How the Potlatch Contributed to Fisheries Management

by

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Presented at the Sixth Annual Conference of the

International Association for the Study of Common Property

VOICES FROM THE COMMONS

5-8 June 1996
Berkeley, California

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ABSTRACT. With population levels and technology that could have led them to overfish their salmon resource, most northwest coast tribes succeeded in generating a surplus from their fishery. A "potlatch" or "give-away" system creates incentives to manage a common property resource at socially optimum levels of harvest effort. The particular institutions of the Kwakiutl are examined in this paper to explore the possibility that their potlatch tradition helped prevent overharvest of their common pool resources. Kwakiutl world view and their system of winter ceremonials are consistent with this interpretation, as is the growth of the size of individual potlatches in the nineteenth century and the decline of the potlatch as Kwakiutl lost control of their fishery in the twentieth century. Because of the success of northwest coast tribes, an institution which requires users of a common pool resource to divide their surplus among each other should be considered in addressing common pool problems.

The native peoples of the Northwest Coast of North America are well-known for their art, wealth, fishing prowess, and the potlatch. This paper shows that the potlatch could have contributed to the wealth of these societies by providing economic incentives for optimal fisheries management. Although some anthropologists (Suttles 1960, Piddocke 1965), have offered ecological analyses of the potlatch, no one appears to have suggested that the material wealth of these societies may have been related to potlatching traditions in the presence of primary dependence on salmon, halibut, and other fisheries.

In the post-contact era, overfishing and dissipation of economic returns have been the major fisheries management problem. Economists James Crutchfield and Guilio Pontecorvo (1969), have studied the problem in the case of pacific salmon, with special attention to Alaska and Puget Sound. As with other fisheries, high short-term rents

combined with free entry led to overinvestment in boats and fishing gear. By 1936, the non-Indian fishery was faced with reduced runs (Crutchfield and Pontecorvo 1969, 57).

Why did this problem not exist with native peoples? The first section of this paper presents evidence that it should have. Indians had excellent boats and gear, extensive knowledge of salmon migration patterns, high population levels, and private property rights in fishing sites. They accumulated wealth and gave the wealth away in extravagant potlatches. Yet the salmon runs at contact were extensive. Why?

The potlatch practice appears to have had the same geographic distribution as dependence upon salmon. The second section of this paper summarizes the characteristics of the potlatch institution, with emphasis on the Kwakiutl, where the potlatch has been extensively studied and debated. Importantly, the potlatch was a coercive institution: Kwakiutl leaders were required to give away their wealth. That wealth ultimately depended upon the salmon harvest. The potlatch, while primarily a system of wealth redistribution, was also part of important social and religious activities. Ceremonies which showed respect to the spirit of the salmon had to conclude with wealth give-aways.

The third section of the paper demonstrates that a requirement to give away the net returns from a fishery solves the common-pool dilemmas of fisheries. The prisoner's dilemma game captures a fundamental problem of fishery management; one can easily show that a requirement to give away net returns removes the dilemma, making it possible for people sharing access to a common salmon run via privately-owned fishing sites to restrain their fishing effort. Some authors, particularly Runge (1981, 1984, 1992), point out that the problem of the common pool should be modeled by the assurance game. The

third section of the paper also shows that a potlatch requirement eases solution of the assurance game.

Native Americans have recently received admiration for an ethic that supports good land use (Callicott, 1989, 177-219)). Economists are well-known for asserting that when it comes to economic activity, humans are all similar in their economic motivations. This attitude leads to some skepticism regarding claims that Native Americans were different, and able to respect nature (Hyde 1995). This paper asserts that the potlatch institution, understood properly as a coercive rule that restricted private conduct, provides an answer that should persuade economists that some Native American societies had institutions as well as ethics that supported respect for nature. In addition to providing respect, the potlatch also provided a way for Native Americans to achieve the economist's *social optimum*: the fourth section of the paper shows how, in a typical model of externalities, the presence of a potlatch-type institution can induce a social optimum. This means that a potlatch institution not only solves a prisoner's dilemma in a fishery: it suggests a way to address other environmental dilemmas similar to common pool problems.

The potlatch contributes to the literature on common pool resources by suggesting an alternative incentive system that is not well-examined. The growing literature on common pool and common property management is emphasizing the expectation that local or indigenous institutions have answers to the dilemmas of the common pool (Berkes 1989; Bromley 1992; Ostrom et al. 1994; Feeny et. al 1996). Ostrom et al (1992, p. 218) report that "share and share alike" is a solution subjects of laboratory experiments attempt to implement if they are allowed to communicate. Fiske (1991) argues that "equality

matching" is one of four fundamental forms of human relations. That the indigenous societies of the Northwest Coast used the incentive system described in this paper with such success suggests that it should be included in the toolbag of institutional recommendations that is available for those dependent on common pool resources.

I. EXCESSIVE HARVEST WAS ACHIEVABLE BY NORTHWEST COAST INDIANS PRIOR TO CONTACT

Because the central assertion of this paper is that the economic incentives of the potlatch worked to prevent unsustainable harvest of the fishery, the paper begins with discussion of the evidence that native peoples of the Northwest Coast could have harvested too many fish. That the problem was a realistic possibility depends on three key factors: indigenous fishing technology, precontact population levels, and property rights.

