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Economic and Management Benefits from the Coordination of Capture and Culture Fisheries: The Case of Prince William Sound Pink Salmon

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Abstract.—Aquaculture developments often create policy conflicts with established fisheries when the two are not coordinated through a common planning framework. The state of Alaska and community-based, fisher-led salmon aquaculture associations have been unusually successful at coordinating, through cooperative management, the traditional salmon capture fisheries and new culture fisheries for pink salmon *Oncorhynchus gorbuscha*, despite predictable problems. The Prince William Sound Aquaculture Corporation in particular has moved from its original involvement in resource enhancement into partnership with the state in harvest planning, allocation, and comprehensive regional planning. Some of the specific economic benefits and the general management benefits of this institutional arrangement are explored. One economic benefit was an 8-year period of price advantage for the association's cost-recovery fish because of large and consistent volume and quality. The ecological, political, and institutional conditions that made these developments possible are analyzed.

There is mounting evidence that cooperative fish and wildlife management, or the sharing of decision making between government agencies and community-based stakeholders, has the potential to improve management in a number of ways. Numerous case studies and broader analyses have documented specific types of improvements and constructed hypotheses about the conditions under which these are most likely to occur (e.g., Drollet et al. 1987; Pinkerton 1987, 1989, 1991; Usher 1987; Yarbrough 1987; Acheson 1988; Feit 1988; Osherenko 1988; Jentoft 1989; Rettig et al. 1989; Albrecht 1990; McGoodwin 1990; Berkes et al. 1991; Pomerantz and Blanchard 1992). Most of these studies could be considered part of a larger literature on community-based institutions for the management of common-property resources, emerging from institutional economics, political theory, and cultural ecology (McCay and Acheson 1987; Feeny et al. 1990; Ostrom 1990; Bromley 1992). The case study of joint resource enhancement presented in this article also contributes to these larger theoretical discussions by adding new kinds of evidence for how, why, and when stakeholder-government cooperation can improve particular management outcomes.

Resource enhancement is one particular management area in which government and fishing communities appear to be able to accomplish more together than either could achieve alone (Amend 1989). It has been hypothesized that one potential

improvement under a comanagement regime is a better bargaining position for fishers' organizations, which can translate into higher prices (Pinkerton 1988).

The almost two decades of experience in enhancement of pink salmon *Oncorhynchus gorbuscha* in Prince William Sound, Alaska, described in this paper, presents an opportunity to test this hypothesis in particular. However, the more fundamental undertaking here is to assess in general the strengths and weaknesses of a cooperative approach to stock enhancement. This discussion therefore poses both a specific and a general question. First, under what conditions have the large numbers of pink salmon that a fishers' enhancement association has produced in Prince William Sound—acting cooperatively with the state—been translated into higher prices for the fishers' association? Second, to what extent has a comanagement approach to enhancement succeeded in integrating the traditional capture fisheries with the new culture fisheries?

The second, more general question is key to understanding the significance of the Prince William Sound model, because the harmonious coordination of new and traditional fisheries may be a far more important benefit than direct price benefits. New or expanded fisheries based on resource enhancement are likely to grow in importance as world population expands and as both fish and agricultural resources suffer overexploitation, mis-

management, or habitat degradation (IDRC 1991; Larkin 1991; Pitt 1993). Yet new fisheries are often introduced by new actors in a manner that threatens or competes with traditional fisheries, either through the market or through access to limited ecosystemic resources (Meggs 1988). The planning of enhancement efforts and subsequent developments through a comanagement arrangement involving established fishers allows the two sectors to coordinate and to avoid some of the incompatibilities and conflicts that often arise between them. The avoidance of conflicts is, in itself, a considerable management benefit.

This discussion is based primarily on interviews conducted between 1987 and 1993 with key actors in the Prince William Sound Aquaculture Corporation (PWSAC), with current and former personnel in the Alaska Department of Fish and Game (ADF&G), and with U.S. and Canadian fish-marketing experts in university, governmental, and nongovernmental settings. Also relevant was my joint research with Steve Langdon on the origin of aquaculture associations in Alaska (Pinkerton and Langdon 1988), my attending a PWSAC board meeting in 1989, research by Jim Payne on the Prince William Sound fishery and the early history of PWSAC (Payne 1985), and my in-depth research in cooperation with Nelson Keitlah of the Nuu-chah-nulth Tribal Council, on the formation, development, and present operation of the Southern Southeast Regional Aquaculture Association.

The Regional Aquaculture Association Concept in Alaska

The PWSAC, founded in 1974, was the first fishers' regional aquaculture association to form in Alaska. A regional aquaculture association in Alaska is formed when the commercial salmon fishers licensed to fish one fishery management area form a nonprofit corporation and apply to the Commissioner of Fish and Game to be certified as a "qualified" regional association. Alaska has seven principal fishery management areas for salmon: Prince William Sound, Southeast, Yakutat, Cook Inlet, Kodiak, the Alaska Peninsula-Aleutian Islands, and Bristol Bay. To qualify as a regional association, the nonprofit corporation must convince the commissioner that it represents the commercial fishers in the fishery management area, as well as the other user groups and affected parties, such as subsistence fishers, sport fishers, Native corporations, local processors, and local communities (ADF&G 1986: Alaska Statute

16.10.380). Commercial fishers form the majority of the association board and are usually elected to fairly represent users of different gear types (e.g., purse-seiners, drift gill-netters). These board members then appoint the other board members to represent the noncommercial local fishing and community interests.

The PWSAC is run by a board of 43 (of which 23 are commercial fishers), which meets in January, June, and September. One-third of the board is elected each year by all licensed commercial fishers in the area. An executive committee is elected by the full board every June, meets monthly or more often, and distributes minutes and a monthly newsletter to the other board members. The full board sets general policy and the executive committee implements it.

The PWSAC first formed under existing law for nonprofit corporations, and then assisted the Alaska legislature in writing statutes to enable other nonprofit corporations to form and be given regional association status. A series of statutes and regulations passed in 1976 and afterward, especially Alaska Statute 16.10.375-620 (ADF&G 1986), granted democratically constituted associations of this sort the power to decide by majority vote to tax its commercial members 2 or 3% of the value of their catch in order to finance and manage salmon rehabilitation and enhancement projects of their own choosing. (Projects and any activity that would affect wild stocks, such as taking eggs, had to be approved by the agency head.) A regional association was also empowered to borrow start-up funds for capital projects from a state revolving-loan fund. Association representatives were empowered to act as partners with the state fishery managers on regional planning teams to develop regional salmon enhancement and management plans, and to evaluate to what extent new enhancement proposals from any quarter complied with these plans. Finally, and most important to this discussion, the association was empowered to sell surplus fish returning to its hatcheries in order to support operations, expansion, research, and other management activities.

