta \cdot (0.5 \cdot Z)$ for the tribal fishery. This implies that total tribal effort must satisfy $E \leq 0.5 \cdot ZF^{-1}(\beta)$. Total effort for the set of marine fishermen is $\sum_m \gamma_m T_m$, where *m* is a marine fisherman and T_m is the time spent fishing by individual *m*. We interpret γ_m as the rate at which individual *m* can apply effort. Total effort for terminal fishermen is $\sum_t \bar{\gamma} T_t$, where *t* is a terminal fisherman and T_m is the time spent fishing by individual *t*. We assume the effective skill parameter $\bar{\gamma}$ is the same for all fishermen because terminal fishing requires less human and physical capital and therefore varies little across fishermen. Total effort for the tribal fishery is $\sum_h \gamma_h T_h = \sum_m \gamma_m T_m + \sum_t \bar{\gamma} T_t$, where "*h*" stands for harvester, and the regulator meets the TAC by constraining fishing time to satisfy

$$\sum_h \gamma_h T_h \leq 0.5 \cdot Z F^{-1}(\beta) \equiv \kappa . \qquad (1)$$

The cost of fishing depends on distance from port and fishing skill. It is given by

$$c_h = d_h \gamma_h T_h + \varphi_h T_h \qquad (2)$$

For a terminal fishermen, the cost is given by $c_t = \varphi_t T_t$, because we assume the only important cost is the opportunity cost of time. For the marine fishermen it is given by $c_m = \bar{d} \gamma_m T_m + \varphi_m T_m$. The key difference is the absence of the distance cost, $\bar{d}$, for the terminal fisherman. Embedded in $\bar{d}$ are the capital costs and operating costs of fishing with capital intensive gear (e.g., a purse seine, troller, or gill netter).

B. First-Best Effort

For an analytical benchmark, we first consider the first-best choice that would be applied if a social planner managed the harvest of the tribal fishery. This planner would be motivated to maximize total tribal profit. Recall that tribal catch is given exogenously by the regulator. We also assume that salmon prices are independent of distance choice (although we plan to explore the possibility that it is not in the empirics of future drafts). Consequently, the planner's optimal policy would solve the following cost minimization problem:

$$\min_{d_h, T_h} \sum_h (d_h) \gamma_h T_h + \sum_h \varphi_h T_h \qquad (3)$$

subject to $d_h \in \{0, \bar{d}\}$, $T_h \in [0, \bar{T}]$ and the regulatory constraint on fishing time described above.

The first-best decisions fall in a straightforward way from the assumptions given. The social planner sets d_h= 0 for each fisherman. This is because (2) is strictly increasing for any tribal member who spends time fishing. Because each terminal fishermen is identical in skill (the rate at which effort can be applied) the first best allocation would employ the lowest opportunity-cost set of fishermen that are necessary to catch the TAC while it is in the terminal zone, $\overline{T}$. If opportunity costs are identical, then the planner could achieve a first-best outcome by randomly selecting fishermen to employ effort. In short, a first-best scenario is one in which no fishermen acquire and operate boats and other capital that would be necessary for marine, outside fishing.

C. Individual Choices by Tribal Fishermen

Now consider the distance choice of tribal fishermen who have the option to fish either inside or outside. An individual fisherman's catch per unit of effort at any location *d* depends on the effort levels and locations of all other tribal fishermen. We denote catch per unit effort by $H\left(d;\, d_h, \gamma_h, T_h, Z\right)$. A tribal fisherman's profit is given by

$$\pi_h = pH(d_h;\, d_{-h}, \gamma_{-h}, T_{-h}, Z)\gamma_h T_h - d_h \gamma_h T_h - \varphi_h T_h \tag{4}$$

where *p* is the exogenously determined price of fish.

The choice of fishing distance can be examined using the marginal and average catch-effort functions, $M\left(E,Z\right) \equiv \partial Q/\partial E = F'(E/Z)$ and $A\left(E,Z\right) \equiv Q/E = F(E/Z)/(E/Z)$. The shape of these functions, as shown in figure 3, are determined by the monotonicity and concavity of $F(\cdot)$. To meet the catch target, the regulator fixes total tribal effort according to (1), at a level denoted κ . If all tribal fishermen fish in the marine zone, all obtain the same average catch per unit of effort, $A\left(\kappa, Z\right)$. Suppose *h* chooses to fish inside while all others fish outside. In this case *h* encounters the stock after others have fished and obtains the marginal (rather than average) catch per unit effort ($M(\kappa)$ in figure 2). Alternatively, if *h* fishes outside while all others fish inside, *h's* catch per unit of effort will be $M(1)$ in figure 2, the marginal catch from the first unit of effort.[19]

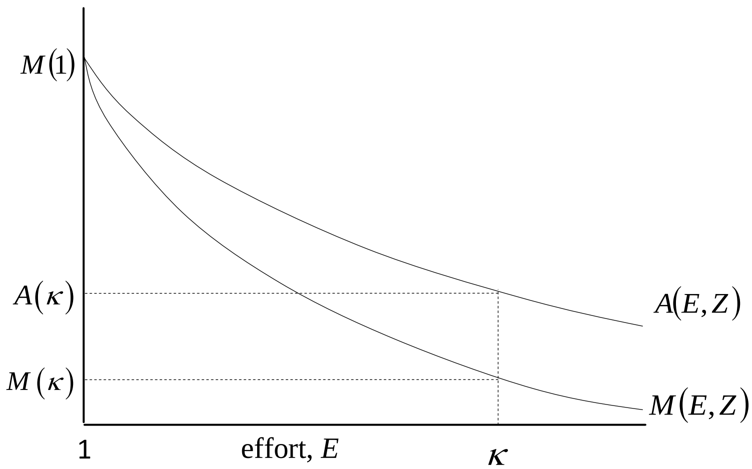


Figure 4. Fisherman *h*'s catch per unit effort, depending on where others fish

If all fishermen are fishing in the outside zone, any individual who deviates to a terminal site would find that cost per unit of effort would fall by $\bar{d}$, but catch per unit effort falls by $A(\kappa)-M(\kappa)$. If $p(A(\kappa)-M(\kappa))>\bar{d}$, which we refer to as Condition (1), then no other fisherman will find it profitable to deviate to the terminal location. If condition 1 holds, which is more likely when $\bar{d}$ is small or when *p* is high, the Nash equilibrium strategy is unique and requires that all κ units of effort fish outside. Suppose, instead, that all fishermen are fishing inside. In this case, any individual who deviates outside will find that cost per unit effort increases by $\bar{d}$, but catch per unit effort increases by $M(1)-A(\kappa)$. If $p(M(1)-A(\kappa))<\bar{d}$, which we refer to as Condition 2, then no fisherman will find it profitable to deviate to the

[19] Fisherman *h*'s catch equals *h*'s catch per unit effort times the effort *h* applies, $\gamma_h T_m$. Catches from the same location will therefore differ among fishermen in proportion to their γ parameters.

outside zone. If Condition 2 holds, which is more likely when $\bar{d}$ is large and p is small, a Nash Equilibrium is unique and all κ units fish in terminal sites.