Fishing technology

Fishing technology consists of boats and fishing equipment , knowledge of the runs, and storage techniques. Along the Columbia River, in Puget Sound, along the Fraser River, on the coast of present-day Canada, and in Alaska, the key fact is that white settlers learned their fishing techniques from the natives. In his study of the fishing industry on the Columbia River, Smith summarizes the technical situation as follows:

> Having this assortment of gear, Native American fishers were well equipped to catch salmon in the various conditions of the river. In fact, their gear encompassed

a range of variability comparable to that of the white fishers who exploited the salmon resources as a commercial enterprise. (Smith 1979, 11)

In her expert testimony for *United States v. Washington*, anthropologist Barbara Lane summarized the situation for the tribes that were party to the case:

> Traditional Indian fishing methods were highly efficient. These methods survived where Indians were allowed to maintain them; that is, where they were not outlawed or where Indians were not prevented access to areas where the methods were feasible. (Lane 1973a, 40-41)

Lane's report provides detailed information for each of the tribes that were party to this suit, which led to the well-known "Boldt Decision" that the treaty tribes of western Washington had rights to half of the salmon and steelhead fishery in that state (Cohen 1986).

As with the Indians living on the Columbia River and living in what was to become western Washington State, Indians in British Columbia were also excellent fishermen:

> The technology of commercial fishing was developed from the expertise of Indians, and it was their equipment that helped start and build the industry. Especially important was their knowledge of fish movement and small boat navigation in the uncharted tidal channels of the coast. Indian women were skilled in fish cleaning and preservation and needed little or no training to work in canneries . . . and salteries. (Kew 1990, 162-163)

In Alaska, use of a key technique by natives, the fish trap, was outlawed in 1889 and by the 1930s the use of fish traps by non-natives was the cause of excessive harvest:

> In 1889 federal legislation was enacted that outlawed aboriginal traps and weirs. A few years later, legislation was adopted that permitted commercial fish traps to be placed in the mouths of salmon streams. . . . The fish traps accounted for 70 percent of all salmon taken in southeast Alaska during 1925 to 1934. ... It was quite evident that the salmon stocks were decreasing and that fish traps were responsible for the decline. By 1953, President Dwight Eisenhower declared the fishing communities in southeast Alaska disaster areas. (Worl 1990, 153)

The current condition of the salmon fishery, in which the ocean catch is a primary problem, diverts attention from the essential efficiency of catching salmon at or near the mouths of rivers. Not only is such a location very efficient, it allows identification of fish stocks with their home streams. Fish caught in the ocean cannot be so identified, and the potential of taking too many is high. That native fishermen caught fish at the mouths of rivers rather than on the high seas does not change the fact that they could have harvested at an unsustainable level.

The characteristics of gear and boats are not the whole story regarding fishing success. Fishermen need to know the locations and times that are most important, particularly for a migratory species. As Kew (1990) reports, the non-native fishermen who maintained an unsustainable harvest for the canneries of the early twentieth century did so using the knowledge gained from native fishermen. Many of the canneries, in fact, employed native fishermen. Non-Indians required more than ten years to learn how to successfully employ reef nets after finding that salmon traps taken from other regions did

not work in the Strait of Juan de Fuca (Lane 1973d, 12-13). Reef nets are still in use today.

Canneries thrived on a preservation technique that allowed sale of salmon throughout the world. Native peoples have stored the salmon in quantities that allowed preservation for their own use throughout the year. The native techniques were based on drying salmon rather than canning it, and are extensively documented by Hilary Stewart (1977) in her book on Indian fishing, and by Barbara Lane (1973) in her expert testimony..

High population levels

Smith (1979, 5) cites Hewes' estimate that the native population of the Columbia River would have harvested 18 million pounds of salmon a year. Smith gives pounds caught per year for all species from 1866 to 1973. The high seems to be 49.5 million in 1911. The modern low is 5.6 million in 1968. The harvest during the canning period, starting in 1889, is 21 million to 45 million pounds per year (Smith 1979, Appendix B). It appears that the population estimated by Hewes was harvesting a substantial amount, but less than the levels which led to decline in the salmon resource.

Boyd (1990) gives a total for Northwest Coast tribes of 188,000 in 1770, and then he charts the decline due to disease for one hundred years.[1] The figure for 1874 is approximately 32,000. The total population of British Columbia, Indians included, was 179,000 in 1901 (Urquhart and Buckley, 1965, p. 14). The population of the state of

[1]The Northwest Coast extends from the Copper River in southeast Alaska southward to the Rogue River in southern Oregon (Suttles 1990, *ix*).

Washington was 518,000 in 1900 (U. S. Bureau of the Census 1971, 12). Indians were less numerous before contact; but the entire population depended upon the fishery, while the later non-Indian population had other food sources.

Property Rights

Throughout the Northwest Coast, the right to fish in particular sites were owned by individuals or by particular groupings of individuals. Few of the sites, however, completely controlled access to particular fish stocks. That private property in sites existed throughout the area is well documented. Boas (1966, 36) briefly states that the rivers were all owned among the Kwakiutl. He also provides a detailed map of gathering areas and fishing areas at the head of Knight Inlet (Boas 1966, 24-28). Galois (1994) provides maps showing settlement sites and resource-collection sites for the Kwakwaka'wakw (Kwakiutl).