The willingness of fishers to tax themselves and to contribute volunteer time to enhancement planning (through serving on association boards and committees, and donating labor and equipment to projects) was the ideological engine that won support for the regional enhancement association concept from all quarters. Conservatives perceived this approach as private enterprise; liberals focused on the collective action aspect. The power

to sell fish not needed as hatchery brood stock, however, was the main economic engine which made enhancement feasible and was to propel the PWSAC into a powerful market position. Its success in both the economic and political realm demonstrates how the regional aquaculture association concept can be a way of positively involving fisher organizations and communities in economic development that has some accountability to those who have already made substantial investments in an existing fishery. At the same time, the idea behind comanagement is to maintain checks and balances between fishers and fishing communities on the one hand and on the other hand state managers mandated to protect the wild stocks.

The Prince William Sound Aquaculture Corporation

How and why aquaculture associations have emerged in some regions of Alaska and not others is explored elsewhere (Pinkerton and Langdon 1988). This discussion is limited to how Prince William Sound, and its oldest nonaboriginal community of Cordova, home for most of the resident commercial fishers, was an advantageous place to lead an initiative. Its history predisposed Cordova fishers to radical political and economic change, and its ecology called for unusual human intervention.

Ecologically, Prince William Sound is a focal point for the transportation of North Slope oil and gas, for increased timber production, and recreational use by adjacent large population centers. The founders of PWSAC, who had lost the 1971 battle to stop the trans-Alaska pipeline, which now has its terminus in Valdez, feared that the health and productivity of fish habitat would inevitably suffer (PWSAC 1975). These predictions were fulfilled by the running aground of the oil tanker, *Exxon Valdez*, in 1989, which oiled areas of Prince William Sound. Major damage had already happened once as a result of the 1964 earthquake and resulting tidal wave, uplift, and subsequent subsiding, all of which destroyed considerable amounts of fish habitat (Roys 1971), in some cases permanently. Climatic and marine environmental cycles also contributed to the decline of salmon runs to historic lows in the 1960s and 1970s. All these factors made Prince William Sound residents particularly interested in strategies for buffering their fisheries from the extreme fluctuations caused by both nature and human intervention.

Political and institutional factors in Prince Wil-

liam Sound, and other places like it, were also key to launching the Alaska concept of fisher-controlled aquaculture. The main population center at Cordova (about 2,000) had been a seat of trade unionism and socialist activism since the 1930s, when strikes and violent strike-breaking were frequent occurrences. The Cordova District Fisherman's Union (CDFU) continued to be active as a political organization despite a 1955 order from the Federal Trade Commission to "cease and desist from any further involvement with price and wage negotiations because of monopolization and trade restraints" (Payne 1985). The Cordova Aquatic Marketing Association (CAMA) was formed in 1955 under the guidelines of the Fisherman's Collective Marketing Act (1934) (15 U.S.C. §521). Considered a collective association of independent businesspeople, the CAMA cannot strike, picket, or interfere with any fisher's right to go fishing. In practice, however, the CAMA was able to engage not only in price disputes, but also in voluntary vessel tie-ups, which functioned as informal social pressure to discourage members from fishing during price negotiations (Payne 1985). Members of the CDFU and the CAMA spearheaded the formation of the PWSAC, and made up the majority of its board of directors. Their history of political activism and their solidarity in a single community favorably predisposed them toward launching Alaska's first aquaculture initiative, and giving fishers a leadership position in it. Payne (1985) argued that their anti-pipeline struggle, as well as their successful statewide fight to bring about a license limitation policy (implemented in 1973), helped build the confidence and connections that worked so well in procuring the legislative and financial support to legalize the fisher-operated aquaculture program.

Ecological Issues

The type of salmon aquaculture for which Cordova fishers and other Alaska fishers fought is sometimes called "salmon ranching." This involves harvesting eggs from a favorable stock, artificially incubating and rearing the eggs to the fry, fed fry, or smolt stage in their first year of life, and releasing these young salmon to the North Pacific "pasture" to feed and grow. The salmon return as adults to the area from which they were released. Timing of release, site of release, choice of stock, and timing of harvest of wild stock can be varied so that hatchery stocks interfere less and mix less with wild stocks. Appropriately and carefully used, salmon ranching ideally can act to stabilize natural

variations in run size without endangering wild stocks.

Prince William Sound fishers were deeply concerned about the potential threat that hatchery production posed to wild stocks in Puget Sound and the Columbia River (Waldo 1981). Some negative impacts of enhanced production on wild stocks in the British Columbia Salmonid Enhancement Program, begun in 1977, were not fully understood for some 15 years (D. D. Bailey, Canada Department of Fisheries and Oceans, 1991, unpublished data). However, the geography and ecology of Prince William Sound appeared to lend themselves well to stock separation. Hatcheries were sited in areas whose immediate vicinity contained little or no wild stocks, and in areas where hatchery returns could be harvested in terminal locations after they had separated from wild stocks. Since the 1964 earthquake, there had been no troll fisheries or interception fisheries outside the sound, so mixed-stock fishery problems seemed unlikely.

Despite the favorable geography, ecology, and hatchery siting, the most recent evidence suggests that mixed-stock fisheries may have become a problem in the western corridor into Prince William Sound. By 1987, when the hatchery pink salmon returns became substantial, a fishery that sometimes occurred in this entrance area of the sound began to attract more boats. Returns in 1987 from the first tagging study of PWSAC fish looked promising: aggregate wild stock escapements were strong (Geiger 1990). The 1989 *Exxon Valdez* oil spill occasioned the funding of larger tagging studies, combined with run reconstruction analysis (enabling a disaggregation of escapement data). The run reconstruction analysis for 1990 and 1991 suggested that the fishery in the western entrance area was a possible cause of a serious decline in wild pink salmon escapement to particular areas (H. Geiger, ADF&G, 1993, personal communication). There is disagreement among experts about how to interpret the data, however, and only further study will clarify the issue (Alaska State Senate 1992; Hull 1993).

Although the management of wild fish was the mandated responsibility of ADF&G, the problem of identifying hatchery fish for management purposes was voluntarily shared by PWSAC. Tagging and tag analysis of new increments of hatchery production did not become the financial responsibility of aquaculture associations until after 1992 (Alaska State Senate 1992). The PWSAC tagged the hatchery fish at its own expense from 1986 to 1988, it funded—with help from fishers and pro-

cessors—a doubling of ADF&G escapement surveys (from once- to twice-weekly flights over 209 indicator streams), it contributed US\$120,000 to ADF&G tagging programs in 1991–1993, and it contributed \$100,000 to tag recovery in 1993.