Finally, suppose $p(A(\kappa)-M(\kappa)) \leq \bar{d} \leq p(M(1)-A(\kappa))$ so neither condition holds. This implies that a Nash equilibrium strategy profile cannot have all potential marine fishermen fishing in either the outside or inside zone. We illustrate this case in figure 5. The horizontal axis now indicates *outside* effort and the dashed line $pA(E)-\bar{d}$ shows outsider profit per unit effort. To characterize Nash equilibrium choices of distance, suppose all potential marine-zone effort was initially fishing in marine zones and successive units were transferred to terminal locations. The first unit transferred inside would earn profit $M(\kappa)$, shown by point *c*, which exceeds the profit from fishing outside. Transferring successive effort units inside causes terminal profit per unit effort to increase toward point *a*, at which point all effort is fishing inside and profit per unit effort equals $A(\kappa)$. The dot-dash line labeled 'insider profit' traces out one possible locus of terrminal profits. If $\hat{E}$ units of effort fish outside and all others fish inside so all earn equal profit, no one has an incentive to deviate. Accordingly, a Nash equilibrium strategy profile in this case is described by this division of inside and outside fishing.

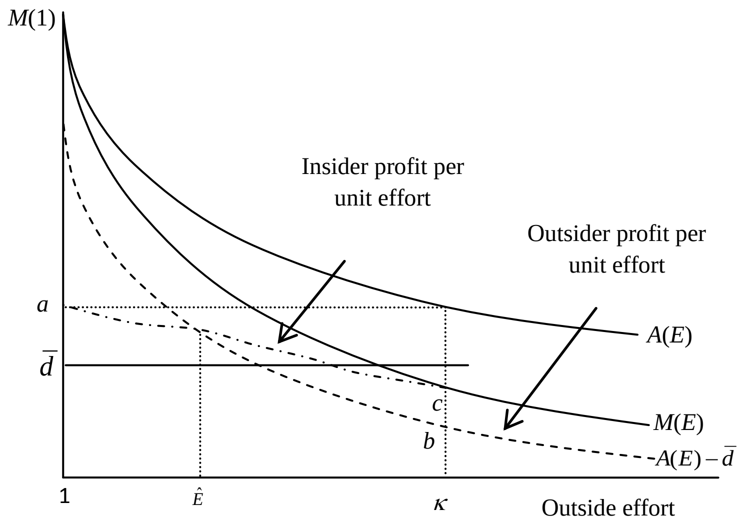


Figure 5. A NE strategy profile in which some fish outside while others fish inside.

D. Discussion and Likely Predictions

The model in its current state is too preliminary to generate welfare results, and also to preliminary to generate precise testable predictions. In its current state, however, some intuitive implications are starting to emerge. First, there are clear conditions under which it is individually rational for fishermen to enter the outside zones, but this is a deviation away from the first best scenario that maximizes aggregate tribal profits. Thus, capital constraints which prevent entry into the outside fishery will increase the profitability of the tribal fishery if the capital constraint is binding for any fisherman who would otherwise fish outside.

Second, exogenous increases (decreases) in the price of salmon will increase (decrease) the likelihood of entry into the marine fishery. This is because price increases increase the probability that $p(A(\kappa)-M(\kappa))>\bar{d}$ for fishermen. Increases in the annual TAC should have the same effect. Exogenous increases (decreases) in the cost of operating boats (e.g., fuel costs, crew costs) will decrease (increase) the likelihood of entry into the marine fishery. These predictions indicate that larger potential rents created by higher salmon prices and TACs, and from lower fuel prices, will be dissipated by the movement to "outside" fishing.

Third, the model implies that increases in time spent fishing will come at the expense of other productive uses of time as long as $\varphi_h > 0$ where $\varphi_h T_h$ is the total opportunity cost of the fisherman's time. If the opportunity cost is productive human capital investment (i.e., education that will increase wages in the long run), then the wasteful investments in fishing "outside" can have a net negative return in the long run. Arguments of this nature are part of other natural resource curse models (e.g., Mehlum et al. 2006, Torvik 2002), but not yet formally integrated into our preliminary model, which simply relies heavily on Deacon et al. (forthcoming).

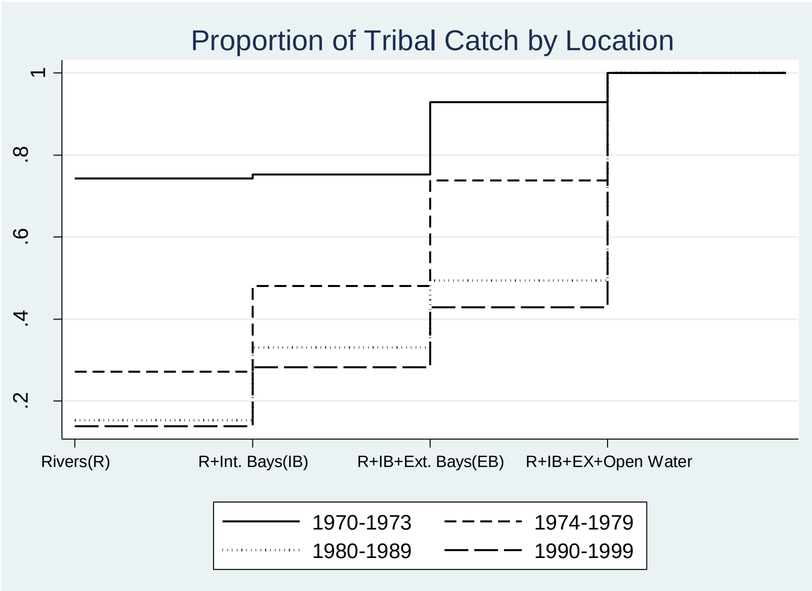
V. Empirical Analysis of Fishing Choices

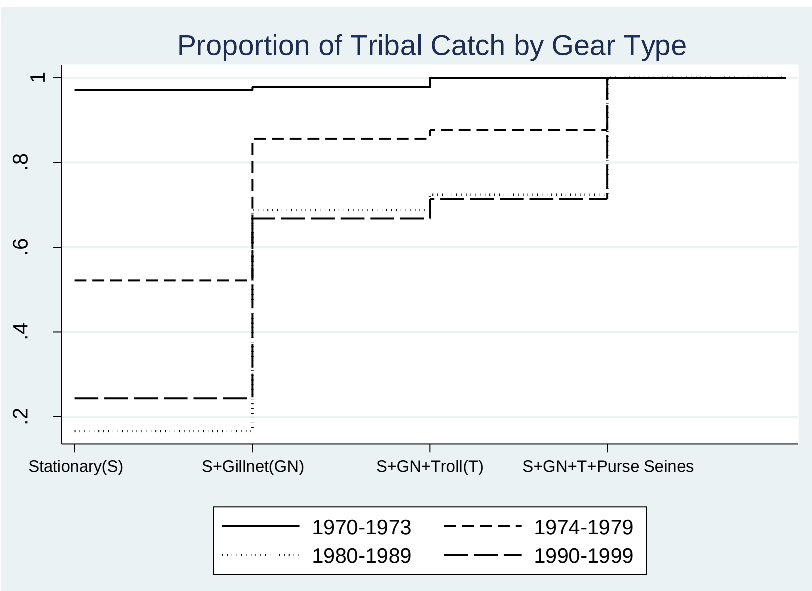
A. Capitalization and Movement towards Outside Fishing in the Wake of Boldt

We begin the empirical analysis by assessing changes in "inside" and "outside" catch in the years following the Boldt Decision and by examining the capitalization of the tribal fishery. The upper panel of figure 6 shows the how the proportion of tribal catch shifted away from terminal locations towards outside waters over time.[20] Prior to the Boldt Decision, during 1970-1973, 74 percent of tribal catch was from rivers and only 7 percent was from outside waters. By the 1990s, only 13 percent of the tribal catch was from rivers while 56 percent was from outside waters. Moreover, the CDFs from the later time periods strictly dominate the CDFs from earlier periods. That is, the 1980s distribution lies entirely below the 1980s distribution, which lies entirely below the 1974-1979 distribution, which lies entirely below the pre-Boldt distribution. Catch clearly shifted towards outside zones over time.