Lane (1973a-d) provides details on the property rights of tribes of western Washington. Several brief quotations give the flavor of her work. Regarding the Makah, whose homeland is on the northwestern most part of the Olympic Peninsula, she reported:

> Among the Makah, as with other Nootkans, ownership rights to important resource areas such as halibut banks, salmon streams, stretches of coastline, cranberry bogs and stands of cedar were inherited or acquired as marriage gifts. Such rights were extremely valuable. They were jealously guarded and were publicly validated and reaffirmed at potlatches and other ceremonials. (Lane 1973b, 18)

Since stretches of beach were private property, anything that washed up on that beach belonged to the owner, whales in particular. The Nootkans, who live across the Straits

of Juan de Fuca (on Vancouver Island) also assigned private rights to offshore fishing waters (Lane 1973b, 28-29, citing Drucker 1951, 247-249).

The Lummi, located near Bellingham, Washington, controlled extensive areas of reef in the Straits. They used reefnets at locations that were claimed by individuals who hired the fishing crews. (Lane 1973d, 20) The Twana-speaking groups along the Hood Canal recognized that weirs were the property of particular communities which built them. Anyone who helped build the weir could spear fish. But individuals owned the dip net platforms on the weirs. (Lane 1973c, 12-13).

Each of the coast communities defended their rights to particular fishing areas against incursion from other Indian communities. They would permit others to use their sites if requested and if they had good relations with the outside group. The fishing areas that were private property of the communities included all freshwater sites, and many productive saltwater sites such as halibut banks and reefs. The deeper salt water areas, including Puget Sound, the straits and the open sea were fished by all (Lane 1973a, 17-19).

Conclusion

The combination of adequate technology, high population levels, and systems of private property cause an economist to ask an obvious question: why didn't the natives have a problem of unsustainable harvest?[2] Although particular sites were privately

[2]I first heard this question while Judge Boldt was hearing the case *United States v. Washington* from Professor Robert Paul Thomas, a member of the economics department of the University of Washington.

owned, migrating salmon would pass many sites and the fishermen would have the same open-access incentive to invest in too much gear that exists in modern fisheries. There is a simple answer: the potlatch. The potlatch institution and management of fisheries complement one another because forced generosity creates incentives to solve common pool dilemmas. The next section of the paper describes the potlatch and the subsequent section shows how the potlatch can address common pool problems.

II. THE POTLATCH INSTITUTION

The word "potlatch" originates from adoption into English of *patshatl*, a word that means gift or giving in Nootka, one of the Northwest Coast Indian languages (Cole and Chaikin 1990, 5). A potlatch institution prescribes ceremonial "give-aways" in which a wealthy individual gives items of personal property to others.[3] Because the practice of give-aways was so foreign to most European cultures of the nineteenth century, scholars were fascinated by the practice. Franz Boas began the study of the potlatch with his visits to the Kwakiutl and other Northwest Coast native communities in the 1880s.

The Kwakiutl Potlatch

Among the Kwakiutl, the potlatch system was part of the "winter ceremonials" that occurred each year. The Kwakiutl divided the year into a summer secular season during

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[3]The literature on the Kwakiutl describes three types of give-aways: potlatches, feasts, and ceremonials. The distinctions among these are not always clear; all of them involve giving away wealth; this paper is referring to them all as a "potlatch." Some authors restrict the definition of a potlatch to particular give-aways related to the life cycle, excluding feasts and winter ceremonies. (Drucker and Heizer 1967; Walens 1981)

which people fished and collected other foods, and a winter sacred season in which they conducted their ceremonies. The villages of the Kwakiutl were organized into clan-like entities called *numaym*; property rights in fishing and gathering sites belonged to *numaym*, and the activity of each *numaym* was under the direction of its chief (Galois 1991, 22-24). As leaders rose in the hierarchy, they obtained "names;" these names were permanent rank positions that successive leaders occupied. Property belonged to the named position rather than to the individual occupying it. In addition to directing and coordinating food-gathering activities, the heads of the *numaym* were responsible in the winter for the ceremonies which ensured that the salmon were given proper respect and would return in the next secular season (Walens 1981). Part of the sacred duties of the leaders was the distribution of wealth to the other *numaym* that were in the village or neighboring villages. The reason for a winter ceremony could include steps in the life cycle of one or more individual leaders, such as birth, marriage, or receiving a ceremonial name.

Boas and some scholars asserted that the purpose of the potlatch was to establish the status of the person giving away wealth (Boas 1966, Cole and Chaikin 1990, Rosman and Rubel 1971). Subsequent commentators have disputed that interpretation. Drucker and Heizer argue that rank was inherited, and high rank gave a duty to conduct potlatches:

> The potlatch did not give, or create, social status. Present data make abundantly clear that this was as true of the Southern Kwakiutl as it was of other northwest coast groups. No matter how many potlatches a chief gave, he did not alter his formal rank one whit beyond that to which he was legally

entitled through heredity or acquisition of rights in marriage. (Drucker and Heizer 1967, 133)

The duty to conduct potlatches was based on the Kwakiutl view of the cause of the return of salmon each year:

> ... we must examine carefully those qualities the Kwakiutl themselves consider to be the return given to person who gives to others at a potlatch. . . . This return is not considered to be given by humans, but is given by the spirits to humans: that is, the man who gives the potlatch receives his reciprocal gift in spirit-power, which will directly enable him during the coming years to secure, by the grace of the spirits, a plentiful supply of food. Prestige has nothing to do with it. The results are considered to be tangible, meaningful, and essential, and they can be achieved only by the giving away of wealth. (Walens 1981, 33-34)

Although the Kwakiutl gave a spiritual explanation for the way in which the potlatch caused food to be plentiful, one can also provide an explanation based on economic analysis: if fishermen are placed in a situation in which they must share the surplus of their fishing activities, then the common pool dilemma which they all face has been removed. Thus, this paper accepts the interpretation of Drucker and Heizer (1967) and Walens (1981) that status required potlatches rather than the older theory that potlatches gave status.

