

IMPROVING EFFICIENCY BY ASSIGNING HARVEST RIGHTS TO FISHERY COOPERATIVES: EVIDENCE FROM THE CHIGNIK SALMON CO-OP

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During 2002–2004 a voluntary, profit sharing harvesters' co-operative was allowed to operate in the Chignik Salmon fishery in Alaska. Regulators split the fishery's total allowable catch between the co-op and independent harvesters. Our economic model predicts that the co-op would centrally coordinate its members' activities, resulting in more efficient effort deployment than in the independent fleet. Empirical analysis of relevant data supports these predictions. We find that, in contrast to the independent fleet, the co-op concentrated effort among its most efficient members, fished closer to port, spread harvesting over a longer time span, and shared information on stock locations.

INTRODUCTION

Under traditional fisheries management, fishermen race to catch as much of the total allowable catch (“TAC”) as possible before the season closes. The

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† This Article appears in Volume 50 Number 2 of the *Arizona Law Review*, which collects papers originally presented at the Program on Economics, Law, and the Environment: Property Rights in Environmental Assets: Economic and Legal Perspectives Symposium, hosted in Tucson, Arizona on October 26, 2007. Thanks are due to Gunnar Knapp for sharing his vessel-owner data and for sharing information about how the Chignik Cooperative operated. Valuable comments were received from James Boyd, D. Bruce Johnsen, and participants at the Symposium. Any errors are the authors' responsibility.

economic consequences of an artificially short fishing season include more dangerous fishing, less fresh seafood, and more dollars sunk into an overcapitalized fishery built for racing.¹ Various forms of property rights or “dedicated access privileges” in the ocean have been proposed to end this waste, and their adoption constitutes one of the most important institutional innovations in commercial fisheries. Economic theory predicts that as fishing assets are secured as private property, their owners have incentives for stewardship and cost reduction, neither of which exists in the traditional “race-to-fish.” The most widespread, widely heralded version of fisheries property rights, known as the “individual transferable quota” (“ITQ”), grants the individual owner a secure right to a portion of each season’s TAC. While widely acclaimed, ITQs may not be sufficient to end the race to fish due to lack of incentives to coordinate harvest among quota holders. A promising alternative assigns harvest rights to firms or to harvester cooperatives. In addition to ending the incentive to race, assigning rights to firms or co-ops can yield benefits by coordinating fishing effort in order to avoid redundant searches and reap gains from cooperating on harvest activities.

In this Article, we highlight the potential efficiency gains from coordinating fishing efforts. The gains from coordination can be realized by forming an association of harvesters whose members agree to have a central manager coordinate their efforts in return for a suitable quid pro quo. In what follows, we focus on one particular type of association, a profit-sharing fishery cooperative. Associations with this format are common in the developing world and are widely believed to incentivize coordinated harvest. The most obvious source of efficiency comes from ending the race to fish induced by the TAC and season closure forms of regulation.² Additional gains from coordination are forthcoming, however, and these gains are best appreciated by considering the inefficiencies that can persist under ITQ regulation. While an ITQ establishes the right to catch a portion of the TAC, it does not precisely delineate where and when the holder may harvest. Across a biologically homogeneous stock, different portions may be heterogeneous in economic value due to their locations or times of availability. This economic heterogeneity can induce a race to catch the most profitable fish even if the right to harvest a specific portion of the TAC is secure.³

1. RÖGNVALDUR HANNESSON, *THE PRIVATIZATION OF THE OCEANS* 70, 141–42, 167 (2004); *EVOLVING PROPERTY RIGHTS IN MARINE FISHERIES* 3–7 (Donald R. Leal ed. 2005).

2. In many fisheries the season is abruptly closed upon aggregate catch reaching the TAC.

3. A. Scott, *Moving Through the Narrows: From Open Access to ITQs and Self-government*, in *USE OF PROPERTY RIGHTS IN FISHERIES MANAGEMENT*, FAO FISHERIES TECHNICAL PAPER 404/1, at 114–15 (Ross Shotton ed. 2000), available at <ftp://ftp.fao.org/docrep/fao/009/x7579e/x7579e02.pdf>; Christopher J. Costello & Robert T. Deacon, *The Efficiency Gains from Fully Delineating Rights in an ITQ Fishery* 7 (Univ. of Cal., Santa Barbara, Dep’t of Econ., Working Paper No. 03’07, 2007), available at <http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1207&context=ucsbecon>. Cancino et al. makes the same observation, noting that economic heterogeneity may arise from patchy stock distributions, spatial productivity differences, or spatial differences in profitability arising from proximity to ports and distribution facilities. José P. Cancino,

Further gains from coordination—under any form of harvest regulation—arise from the fact that fish often are difficult to find, so fishermen generally devote costly effort to search. When searching, the fisherman cannot easily know which locations have already been searched or what was found, so some search effort inevitably will be redundant. Coordinating effort across harvesters effectively eliminates these two sources of waste.⁴

While we focus on efficiency, harvesting cooperatives may also produce political advantages. Individuals who compete most effectively in the traditional race to fish may resist implementing an ITQ system if they believe they would fare poorly in the initial allocation of quotas. Such resistance may be diminished if the only assignment of rights is to a voluntary co-op; in this case, traditional “highliners” might reason that they can avoid losses by refusing to join. Also, the ability to opt out may defuse arguments by any who would claim that their traditional right to fish is being usurped—as they might well under an ITQ system. Further, gaining agreement on a simple division of a TAC between a co-op and an independent fleet is arguably a simpler negotiating task than crafting individual TAC assignments for scores of individual harvesters.⁵

The Chignik fishery for sockeye salmon, which we empirically examine in order to illustrate the efficiency analysis, was originally managed under a traditional TAC and season closure policy and no quantitative harvest rights. A harvester co-op was then allowed to form and was allocated a portion of the TAC; harvesters not joining the co-op continued to harvest independently, with a separate TAC and season closure. Members of the cooperative agreed to operate under the direction of a central manager and received a portion of the enterprise’s profits. Our *a priori* expectations about how the co-op would affect harvester behavior follow from the potential gains from coordination described earlier. Because they share profits, cooperative members should have no incentive to race and little reason to compete with one another for sub-stocks with high economic value. Instead, they should have strong incentives to share information, thereby avoiding redundant search. We expect the net gains from coordination to be highest when stock locations are highly uncertain, economic values within a stock vary greatly, and the internal costs of policing fishing effort and enforcing the cooperative agreement are low.⁶ These and similar insights are compatible with

Hirotsugu Uchida & James E. Wilen, *TURFs and ITQs: Collective vs. Individual Decision Making*, 22 MARINE RESOURCE ECON. 391, 398 (2007).

4. Costello & Deacon, *supra* note 3, at 2. This is not the only way to achieve efficiency gains, however. Costello & Deacon note that these inefficiencies could be eliminated if ITQs were defined more completely over time and space. *Id.* at 19.

5. Distributional concerns were a primary factor behind the four-year moratorium on new ITQ systems contained in the Magnuson-Stevens Fishery Conservation and Management Act reauthorization in 1996. Scott C. Matulich, Murat Sever & Fred Inaba, *Fishery Cooperatives as an Alternative to ITQs: Implications of the American Fisheries Act*, 16 MARINE RESOURCE ECON. 1, 2 (2001).

6. These basic tradeoffs resemble those articulated by Coase in his analysis of the costs and benefits of using firms (instead of individual contractors) to organize production. R.H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937). The costs of coordinating inputs in a centralized way, as opposed to allocating them across a market, include the information, monitoring, and computational costs associated with non-market

conclusions from a small but growing literature on the economics of fishery cooperatives.⁷

We offer three contributions to this literature. First, we examine how the characteristics of permit holders who voluntarily join cooperatives differ from the characteristics of those who refuse to join. This analysis has important policy implications as it informs the structure of regulations that can achieve fully voluntary participation. Second, we examine how joining a cooperative changes certain behaviors of fishermen, including where and when they harvest fish and how much fishing effort they expend throughout the season. This analysis helps to identify the exact mechanisms by which cooperatives can improve the economic—and ecological—performance of a fishery. Our analysis also identifies circumstances under which cooperative ventures are likely to generate the largest efficiency gains relative to independent fishing regimes. In addition, we examine whether some members of a fishery can be disadvantaged if a cooperative is allowed to form. Third, we test our theoretical insights with a data set on a salmon fishing cooperative in Chignik, Alaska.