[20] The intermediate distances are "interior bays" and "exterior bays". Map A1 in the appendix and the footnote describes our assignment of distance zones.

Figure 6: CDFs of the Proportion of Tribal Catch by Distance and Gear





The same basic pattern is found in the lower panel of figure 6, which shows how the proportion of tribal catch shifted away from stationary gear towards more capital intensive gear. Here we have ordered the gear type from least capital-intensive ("stationary gear") to most capital intensive (purse seines). The set net is the most prominent type of stationary gear in the tribal fishery, and it used in artisanal fisheries all over the world because of its low cost. Gill nets can be deployed by skiffs or power boats. According to Boxberger (1989), skiff operators in the 1980s had to come up with approximately $5,000 to begin fishing. By contrast, gill nets operated by large power boats required a capital investment ranging from $45,000 to $75,000. Purse seiners required large capital investments ranging from $155,000 on the low end, to $820,000 on the high end.

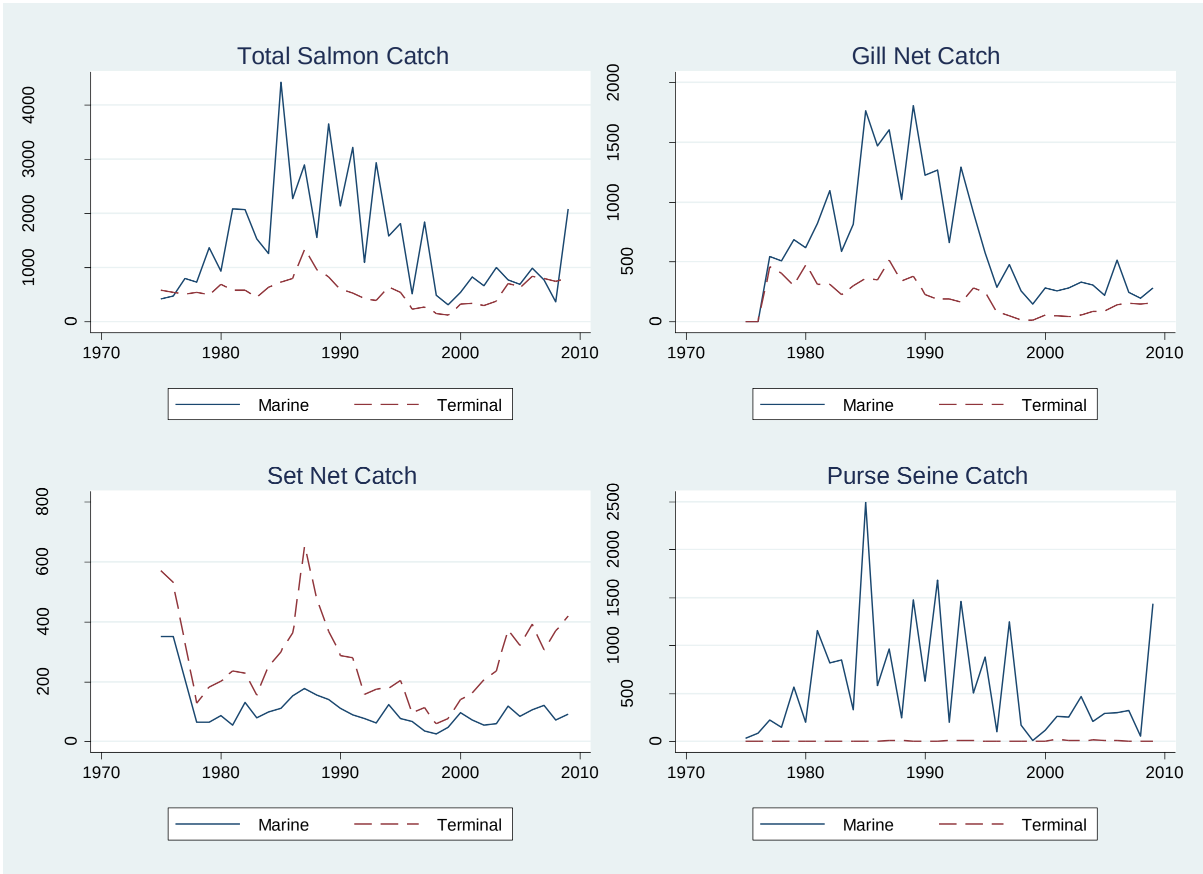
Panel B shows that 97 percent of the tribal catch was made with stationary gear prior to Boldt. This percentage fell to 17 percent by the 1980s. There was no purse seine catch prior to Boldt but purse seiners caught an average of 12 percent of the tribal catch during 1974-1979 and 29 percent of the catch during the 1980s and 1990s. The proportion of gill net catch was only one percent prior to Boldt, it increased to 33 percent during 1974-1979, and peaked at 52 percent during the 1980s.[21]

Figure 7 shows another relevant comparison, the catch of tribes with marine U&As versus the catch of tribes with terminal U&As. The fish ticket data report tribe-specific data beginning in 1975, so our comparisons start in that year. As the first panel shows, the total number of salmon caught by terminal and marine tribes was initially similar, but the gap began to dramatically widen in the 1980s with the marine tribes beginning to dominate the fishery. The gap shrank during the 1990s, however.[22] By gear type, we see that the marine tribes dominated gill net and, especially, purse seine catch. Terminal tribes, however, caught more fish with stationary set nets.

[21] Gill nets are the less specialized than purse seines, which target schooling salmon species primarily pinks and sockeyes. By contrast, gill nets are also well equipped to catch kings, chum, and coho.

[22] This provides some evidence that inter-tribal catch-share agreements initiated in the late 1980s were effective. This is an issue we are presently learning more about.

Figure 7: Catch by Tribes with Marine and Terminal U&As, 1975-2009



B. Entry and Exit Responses to Exogenous Windfalls during 1980-2009

The theoretical model implies that potential rents due to price increases and other exogenous factors will induce entry into the "outside" fishery thereby dissipating rents. To initially test for this, we have compiled an annual data set of tribal catch, along with salmon prices and other variables. We focus on the period from 1980 to present because this is time period when tribes were catching their full 50 percent share of the TAC (see fig. 1).

Table 1 gives summary statistics. Revenue ranged from $4.66 million to 154 million (in 2005 dollars). The annual average real price (per pound) paid to Washington fishermen ranged from $0.72 to $3.08 with a mean of $1.21. There are two reasons why this average price varied over time. The first is that there were changes in the world price of each of the five salmon species. The second reason is that the composition of the annual catch varied from year to year. For example, in years where pinks and chum comprised a large portion of the total catch, the average price was relatively low because these are the least valuable species of salmon.