One must emphasize the fact that giving away wealth was required; this is not a system in which people voluntarily gave away their wealth in order to obtain prestige or to have their rank recognized:

> . . .The potlatch system itself was coercively intolerant of dissent. Agents noted again and again that some, especially younger natives, did not wish to participate but could find no escape. Kwakiutl children were involved long before they had reached any age of conscious decision and marriage was arranged without choice. . . . Younger Gitksan were intimated into participation by ridicule, insults and other means. "If we do not participate,"said one young man, "you know there are still *nadowigets* (witchcrafters) and there are yet many ways of making you embarrassed among our people. So we have to subscribe to their views." Another said that "we have to do this or our lives will be miserable amongst our people." The potlatch as a "*total* social phenomenon," precluded alternatives necessary to real choice. (Cole and Chaikin 1990, 178 {citing Adams 1973, 118}).

In addition, although chiefs held potlatches, everyone was involved in the giving and receiving of wealth in the potlatch system. The chiefs obtained the goods they gave away from the members of their *numaym*; when a chief received wealth from the potlatch of another chief, he would distribute what he had received to his own group. There was clear hierarchy within the Kwakiutl's *numaym* and similar groups in other Northwest Coast communities (Drucker and Heizer 1967, 36-38; Rosman and Rubel 1971, 203).

The Kwakiutl were organized into what Drucker and Heizer called "festival groups:"

> The groups that were in frequent contact--those who were both closely related by frequent intermarriages and who customarily invited each other to feasts and potlatches--were just as one would anticipate on logical grounds those occupying contiguous territories, who at times even held adjoining tracts on fishing grounds and the like. . . . The informants were specific as to the definite limits of what we may term the "festival groups" in former days. Although there was not formal native term for these festival units, they were nevertheless quite real, and their basis was geographic proximity. (Drucker and Heizer 1967, 39-40)

Drucker and Heizer then list the groups specifically. There were five or six of the groups, and:

> Feasts were normally given among groups that were in frequent, friendly contact: the several groups sharing a winter village or neighbors with in a well-marked physiographic region, such as an inlet. (Drucker and Heizer 1967, 142)

Galois (1991) provides detailed maps of the festival groups, showing that they shared fishing areas in the secular season.

The Kwakiutl ideal for a potlatch had the host completing the give-away with completely empty boxes. The chief had to impoverish himself, which would mean he gave away everything. The anthropologists did not, it appears, obtain detailed accounting of how much of a chief's wealth was given away, and how much was retained. According to

Walens (1981, 55, 73-77), the chief's share of harvest was determined by rules that set the amount due him, as defined by boxes of different sizes. Since his "subjects," the members of his *numaym* who used the lands, kept a share for themselves, one might reasonably assume that the chief's wealth consisted of at least the *surplus* above daily needs.

While the above quotations emphasize the exchange aspects of the potlatch, the interpretation offered here is complementary rather than competitive to many of the other explanations offered. The potlatch could contribute to the solidarity of a community, as interpreted by Rosman and Rubel. It can have a religious importance, as asserted by Walens. The interpretation offered is inconsistent with some interpretations, such as that of Suttles (1960) and Piddocke (1965), who asserted that the potlatch served an as insurance against famine. According to Suttles, the ability to receive gifts between villages could be a response to the need to have a way to survive in bad times. Drucker and Heizer note that most potlatches occurred within villages and between villages who shared an inlet, usually seen as one "tribe" among the Kwakiutl people. Suttles's theory would require potlatching between groups with different sources of food. In addition, recipients of gifts already "had food in plenty in their own storage boxes and baskets." (Drucker and Heizer 1967, 142-143). The interpretation offered here connects the potlatch to the preservation of good times in the specific sense of an *economic optimum.* By helping fishermen restrain themselves from excessive investment in gear and fishing effort, the potlatch could maximize resource rent.

Interpreting the History of the Potlatch after European Settlement

This explanation of the potlatch also contributes to an understanding of its subsequent evolution, after contact with non-Native settlers and the development of a industry that canned salmon for sale outside of the region. Codere (1990) has divided the history of the potlatch into the following periods: pre-contact, 1849-1920, 1920-1970, 1970-present. Prior to contact, the Kwakiutl had small potlatches both within and between tribes. After 1849, potlatches grew in size and potlatches between tribes became more important. Population levels fell due to disease, and many traditional "names" had to be held by more than one person, or not held at all. The potlatch survived being outlawed in 1885 by going underground. Between 1920 and 1970, according to Codere, the potlatch disappeared as even an underground event. It has been revived since 1970, but not in its former form.

These four periods can be related to the economics of optimum exploitation of the fishery. Prior to 1849, potlatches played the role to be described formally in the next section of the paper: allowing maximum economic rent. But because population levels were high and external trade was not extensive, potlatches were small. When population declined and the cannery market developed in the late nineteenth century, Kwakiutl fishermen still dominated the fishery. Economic rent on a per capita basis was higher than it had been as salmon could be traded for other goods. Potlatches grew in size. It may be that the Kwakiutl began to fish each other's stocks, which would be consistent with the increase in inter-tribal potlatching.