The next Part presents a brief literature review. Part II presents our theory of cooperative formation within a fishery having heterogeneous economic value. Here, we use game theory arguments to characterize which permit holders will choose to join a co-op and, given this decision, how they will subsequently choose to deploy fishing effort across time and space. In Part III we test the predictions of the model against data from Alaska's Chignik Salmon Cooperative, which operated from 2002 until it was shut down by the Alaska Supreme Court in 2005.⁸ We also discuss the court's decision in Part III. The Chignik cooperative represents an ideal empirical case study because the economic value of salmon varies considerably across time and space as the fish migrate toward their home stream to spawn. The Chignik cooperative is also interesting because a subset of non-joiners filed the lawsuit ending the cooperative.⁹ The fact that some harvesters opposed the co-op, even though it was voluntary, prompts us to direct part of our analysis toward uncovering the features of a voluntary co-op that may impose losses on some fishermen. Finally, we conclude by highlighting lessons for policymakers wanting to encourage fishing cooperatives.

allocations. In addition, a cooperative faces the free-rider problem that potentially stems from the sharing of profits and the fact that effort applied toward the group's goal may be difficult to monitor. While acknowledging the importance of these factors, we do not emphasize them here; instead, we refer the reader to Coase's classic discussion of these points in *The Nature of the Firm*, *supra*.

7. See generally F.T. Christy, *Common Property Rights: An Alternative to ITQs*, in USE OF PROPERTY RIGHTS IN FISHERIES MANAGEMENT, FAO FISHERIES TECHNICAL PAPER 404/1, *supra* note 3; Scott, *supra* note 3; Ralph E. Townsend, *Producer Organizations and Agreements in Fisheries: Integrating Regulation and Coasean Bargaining*, in EVOLVING PROPERTY RIGHTS IN MARINE FISHERIES, *supra* note 1, at 127; Andrew W. Kitts & Steven F. Edwards, *Cooperatives in US Fisheries: Realizing the Potential of the Fishermen's Collective Marketing Act*, 27 MARINE POL'Y 357 (2003); James A. Wilson, *Fishing for Knowledge*, 66 LAND ECON. 12 (1990); Costello & Deacon, *supra* note 3.

8. Grunert v. State, 109 P.3d 924, 936 (Alaska 2005).

9. *Id.* at 928.

I. THE LITERATURE ON FISHING COOPERATIVES

Scholars are producing a small but growing literature on the economics of private harvesting agreements, a broad category of user-based management systems to which harvester cooperatives belong. Several observers have claimed potential efficiency advantages for user-based organizations that coordinate the activities of individual members. Scott, for example, relies on this basic reasoning in arguing that fishery governance by harvester-based organizations represents a logical next step—beyond ITQ regulation—in the development of fishery management.¹⁰ He attributes these coordination benefits to the public good aspects of regulatory enforcement, to the collective benefit of sharing information on fish stocks, and to the fact that a wasteful race to catch the best fish may persist even under an ITQ regime.¹¹ Focusing on a different element of the co-op phenomenon, Townsend traces the move to self-governance to recognition that government-centered regulation has failed and that the resulting antagonism between harvesters and regulators has been destructive.¹² Considering how self-governing institutions should be organized, he argues that a corporate structure is likely to provide better long-run incentives for stock conservation than a cooperative structure because the former creates a tighter link between initial sacrifices and future rewards. Focusing on the broader question of incentives under traditional regulation, Leal identifies several advantages of private harvesting agreements, including reduced transactions costs, better monitoring incentives, and a reduced role for regulatory oversight.¹³

Several authors have examined the structure and performance of harvester-based management systems. Da Silva and Kitts report survey information on the structure, activities, and objectives of existing and proposed harvester-based management initiatives in the northeast United States.¹⁴ They find a significant increase in collaborative and co-management arrangements and argue that this creates a platform for more decentralized fishery governance.¹⁵ Focusing more directly on the economic benefits of cooperative marketing, Kitts and Edwards describe how recent regulatory changes have affected the viability of harvester cooperatives, summarize the history of relevant regulation and antitrust

10. Anthony Scott, *Obstacles to Fishery Self Government*, 8 MARINE RESOURCE ECON. 187, 196–97 (1993); Scott, *supra* note 3, at 115.

11. Scott, *supra* note 10, at 196–97.

12. Ralph E. Townsend, *Fisheries Self-governance: Corporate or Cooperative Structures?*, 19 MARINE POL'Y 39, 39–43 (1995).

13. DONALD R. LEAL, FENCING THE FISHERY: A PRIMER ON ENDING THE RACE FOR FISH 35–37, 46–50, 55–57 (2002), available at http://www.perc.org/pdf/guide_fish.pdf. Matulich et al. provide an analysis of the North Pacific Pollock cooperatives but focus on issues separate from those raised here, e.g., implications for price formation and for the distribution of gains between harvesters and processors. Matulich, Sever & Inaba, *supra* note 5, at 1–16.

14. Patricia Pinto da Silva & Andrew Kitts, *Collaborative Fisheries Management in the Northeast US: Emerging Initiatives and Future Directions*, 30 MARINE POL'Y 832, 834–38 (2006).

15. *Id.* at 838–40.

policy toward co-ops, and describe recent experience in the United States.¹⁶ They conclude that securing private access enhances the efficiency of fishery cooperatives.¹⁷

A specific form of private harvester agreement, the commercial stakeholder organization (“CSO”), has become sufficiently common in New Zealand that it has attracted much scholarly attention. CSOs are typically layered onto ITQ management systems, with quota holders as members and decision makers. Yandle provides survey results for CSOs in New Zealand and identifies their key activities and institutional challenges.¹⁸ Deacon and Costello describe the activities of a CSO formed by the ITQ holders for *paua* (abalone) in one of New Zealand’s management zones.¹⁹ This CSO shares information on stock locations, provides enforcement of size limits, funds stock enhancement, and allocates effort across space to avoid competition for heterogeneous stocks.²⁰

While much scholarly attention has been focused on the advantages of harvester cooperatives and the activities they pursue once they are formed, basic questions remain unexamined. Given incentives for individual operators to pursue their own profits, how can harvester cooperatives form? How is their behavior shaped by their institutional structure? What factors determine the likely magnitudes of their efficiency advantages? How do members sort themselves into voluntary cooperatives, where profits are shared and membership is not compulsory? In the next Part we develop a model that helps answer these important questions.

II. MODEL

We focus on the example of a migrating fish stock and present, in intuitive terms, a set of results established more formally in a companion paper.²¹ We concentrate on within-season efficiency issues, so we assume the stock available each year is exogenously given. We also assume the TAC is set exogenously by a regulator and do not consider whether the TAC is optimal. We further assume a fixed price per fish. We impose these assumptions in order to

16. Kitts & Edwards, *supra* note 7. Sullivan discusses transaction-cost and enforcement advantages that harvester cooperatives may have over ITQ policies, but concludes that harvester co-ops may be less durable than ITQ systems since they exist at the pleasure of their members. Joseph M. Sullivan, *Harvesting Cooperatives and U.S. Antitrust Law: Recent Developments and Implications*, at 8–9 (2000), <http://oregonstate.edu/Dept/HIFET/2000/papers/sullivan.pdf>.

17. Kitts & Edwards, *supra* note 7, at 364–65.

18. Tracy Yandle, *The Challenge of Building Successful Stakeholder Organizations: New Zealand’s Experience in Developing a Fisheries Co-management Regime*, 27 MARINE POL’Y 179, 179–91 (2003).

19. Robert T. Deacon & Christopher Costello, *Strategies for Enhancing Rent Capture in ITQ Fisheries* 9–10 (Univ. of Cal., Santa Barbara, Dep’t of Econ., Working Paper No. 04’07, 2007), available at <http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1208&context=ucsbecon>.

20. *Id.* at 9.

21. Robert T. Deacon, Christopher Costello & Dominic P. Parker, *A Model of Fishery Harvests with a Voluntary Co-op* (Univ. of Cal., Santa Barbara, Dep’t of Econ., Working Paper No. 02-08, 2008), available at <http://econ.ucsb.edu/papers/wp02-08.pdf>.

concentrate attention on the issues of primary interest: the process whereby individual fishermen will choose whether to join a co-op or fish independently, the ways in which fishing behavior will differ between the two groups, and the efficiency gains that can result from centralized effort and coordination of a co-op. In the context of our model, uncoordinated harvesting leads to waste because fishermen deploy effort too early in the season or too far from port, in order to exploit the stock before other harvesters do. We find that a co-op can eliminate this waste by coordinating the effort decisions of its members. We use this effort deployment benefit as a metaphor for a broader class of coordination benefits, of which one important example is the public good benefit from sharing information on the location of fish stocks. Independent harvesters have no incentive to share such information, while the co-op does have an incentive. Rather than examining this second potential advantage to coordination explicitly, we focus only on the gains from coordinating the timing and location of effort deployment and argue that our general results extend to the benefit of sharing information as well.

Our theoretical results, which we test empirically in Part III, are developed in terms of a hypothetical fishery with the following basic elements. At the beginning of the season, a stock of fixed size becomes available for harvest. During the season, the stock migrates toward a port where fishing vessels are based and processing facilities are located. In the absence of harvest, the stock becomes more concentrated as the season progresses. The number and identity of vessels eligible to harvest the stock is fixed exogenously by a licensing requirement. During the season, each harvester chooses the amount of effort to apply and its preferred location. A loose interpretation of effort is the amount of time spent fishing; it is limited by a vessel's capacity and by the amount of time fish are available within profitable proximity to port. Fishermen may embody different maximal effort levels.