Table 1: Summary Statistics of Annual Data
1980 – 2009

	Mean	Std. Dev.	Min	Max
All Fishermen				
Number of fish (millions)	4.22	2.32	0.65	9.75
Revenue (millions of $s)	46.2	42.0	4.66	154
Average price from WA fishery ($s)	1.21	0.72	0.35	3.08
Average price from AK fishery ($s)	0.87	0.54	0.29	2.63
Washington unemployment rate	6.85	1.86	4.60	11.8
Treaty Fishermen				
No. of Fishermen	2104	775.7	1030	3571
No. of Gill Netters	1196	540.5	504	2029
No. of Trollers	136.4	81.33	49	315
No. of Purse Seiners	65.2	30.10	21	124
Revenue per fisherman ($s)	8735	4989	2478	21401

Notes: N = 30. Revenue and prices are in 2005 dollars. Prices are reported on a per round pound basis and reflect the payment to fishermen from dealers.

Figure 7a shows the average (wholesale) price paid to fishermen from fish dealers for each species during 1970-2009. Figure 7b plots the average Washington price alongside the average Alaskan price. We use the Alaskan price to instrument for the Washington price (the correlation is 0.91) to mitigate the possible endogeneity of prices. (We assume that the Alaska price is a better proxy for world prices, because the Alaskan share of the market is much larger and not strongly influenced by the Washington salmon market).

Figure 7a: Washington Salmon Prices, 1970-2009

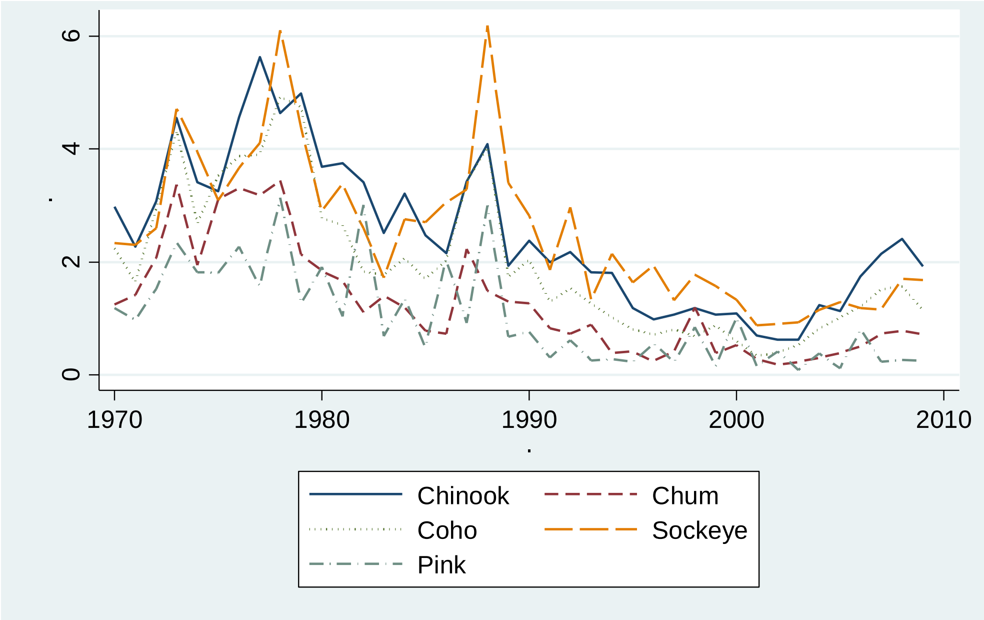
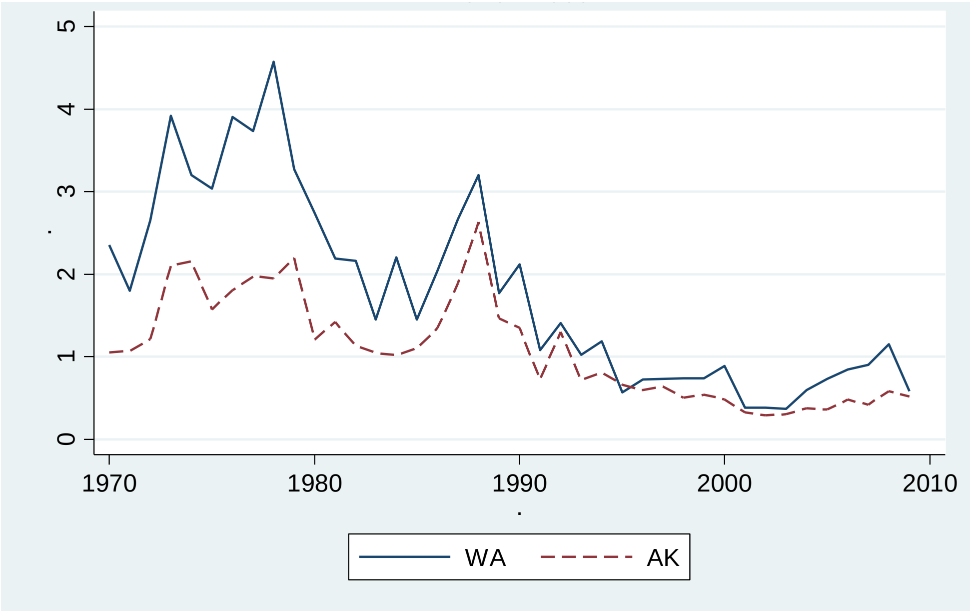


Figure 7b: Washington vs. Alaska Average Salmon Prices, 1970-2009



To examine the entry and exit decisions, we begin by estimating the following regression model, which focuses only on the treaty fishery.

$$ln\ number\ of\ fishermen_t = \alpha + \beta \cdot ln\ total\ fish_t + \pi \cdot ln\ price_t + \delta \cdot ln\ uerate_t + \mu \cdot time + \varepsilon_t \quad (5)$$

where t = year and the notation "*ln*" indicates the variables are logged. We include a linear time trend in an attempt to account for patterns in entry and exit that are not otherwise captured. This specification tests for the effects of changes in the TAC, salmon price, and opportunity costs on the number of treaty fishermen actively fishing during the season. Here the state-wide unemployment rate variable is a proxy for the opportunity cost of fishing; when the unemployment rate is high the opportunity cost of fishing is low.

Table 2 shows the estimated coefficients. The dependent variable in columns 1 and 2 is the number of all treaty fishermen, regardless of gear type. Column 1 employs OLS and column 2 employs 2SLS. In column 2 we instrument the average price received by Washington salmon fishermen with the average price received by Alaskan salmon fishermen to eliminate some of the endogeneity that may be present in Washington prices.

The column 1 and 2 coefficients provide evidence that entry and exit decisions are sensitive to the amount of fish available for harvest, the price of fish and, to a lesser extent, the opportunity cost of time. Because the data are logged, the coefficients have simple interpretations. For example, the coefficient of 0.465 on price in column 2 means that a 10 percent increase in price is associated with a 4.65 percent increase in the number of treaty fishermen. The coefficient of 0.209 on the unemployment rate means that a 10 percent increase in the annual unemployment rate is associated with a 2.09 percent increase in the annual number of treaty fishermen.

Table 2: Regression Analysis of Annual Number of Treaty Fishermen
1980 – 2009

	(1) Y=ln of # treaty fishermen OLS	(2) Y=ln of # treaty fishermen 2SLS	(3) Y=ln of # treaty gillnet fishermen OLS	(4) Y=ln of # treaty gillnet fishermen 2SLS
ln of total lbs of salmon	0.297*** (0.051)	0.274*** (0.054)	0.287*** (0.051)	0.262*** (0.051)
ln of salmon price	0.403*** (0.049)	--------	0.351*** (0.068)	--------
ln of instrumented salmon price	--------	0.465*** (0.061)	--------	0.418*** (0.062)
ln of unemployment rate	0.165 (0.126)	0.209* (0.124)	0.179 (0.112)	0.227** (0.103)
Time trend	0.015 (0.037)	0.005 (0.004)	-0.016*** (0.005)	-0.012*** (0.004)
Constant	2.141** (0.717)	2.037** (0.745)	2.124** (0.756)	2.049** (0.765)
Observations	30	30	30	30
Adjusted R^2	0.954	0.952	0.954	0.952

Notes: *** significant at 0.0l for a two-tailed test, **significant at 0.05, * significant at 0.10. Robust standard errors are shown in parentheses.