Although PWSAC fishers will benefit from better information about mixed-stock fisheries if better information shows that more fisheries are possible, they run the risk that better information will indicate that fewer and more-constricted fisheries are required to conserve wild stocks. Thus, PWSAC's commitment to better information indicates a willingness to take this risk and to support management of both wild and hatchery stocks.

Prince William Sound may not have escaped the problems that have plagued state-operated salmon enhancement programs elsewhere, and there is predictable pressure from the industry (processors and individual fishers) to ignore the problem, as there is in other jurisdictions. However, Prince William Sound comanagers are in a better position to resist these pressures and to address such problems because of the logistical, financial, moral, and entrepreneurial support ADF&G receives from PWSAC and similarly situated efforts.

The entrepreneurship of Douglas Island Pink and Chum (DIPAC) hatchery, a small private non-profit hatchery in southeast Alaska, has made more acceptable in Alaska a far superior and more economical tool for in-season run analysis and management (Parker et al. 1990; Munk et al. 1993). The DIPAC hatchery has worked for 6 years with Eric Volk, a consultant from the Washington Department of Fisheries, and his colleagues, who applied the concept of mass thermal marking of otoliths to hatchery-raised Pacific salmon. Otoliths, which are biogenic crystals found in the brain capsules of most fish species, lay down a prominent dark ring, detectable under transmitted light microscopy, in response to a properly timed temperature drop during hatchery rearing. This marking can be varied to identify specific releases and involves almost no cost to hatcheries, whereas analysis of recovered otoliths is estimated at half the cost of conventional coded-wire tagging and tag analysis. Through the combined encouragement of Volk, researchers at the University of Alaska at Juneau, and the DIPAC hatchery, ADF&G began otolith marking at two of its own laboratories in 1991. By 1993, one laboratory began to also participate in analyzing the pink salmon returns from DIPAC's second mass-marking effort by analyzing the otoliths of a harvest sample.

Through a cooperative agreement between DIPAC and ADF&G, DIPAC provided staffing for the sample processing and analysis, and ADF&G provided the laboratory and technical supervision. According to one involved party, without DIPAC, Alaska would not be anywhere near mass marking. The ADF&G sees this exercise as directly applicable to the improvement of in-season management of mixed-stock fisheries in Prince William Sound, where managers are being kept abreast of developments.

Mass marking of hatchery fish, if it were adopted and funded in Prince William Sound, would greatly improve the ability of ADF&G to meet fixed wild escapement targets again. Under this conservation strategy, fisheries are tailored to the degree of escapement documented at particular time periods of the run; thus, escapement and conservation are guaranteed before a fishery can occur. Under this scenario, problems are likely to occur only when the runs are late and concentrated into a short time period. Alaska Statute 16.05.730, passed in 1992, stated, "Fish stocks in the State shall be managed consistent with sustained yield of wild fish stocks and may be managed consistent with sustained yield of enhanced fish stocks." Through this statute, managers have far stronger grounds for resisting pressure to open a fishery in the absence of clear information on the impact on wild stocks. In 1993, ADF&G closed the questionable entrance area fishery.

During the 1992 legislative review of the Alaska salmon enhancement program (Alaska State Senate 1992), there was a general recognition that hatchery programs had been instituted in a climate of alarm about declining wild stocks, in which the caution of ADF&G staff about mixed-stock fisheries, and the eventual limits of the North Pacific pasture and local estuarine environments, seemed less important than they do now. Many Alaskans even felt that if the North Pacific pasture was limited, they should send out more Alaskan fish to graze before other countries do. The smaller average size of salmon throughout the Pacific region in 1991 raised questions for Alaskans about whether the commons was now overgrazed. Changes in climate and marine environment may partly or fully explain this occurrence (Beamish and Bouillon 1993). However, with the renewed concern in the early 1990s for the need to protect wild salmon, and to better identify and understand genetically distinct populations, it appears likely that ecological concerns will gradually be translated into management actions.

Institutional Issues

The institutional form of aquacultural development that Alaska fishers successfully promoted was called "private nonprofit." The latter term was to distinguish it from two other forms feared by the fishers. Private for-profit salmon ranching was permitted in Oregon, where the Weyerhaeuser Corporation released its own fish. Because of the size and influence of the corporation, many feared that it would attempt to influence harvest management so that a large percentage of the fish would return to be harvested at its hatchery—at the expense of commercial fishers. Alaska fishers' abhorrence of private ownership of public resources had solidified around the campaign to ban the use of private fish traps, owned chiefly by out-of-state processors, during Alaska's bid to become a state in the late 1950s. The new state government did ban the fish traps, and by implication affirmed its commitment to assuring that benefits from public resources would not be reserved for a few private interests.

The other form of aquacultural development that Alaska fishers feared was in the state of Washington, where the Department of Fisheries operated state hatcheries. Much of the hatchery construction predated current scientific understanding of the impact of hatcheries on wild stocks. The location and planning of volume and release timing of hatchery stocks contributed substantially to the decline of wild stocks in Puget Sound and on the Columbia River. A 1971 state hatchery program in Alaska under the Fisheries Rehabilitation and Enhancement Division of ADF&G suffered some of the same accusations. Fishers often opposed state hatchery locations and species selected for enhancement. These were believed to be influenced more by political and budgetary convenience than by sound biological arguments: the Snettisham hatchery was the most cited sample of poor siting and species selection.

The private nonprofit program was launched in Alaska largely in reaction to these perceived problems in conventional private and state-operated hatchery programs. Fishers believed they could make better decisions than either private industry or state agencies alone about where best to locate enhancement projects, what species to enhance, and how large the projects should become.

The private nonprofit program, as legislated in 1976, made two helpful mechanisms available to the regional aquaculture associations. First, an association could develop its own enhancement plan

and submit it to the regional planning team. Second, the regional aquaculture association constituted half the membership of the regional planning team, which produced a 20-year plan (PWSRPT 1983). The team in each management area comprised three regional association representatives and three ADF&G personnel. The regional planning team had to approve all applications for such projects as building new hatcheries, enlarging existing ones, and taking eggs, before these could be approved by the head of ADF&G. Thus, fishers' associations in a private nonprofit system not only can take the initiative in launching their own projects, but also have a say in state and small private projects, and in creating a vision for the region.

As it has turned out, regional enhancement associations have become the dominant institutional form: state hatcheries are now being leased to the regional enhancement associations. (Usually the associations feel it is worth paying to have the hatcheries in operation rather than having them closed.) Small private ("mom-and-pop") enhancement enterprises like the DIPAC hatchery, which do not have association status and cannot tax members, but can sell cost-recovery fish, are adopting the board structure of the associations. Fishers' associations can operate the hatcheries more economically than the state because they can avoid certain civil service inflexibilities.