The arrival of power boats in 1911 allowed non-Indians to enter the fishery and to have a competitive advantage over the Kwakiutl, who did not have access to capital. Because settlers did not recognize the ownership rights of the native peoples, tribes could no longer exclude non-members from their fisheries. By 1920, Kwakiutl incomes had fallen and the potlatch began to decline. The non-Indians did not participate in potlatch exchanges, and difficulties in restraining extensive harvest began to occur (Crutchfield and Pontecorvo 1969, 126; Munro and Scott 1985, 634) In Canada, the potlatch survived government suppression but succumbed to the loss of the fishery.

The revived potlatch after 1970 is a different and smaller affair. Fishing tribes of the Northwest, while they may conduct give-aways, do not conduct them in the context of the "total social phenomenon" that once characterized the potlatch. G. C. Webster, a Kwakiutl and trained anthropologist, participates in the modern Kwakiutl potlatch. In an article that describes the potlatch in some detail, she describes preparation as follows:

> A typical modern potlatch is much shorter than in the past, when one potlatch might last over several days or a week. [Today], a potlatch must be compressed into less than twenty-four hours, beginning in the afternoon, so that mourning songs can be sung before sunset, and ending in the late evening or early hours of the next morning. . . . Several days before the potlatch, relatives and friends begin arriving, staying with local families and visiting other homes, while there is time. . . .Everyone works together with incredible energy and enthusiasm to ensure that everything will be ready on time. While the food and big house crews are finishing their jobs, others are loading trucks with potlatch goods and ceremonial gear to deliver to the

big house. Such cooperative effort seems to surface only during potlatch time and is probably indicative of another change in our lives; that is, we are no longer able to help each other in any kind of ongoing way. However, it is of some consolation that such cooperation has not completely disappeared and that it does emerge for the right reasons. (Webster 1991, 231-232)

As Northwest Coast tribes lost control of their fisheries, the potlatch institution declined. The decline was greater in the United States than in Canada, where the legal prohibition of the potlatch may have aided its preservation in form.

III. ANALYSIS OF FORCED GENEROSITY SOLUTIONS TO GAME THEORY MODELS OF FISHERIES DILEMMAS

In order to provide a model of the potlatch form of give-aways, suppose there are n firms (*numaym* among the Kwakiutl) each of which generates a surplus S_i, $I = 1 \ldots n$. A *generosity rule* is a set of weights which describe the distribution of each firm's surplus among the other firms.

v_{ij} = share of S_i that is distributed to firm j.

where

$$\sum_{j=1}^{n} v_{ij} = 1$$

The *symmetric generosity rule* occurs when

for each *i,j*, $v_{ij} = 1/n$.

Because chiefs emptied their boxes completely, what might have been a *Kwakiutl generosity rule* occurs when for each *i,j*,

$$v_{ij} = \frac{1}{n - 1} \quad \text{for} \quad i \neq j \quad \textit{and}$$

$$v_{ii} = 0$$

This paper will confine itself to analysis of only the symmetric and Kwakiutl generosity rules. Other generosity rules are of course possible. The pure selfishness, or private profit, rule would be:

$$v_{ii} = 1 \textit{ and } v_{ij} = 0 \textit{ for } i \neq j.$$

That the Kwakiutl used a form of the generosity rule just described is confirmed by the festival group organization that was described above. Each chief directe the activites of his *numaym*, collected the surplus, and gave it away to the chiefs of other *numaym* in his festival group.

The Prisoner's Dilemma Model of a Fishery

Neighboring Kwakiutl sharing an inlet would face a common pool problem. The game of prisoner's dilemma is often presented to illustrate the fundamental puzzle that faces any two or more persons that are harvesting from a common pool resource. (Binmore, 1994; Ostrom et. al, 1994) Notation varies. There are two players, Player 1 and

Player 2. Each has a choice of two strategies: Cooperate or Defect. Their maximum joint payoff occurs when both cooperate. But the payoff structure of the game is set up in such a way that neither player will cooperate unless some condition outside of the game provides inducement to do so.

Let

C = The payoff each receives if both cooperate

D = The payoff each receives if both defect (D < C)

b = The amount added to C a defector receives if the other player cooperates

a = The reduction in D received by the cooperator if the other player defects.

In abstract form, the payoff matrix for the prisoner's dilemma can be written as follows:

	cooperate	defect
cooperate	(C, C)	(D-a, C+b)
defect	(C+b, D-a)	(D, D)

For C = 10, D = 5, a = 1, and b = 2, the prisoner's dilemma payoff matrix is as follows:

	cooperate	defect
cooperate	10, 10	4, 12
defect	12, 4	5, 5

From the point of view of the first player, if the second player chooses to cooperate, then the first player has a higher payoff (12) for defecting. Similarly, if the second player chooses to defect, then the first player has a higher payoff (5) for defecting. The situation is the same for the second player. Thus, individual incentives cause both to defect. The analogy to a fishery is that the defecting player invests in better equipment which should improve his catch. But when all fishermen have better equipment and increase their fishing effort, each has a smaller profit.