The cost of applying a unit of effort falls as the stock approaches port due to reduced outlays for travel and search. Cost also depends on individual skill, which varies among harvesters. Distance and skill are assumed to affect cost additively, so the cost disadvantage of fishing at a greater distance is the same for all fishermen, but fishermen with different skill levels experience different total costs. Specifically, harvester i 's cost per unit of effort is specified to be $\alpha_i + d_i$, where the parameter α_i is inversely related to skill and d_i is the distance from port at which i fishes. Finally, we assume there are a fixed number of distance zones within which fishermen may choose to deploy their gear. To maintain analytical tractability, we assume that each fisherman's maximal effort can be expended during the time the stock is in any particular distance zone.²²

When a unit of effort is applied, it catches a fixed fraction of the uncaught stock. The catch resulting from a unit of effort is therefore proportional to the stock not already caught by others. An individual who encounters the stock and applies fishing effort before others do—by fishing at an advantageous time or location—obtains a commensurately larger catch. A common regulatory regime

22. This implies that the fish stock resides in a zone for the duration of any individual's harvest.

involves opening the season and allowing licensed harvesters to fish when and where they wish until the TAC is filled, at which time the fishery is closed and all effort ceases. This process induces the familiar race to fish; each harvester seeks to deploy effort before others do in order to exploit all profit opportunities before the season is closed. Because the stock migrates toward port, a visible consequence in the present circumstance is that harvesters deploy effort far from port in order to encounter an unexploited stock.²³

Suppose, however, that before any fishing starts, the regulator announces that harvesters will be allowed to join a cooperative harvesting organization that will coordinate the activities of its members. The regulator also agrees to set aside a portion of the TAC for the co-op to harvest, with the set-aside proportional to the co-op's membership so the TAC per boat is equal for co-op members and for non-joiners. While joining the co-op is entirely voluntary, any fisherman who does join surrenders to the co-op the right to decide where, when, and at what level his or her effort will be applied. The co-op makes all such allocation decisions by majority rule, and the resulting profits are shared equally by all members.²⁴ To effectively divide the TAC, the regulator must partition the available stock between the two groups, possibly by designating different openings if different runs become available at different times or by designating different fishing areas if fish arrive in a single run but migrate toward port along different routes. For simplicity, we assume this division renders each group's harvest independent of the other group's actions.

Those who do not join choose distance and effort level individually, without coordination. Each will choose the distance at which to fish and the effort level to deploy taking as given the decisions of other non-joiners. Once the non-joiners' season is opened, the regulator will allow fishing to proceed until their share of the TAC is filled, at which point their season is closed.

A. The allocation chosen by the co-op

We develop our argument by backwards induction. We start by assuming firms have already separated themselves into joiners and non-joiners and consider their effort allocations contingent on this first-stage choice. The incentives to join the co-op or to remain in the independent fleet are analyzed later in the manuscript. Co-op members each receive a pro rata share of the co-op's total profit. Given that profits are shared in this way, each member will prefer a policy that maximizes total co-op profit. Co-op revenue equals the exogenous price times the TAC the regulator assigns to the co-op. Co-op revenue is consequently determined by factors exogenous to the members' decisions, and the optimal policy is therefore

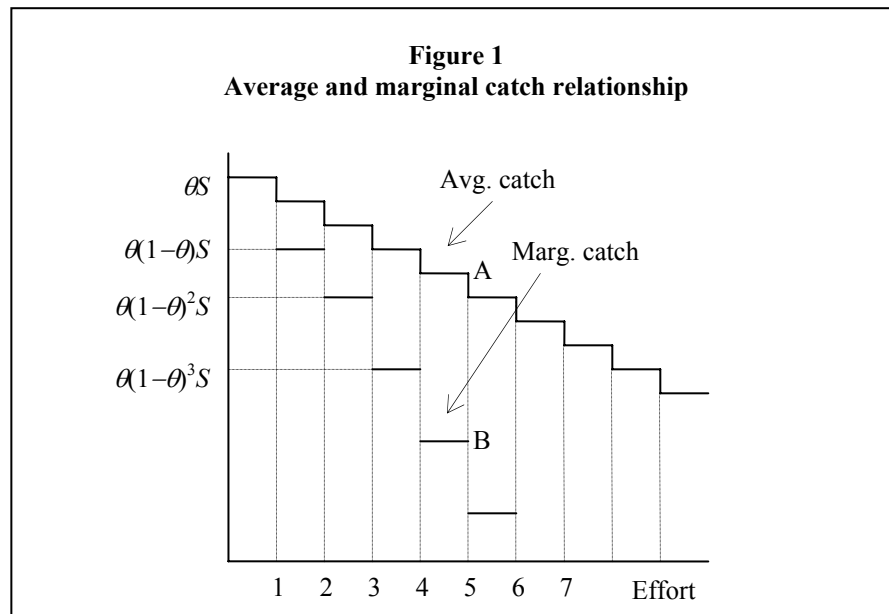
23. A similar form of dissipation can arise if stocks are stationary but exist in patches at different distances from port. If market forces or seasonal effects cause the unit value of catch from these patches to vary over the year, competition can cause harvesters to catch fish too far from shore and too early in the season. See Deacon & Costello, *supra* note 19, at 4, 6. We assume that the number of fishing permits issued is more than sufficient to harvest the entire TAC, if all harvesters apply maximal effort.

24. Different divisions of the stock could be considered but would imply a regulatory bias in favor of one group, which is not part of our story.

one that minimizes cost, subject to the constraint that total effort is just sufficient to harvest the co-op's TAC. The co-op's cost depends on the effort levels assigned to individual members and on where this effort is deployed. Given the assumption that each harvester's cost per unit effort is additive in distance and skill, the solution to this problem is both simple and intuitive. First, the co-op fishes as close to port as possible to minimize transportation cost, a practice we refer to as fishing inside. Second, the co-op deploys only its most efficient vessels—those with maximal skill—and each of these vessels applies maximal effort. The number of members actually fishing equals the smallest number of members capable of harvesting the co-op's share of the TAC, given that only the most efficient members fish. Interpreting the effort level each applies as time spent fishing, the co-op spreads its harvest over the entire time the stock is available. Because co-op profits are shared by all members, this choice is unanimous and becomes the co-op's policy.

B. Behavior in the independent sector

Behavior in the independent sector is more complicated because each harvester independently chooses where and when to fish. To motivate our analysis and develop intuition, we start with a simple case in which fishing can take place at only two distances, 0 and \bar{d} , before considering a more general setting. Because non-joiners harvest without coordination, we must determine how their actions impinge on one another. By assumption, each unit of effort catches the fraction θ of the remaining stock, so a marginal unit of effort depletes the stock and reduces the catch of subsequent effort units. Figure 1 illustrates this process. The first unit of effort catches θS , the second unit catches the same fraction of the stock that escaped the first unit of effort, $\theta(1-\theta)S$, and so forth. Because marginal catch declines with effort, average catch also declines and lies above marginal catch.



We assume that if all fishermen deploy effort at the same distance, all obtain the average catch per unit effort. In Figure 1, suppose there are 5 non-joiners, and each deploys 1 unit of effort at distance \bar{d} , so each incurs a transportation cost of \bar{d} . Their catches are given by point A, the average catch for 5 units of effort. Any non-joiner could reduce transportation cost by fishing inside, but this would reduce catch to point B on the marginal catch curve. If the vertical distance between average and marginal catch is greater than \bar{d} , then the move is not worthwhile, and the individual will choose to remain outside. Since all non-joiners face the same comparison, the same condition implies that none will perceive a gain from moving inside.

In what follows, we assume this condition is met, i.e., the difference between average and marginal catch for non-joiners exceeds the transport cost, so individual non-joiners perceive no net advantage to moving inside when all others are fishing outside. Loosely speaking, this will be true if the number of non-joiners is sufficiently large and/or the outside distance is sufficiently small.²⁵ The same condition implies that individuals have no incentive to fish at *any* distance closer to port than \bar{d} because moving part way inside would result in the same loss in catch but a smaller transport cost savings. Finally, the same condition implies that if all non-joiners are fishing inside at distance 0, each will perceive a net gain from switching to the outside fishing location, \bar{d} ; that is, the catch gain that results from encountering an unexploited stock necessarily exceeds the added transportation cost, so no individual non-joiner would be content to fish inside with all other non-joiners in this circumstance.²⁶

This setup gives rise to the following result: All independent fishermen electing to fish outside (at the maximum distance \bar{d}) is an equilibrium in the sense that no individual in this group is motivated to fish at any location closer to port. Further, this is the only symmetric equilibrium (a circumstance in which all non-joiners adopt the same behavior); if all non-joiners were to fish at any distance closer to port than \bar{d} , each would perceive that the gain in catch from moving outside would more than offset the increase in transportation cost.