Even more importantly, however, the association-operated hatcheries are self-supporting because of their legal ability to sell hatchery escapement not needed as brood stock, and to tax their members to pay operating costs. Thus, state taxpayers are relieved of the burden of paying for hatchery operations, as fishers' associations take them over. The regional associations are becoming the predominant institution for enhancement, both because they use fewer public resources and because they have gained credibility with ADF&G and the state over time.

Of course, the associations and the small mom-and-pop hatchery projects borrowed money from the state revolving-loan fund. To conduct full cost-benefit analysis, these loans and the fishers' self-imposed tax on their landings would need to be evaluated against the contribution of hatchery fish to fishers' incomes and regional economies, and other factors beyond the scope of this discussion also would need to be considered. Here the focus is on general management benefits and a particular type of economic benefit (discussed below).

The most important management benefit in recent years has been the expansion of the regional

associations' "mandate" for comanagement of enhancement to include comanagement of allocation and harvest planning. This occurred because PWSAC's cost recovery was sufficiently lucrative to pay for management activities, and also because the association had a good working relationship with ADF&G and had established its credibility. The PWSAC thus contributed to management, both fiscally and logistically, in ways that ADF&G could not have done alone.

The management of allocation is a prime example. As the number of hatchery fish increased, so did conflict over allocation of these fish. Under instruction from the Board of Fish (a citizens' board that is the body responsible for setting allocation policy), PWSAC formed its own allocation task force in 1989 and developed a policy for internal allocation of wild and enhanced stocks among its members by gear types, principally purse seine and drift gill net (PWSAC 1990). The PWSAC planner got representatives of these gear groups working together by putting many small mixed groups in rooms and giving them the assignment to decide upon fair allocation principles. The small groups then came together in a larger whole and were able to reach agreement. The PWSAC members, ADF&G, and the Board of Fish thus avoided the costly and acrimonious court battles over allocation such as those that have occurred in British Columbia, Washington State, and one area of Alaska.

The PWSAC then used the allocation principles of its own task force to develop a comprehensive production plan (PWSAC 1991) and to work with the regional planning team toward a new salmon management plan (PWSAC and ADF&G 1991) for wild and enhanced stocks in Prince William Sound. The recommendations of these bodies have been adopted by the citizens' Board of Fish, and by the regional planning team, which includes ADF&G members.

Participation in these new activities by the regional enhancement association means that comanagement has been extended from enhancement into harvest planning, comprehensive regional planning (coordination of enhancement and wild-stock management), and allocation. To briefly note a point that is developed in more depth elsewhere (Yarbrough 1987; Pinkerton 1989, 1991; Pinkerton and Keitlah 1990), when regionally or locally based stakeholder organizations become involved in management, they are likely to improve the quality and credibility of decisions, because they balance the state agency perspective

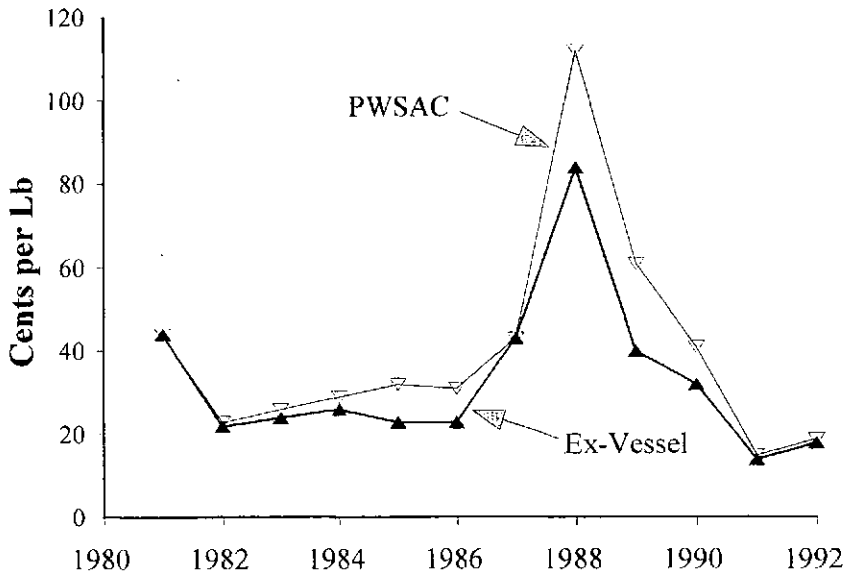


FIGURE 1.—Prince William Sound Aquaculture Corporation's (PWSAC) cost-recovery price compared with Prince William Sound ex-vessel price for pink salmon, 1981–1992. Sources: Commercial Fisheries Entry Commission and PWSAC (unpublished sales data). (To convert to cents per kilogram, multiply the cents-per-pound value by 2.20.)

with a local, holistic perspective, which encourages a more integrated, comprehensive approach to planning. Locally based bodies tend to be concerned with the territorial and ecosystem integrity of the local area, which is a good basis for integrating the culture and capture fisheries of an area in a sustainable way. At the same time, potential excesses are likely to be checked by nonlocal bodies.

Cost-Recovery Sales: Do They Affect the Price of the Other Fish?

One institutional issue, the relationship of cost-recovery price to ex-vessel price (also called grounds price), has had a more positive outcome than the one envisaged by the fishers. Originally fishers feared that sales of cost-recovery returns to the hatchery would depress the price of fisher-caught common-property fish taken in marine areas. (In this context, "common-property fish" means the surplus of fish above reproduction needs of wild and hatchery stocks that are available to be caught by licensed fishers. These fish are distinguished from "PWSAC fish," which are the "cost-recovery" portion of the hatchery fish that return to the hatchery, then are held live in floating pens, and are sold to support PWSAC projects.)

Fishers thought of their organization, PWSAC, as separate from their private fishing efforts, and

feared that they might be setting up a monster that would dump massive quantities of lower-quality fish harvested at the hatchery site, thus lowering the price of the fish they caught in marine areas. As a result, one of the original statutes (Alaska Statute 16.10.450) was written with the following requirement: "Fish returning to hatcheries and sold for human consumption shall be of a comparable quality to fish harvested by commercial fisheries in the area, and shall be sold at prices commensurate with the current market." This requirement did little to reassure the fishers that prices of all fish would not be depressed by the entry of a greater quantity of fish on the market. The following discussion of the history of the relationship of the price and volume of PWSAC cost-recovery fish to the ex-vessel price of common-property caught fish will show that this fear was ill founded. The real point of the next section, however, is that, for the 8-year period 1983–1990, PWSAC (cost-recovery) pink salmon commanded a higher price than the ex-vessel (common-property) pink salmon in Prince William Sound, and also in southeast Alaska, the other major producer of pink salmon.