The dependent variable in columns 3 and 4 of table 2 is the subset of treaty fishermen using gill nets. We focus on gill net fishermen for several reasons. First, this is the most prevalent and least selective gear meaning that each of the five types of salmon – coho, pink, chum, sockeye, and chinook–are caught by gill nets. By contrast, purse seines and trolls are much more selective. Because gill nets are not selective, we expect the entry and exit of gill net fishermen to respond to changes in the TAC of all salmon species, and to changes in the price of all species. This is unlikely to be true of the more selective gear. Second, capital constraints are not as important in the gill net fishery when compared to the more capital-intensive troll and purse seine fishery. Because our present theory is silent about capital constraints, focusing on gill nets seems to provide a better test. In any case, the coefficient estimates in columns 3 and 4 are qualitatively similar to those found in columns 1 and 2. In summary, the table 3 evidence is consistent with theory that entry and exit decisions in the treaty fishery will be sensitive to changes in the value and cost of fishing.

VI. Diverted Human Capital Effort and Investment

To test whether or not fishing after the Boldt Decision diverted productive human capital investments, we use *Indian Service Population and Labor Force Estimates* published by the Bureau of Indian Affairs (BIA). The reports were published for various years between 1972 and 2005. In this draft, we rely on data from 1981, 1984, 1986, 1988, 1990, 1993, and 1995. In the future we plan to add the data from the 1997-2005 reports.[23]

The reports are based on data gathered by local BIA agencies. For each period, the local agencies estimated tribal populations, labor force sizes, employment, and the number of American Indian students 16 years or older "living on and adjacent to reservations." The data are reported for nearly all reservations in the U.S, although we have yet to enter data for California and Oklahoma tribes. The BIA was unable to collect data for every reservation during every period, however. In these cases, data from the previous period are repeated. We therefore end up with an unbalanced panel, where t=7 for some reservations and t<7 for others.

Table 3 shows summary statistics. The top panel summarizes data for the 25 tribal reservations in Washington state, and the bottom panel summarizes data for all of the tribal areas. The key dependent variable is the number of Native Americans, aged 16 or older, who are out of the labor force because they are "students". Within Washington, this variable ranges from 0 to 1880 with a mean of 161. The key explanatory variable is the revenue from the fishery in

[23] An earlier version of the report was also published in 1972, but the data from that report is less useful for our purposes because it does not report the number of tribal students in each reservation area.

each year that the BIA data were compiled. The revenue variable ranges from zero for non Boldt treaty tribes to a high of $15.1 million for the Lummi Tribe in 1986.

Table 3: Summary Statistics from BIA Reports, 1982-1995

	N	Mean	Std. Dev.	Min	Max
Tribes in Washington[a]					
Students 16 years and older	148	160.9	333.0	0	1880
Students 16 years and older, lagged	125	138.6	285.6	0	1880
Fishery revenue, 2005 $000s	175	1350.8	2583.9	0	15111.5
Instrumented fishery revenue, 2005 $000s[b]	175	13076.4	13999.2	0	50746.7
All Tribes in U.S.[c]					
Students 16 years and older	1002	299.4	723.9	0	8700
Students 16 years and older, lagged	860	293.7	735.4	0	8700
Fishery revenue, 2005 $000s	1127	209.8	1127.5	0	15111.5
Instrumented fishery revenue, 2005 $000s	1127	2030.5	7261.7	0	50746.7

Notes: a) Data are reported for 25 tribes in Washington, but are available for fewer than 7 years for some tribes. b) The instrument is constructed by multiplying the total tribal revenue (i.e., average price x TAC x 0.5) by an indicator variable that equals one if the tribe has a marine U&A and is otherwise equal to zero. c) We have yet to enter data for California and Oklahoma tribes.

We use the data in Table 4 to estimate the regression model given by

$$students_{rt} = \alpha'_r + \lambda'_t + \beta\ fishrevenue_{rt} + \delta students_{r,t-1} + \varepsilon_{rt} \qquad (6).$$

Where r=reservation and t=time period. The specification allows each reservation to have its own fixed effect. Each time period also has its own effect. This implies that β, the fishing revenue effect, is identified from changes over time within reservations. The standard errors in each regression are clustered by reservation, to control for potential serial correlation over time.

Table 4 shows the estimates. Focusing on the first four columns, we see that fishing revenue is negatively associated student enrollment. The -0.059 coefficient in column 2, for example, means that a fishery revenue increase of $1 million is associated with a decrease in student enrollment of 59 students. Although this number may seem unreasonably high, consider data from the Lummi Tribe. From 1986 to 1995 its fishery revenue dropped $13.03 million, from

$15.11 million in 1986 to $2.08 million in 1995. During the same time span, the number of Lummi students increased by 1327, from 228 to 1555.

Table 4: Fixed Effects Estimates of American Indian Students, 1982 to 1995

	WA only (1)	WA only (2)	All Tribes (3)	All Tribes (4)	WA only (5)	WA only (6)	All Tribes (7)	All Tribes (8)
Fishery Revenue	-0.054*** (0.019)	-0.059*** (0.016)	-0.058*** (0.015)	-0.066*** (0.014)	----	----	----	----
Instrumented Fishery Revenue	----	----	----	----	-0.026 (0.020)	-0.037*** (0.020)	-0.050** (0.027)	-0.062** (0.026)
Lagged Students	----	0.690*** (0.147)	----	0.091** (0.047)	----	0.672*** (0.185)	----	0.090** (0.039)
Res. Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.218	0.514	0.031	0.043	0.288	0.483	0.032	0.043
Observations	148	102	1002	764	148	102	1002	764
First-stage *t-stat* on instrument	----	----	----	----	6.16	5.30	24.68	22.92

Notes: ***significant at 1 percent level for a one-tailed test; ** 5 percent; * 10 percent. Standard errors are clustered at the reservation level. The instrument is constructed by multiplying the total tribal revenue (i.e., average price x TAC x 0.5) by an indicator variable that equals one if the tribe has a marine U&A and is otherwise equal to zero. c) We have yet to enter data for California and Oklahoma tribes.

Columns 5-8 use an instrumental variable approach to account for the endogeneity of fishing revenue at the tribe-year level.[24] The potential problem is that tribes may choose to harvest more salmon because a large number of its younger members are not enrolled in school. To correct for this, we use an instrumental variable approach. Our instrument is constructed by multiplying the total revenue earned by all treaty tribes (i.e., average price x TAC x 0.5) by an indicator variable that equals one for tribes with marine U&As. The instrument is otherwise equal to zero.