The numerical example can demonstrate the consequence of imposing the symmetric generosity rule. If we interpret each of the payoffs as the surplus received by each player from an economic activity, such as harvesting salmon, then imposition of a symmetric generosity rule changes the payoff matrix to the following:

	cooperate	defect
cooperate	10, 10	8, 8
defect	8, 8	5, 5

In this matrix, the incentive to defect has been removed for each player.

If we apply the Kwakiutl generosity rule to this two person game, then each player's payoff becomes the payoff of the other player. The new payoff matrix is as follows:

	cooperate	defect
cooperate	10, 10	12, 4
defect	4, 12	5, 5

In this matrix, the incentives also support cooperation by both players.

The Kwakiutl generosity rule always transforms the prisoner's dilemma into a game with a clear solution. If the absolute values of a and b are large in comparison to C and D, then the application of the symmetric generosity rule will generate either the game of chicken or the assurance game. In all cases, the application of a symmetric generosity rule will eliminate the prisoner's dilemma, replacing it with other games.

The Assurance Game as a Model of Common Pool Resources

Carlisle Ford Runge (1984, 1994) argues that the assurance game should also be considered as a model for common pool situations. Ostrom *et al.* (1994) also present the assurance game as one of the games relevant for common pool analysis. The dilemma occurs when the assurance game has extreme differences in payoffs, because although both players benefit from cooperating, the cost to the player who chooses to defect is low, while the cost to the other is high if he simultaneously chooses to cooperate. The player with the high cost may doubt whether the low cost player will cooperate. For instance, using the notation above, if we set $a = 4$ and $b = -2$, then the game becomes:

	cooperate	defect
cooperate	10, 10	1, 8
defect	8, 1	5, 5

In this game, the player who defects loses only 2 units; the player who fails to defect loses 9 units. If he fears the other player will select "defect", then he does better by also

defecting. This is not a prisoner's dilemma, since the defecting player does have a loss in comparison to the cooperative solution.

If the Kwakiutl rule is applied to this assurance game, the game again simplifies to one in which the private calculation of each player gives the solution "cooperate:"

	cooperate	defect
cooperate	10, 10	8, 1
defect	1, 8	5, 5

If the symmetric generosity rule is applied, then an assurance game remains, but the uncertainty about what the other player will do is much less:

	cooperate	defect
cooperate	10, 10	4.5, 4.5
defect	4.5, 4.5	5, 5

If one player is convinced the other player will defect, he should also defect; but the cost of defecting is the same for both, thus reducing the risk of cooperating.[4]

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[4]That the symmetric generosity rule always eases the solution of an assurance game can be proved formally using the concept of "risk dominance" introduced by Harsanyi and Selten (1988, pp. 82-88.). The decision to cooperate is favored by risk dominance if the following condition holds for the original assurance game:

$$b^2 > a^2$$

This condition may or may not hold, depending on the relative values. But if we apply the symmetric generosity rule, then the decision to cooperate is favored if the following condition applies:

$$(C-(D-a+C+b)/2)^2 > (D-(D-a+C+b)/2)^2$$

One can show that the parameter relationships for this to be an assurance game, namely the following:

$$a>0, \quad b<0, \quad C>D$$

assures that the condition is true. The result is evident by inspection if one clears the interior parenthesis of the condition and rearranges to obtain the following:

$$(C-D+a-b)^2 > (D-C+a-b)^2$$

[Note that a-b>0 and D-C<0.]

In their conclusion, Harsanyi and Selten (1988, pp. 358-359) argue that for a game theorist to believe that risk dominance will not prevail in an assurance game with $b^2 < a^2$, he must assume that the idea of "payoff dominance" is part of the concept of rationality as used in game theory. This paper presents another source of such rationality: an institution that forces the sharing of net returns.

A special case of the assurance game is the "stag hunt," when hunters have to decide whether to cooperate in hunting the stag or individually hunt rabbits. In the notation of this paper, a stag hunt occurs when b = D-C. This is also a much analyzed game which becomes simple when the generosity rule is applied. Because it is a special case of assurance, the result applies that the jointly superior equilibrium is also the selected solution in the presence of a potlatch. It is easy for the players to join in hunting the stag and not individually hunt rabbits.[5]

Other Institutional Analyses

In the growing literature on common pool resources, many authors recognize that the prisoner's dilemma model may not apply. Feeny *et al.* (1996) have summarized the reasons given. Without providing citations, Varian tells us, "It has long been known that the ability to make binding preplay commitments allows for a solution to the prisoner's dilemma." (Varian 1994, 1291) The problem is that many institutional situations in the modern world do not allow such prepay commitments. Feeny and his coauthors recognize that prior to the modern era,

> . . . traditional hunting and gathering groups defined and enforced exclusive harvesting zones. In addition, customs served to regulated intra-group use and when coupled with ethical norms that stressed sharing and cooperation, these

[5]The first example in one of the texts in game theory is the stag hunt game: see Drew Fudenberg and Jean Tirole (1992), 3-4. See also Carlsson and van Damme (1993).

customs served to limit exploitation to levels that could be sustained (Feeny *et al.* 1996, 192).

The point of this paper is that on the Northwest Coast *more was involved* than "ethical norms;" the norms were enforced by institutional requirements. Game theorists such as Binmore (1992) as well as economists (Feeny *et al.* 1996, 198) doubt that norms are enough, because individual self interest must be taken into account to assure that cooperative solutions are permanent over time.