The amount of effort applied by each non-joiner and the length of the non-cooperative fishing season can also be described. No harvester will choose to be a non-joiner unless the associated profit is positive. Given our cost structure and assumptions about harvests, total vessel profit is proportional to the level of effort the vessel applies. Each non-joiner will therefore fish the entire time the non-joiners' season is open. Earlier, we assumed that the number of licenses exceeds the number of vessels required to harvest the TAC if all fished the entire season and this is also true for the stock assigned to each group. It follows that the independent sector's season must be closed earlier to avoid exceeding its share of the TAC. This is not true for the cooperative sector, which stretches fishing out as

25. The comparison also depends on θ , the TAC, and the stock size.

26. Given the assumption of an additive cost structure, these incentives are independent of the individual's skill level and thus apply universally to all non-joiners.

long as possible in order to concentrate the catch among its most efficient boats. In the independent fishery, all boats fish until the independent group's share of the TAC is filled.

C. Comparing efficiency in the cooperative and independent sectors

To summarize our results so far, there are three ways in which efficiency differs between the two groups. First, the co-op does not engage in a race to fish and therefore avoids the unnecessary transport cost that accompanies fishing outside. The associated loss in the independent fishery amounts to $N\bar{d}$, where N is the number of non-joiners. Second, the co-op deploys only its most efficient units, whereas each independent harvester deploys maximal effort until the season closes. Intuitively, the inefficiency suffered by the independent fleet on this count increases with the diversity of the independent harvesters' cost parameters. Finally, the co-op fishes over a longer season than does the independent fishery. Because product quality generally declines when fishing and handling of the catch are rushed, the per unit value of the independent group's catch will be lower than the co-op's, an additional source of inefficiency.

D. Who will join?

Each fisherman faces a decision into which group he or she will self-select. We initially conduct that analysis under the assumption that fishermen embody the same maximal effort, but that they may embody different skill.²⁷ The logical criterion for joining is that a fisherman would gain greater profit in the co-op than in the independent fishery.²⁸ The revenue component of the profit comparison is the same for both sectors due to the regulatory constraint that each sector achieves the same catch per boat. The relevant comparison therefore only involves costs. Harvester i will join the co-op if the cost i would experience as an independent fisherman, including transportation cost, exceeds the co-op's minimized average cost, or what i would incur by joining. Logically, if this condition is met for harvester i , it will also be satisfied for any harvester whose costs are higher, implying that the fishermen who choose to join the co-op have the highest cost parameters—the lowest skill.

We can characterize more precisely the factors determining the size of the co-op by breaking down costs into distance and skill components. If i joins the co-op, there will be a gain from eliminating the transport cost, \bar{d} , caused by the race to fish in the independent sector. There will also be a loss, however, because i will be joining and sharing costs with a relatively high cost (low skill) group. As co-op

27. To obtain a richer set of conclusions, we later allow differences in maximal effort.

28. The correct comparison is based on economic profit, which equals revenue minus the opportunity cost of effort. A component of the opportunity cost of effort is the alternative wage a harvester could earn if not fishing. For an individual who joins the co-op and earns a share of the co-op's profit but does not fish, the profit is just his or her share of the co-op's net revenue. If the same individual considered fishing independently, the correct profit to use in making a comparison is the revenue minus direct outlays, minus the wage he or she could have earned by working in an alternative occupation.

size gets larger, the cost difference becomes more dramatic because marginal joiners are increasingly efficient while the average skill among co-op members rises more slowly. The equilibrium number of joiners is determined where the transport cost savings from joining just equals the disadvantage in skill-related cost.

Figure 2 illustrates this logic. Harvesters are ordered from lowest to highest cost (parameter α_i) along the horizontal axis. The upward sloping curve shows the difference between average co-op cost and marginal cost in the independent fishery. If all fishermen's cost parameters were identical, this curve would coincide with the horizontal axis, in which case all harvesters will join the co-op. If cost parameters are diverse, so marginal and average costs diverge as the number of joiners grows, then the upward sloping curve in Figure 2 will intersect \bar{d} for $J < K$, determining J^* as shown. If the cost parameters are highly diverse, the curve will be steep and the equilibrium number of joiners will be small. Notice that the shaded area illustrates the independent sector's excess transport cost. This is not the only loss from independent fishing, however.

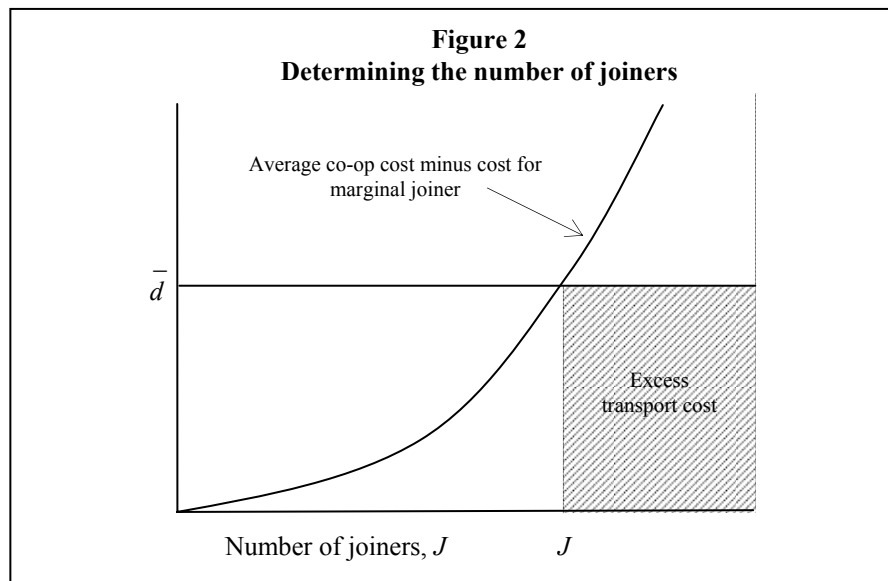
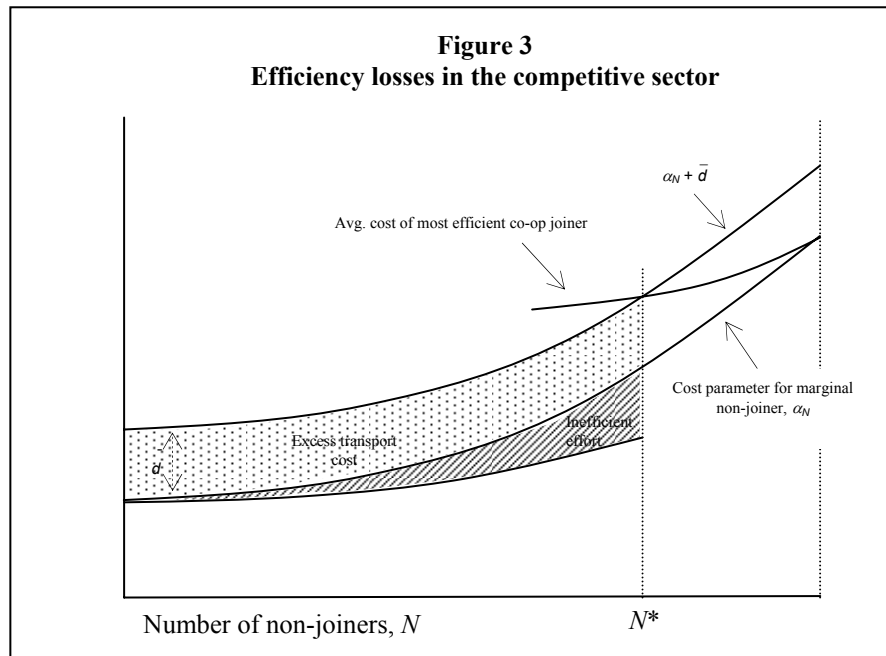


Figure 3 illustrates the rent losses in the independent sector more completely. The horizontal axis is reversed, so the number of non-joiners is read from left to right and the number of joiners in the opposite direction. The cost parameters for non-joiners increase as the number of non-joiners increases because the lowest cost firms are the last to join a co-op. Adding the non-joiners' transport cost to these cost parameters gives the cost of a marginal unit of effort in the independent sector. If only one firm joins the co-op, its cost per unit effort will approximately equal the cost of the highest cost non-joiner; for greater numbers of co-op members, average co-op cost falls in part because more efficient fishermen join and in part because the co-op assigns effort to its most efficient members. Thus, the average cost of effort for the co-op is below what average cost would be

if all members fished, but above the cost of the marginal (lowest cost) joiner. The number of non-joiners is determined by the intersection of the marginal cost of effort in the independent fishery and the average cost for the co-op. Transportation cost in the independent sector, the shaded area, is a waste. The loss in the independent sector due to having less efficient units participate (“inefficient effort allocation”) is shown by the lined area.