Ex-Vessel Price Compared with PWSAC Price

The PWSAC chose to enhance mostly pink salmon, and for simplicity, this discussion is confined to this species. The first hatchery was built

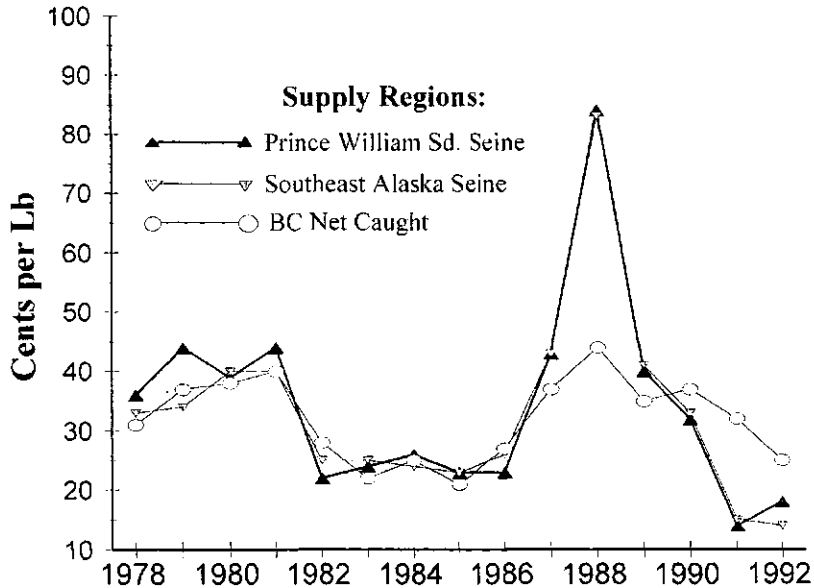


FIGURE 2.—Ex-vessel price for pink salmon caught in Prince William Sound (seine), southeast Alaska (seine), and British Columbia (BC seine and gill-net average), 1978–1992. Sources: Commercial Fisheries Entry Commission, and Department of Fisheries and Oceans Canada (unpublished data). (To convert to cents per kilogram, multiply the cents-per-pound value by 2.20.)

in 1975, but the first available records of sales prices are 1981. The 1981 and 1982 average prices of PWSAC fish were the same as average ex-vessel prices in those years (Figure 1).

Dramatic increases in volume of returns were apparent already in 1981–1982, however. In 1979 began a dramatic climb in pink salmon returns from a historical average (since the 1920s) of 5 million fish to a 10-year average (1979–1988) of 18 million fish. During most of the 1980s, a rebounding of wild stocks contributed to this trend, but by the late 1980s, a downturn in wild stocks meant that in some years the stocked fish contributed up to 80% of the common-property harvest.

The PWSAC policy requires that approximately 70% of the hatchery returns be taken in the common-property fishery, and only 30% (less brood requirements) be sold for cost recovery by PWSAC. The increasing volume of hatchery contributions, even when wild fish returns fluctuated—and therefore the increasing volume of the cost-recovery fish—was to play an important role in PWSAC prices.

Up through 1983, the CAMA acted as the bargaining agent for both the ex-vessel price and the PWSAC fish. Average ex-vessel prices for pink salmon in Prince William Sound tended to be

roughly equivalent to average ex-vessel prices for pink salmon seined in southeast Alaska and for those seined or caught by gill net in British Columbia, the other large pink salmon production areas (Figure 2). (In British Columbia, unionized bargaining first missed and later, in 1987–1992, targeted pink salmon—hence the different pricing pattern.)

Events in 1982 created a turning point for PWSAC and the traditions of collective bargaining by the CAMA. After the botulism scare of 1981, and the greater difficulty of marketing Alaskan canned fish, the local processors offered only \$0.23/lb in 1982 (compared with \$0.44/lb average in 1981). (To convert to price per kilogram, multiply the per-pound price by 2.20.) However, the run was large, so the governor invited in foreign floating processors after the local capacity was taken up, as is legally required. By this time the volume of PWSAC fish was considerable, and one U.S. company offered \$0.35/lb if all the PWSAC cost-recovery fish, plus a matching number of the common-property fish caught, could be sold as a unit. The CAMA was not prepared to deal in partial units at this point, so this offer was refused and the fish were sold to a Korean processor at \$0.23/lb, instead of the \$0.35/lb offered before the season

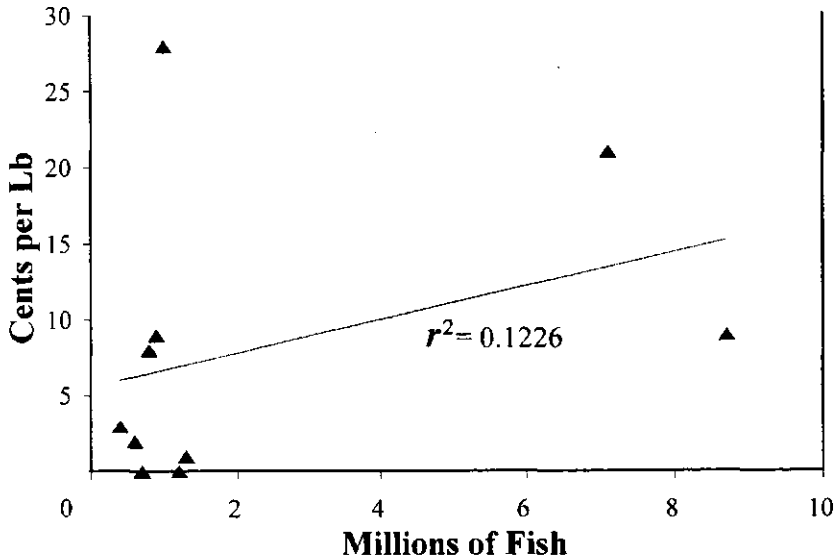


FIGURE 3.—Prince William Sound Aquaculture Corporation's (PWSAC) premium price for cost-recovery pink salmon in relation to the volume of cost-recovery fish, 1981–1990. Sources: PWSAC and Commercial Fisheries Entry Commission (unpublished data). (To convert to cents per kilogram, multiply the cents-per-pound value by 2.20.)

by the other floating processor, or the \$0.16/lb some local processors were offering at the peak of the run.

For the first time it became apparent that a large volume of live fish sold as a unit could attract a higher price. It was also apparent that the cost-recovery PWSAC fish were of high quality for the most part. They were held live in floating pens as they came in, and brood stock was taken from the early, middle, and late part of the run. Their sex was known so that a buyer was purchasing a known quantity of eggs and fish of known quality. Floating processors could literally lift the live fish onto their decks and process them instantly.

By 1983 volume had become the price driver for PWSAC fish. In 1984 the processors refused to bargain any more with the CAMA for either PWSAC or common-property fish. But by this time floating processors were being attracted to Prince William Sound to bid on the now predictably large quantity of high-quality fish. The attorney general's office rejected the legal objections raised by Icicle Seafoods, a major canning company, to PWSAC's putting up its fish to open bid.