IV. FORCED GENEROSITY APPLIED TO SIMPLE EXTERNALITIES

Because the prisoner's dilemma game captures the essence of many common pool problems, the generality of the results just given are potentially very great. Some readers, particularly economists, may ask whether a potlatch-type system of distributing profits generates an economic optimum in a continuous model of production. The prisoner's dilemma game is a discrete version of the common static fisheries model which shows the dissipation of rent by overinvestment (Crutchfield and Pontecorvo, 1969 ; Munro and Scott 1985). Rather than analyze that model, which is so similar to the prisoner's dilemma, this section of the paper examines a typical one-way externality model that is also a common type of mathematical way to examine external effects. The model can be used to recognize that many fisheries share ecosystems with other industries, particularly forestry and hydropower, as Feeny *et al.* urge that we do (1996, 199).

Varian (1994) recently analyzed many externality models with an emphasis on the implicit information assumptions of externality problems. This section of the paper shows

that a symmetric generosity rule can solve the problem Varian poses. Recognizing that a regulator may not have the information required to set the proper tax rates, Varian proposes to have the regulator enforce a two-stage game in which firms announce penalties to each other in the first stage and decide production levels in the second stage. If the firms know each other's production costs, then they will announce penalties which generate jointly optimal production levels. This section shows that if the regulator enforces a symmetric generosity rule as a form of penalty, the firms will also select jointly optimal production levels.

Varian presents several models, each of which has one firm producing an external effect. His three-firm model has the following structure. One firm produces a product x which has a sole price of r and costs $c(x)$. Thus the first firms' profits are

$$\pi_1 = rx - c(x)$$

Each of the other firm's profits are negatively dependent only on x

$$\pi_2 = - e_2(x)$$

$$\pi_3 = - e_3(x)$$

The social optimum level of production would be determined by the first order conditions of the social profit function

(1) $$\pi_s = rx - c(x) - e_2(x) - e_3(x).$$

The optimum solution occurs for that x which solves the first derivative of the social profit function, namely the x that solves this equation:

(2) $$r = c'(x) + e_2'(x) + e_3'(x).$$

Varian assumes that a regulator does not know $c(x)$, $e_2(x)$ or $e_3(x)$. Each of the firms, however, do know these functions and consequently can solve for the global optimum and their own best position. The regulator enforces a rule of the following form:

Stage 1:

Firm 1 announces the prices p_{21}^{1} and p_{31}^{1} that he will pay firms 2 and 3. Firm 2 announces the price p_{21}^{2} that firm 1 will pay firm 2. Firm 3 announces the price p_{31}^{3} that firm 1 will pay firm 3.

Stage 2:

Firm 1 selects the level of output x. The following equations determine post-penalty payoffs:

$$\pi_1^v = rx - c(x) - [p_{21}^2 + p_{31}^3]x - \|p_{21}^2 - p_{21}^1\| - \|p_{31}^3 - p_{31}^1\|$$

$$\pi_2^v = p_{21}^1 x - e_2(x)$$

$$\pi_3^v = p_{31}^1 x - e_3(x)$$

Varian shows that with their knowledge of the functions, each of firms 2 and 3 will select penalties that equal their marginal costs at the optimum level:

$$p_{21}^{2} = e_2'(x^*)$$

$$p_{31}^{3} = e_3'(x^*)$$

Firm 1, desiring to minimize its penalty for selecting prices different from those selected by the other firms, selects in the first stage

$$p_{21}^{1} = p_{21}^{2}$$

$$p_{31}^{1} = p_{31}^{3}$$

Given these penalties, in the second stage firm 1 selects the equilibrium x^* that maximizes

$$\pi_1^V = rx - c(x) - p_{21}^{2}\, x - p_{31}^{3}\, x$$

which is precisely the social optimum x^* which solves

$$r = c'(x^*) + p_{21}^{2} + p_{31}^{3}$$

$$= c'(x^*) + e_2'(x^*) + e_3'(x^*)$$

The approach of this paper would have the regulator impose a symmetric generosity rule that each firm will pay each of the other firms one-third of its profits, be those profits positive or negative. The post-distribution situation of each of the firms will therefore be as follows:

$$\pi_1^T = \frac{1}{3}[rx - c(x)] - \frac{1}{3}e_2(x) - \frac{1}{3}e_3(x)$$

$$\pi_2^T = -\frac{1}{3}e_2(x) + \frac{1}{3}[rx - c(x)] - \frac{1}{3}e_3(x)$$

$$\pi_3^T = -\frac{1}{3}e_3(x) + \frac{1}{3}[rx - c(x)] - \frac{1}{3}e_2(x)$$

In other words, the total social returns are divided equally among the three firms. When the first firm solves his maximization problem, he will select the social optimum x^*. The first order condition for a maximum for the first firm is the following:

$$\frac{\partial \Pi_1^T}{\partial x} = \frac{1}{3} r - \frac{1}{3} c'(x) - \frac{1}{3} e_2'(x) - \frac{1}{3} e_3'(x)$$

When this equation is set to zero and multiplied by 3, it is identical to the condition for a social optimum given above.[6]

The symmetric generosity rule has lower information requirements than does Varian's proposal. The firm producing the externality needs to know $e_2(x)$ *and* $e_3(x)$. But the two recipients of the externality do not need to know $c(x)$. In both solutions, the government regulator has to impose a transfer among the firms. If a society has an institution that enforces a symmetric generosity rule, the firm producing the externality (such as the owner of a forest that surrounds a salmon spawning stream) will select the socially optimum level of production.