Notice that the welfare effect of limiting the outside distance could be ambiguous, depending on the limit imposed. Reducing the equilibrium travel cost would reduce the loss per unit effort for all effort deployed by the independent sector, which is beneficial. It would also make the independent sector attractive to some units that would otherwise join the co-op, however, causing N^* to increase. This is costly because it would increase the loss due to inefficient allocation. On net, total losses from competitive fishing could go up or down.

This conceptual model yields the following set of theoretical predictions:

- P1. The cooperative fleet will deploy only a subset of its capacity toward fishing; it is composed of only the most efficient fishermen of that group.
- P2. The cooperative fleet will spread harvest over a longer season than will the independent fleet, thus fishing at a slower rate.
- P3. The cooperative fleet will coordinate to harvest close to port—inside. The independent fleet will inefficiently race to an equilibrium in which all members fish far from port—outside.

P4. Product quality will be higher for fish harvested by the cooperative fleet than for those harvested by the independent fleet.

P5. The lowest cost—highest skill—fishermen will elect to remain in the independent fleet.

These predictions were all derived under the simplifying assumption that each fisherman embodied the same amount of maximal effort. Under that assumption, it is straightforward to show that all fishermen, whether in the cooperative or not, are not made worse off by having the choice of entering the co-op or the independent fleet than they were under the status quo. Whether this conclusion remains when maximal effort, E_i , can differ requires some additional analysis. Before turning to that question, however, we must determine how E_i affects the decision of which sector to enter. It turns out that a fisherman's choice whether to join the cooperative will depend on both maximal effort E_j and the efficiency of harvest (α_j). The profit comparison is now significantly more complicated because both revenues and costs are affected by a sector's membership. Higher E_i tends to favor the independent sector, so the independent fleet will consist of the high efficiency, high maximal effort individuals.

Now consider a fisherman k whose profit maximizing choice is to join the independent fleet. How will k 's profits compare to the profits k would have earned if the co-op were not allowed to form? To make the comparison concrete, let k be a high efficiency (low α_k), high effort (high E_k) fisherman, who thus finds the independent sector more attractive than the cooperative. Before the institutional change allowing the co-op, the entire fleet acted as if it was an independent sector. The payoff for fisherman k would have consisted of a revenue term and a cost term. The revenue term is simply the product of price, industry wide TAC, and the fisherman's effort share of total industry effort. The cost term must also account for the share of industry effort required to harvest the TAC.

Under the new institution, fisherman k selects into the independent fleet where the new revenues and costs are both affected by his effort embodiment, E_k . It turns out that whether fisherman k is financially better off or worse off under the new institution will depend on model parameters. But since both revenues and costs are affected by E_k , it is possible that an independent fisherman could be made worse off by the imposition of the new institution. This result is summarized as follows:

P6. If E_i can differ, it is possible that some fishermen who self-select into the independent fleet will be worse off under the new institution (a choice between cooperative and independent fleets) than under the status quo (where all fishermen are independent).

To summarize, our analysis predicts that the co-op will coordinate effort in order to concentrate effort among its most efficient members, harvest at the closest feasible distance to port, and fish the maximum amount of time the stock is available. In contrast, independent harvesters will tend to deploy effort at the maximum feasible rate until the independent fleet's TAC share is filled and will deploy effort farther from port. While not addressed in our model, a corollary of

the reasoning that leads to these results is that the co-op will share information on fish stocks among its members and, more generally, take actions that yield public good benefits for its members. In the next Part we assemble an empirical case study, based on a voluntary salmon fishing cooperative in Alaska, to test these predictions.

III. THE CHIGNIK SALMON COOPERATIVE

Prior to 2002, the sockeye salmon harvest in the Chignik region of Alaska on the southern side of the Alaska Peninsula was managed by a fishery-wide TAC.²⁹ Typically, about 100 purse seine permit holders had competed for harvest shares in any given year. (Purse seines are large fishing nets that drop vertically into the water, pulled downward by weights and held by floats at the water's surface. The bottom of the net is cinched around schools of fish to prevent them from escaping). In the late 1990s, some permit holders asked the Board of Fisheries to let the seiners form an annual cooperative. Their proposal stated: "The current fishing fleet is overcapitalized and the competitive harvest system does not allow for real improvements in produc[t] quality or flexibility in competing with farmed salmon."³⁰ The Board approved the request in 2002, and the majority of seine operators chose to join.³¹ Some who did not, however, challenged it in court. In early 2005 the Alaska Supreme Court shut down the co-op, ruling that it violated Alaska's limited entry law.³² This Part tests our theory against available data from the Chignik experiment, which provides useful information about how fishing cooperatives will behave and about who is likely to join. We conclude with a discussion of the court ruling.

A. Allocation of co-op effort

Seventy-seven of the 100 Chignik permit holders elected to join the co-op in 2002, the first year the regulation took effect.³³ Each co-op member was individually allocated a 0.9 percent share of the total sockeye TAC, bringing the co-op's collective share to 69.3 percent.³⁴ The remaining 30.7 percent was allocated to those permit holders who had not joined the co-op.³⁵ This allocation was in accordance with regulations requiring co-op allocations to be nine-tenths of one percent of the TAC per participant and presumably reflected the Board's

29. This Chignik fishery is one of Alaska's oldest commercial fisheries dating back to the 1880s. See *Grunert v. State*, 109 P.3d 924, 926 (Alaska 2005). For maps of the Chignik Management Area, see *infra* figs.A1 & A2.

30. *Grunert*, 109 P.3d at 927.

31. *Id.* at 928.

32. *Id.* at 926. A constrained version of the co-op was allowed to operate during 2005. The constraint required all co-op members to spend time at sea aboard fishing vessels. MARK A. STICHERT, ALASKA DEP'T OF GAME & FISH, 2005 CHIGNIK MANAGEMENT AREA ANNUAL MANAGEMENT REPORT, FISHERY MANAGEMENT REPORT No. 07-15, at 6 (2007), available at <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-15.pdf>. Our economic model implies that this requirement raised the co-op's costs and eliminated many of the advantages to joining.

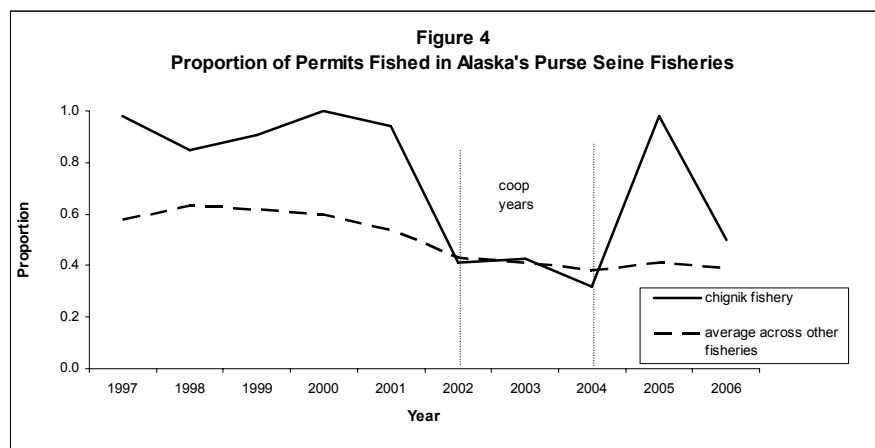
33. *Grunert*, 109 P.3d at 928.

34. *Id.* at 928.

35. *Id.*

anticipation of higher joining rates among fishermen with lower catch histories.³⁶ The co-op and the independent fleet mostly fished separate openings as determined by the Board of Fisheries.³⁷

Our theory predicts the co-op will deploy only its most efficient vessels and that each of these vessels will fish the entire length of the season. Figure 4 compares the annual proportion, for 1997 through 2006, of total permits actively fished at Chignik with the average proportion of permits actively fished in the five neighboring purse seine salmon fisheries.³⁸ These data are consistent with theoretical predictions 1 and 2. As Figure 4 indicates, the proportion of permits fished at Chignik dropped from 0.94 in 2001 to 0.41 in 2002. From 2004 to 2005, when the co-op was dissolved, the proportion of permits fished at Chignik increased from 0.32 up to 0.98. Moreover, the lower proportion of Chignik permits fished from 2002 through 2004 is statistically significant even when we control for annual TAC, general time trends, and fishery specific influences.



The co-op's decision to retire the majority of vessels in its fleet caused the decline in Chignik permits fished from 2002 through 2004. In 2002, for example, 22 co-op vessels fished on behalf of the co-op's 77 members.³⁹ The co-op paid salaries to the active fishermen and all members earned an equal share of

36. *Id.* at 927.

37. KENNETH A. BOUWENS & AARON POETTER, ALASKA DEP'T OF FISH & GAME, 2002 CHIGNIK MANAGEMENT AREA ANNUAL MANAGEMENT REPORT, FISHERY MANAGEMENT REPORT NO. 06-21, at 69 (2006), available at <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr06-21.pdf>.

38. See STATE OF ALASKA COMMERCIAL FISHERIES ENTRY COMM'N, PERMIT STATISTICS FOR ALASKA'S LIMITED ENTRY SALMON FISHERIES: 1997-2006, available at http://www.cfec.state.ak.us/research/salmon/salpmt97_06.pdf.