The instrument works well in the first-stage, with t-stats ranging from 5.30 to 24.68, because fishing revenue is strongly linked to TACs, salmon prices, and because a tribe's share of the annual catch is largely determined by the spatial location of its U&A (see figure 7). The

[24] Our fishing revenue variable is similar to variables used for cross-country estimates of the resource curse that represent how much revenue a country earns from its natural resource sector. Such variables are likely endogenous, however, and may simply indicate a backward economy (see, e.g., Brunnschweiler and Bulte 2009).

instrument should also meet the exclusion requirement because the components of the instrument should not directly influence student enrollment except through the channel of increased tribal fishing effort. For example, we doubt that changes in student enrollment in the 1980s and 1990s would be influenced directly by where tribal ancestors fished in the 1850s.[25]

Columns 5-8 show that instrumented fishery revenues are still negatively associated with student enrollment, but the coefficients are a bit less precisely estimated; in column 5 the relationship is statistically insignificant by conventional standards. The coefficient estimates now have different interpretations when compared to columns 1-4 but they are still economically large. The column 5 coefficient, for example, indicates that an increase of $1 million in the instrument corresponds with a decrease of 37 students.

VII. Decadal Income Growth

We now estimate the effect of windfall fishery revenues on the median and per capita income of tribes. We employ data from the 1970, 1980, 1990, and 2000 U.S. census reports. The Census decadal reports are a comprehensive source of tribal income data, but the shortcoming is that in the 1970 census data are reported for only seven Boldt treaty tribes. Data are reported for 15 Boldt treaty tribes in 1979, and all of the Boldt treaty tribes in 1989 and 1999.

A. The 1970s

Table 5 presents first-difference regression estimates of the 1969 to 1979 period. During this decade, fishing revenue across all tribes increased by $38 million (in 2005 $s). The dependent variable in columns 1-4 is the change in the per capita income of tribes. The dependent variable

[25] However, it is worth noting that our instrument is effectively ignoring temporal variation in fishery revenue within tribes having terminal locations. This is not ideal.

in columns 5-8 is the change in the median family income. The key independent variable is the change in tribal fishing revenue over the same period.[26]

The first-difference regression specifications are given by

$$\Delta income_{ar} = \alpha + \beta(\Delta fishrevenue)_{ar} + \eta(initial\_income)_{ar} + \theta_a' + \varepsilon_{ar} \qquad (7)$$

where r=reservation and some specifications control for initial income.[27] The θ term indicates that some specifications include fixed effects for the eight BIA administrative areas.

Table 5: First Difference Estimates of Changes in Reservation Incomes, 1969 to 1979

	Y = American Indian Per Capita Income				Y = American Indian Median Family Income			
	OLS (1)	OLS (2)	OLS (3)	2SLS (4)	OLS (5)	OLS (6)	OLS (7)	2SLS (8)
Δ in Fishery Revenue	0.289*** (0.106)	0.235*** (0.079)	0.287** (0.141)	----	0.735*** (0.091)	0.916*** (0.099)	0.751** (0.333)	----
Instrumented Δ in Fishery Revenue	----	----	----	0.175 (0.176)	----	----	----	0.715*** (0.075)
Per capita income, 1969	----	-0.393*** (0.124)	----	----	----	----	----	----
Median income, 1969	----	----	----	----	----	-0.575*** (0.125)	----	----
BIA Area Effects	No	No	Yes	No	No	No	Yes	No
R^2	0.014	0.145	0.064	0.205	0.023	0.307	0.098	0.023
Reservations	98	65	138	130	65	65	65	65
First-stage F-stat				6.04				61.7

Notes: ***significant at 1 percent level for a one-tailed test; ** 5 percent; * 10 percent. Columns 1-4 employs only seven reservations affected by the Boldt decision because per capita income is only reported in the 1969 Census for the Lummi, Makah, Quinault, Skokomish, Swinomish, Tulalip, and Yakima. Columns 5-8 employ only three reservations affected by the Boldt decision because family income is only reported for three of these tribes in 1969: Lummi, Quinault, and Yakima. Incomes and fishery revenues are reported in 2005 dollars, and robust standard errors are reported. The instrument is the product of the difference in all tribal fishery revenue over 1975 to 1979 multiplied by an indicator of whether or not the tribe was assigned a "marine" usual and accustomed fishing area.

[26] We calculate the change from 1975 to 1979 because our fish-ticket data do no report the specific tribal affiliation of tribal fishermen prior to 1975.

[27] We do not control for first period income in all specifications because this is a controversial practice in growth equations used to test resource curse theories (see Alexeev and Conrad 2009).

The table 5 estimates show a positive relationship between fishing revenue and income growth, whether measured in per capita dollars or by median family income. The column 2 coefficient of 0.235, for example, means that an increase of $1 million in fishing revenue is associated with a $234 increase in per capita income. The column 6 coefficient indicates that a $1 million increase is associated with a $916 increase in median family income (in 2005 dollars).

Columns 4 and 8 report results from a 2SLS regression. The instrument is the product of the difference in all tribal fishery revenue over the decade multiplied by an indicator of whether or not the tribe was assigned a “marine” usual and accustomed fishing area. In the 2SLS regressions, we find that the positive relationship persists, but it is estimated with less statistical precision.

To summarize, we find positive relationships between tribal income growth and fishery revenue during the 1970s, the first decade during which tribes had access to the fishery. The results are consistent with the idea that the Boldt Decision was initially a blessing for tribes.

B. The 1980s

Table 6 presents the same first-difference regression estimates, but for the 1979 to 1989 period. During this decade, fishing revenue across all tribes increased by $28 million (2005 $s). Comparing the results in Table 7 with those in Table 6, we see that the relationship between fishery revenue and income during the 1980s is much different than the relationship during the 1970s. In the 1980s, there is some (weak) evidence that increases in tribal revenue caused decreases in tribal incomes. In any case, there is no evidence in table 7 to suggest that tribal per capita or median incomes increased with increases in fishery revenues.

Table 6: First Difference Estimates of Changes in Reservation Incomes, 1979 to 1989

	Y = American Indian Per Capita Income				Y = American Indian Median Family Income			
	OLS (1)	OLS (2)	OLS (3)	2SLS (4)	OLS (5)	OLS (6)	OLS (7)	2SLS (8)
Δ in Fishery Revenue	-1.026** (0.592)	-0.120 (0.541)	-0.804 (0.752)	----	-2.44* (1.542)	-0.311 (1.182)	-1.202 (2.089)	----
Instrumented Δ in Fishery Revenue	----	----	----	-2.554* (1.719)	----	----	----	-9.585* (6.588)
Per capita income, 1979	----	-0.674 (0.129)	----	----	----	----	----	----
Median income, 1979	----	----	----	----	----	-0.735*** (0.108)	----	----
BIA Area Effects	No	No	Yes	No	No	Yes	Yes	No
R^2	0.023	0.519	0.110	0.205	0.0218	0.501	0.230	0.201
Reservations	139	139	139	139	132	132	132	132
First-stage F-stat				7.89				7.88

Notes: ***significant at 1 percent level for a one-tailed test; ** 5 percent; * 10 percent. Incomes and fishery revenues are reported in 2005 dollars, and robust standard errors are reported. The instrument is the product of the difference in all tribal fishery revenue over the decade multiplied by an indicator of whether or not the tribe was assigned a "marine" usual and accustomed fishing area.

C. The 1990s

Table 7 presents first-difference regression estimates for the 1989 to 1999 decade. This was a decade during which the Washington salmon fishery collapsed in terms of prices and stocks (see figure 1 and figure 7a); revenue across all tribes decreased by $13 million (in 2005 dollars). This was also the first decade during which casino gambling became important revenue generator on some reservations. To control for gambling activity, we include a measure of the number of slot machines on reservations as of 1999 from Anderson and Parker (2008).