The pattern that began to emerge in 1983 was that PWSAC fish commanded a significantly higher price than the common-property fish in Prince William Sound, southeast Alaska, and British Columbia (Figures 1, 2). Except in 1987, this pattern prevailed until 1991, when the price differential

became only \$0.01/lb. A positive correlation between the volume of PWSAC fish and the premium for these fish supported interview statements that volume was the price driver (Figure 3). There was no significant correlation between world supply of pink salmon and the PWSAC premium during those years (Figure 4). The most likely explanation for the higher price during times of higher PWSAC volume is simply that one reliable, consistent large supplier who could guarantee quality and eliminate tendering costs lowered risks to buyers and commanded a premium.

New supply and harvest timing conditions in 1990 began the breakdown of the bidding system that had supported the higher PWSAC prices, a breakdown that would be completed by world market changes in 1991–1992. A record return to Prince William Sound in 1990 produced an overabundant harvest of fish, which required special supply management strategies for the first time. The timing of the harvest "opening" by ADF&G created a local market glut and quickly put the volunteer fishers who were called in to help PWSAC harvest cost-recovery fish in conflict with their own fishing activities. Processors were able to take advantage of the situation, and fishers sold cost-recovery fish at lower prices in order to get back quickly to their own private fishing businesses.

New supply conditions and political constraints also contributed to a further price collapse in 1991.

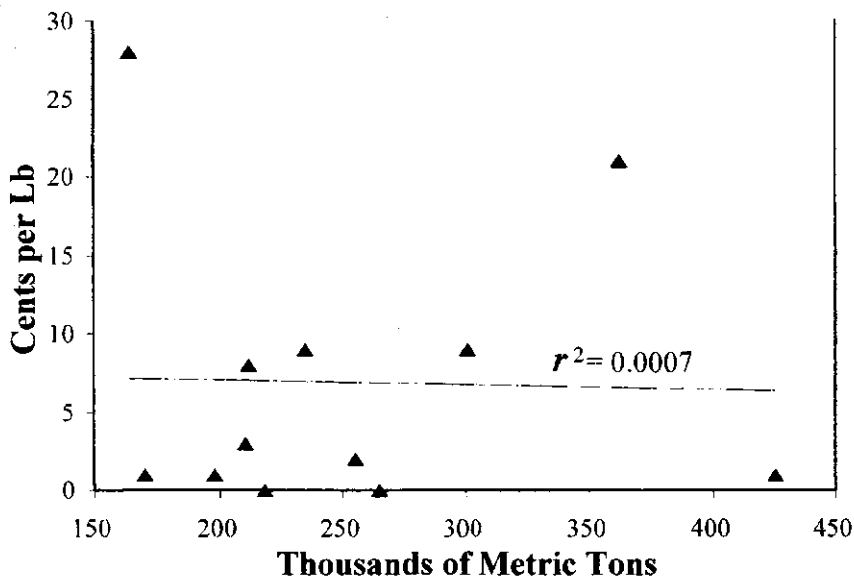


FIGURE 4.—The lack of relationship between Prince William Sound's premium price for pink salmon and world production of pink salmon, 1981–1992. Sources: Prince William Sound Aquaculture Corporation (unpublished data); FAO (1992). (To convert to cents per kilogram, multiply the cents-per-pound value by 2.20.)

The record high Alaska pink salmon returns in 1989 and 1990 had already resulted in a backlog of unsold canned pink salmon among domestic processors, including some of PWSAC's usual buyers. These processors suggested to PWSAC they would not be major buyers in 1991 when a third consecutive record return was projected. The PWSAC began negotiating with foreign processors in the expectation that the state would license them to buy fish. (The Magnuson Fishery Conservation and Management Act, Public Law 94-256 of 1976, requires the United States to open its 200-mi extended economic zone to foreign processors if domestic processors cannot handle all the fish.) Domestic processors were able to take advantage of a new state committee appointee and convince the state not to license foreign processors in 1991 (interviews, Alaska State Senate 1992:76). In addition, ADF&G and PWSAC differed in their in-season analysis of run strength, and in whether an up-front fishery was advisable because of wild stocks damaged by the oil spill. Low early returns, brood-year data, and percentage of females returning signaled to PWSAC that the run was going to be late, but ADF&G disagreed with PWSAC's prediction (which was first stated in January 1991) that the local run size would be 28 million. Consequently, a second, emergency, petition by PWSAC to license foreign processors was denied.

Bidding stopped soon thereafter, and the PWSAC price did not exceed the ex-vessel price for much of the season. This record return arrived later, in more mature condition, and in a more concentrated time period than normal, and domestic processors stopped buying. By the end of the 1991 season, millions of PWSAC pink salmon had been donated to Alaska charities and to the Soviet Union, or simply dumped. Early bidding and sales to foreign processors could have allowed the sale of all or most PWSAC fish, although it is doubtful that the price would have been higher for much of the season.

New Supply and Market Conditions Facing PWSAC

The eventual price of a good portion of PWSAC's 1991 pink salmon would probably have been the same as the ex-vessel price, because of 2 years of accumulated high inventory (1.2 million cases) added to a third high-production year (Knapp 1993; NMFS 1993a:66; Figure 4). The PWSAC premium had previously occurred in years when the U.S. preseason inventory was about 1 million cases or less, but by 1992, when preseason inventory was about 1 million cases, bidding had not been reestablished. It is likely that the traditional canners had become more cautious because of slow inventory sales, and the marked 1991 increase in Rus-