39. For data on the number of co-op members, see *infra* tbl.2. For information on the number of co-op members who fished, see GUNNAR KNAPP & LEXI HILL, EFFECTS OF THE CHIGNIK SALMON COOPERATIVE: WHAT THE PERMIT HOLDERS SAY, UA RES. SUMMARY NO. 1 (Inst. of Soc. and Econ. Res., U. Alaska Anchorage, Anchorage, Alaska), June 2003, at 1.

the total profits. In 2002, for example, the salary for active vessels was \$40,000 per boat and each of the 77 members received a shareholders payment of \$23,000.⁴⁰

Although exact data on the catch histories of co-op and independent vessels are unavailable, our analysis of the characteristics of co-op joiners shows that about twenty co-op vessels had marked equipment advantages over the remainder of the fleet.⁴¹ This number closely matches the number of co-op vessels actually deployed and thus provides at least circumstantial evidence supporting our prediction that the co-op will deploy its most efficient vessels.

B. Fishing distance from harbor

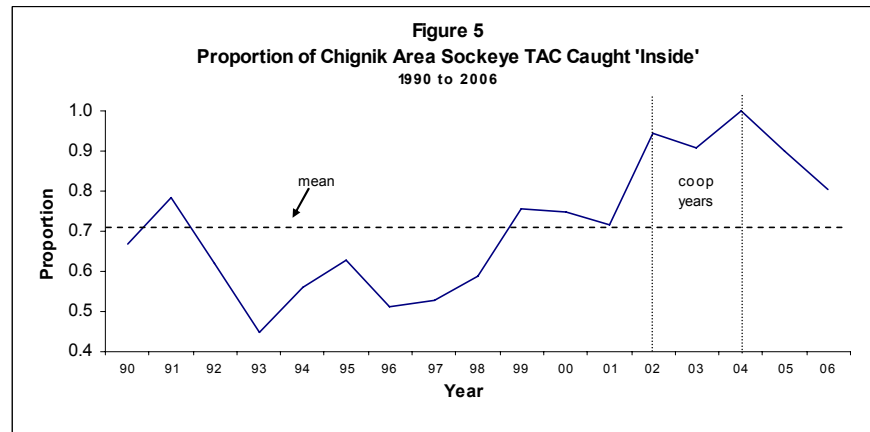
Our theory predicts the co-op will choose to fish at the smallest feasible distance from port (inside), while the independent fleet will fish outside. Data from annual management reports indicate how many fish were caught in each of the five statistical districts shown in Figure A2. All spawning sockeye migrate towards Chignik Bay district 271-10, which is shown in more detail by Figure A3. We therefore consider the Chignik Bay district inside. The remaining four areas are outside.

Figure 5 shows the annual proportion of sockeye caught inside the harbor from 1990 through 2006. Over this seventeen-year interval, the mean proportion of sockeye caught inside the harbor was only 0.71, with the proportion of catch during the co-op years ranging from 0.91 to 1.00. It is particularly striking that the proportion of inside catch increased from 0.72 to 0.95 from 2001 to 2002, when the co-op first began. Figure 5 also shows a decrease in the proportion of inside catch in 2005 and 2006 as cooperative fishing in Chignik ended.⁴²

40. See KNAPP & HILL, *supra* note 39, at 1. The co-op's decision to keep part of its fleet in port during the fishing season is similar to the decision of oil field operators to shut down oil wells following a shift from rule of capture exploitation to unitization. See generally Steven N. Wiggins & Gary D. Libecap, *Oil Field Unitization: Contractual Failure in the Presence of Imperfect Information*, 75 AM. ECON. REV. 368 (1985).

41. See *infra* tbl.2.

42. The data for fig.5 are calculated from MARK A. STICHERT, ALASKA DEP'T OF FISH & GAME, 2006 CHIGNIK AREA SALMON AND HERRING ANNUAL MANAGEMENT REPORT, FISHERY MANAGEMENT REPORT NO. 07-56 (2007), available at <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-56.pdf>.



How did the inside harvest of the co-op fleet compare with the inside harvest of the independent fleet during the co-op years? Table 1 shows comparisons for 2002 through 2004. Notice the co-op caught 100 percent of their sockeye within the inside district. In contrast, the proportion of the independent fleet's inside catch ranged from 0.79 to 1.00 depending on the year considered.⁴³ These results are consistent with theoretical prediction 3 regarding fishing location, but there are caveats to consider. Unlike co-op fishermen, independent fishermen may have allocated more effort towards harvesting salmon species other than sockeye.⁴⁴ This would bias independent fishing towards the outside if non-sockeye salmon do not as consistently migrate towards Chignik Bay. Yet, two other factors could actually bias independent fishing towards the inside. First, some tender operators were unwilling to send boats outside of Chignik Bay during the co-op years.⁴⁵ Second, independent openings were shorter than co-op openings. Independent openings usually ranged from one to three consecutive days, while co-op openings often exceeded seven consecutive days.⁴⁶ Thus, independent fishermen generally had less time to move vessels outside for fishing.

43. The independent fleet's proportion of inside catch was 1.00 in 2004, the year that co-op membership peaked at 87. *See infra* tbl.2.

44. Telephone Interview by Dominic Parker with Mark Stichert, Chignik Area Management Biologist, Alaska Commercial Fisheries Division (Nov. 16, 2007).

45. *See* KNAPP & HILL, *supra* note 39.

46. *See, e.g.*, BOUWENS & POETTER, *supra* note 37, at 6–7, 69.

Table 1		
Proportion of Sockeye Caught Inside by Co-op and Independent Fleets (on days reserved exclusively for one of the two fleets)		
	Cooperative fleet	Independent fleet
2002 ⁴⁷		
Number of sockeye harvested	576,757	162,979
Proportion of fish caught inside	1.00	0.82
2003 ⁴⁸		
Number of sockeye harvested	757,974	334,330
Proportion of fish caught inside	1.00	0.79
2004 ⁴⁹		
Number of sockeye harvested	541,400	61,446
Proportion of fish caught inside	1.00	1.00

C. Quality of fish and harvest costs

Our theory predicts the co-op will fish over a longer season than the independent fishery, which should improve product quality by slowing the rate at which fish are handled and processed. Figure 6 shows the sockeye season length for the Chignik fishery from 1990 through 2006. The average length over this 16-year period was 68 days compared to an average of 86 days during the co-op years.⁵⁰ Moreover, these stark differences in season lengths are not attributable to differences in annual sockeye harvests. Figure 7 shows the average sockeye catch per fishing day in the Chignik Area. The average for the entire 16-year period was 22,693 compared to an average of 10,992 during the co-op years. The catch per

47. *Id.* The data used to calculate the statistics shown in tbl.1 were acquired in two steps. First, we used pages 102–09 of the report to determine which days during the 2002 season were fished exclusively by the cooperative and independent fleets. Second, we used pages 42–44 of the report to determine the number of sockeye that were caught inside and outside on each day during the 2002 season.

48. GEORGE PAPPAS & KEVIN CLARK, ALASKA DEP'T OF FISH & GAME, CHIGNIK MANAGEMENT AREA COMMERCIAL SALMON FISHERY, STOCK STATUS, AND PURSE SEINE COOPERATIVE FISHERY REPORT 56–63 (2003), available at http://www.cf.adfg.state.ak.us/region4/pubs/2003/nov_bof/4k03-54.pdf. The data used to calculate the statistics shown in tbl.1. come from pages 56–63 of the report.

49. KENNETH A. BOUWENS & MARK. A. STICHERT, ALASKA DEP'T OF FISH & GAME, 2004 CHIGNIK MANAGEMENT AREA ANNUAL MANAGEMENT REPORT, FISHERY MANAGEMENT REPORT NO. 06-69, at (2006), available at <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr06-69.pdf>. The data used to calculate the statistics shown in tbl.1 were acquired in two steps. First, we used pages 128–33 of the report to determine which days during the 2004 season were fished exclusively by the cooperative and independent fleets. Second, we used pages 39–40 of the report to determine the number of sockeye that were caught inside and outside on each day during the 2004 season.