Table 7: First Difference Estimates of Changes in Reservation Incomes, 1989 to 1999

	Y = American Indian Per Capita Income				Y = American Indian Median Family Income			
	OLS (1)	OLS (2)	OLS (3)	IV (4)	OLS (5)	OLS (6)	OLS (7)	IV (8)
Δ in Fishery Revenue	0.104 (0.148)	0.081 (0.134)	0.073 (0.163_	Coming Soon	-0.227 (0.401)	-0.386 (0.365)	0.263 (0.392)	Coming Soon
Instrumented Δ in Fishery Revenue	----	----	----		----	----	----	
Per capita income, 1989	----	-0.173 (0.154)	----		----	----	----	
Median income, 1989	----	----	----		----	-0.509*** (0.234)	----	
Slot Machines	1.366*** (0.423)	1.306*** (0.435)	0.791 (0.567)		4.536*** (1.401)	3.971*** (1.525)	3.310** (1.54)	
BIA Region Effects	No	No	Yes		No	Yes	Yes	
R^2	0.062	0.072	0.198		0.058	0.177	0.210	
Reservations	147	147	147		144	144	144	
First-stage F-stat								

The regression results show no relationship between per capita income and fishing revenues. Apparently, the reduction in fishery revenues during the 1990s did not have a measurable effect on tribal incomes, either positive or negative.

D. Marine versus Terminal Tribes

Table 8 compares the decadal per capita income growth and population growth of tribes with marine U&As against those with terminal U&As. Columns 1-3 suggests that marine tribes experienced more per capita income growth than terminal tribes during the 1970s, but after that first decade there are not significant differences. In columns 4-6, the dependent variable is American Indian population. The results suggest the Boldt Decision triggered a flood of migration to both marine and terminal tribes during the 1970s. Above-average population growth continued in the 1980s for marine tribes, but not for terminal tribes, as the Washington state fishery continued to boom.[28] These results are generally consistent with our story. The fishery became highly capitalized during the 1980s because of the lack of constraints on entry, and potential rents were competed away.

Table 8: Per Capita Income and Population Growth by Decade

	Dep. Var. is Δ in Per Capita Income			Dep. Var. is Δ in Am. Indian Population		
	69-79 (1)	79-89 (2)	89-99 (3)	69-79 (4)	79-89 (5)	89-99 (6)
Marine Tribes	1572** (677.1)	-140.8 (1149)	-804.8 (871.9)	718.4*** (114.1)	229.0*** (95.6)	122.8 (88.1)
Terminal Tribes	-1015 (1718)	1236 (974.6)	-756.5 (605.7)	798.9*** (177.4)	133.6 (128.0)	-20.85 (102.9)
Beginning period per capita income	-0.411*** (0.121)	-0.661*** (0.145)	-0.169 (0.151)	----	----	----
Beginning period population	----	-----	----	0.818*** (0.039)	0.354*** (0.013)	0.216*** (0.003)
Slot machines in 1999	----	-----	1.269*** (0.444)	-----	-----	0.098* (0.055)
Constant	4995 (686.2)	5380.3*** (1216)	4183*** (1286)	-676.2 (116.4)	-201.1*** (82.2)	-90.44 (66.7)
R^2	0.162	0.525	0.075	0.954	0.915	0.911
Reservations	98	139	147	98	142	148

Notes: ***significant at 1 percent level for a one-tailed test; ** 5 percent; * 10 percent. Incomes are reported in 2005 dollars

VIII. Conclusions

We contribute to the literature on the resource curse in two unique ways. First, we are the first to explicitly study it in the context of fishery windfalls. Fisheries are a natural setting to test for a resource curse, as a large body of literature documents the dissipation of fishery rents in the absence of property rights across the globe. Consider the World Bank's (2009) recent *Sunken*

[28] Our findings with respect to population growth differ from Caseli and Michaels (2011), who find no significant relationship between oil revenues and population growth in Brazilian municipalities.

Billions report. It estimates that $50 billion is lost annually because of poor fishery management, and that $2 trillion has been lost over the past three decades. According to the report, some fisheries have generated *negative* rents.

Second, we recognize that litigation over the interpretation of treaties between Native people and colonists can provide excellent settings for micro analysis of the resource curse. Some recent legal decisions in Canada, for example, clarify and reinforce aboriginal treaty rights over land and forests (see Keay and Metcalf 2011). In the case of fisheries, indigenous people in Canada, Australia, and New Zealand have experienced gains in access and allocation in recent years (see, e.g., Burnett 1996, Kai Guth 2001, De Alessi 2012). Detailed study of these and similar cases may provide excellent information about if, how, and when resource curses are real.

Our preliminary analysis of the Boldt Decision provides some support for the idea that sudden access to a booming fishery eventually caused somewhat of an economic curse for Pacific Northwest tribes. The fishery became quickly over-capitalized and rents were apparently dissipated in the race to catch fish. The evidence also suggests that young tribal members gave up schooling to participate in the fishery. To be sure, however, the Boldt Decision conveyed large economic benefits for tribes in the short-run.

Although our evidence of an economic curse is somewhat tenuous, it is clear that the tribal fishery operated in a manner that was far from first-best. Had a system been in place to control – or prohibit – entry into outside zones, more rents could have been captured for the benefit of impoverished tribes. Alternatively, if tribes were able to coordinate their effort as a single fishing enterprise then the dissipation of rents could have been avoided. Where such voluntary coordination has been attempted, the rent gains have been significant (see Deacon et al. forthcoming).

The details and context of the Boldt Decision, however, made the prospect of entry controls on marine fishing and inter-tribal coordination very slim. By assigning usual and accustomed areas that gave some tribes superior access to migrating salmon, the decision significantly raised the transaction costs that tribes would have to overcome to achieve a coordinated solution. It is because of these transaction costs that Barsh (1977) predicted that the tribal fishery would ultimately replicate the inefficient management systems of non-tribal salmon fisheries, thereby losing the benefits of their court victory. The preliminary evidence in this paper suggests that Barsh was correct.

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Treaty of Point No Point, 12 Stat 933.

Treaty with Yakimas, 12 Stat 951.