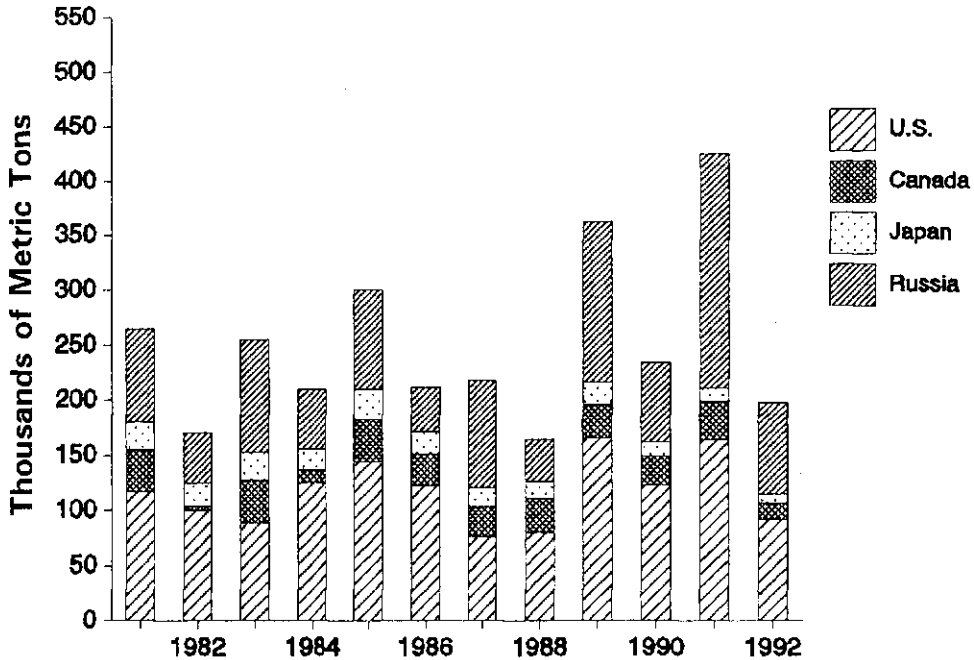


FIGURE 5.—World production of pink salmon, 1981–1992. Sources: for 1981–1990 data, FAO (1992); for 1991–1992 data, National Marine Fisheries Service (1993a), and Department of Fisheries and Oceans Canada and International North Pacific Fisheries Commission (unpublished estimates). The Russo-Japanese joint venture catches were counted under Russia; 1991–1992 Japanese catches are very preliminary estimates.

sian production, which was about 50% of world pink salmon production in that year (Figure 5).

The former Soviet Union was beginning to move beyond its traditional sales to Soviet bloc countries, selling small quantities of frozen and canned pink salmon in Europe (e.g., in 1991, the former USSR sold 2,400 metric tons of the canned product to Europe, whereas the United States sold 21,416 metric tons) and exporting larger quantities of fresh and frozen pink salmon to Japan through quota allocations to Japanese vessels in its extended economic zone (e.g., 10,000 metric tons in 1992; ACIB 1993; ITC 1993; NMFS 1993b). Observers predict that this amount may already be underestimated, and will increase to 50,000–70,000 metric tons (including all salmon species), for the reasons discussed below (P. Christiansen, Institute for Current World Affairs, 1993 personal communication; G. Knapp, University of Alaska, 1993 personal communication).

Since 1987, Russia has undertaken a series of joint ventures with Japanese companies in the construction of pink salmon hatcheries (several not yet producing), in processing technology, and in marketing research (Kravanja 1992; Akaha 1993). The basic dynamic in this relationship ap-

pears to be Russian access to Japanese capital, technology, and marketing experience in exchange for Japanese access to Russian fish. In recorded sales of pink salmon to Europe and Japan, the price of Russian pink salmon has been substantially lower than that of other suppliers (ACIB 1993; ASMI 1993). This price difference is consistent with the observation that considerable amounts of salmon leave Russia through Korean companies and other buyers who make individual arrangements through patron-client relationships with bureaucrats in the Russian Ministry of Fisheries. It appears that Russian pink salmon have captured and may continue to hold Asian markets to which Alaskan fish once had greater entry (Christiansen, 1993 personal communication).

Where does this leave PWSAC? Should Alaskan hatcheries scale down production, as the legislature is now considering? What are the prospects for the expansion of the other markets for pink salmon, or the eventual reentry of Alaska into some Asian markets?

Currently, Alaska pink salmon are mostly canned, and the United States is by far the largest buyer. The U.S. per-capita consumption of canned salmon (mostly pink salmon) remained, in 1991–

1992, at the level it was 10 years before (0.5 lb/person), while the population grew and canned exports increased (NMFS 1993a). Therefore, the canned salmon market grew.

However, even with this expansion, these traditional markets are clearly not enough to absorb the new surplus. World consumption of fish and North American consumption of fish per capita has been growing, but not of fish in the canned form. Considered in the context of declining world supplies of fish, especially low-value fish, product form may be the issue more than supply, at least for the low end of the salmon market.

The canners' traditional domination of the market has inhibited the development of new product forms until recently. In 1993 McDonald's was testing Alaska pink salmon "McNuggets"; a PWSAC-contracted researcher was testing smoked, vacuum-packed pink salmon filets; and the federally funded Alaska Fisheries Development Foundation was to test three new product forms by buying the fish from PWSAC, working with a local processor, and developing markets.

Although the immediate prospects for expanding pink salmon markets are unclear and may deteriorate before they improve, longer-term prospects could be brighter. Some question the long-term sustainability of the Russian pink salmon fishery, given the lack of effective surveillance of either harvest or habitat destruction (Akaha 1993; Christiansen, 1993 personal communication), or because of other limiting factors (Johnson 1992).

Ironically, the 1993 Prince William Sound commercial pink salmon harvest was only 5.8 million pieces, constituting a run "failure" that did not appear elsewhere in the state. Speculation at ADF&G points to genetic change in wild fish in streams affected by the *Exxon Valdez* oil spill. Although the future of Prince William Sound itself is unclear, the issues raised by its experience have broad relevance and are summarized in the next section.

Synthesis and Conclusions

Economic and Culture-Capture Management Benefits

The PWSAC experience provides an example of how comanagement of enhancement can put a fishers' organization such as PWSAC into a better bargaining position for fish prices, provided that a world oversupply of the fish being enhanced is not too great. The better bargaining position was related to four factors that lowered the risks of buyers: high quality, large volume, predictability

in both quality and volume, and the possibility of dealing with one seller. These are, of course, generally favorable factors in achieving a good selling position for any highly perishable and seasonally available product. For fisheries with annual fluctuations in production, these factors are especially important in reducing processor risk.

What is important about the finding for fishers and managers is the advantage of collectively selling at least a portion of the catch live through a fishers' organization and distributing the benefits. In this case, the benefits were distributed by reserving 70% of the hatchery fish for area-licensed fishers to catch. Even at the low 1990 pink salmon prices (\$0.32/lb), gross benefits to Prince William Sound seiners attributable to PWSAC-produced fish were \$17,868,800, or an average of \$70,907 per seiner, and a seiner paid an average of only \$2,974 as a 2% landings tax to support enhancement. Of course, there were community benefits as well, including an increase in processing jobs in the area and PWSAC's employing of about 100 local residents. Benefits also accrued to ADF&G, which was relieved of some of the costs of harvest planning, regional enhancement planning, allocation, tag recovery, and operation of state hatcheries. In this type of cooperative management of resource enhancement, there are benefits to government and to a broad range of community residents, and opportunities for substantially improving the selling position of comanaging institutions and increasing the catch volume for their members.

Under what economic conditions are these benefits sustainable? How much did the scale of PWSAC production contribute to the oversupply that eventually outstripped existing markets and lowered the price? Alaska's hatchery-attributable production of pink salmon was 30% of total production in 1989 and 45% in 1990 (equivalent to about a million cases in each year). Therefore, in some sense, both PWSAC (as the largest single producer of pink salmon) and all other state and private hatcheries raising pink salmon contributed to the surplus that eventually eliminated PWSAC's premium and lowered ex-vessel prices.