50. The data summarized in fig.6, and used to calculate the statistics in fig.7, come from several sources. PAPPAS & CLARK, *supra* note 48, at 81 (1990–2003 data); BOUWENS & STICHERT, *supra* note 49, at 39–40 (2004 data); STICHERT, *supra* note 32, at 43–44 (2005 data); STICHERT *supra* note 42, at 34–35 (2006 data).

fishing day dropped dramatically from 26,993 in 2001 to 11,673 when the co-op was formed in 2002.⁵¹

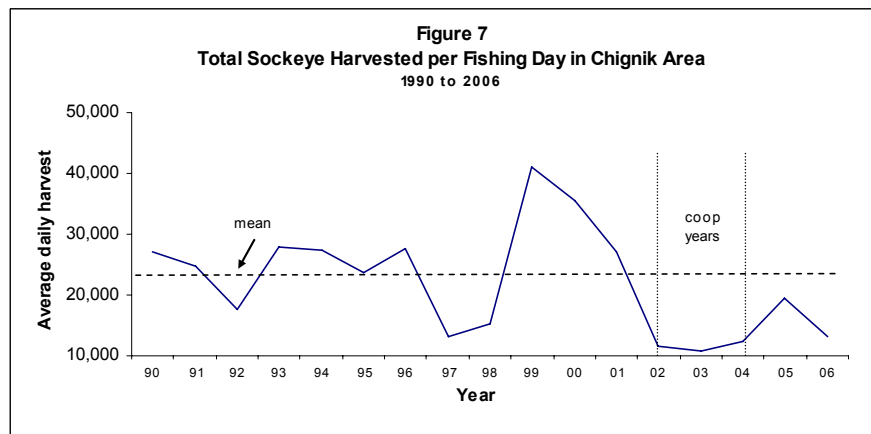
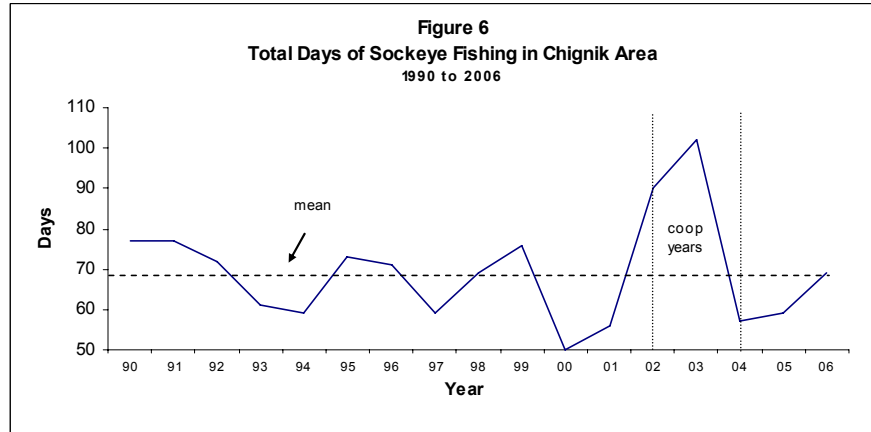


Table 2 compares season lengths and average catches per day for the cooperative and independent fleets during 2002 through 2004. The most striking evidence that the co-op slowed the rate of catch is seen in the average catch per day statistics. Here, we see the co-op's average catch per day was typically less than that of the independent fleet despite the fact that co-op membership greatly exceeded the number of independent fishermen. The co-op was able to enhance harvest efficiency by installing fixed leads, stationary nets along the major migration route that concentrated the fish. To improve product quality, the co-op received permits to hold live fish in net pens for up to three days to better match deliveries to processing capacity.⁵² The co-op on occasion even released live fish from capture when processing capacity was insufficient.⁵³

51. See *supra* note 50.

52. STICHERT, *supra* note 32, at 4.

53. See PAPPAS & CLARK, *supra* note 48, at 13.

	Cooperative fleet	Independent fleet
2002 ⁵⁴		
Number of members	77	22
Length of fishing season (days)	78	30
Average sockeye caught per day	9,274	10,667
2003 ⁵⁵		
Number of members	77	24
Length of fishing season (days)	89	37
Average sockeye caught per day	8,517	9,036
2004 ⁵⁶		
Number of members	87	13
Length of fishing season (days)	51	8
Average sockeye caught per day	11,868	11,681

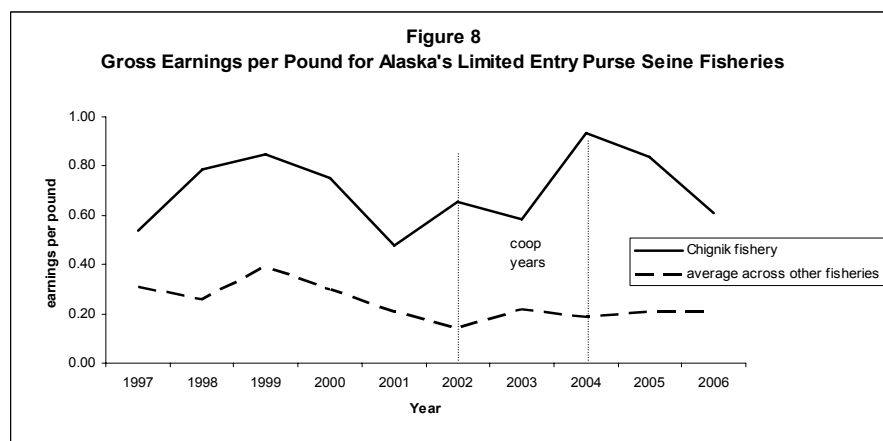
The co-op appears to have slowed harvest rates and to have increased the quality of harvested fish, but it is more difficult to statistically determine the effect the co-op had on salmon prices. Figure 8 compares gross earnings per pound of salmon caught at Chignik against the average gross earnings per pound for the other fisheries.⁵⁷ Chignik salmon prices increased during the co-op years, and there is some visual evidence that this increase was not part of a broader time trend. This evidence is loosely consistent with the fourth prediction. Note that salmon prices in the other fisheries were mostly stable during the cooperative years.

54. BOUWENS & STICHERT, *supra* note 49, at 19 (data on number of members); BOUWENS & POETTER, *supra* note 37, at 102–09 (data on number of days fished and the number of sockeye harvested by each fleet).

55. BOUWENS & STICHERT, *supra* note 49, at 19 (data on number of members); PAPPAS & CLARK, *supra* note 48, at 56–63 (data on number of days fished and the number of sockeye harvested by each fleet).

56. BOUWENS & STICHERT, *supra* note 49, at 19, 128–33 (data on number of members and data on the number of days fished and the number of sockeye harvested by each fleet).

57. See STATE OF ALASKA COMMERCIAL FISHERIES ENTRY COMM'N, *supra* note 38. We interpret gross earnings per pound to be the average unit price.



Other outcomes, such as the co-op's effect on bottom-line profits, are difficult to assess with numerical data. To get at this and related questions, Knapp et al. conducted an extensive survey of joiners and non-joiners to assess their opinions about changes in the Chignik fishery.⁵⁸ Results from the survey indicate that a strong majority of co-op members believed they were better off financially because they had joined.⁵⁹ In addition, 100 percent of the co-op members who fished thought the quality of fish improved because of how the cooperative paced their fishing effort;⁶⁰ again, this result is consistent with the fourth theoretical prediction.

D. Characteristics of joiners and non-joiners

Our theory of co-op formation implies that most skilled fishermen will remain fishing competitively. The ideal way to test this prediction is with data of catch histories for each individual joiner and non-joiner prior to 2002. With these data, one could estimate the probability of an individual joining as a function of his historical performance in the independent fishery. Unfortunately, catch histories for individuals are not publicly available.

In lieu of the ideal data, we use published data from Schelle et al. to relate harvest levels prior to 2002 to the decision to join the co-op.⁶¹ Figure 9 shows how many co-op joiners and non-joiners came from each sockeye harvest decile during the 1999 to 2001 competitive period. The first points on the graph, for example, indicate that 25.4 percent of the set of non-joiners averaged catches that were in the top harvest decile during 1999 to 2001 compared to only 5.8 percent of the set of joiners. In general, the graph shows that a higher percentage of non-joiners

58. GUNNAR KNAPP ET AL., EFFECTS OF THE 2002 CHIGNIK SALMON COOPERATIVE: A SURVEY OF CHIGNIK SALMON PERMIT HOLDERS (2002), available at <http://www.iser.uaa.alaska.edu/Publications/ISERChignikSurveyReportpt1.pdf>.

59. *Id.* at 17.

60. *Id.* at 35.