If this answer is so simple, why have so many commentators not stressed it? The answer is that few commentators, such as Sugden (1984) recognize the possibility of *forced* generosity. Sugden examines equilibria which result when people sharing a

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[6]The post-penalty or post-division of profits receipts of firms for Varian's solution (π_j^V) and for mine (π_j^T) will be identical only for the case in which the first derivatives of the costs and externality functions at the optimum x^* solve the following equations:

$$e_2(x^*) = x^*[e_3'(x^*) - \frac{1}{2}e_2'(x^*)]$$
$$e_3(x^*) = x^*[e_2'(x^*) - \frac{1}{2}e_3'(x^*)]$$
$$c(x^*) = x^*[c'(x^*) + \frac{1}{2}e_2'(x^*) + \frac{1}{2}e_3'(x^*)]$$

common pool resource (in his case, a public good) each has an ethic that he or she will contribute at most what is the least amount contributed by others. This rule can generate a supply of the public good, but most probably would generate a suboptimal supply of the public good. Sugden names his rule "the principle of reciprocity," which excludes a potlatch-type principle of reciprocity as an alternative. Sugden assumes his reciprocity rule applies to organizations using voluntary compliance in production of a public good.

V. SUMMARY AND CONCLUSION

This paper has proposed a new factor to add to existing interpretations of the potlatch: its role in affecting incentives for management of the fishery. This additional factor does not necessarily change most prior interpretations. Prior analysis has shown that chiefs and other wealthy leaders were required to give away their wealth on many occasions. Examples of such occasions are events of one's life, such as the assumption of a new name, the funeral of a former chief, a marriage, or the naming of a child. Other examples are purely sacred in nature, as in the winter ceremonials of the Kwakiutl devoted to return of the salmon in the next season. There is overlap between these categories, in that when chiefs of a village scheduled winter ceremonials, they could include assumption of a name or a marriage. The important fact for this interpretation is that a cycle of winter potlatches should occur among units of a tribe which shared common fish resources. indeed most traditional Kwakiutl potlatching occurred within single villages or between neighboring villages.

The later sections of the paper presented two types of economic analysis of give-aways to show that the incentives of the potlatch could assist in economically optimal management of a fishery: game theory and a one-way externality. The certainty of sharing returns from a fishery removes the incentives of a prisoner's dilemma game that cause overinvestment and overfishing. The milder dilemma of an assurance game is also removed. In a model in which an externality by one firm affects the profits of two other firms, if all three firms must share their net returns, the optimum level of production for the polluting firm becomes the optimal level for all three firms considered together. Given its ability to solve the common pool prisoner's dilemma, the Kwakiutl were right to believe that the winter ceremonials, with their potlatches, were responsible for "a plentiful supply of food" in the coming years.

Most analysts assume that an agreement to share the outcomes of a game such as the prisoner's dilemma is not enforceable. Underlying this assumption is a theory of the origins of social institutions that is of the social contract school. Binmore (1994) makes this clear in his extensive consideration of the prisoner's dilemma in the context of many theories of the social contract. We do not know the process by which the potlatch came to be so common among the societies of the Northwest Coast. Perhaps a potlatch institution in the presence of the salmon fishery gave some communities and advantage over others, and eventually all the communities competing to use the salmon resource also came to have potlatches.[7] Whatever its origin, once in place, the presence of a potlatch

[7]Binmore (1994, 184-203) concludes his survey of the literature on evolutionary analysis of cooperative strategies for solution of the prisoner's dilemma show that strategies involving cooperation tend to dominate the simulations, in the sense that

tradition requiring give-aways makes the enforcement mechanism credible as a solution to externality and common pool problems.

Although the positive value of sharing one's wealth has survived the process of forced culture change undertaken by both the Canadian and United States governments, the institutions which carried out the sharing of wealth have been fairly well dismantled. When the Boldt decision gave half of the salmon catch back to Indians in the United States, the Northwest Tribes did not recreate potlatch-like institutions, even among themselves (Cohen 1986). Limiting the salmon harvest remains a problem (Busch 1995). The analysis of this paper suggests that one way to address the open-access problems of the salmon fishery would be to establish a potlatch-like method of sharing the net returns to salmon fishing.

A more interesting approach to some of the problems of ecosystem management of ecosystems that involve the interaction of different types of commodity harvests. Consider the interaction between forests and salmon. The simple model of this interaction is that clear cutting of too great a percentage of a watershed, particularly if the clearcuts extend to the edge of streams, increases silt deposition to a level that reduces salmon survival in the spawning areas of the streams. A potlatch-type institution would give a share of the net returns from timber management to fishermen and a share of net returns from salmon harvest to the owners of timberland. Similarly, the involvement of

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individuals with the preference to cooperate remain in a population because of better fitness. Boyd and Richerson (1985, 204-240) provide an analysis that applies to the survival of groups of individuals with cooperative institutions. The type of group selection they identify is a possible model for the evolution of the potlatch and its related institutions.

hydroelectric dams in reduction of salmon harvests would argue that the net returns from electricity sales should be shared with fishermen, and vice-versa. In neither of these cases would a *tax* be equivalent to a potlatch-type interdependence. A tax involves the general public and the budgetary system of the government imposing it. A potlatch system prescribes exchanges only among those who share a common ecosystem.

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