But the real question here may be about the pace of product form and market development in relation to the pace of increase in supply. Not until 1992-1993 did a foundation, the private food industry, and PWSAC itself, begin serious research on new product forms. It is widely believed that the Alaska Seafood Marketing Institute, theoretically set up to deal with such issues a decade ago,

has not done so because of the traditional canners on its board, who have had little interest in innovation. Canners have perhaps perceived the immediate benefits of increased production as a lowering of price, and have focused less on longer-term implications.

Most experts believe that if the United States is to continue as the main buyer of pink salmon, processors of Alaskan pink salmon will need to find ways to convert some portion of the product into microwavable dinners, frozen or vacuum-packed fillets, or other product forms requiring little preparation time or little specialized knowledge of fish. At any rate, the economic benefits described here are apparently sustainable only if expansion of production is coordinated with the development of new markets.

In addition, international price competition for pink salmon may force Alaskans to lower the cost of production. It is already rumored that Russia is selling pink salmon live from estuarine traps at \$0.035–0.05/lb. Meanwhile, part of the Canadian government's Aboriginal Fisheries Strategy in British Columbia involves comanagement agreements between the Department of Fisheries and Oceans and First Nations, through which First Nations sell salmon selectively caught in traps. This strategy is likely to continue because it is considered highly desirable as a technique for stock identification and separation.

One method for lowering the cost of production while widely sharing benefits is through the low-cost harvesting and live fish sales by comanagement institutions such as PWSAC. At present Alaskan fishers have invested heavily in vessels and gear and say they would resist this alternative, unless it is based on past catch records. Equitable distribution would be difficult, but not impossible. The idea may be taken more seriously—at least as an interim measure—if price and volume do not improve in the near term.

Another alternative is to increase the percent share of PWSAC sales, especially during low-price years, and to eliminate the tax. In 1993 the PWSAC board decided to increase the PWSAC share by 5%. Theoretically, there will be declining fisher support for PWSAC as the percent of PWSAC's harvest increases, unless prices rise enough to cover fisher production costs. Hull (1993) considers various scenarios. In good-price years, replacing the tax on fishers with a higher PWSAC percentage is rational, because these fish fetch a higher price and thus fewer of them would be required to raise the same amount of revenue for PWSAC.

To what extent has a comanagement approach to resource enhancement succeeded in integrating the culture and capture fisheries? Here the biological, economic, and political aspects of this question are summarized.

As the discussion has suggested, for mixed-stock fisheries issues, PWSAC working with ADF&G was no worse and probably much better than conventional bodies dealing with fishery resource enhancement, such as enhancement divisions of government fisheries agencies or private companies like Weyerhaeuser. The PWSAC sales generated more money for tagging studies and escapement counts so that wild populations, as well as interactions between wild and hatchery stocks, could be better understood. The PWSAC supported both financially and logistically the extensive planning and study involved in producing the integrated harvest plan for wild and enhanced stocks, and supported the continuing research on wild-hatchery stock interactions through cosponsorship of a 2-d symposium on the subject in Cordova in 1991, and through continued tagging and tag analysis studies.

At times, the local holistic ecosystem perspective of PWSAC has put it in a better position to predict accurately or to take a strong position. In 1971 PWSAC's founders strongly opposed the proposed oil port at Valdez, and predicted the very disaster to their fisheries that came to pass as the *Exxon Valdez* oil spill. Although the ADF&G prediction of in-season run strength is usually fairly accurate, in 1991 the PWSAC analysis, which was based on low early returns to neighboring Valdez's hatchery facility, brood-year data, and percentage of females returning, was more accurate. This episode indicated that, when ADF&G and PWSAC disagree, the analysis of the latter may have something more valuable to contribute than has been acknowledged.

Economically, the comanagement of enhancement by PWSAC and ADF&G has used fewer public resources than ADF&G would have used producing the same amount of fish and then trying to explain and resolve the culture-capture issues with the fishers and the general public. The PWSAC sales have paid for the hatcheries, additional data generation, analysis, planning, and conflict resolution, and fishers have contributed weeks of volunteer time and labor because of their support of these processes.

Politically, PWSAC has contributed to conflict resolution over allocation of enhanced stocks and wild stocks, and over development planning in

general. The involvement of PWSAC in these processes has made the organization seen more legitimate to local communities and fishers, who felt they were fairly represented because PWSAC had some accountability to them. Although the harmonizing of the concerns of culture and capture fisheries is never easy or perfect, PWSAC has been able to take a more balanced approach than could a state agency or a private company alone. Furthermore, the checks and balances applied to PWSAC by ADF&G and the Board of Fish has meant that decisions are more likely to be balanced.

General Conditions for Comanagement of Resource Enhancement

Although every jurisdiction has a unique history and circumstances that do or do not permit the development of such biological, economic, and political benefits, a few general favorable conditions may be identified from this Alaskan pink salmon comanagement example. These conditions are presented here as working hypotheses.

First, fishers' organizations may develop price advantage in collective sales from enhancement activities if they have

- the right to sell a substantial percentage of the enhanced fish,
- sufficient and sufficiently predictable volume and quality of product, and
- market and market product development concomitant with supply.

Second, fishing-dependent communities such as Cordova will continue to experience economic benefits from enhancement activities when fish prices drop (even when fishers do not experience such benefits) if

- there is sufficient volume of marketable fish to maintain shore-based jobs in the association and in processing plants; and
- the association is allowed to sell enough fish to maintain itself during low-price or low-volume years.

Third, management benefits from coordinating capture and culture fisheries may accrue if

- the quality of the enhanced stock is sufficient when it reaches the terminal area to compare favorably with its quality where it might otherwise be intercepted;
- legislation supports feasible conditions for the setting up of fisher enhancement organizations

and affords them access to capital and allows a repayment schedule that coincides with the appearance of benefits;

- the local board is structured to have accountability to both fishers and local communities, and is checked and balanced by accountability to other statewide bodies;
- there is ideological support locally and statewide for the concept of collective action by local organizations that want to share responsibility with the state agency; and
- there is a preexisting local institutional base with an orientation toward regional or local sustainable ecosystem management, or it is possible to create such a base because of preexisting social capital (experience, credibility).

The latter condition is not necessary for all areas, but helps a great deal in an area pioneering a new concept, as it did in Cordova.

In summary, the comanagement approach to resource enhancement adopted in Prince William Sound has produced considerable specific economic benefits to fishers and communities, and has also created a number of political, economic, and biological management benefits for the state and local community. This paper has identified the principal conditions that appear to permit the setting up of institutional arrangements that can allow these benefits to accrue.

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