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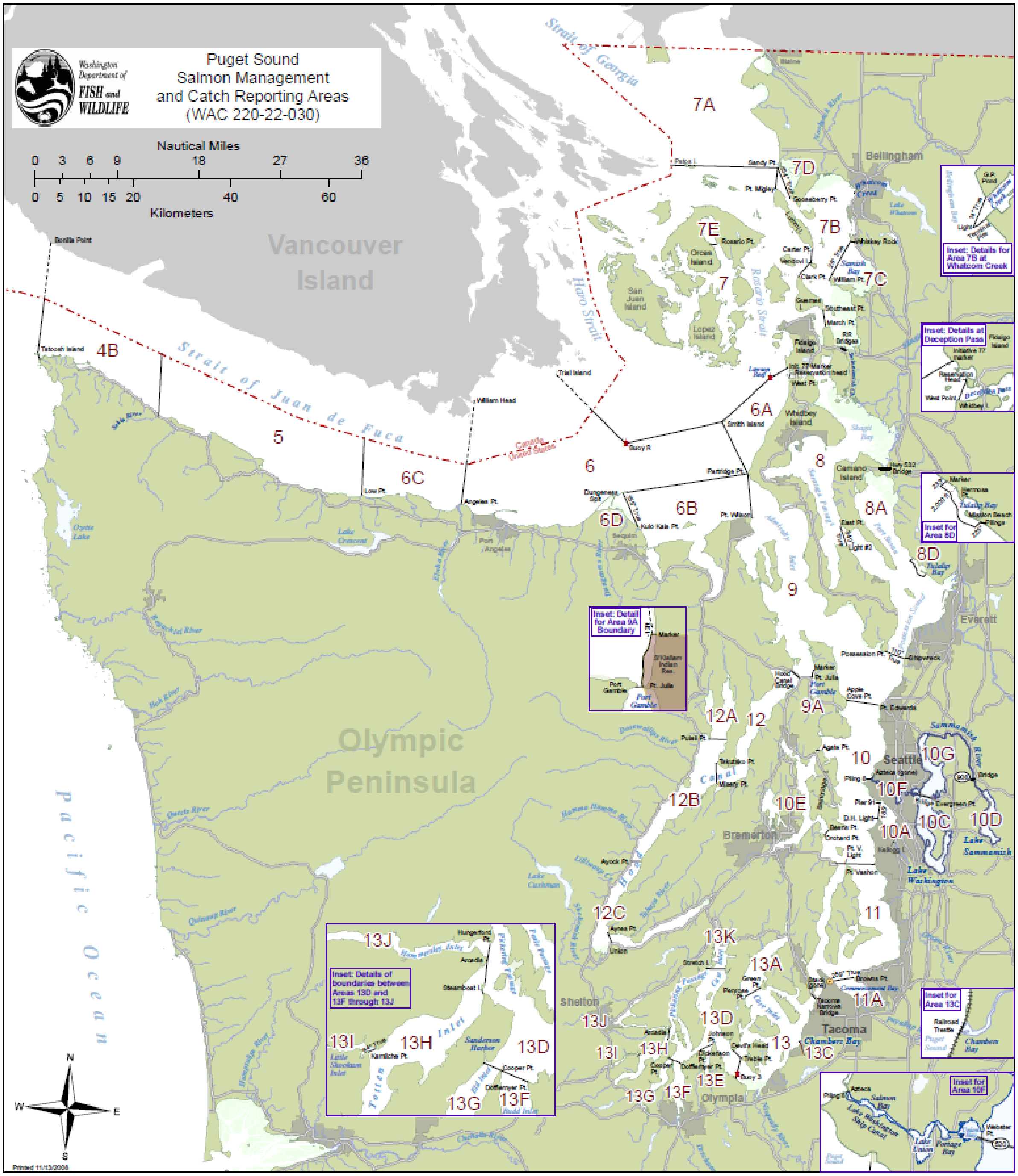
Sohappy v. Smith, 302 F. Supp, 899, 1969.

United States v. State of Washington State, 384 F. Supp. 312, 1974.

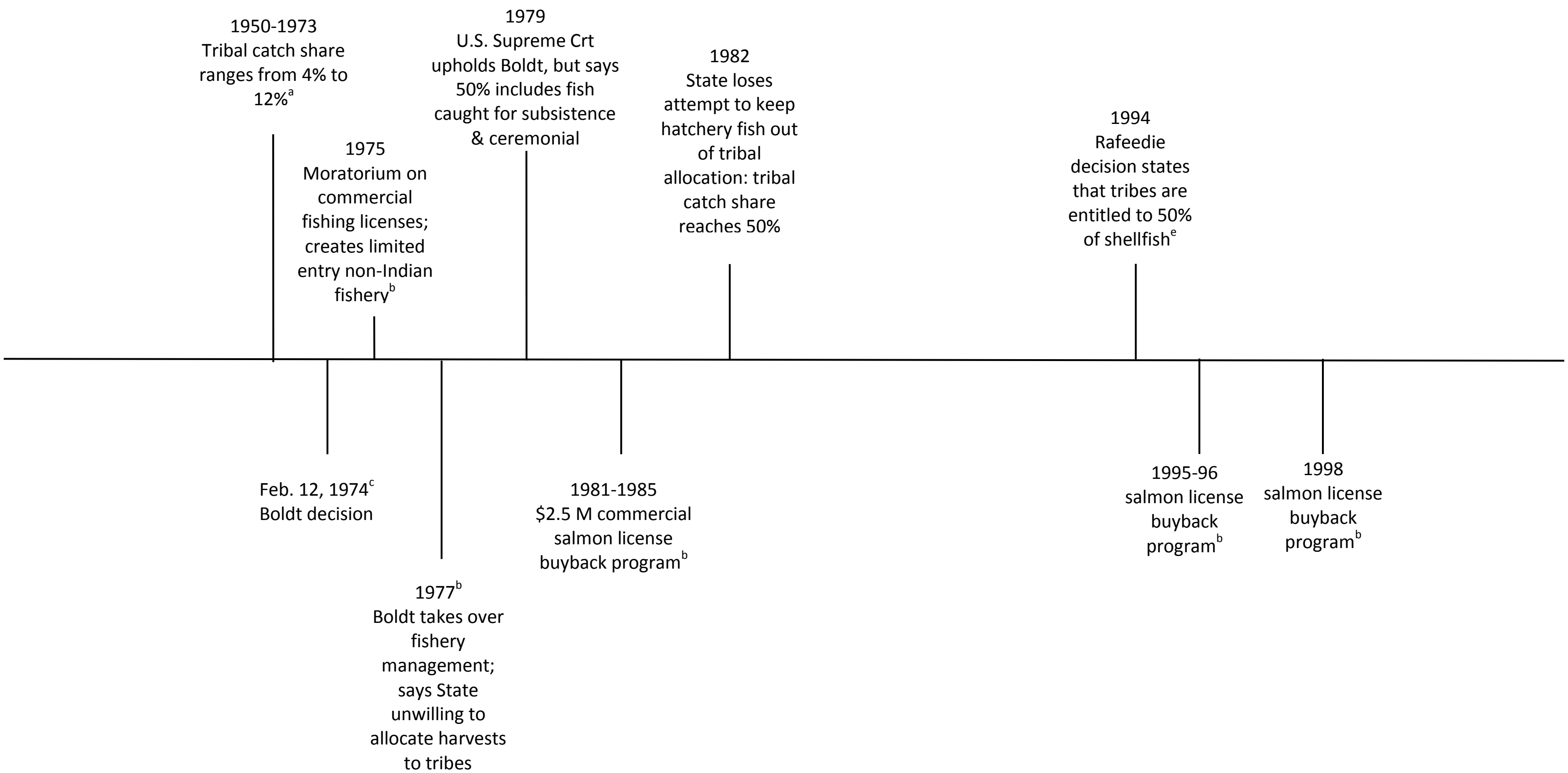
Appendix

Washington Salmon Management and Catch Reporting Areas



Notes: “Outside Waters” are areas 3, 4A, 4B, 5, 6, 6A, 6B, 7, and 7A. “Exterior Bays and Inlets” include areas 7B, 7C, 7D, 8, 8A, 8D, 9, and 10. “Interior Bays and Inlets” include areas 9A, 10A, 10C, 10D, 10F, 10G, 11,11A, 12, 12A, 12B, 12C, 13A, 13B, 13C, 13D, 13E, 13F, 13G, 13H, 13I, 13J, and 13K. “Rivers” are not shown on the map but include all waters in the Puget Sound drainage not specified above.

Timeline of *U.S. v. Washington* Decisions and Surrounding Events



Sources: (a) Barsh (1977); (b) Kersteter (2000) ; (c) *United States v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974); (d) *Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n*, 443 U.S. 658, 99 S. Ct. 3055; (e) *United States v. Washington*, 873 F. Supp. 1422 (W.D. Wash. 1994)