61. KURT SCHELLE ET AL., ALASKA BD. OF FISHERIES, CHIGNIK SALMON PURSE SEINE FISHERY: SUMMARY DATA ON ISSUES RELATED TO THE 2002 COOPERATIVE FISHERY 5-23 (2002), available at http://www.cfec.state.ak.us/research/02_6n/chigcoop.pdf.

performed in the top three deciles from 1999 to 2001, while a higher percentage of joiners performed in the lowest three deciles over that period. Figure 9 appears consistent with the theoretical model if we assume that high levels of prior harvest correlates positively with high fishing ability.⁶²

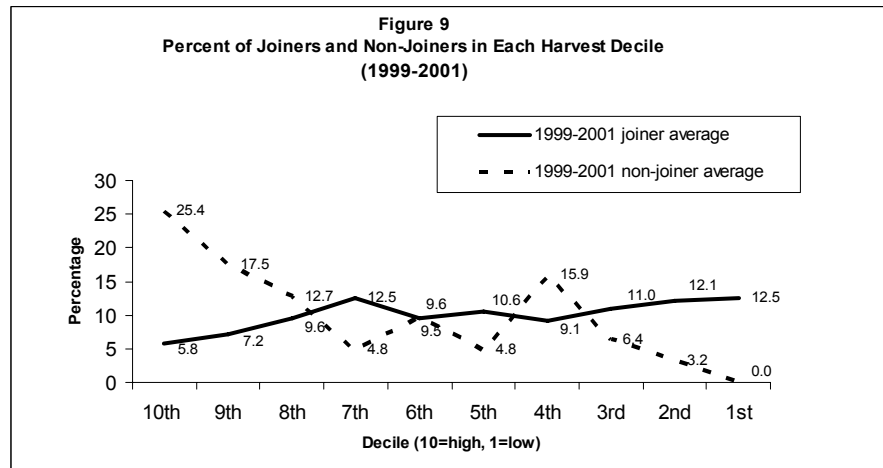


Table 3 compares other characteristics of co-op joiners with those of non-joiners. As the table indicates, a larger proportion of joiners were non-locals (permit holders with home addresses outside the Chignik area). If we assume that non-locals faced higher fishing costs, then the finding that non-locals were more likely to join the co-op is consistent with the theoretical model. The assumption that non-locals have higher costs seems appropriate because non-locals must travel to fish at Chignik, and they may forgo economic opportunities in their home area.

62. Moreover, our theory suggests that those joiners who did come from the top harvest deciles were the ones who actively fished on behalf of the co-op for the annual salary, but we lack the data needed to confirm this prediction.

	Mean			Median		Standard Deviation		
	Joiners (obs)	Non- Joiners (obs)	t-stat for diff	Joiners (obs)	Non- Joiners (obs)	Joiners (obs)	Non- Joiners (obs)	F-stat for variance ratio test ^b
Local permit holder = 1 if local, 0 otherwise	0.41 (78)	0.74 (23)	2.87*	-----	-----	-----	-----	-----
Year of vessel ^a	1983 (75)	1982 (22)	1.05	1981 (75)	1981 (22)	6.12 (75)	6.02 (22)	1.04
Vessel length (feet)	46.4 (76)	46.3 (22)	0.22	46.5 (76)	47.0 (22)	6.44 (76)	6.37 (22)	1.02
Vessel horsepower	779 (72)	531 (21)	1.58	381 (72)	425 (21)	701 (72)	303 (21)	5.36*

Notes: (*) differences are statistically significant at a 0.05 level; (a) all tests are parametric in that normality is assumed; (b) under the null hypothesis, the ratio of the variance (the F-stat) of joiners to non-joiners is one.

Table 3 also compares the mean, median, and standard deviations of selected characteristics of vessels owned by joiners and non-joiners. Most noteworthy, the mean vessel horsepower is significantly *higher* among the group of joiners. This result seems to be inconsistent with the theoretical model if horsepower correlates positively with fishing ability. Yet, several comments are in order. First, the mean horsepower of vessels is sensitive to outliers. Notice that median horsepower was actually *higher* for non-joiners than for joiners.⁶³ Second, the variation in horsepower is higher among joiners than it is among non-joiners. Owners of the twenty boats with the greatest horsepower all joined the co-op, while owners of seventeen of the twenty boats with the lowest horsepower also joined. Recalling the co-op hired about twenty boats to fish on behalf of all members, these results may indicate that highliners joined the co-op to earn the annual salary. The empirical evidence on the fifth prediction is therefore mixed. An extension of our theoretical model that recognizes the co-op's ability to make side payments (e.g., pay salaries) to attract highliners is something we intend to explore. That setup would more closely match the design of the Chignik cooperative, and we conjecture that it would give rise to a theoretical prediction that is better supported by the empirical evidence.

63. Non-parametric tests, such as those comparing rank and order statistics across groups, do not show significant differences in median horsepower across joiners and non-joiners.

E. Alaska Supreme Court case and the co-op controversy

Our final prediction (P6) was that if certain fishermen embodied more effort than others, they could be made worse off under the new co-op institution. In such cases, one might expect those fishermen to oppose the adoption of the new institution. We argued that the characteristics of those most likely to fall into this category were fishermen with high effort and high efficiency. The evidence in Chignik is the filing, and eventual success, of a legal claim opposing the new institution.

Michael Grunert and Dean Anderson, apparently two of the higher-effort and higher-earning Chignik fishermen, opted into the independent fleet and filed a court complaint against the state challenging the validity of the new management regime.⁶⁴ The plaintiffs initially lost the case but appealed the ruling, arguing, among other things, that the Board of Fisheries exceeded its statutory mandate in promulgating the co-op for the purpose of increased economic efficiency.⁶⁵ The Alaska Supreme Court disagreed with Grunert's contention stating in its majority opinion:

The board urges . . . that increased economic efficiency in fishing serves a development purpose. It contends that if participation in a fishery becomes cost-prohibitive, the fishery will no longer be viable and fishery resources will not be developed at all. To the extent increased economic efficiency is necessary to the utilization and survival of the Chignik fishery, we agree that the co-op regulation pursues a permissible objective.⁶⁶

The Alaska Supreme Court, however, did agree with Grunert's contention that the co-op regulation contradicts the intended purposes of the state's Limited Entry Act of 1973⁶⁷ because the Act requires "present active participation" of permit holders.⁶⁸ Under the Limited Entry Act, the Commercial Fisheries Entry Commission ("CFEC") determines who is eligible to take fish.⁶⁹ The CFEC is authorized by statute to accept applications from only those persons "who have harvested fishery resources commercially while participating in the fishery as holders of gear licenses."⁷⁰

The majority opinion cites an earlier Alaska case, *Johns v. Commercial Fisheries Entry Commission*,⁷¹ as support for the proposition that, under the Limited Entry Act, a "person" cannot be defined as a corporation, partnership, firm, association, organization, or any other legal entity other than a natural person.⁷² This provision reinforces the court's earlier interpretation from *Johns* that

64. Grunert v. State, 109 P.3d 924, 928 (Alaska 2005).

65. *Id.* at 928–30.

66. *Id.* at 930.

67. ALASKA STAT. §§ 16.43.010–.990 (1973).

68. Grunert, 109 P.3d at 934–35.

69. ALASKA STAT. § 16.43.260.

70. *Id.*

71. 758 P.2d 1256 (Alaska 1988).

72. Grunert, 109 P.3d at 934–35.

the legislature intended the number of permits issued to reflect the number of permits actually fished. The court continued by arguing:

The working assumption since Alaska became a state has been that individuals operate Alaska's commercial salmon fisheries. The co-op regulation in contrast transforms the limited entry permit from what used to be a personal gear license into a mere ownership share in a cooperative organization. . . . Before this regulatory scheme accomplishes such radical departure from the historical model of limited entry fisheries in Alaska and the spirit of the Limited Entry Act, however, we conclude that the legislature must first authorize the board to approve cooperative salmon fisheries.⁷³

The court's decision is clear. Legislative action explicitly allowing fishing cooperatives is necessary if operations like the Chignik Salmon Cooperative are to be allowed in Alaska. And if the CFEC wants to re-implement the co-op regime at Chignik, it must first convince the state legislature to relax the "present active participation" requirement by amending the Limited Entry Act.

What is less clear—at least through the lens of our theoretical model—is why the Chignik co-op was so controversial. One element of controversy was whether the allocation between the co-op and independent fleets was fair and another concerned exclusive agreements between the co-op and the tendering and processing operations at Chignik. Because of these and related reasons, the Knapp et al. survey indicates that 83 percent of independent fisherman respondents had mixed or negative feelings about the co-op generally.⁷⁴ And additional groups in the Chignik area may have also felt negatively affected, including Chignik salmon processors and tender operators who were unable to do business with the co-op and Chignik-area residents who may otherwise have been hired as crew by retired co-op boats.⁷⁵

In summary, the bulk of the evidence from the Chignik experiment is consistent with our economic theory of fishing cooperatives. Fewer boats were deployed at Chignik during the co-op years, fishing seasons were significantly longer, and co-op members spent all of their effort fishing "inside" the bay. These changes in behavior presumably lowered harvest costs as our model suggests. In addition, there are indications that Chignik sockeye prices rose in response to the co-op's success in increasing the quality of fish sold to consumers. The available evidence is also roughly consistent with the model's prediction that the most skilled fishermen will refrain from joining a voluntary co-op. However, other differences among fishermen, besides their relative fishing skill, probably also help to explain who chose to join the Chignik co-op.

CONCLUSION

The economic payoff from harvesting a marginal unit from a stock of fish can vary widely over time and space, even if the stock itself is biologically homogeneous. Fishermen have an incentive to apply effort at the most

73. *Id.* at 936.

74. KNAPP ET AL., *supra* note 58, at 23.

75. KNAPP & HILL, *supra* note 40, at 3–4.

advantageous time and place, and they know that the stock will be relatively dense and harvest costs relatively low if they contact the stock before other harvesters do. This force can effectively create a race for harvest, pulling harvesters away from the economically “best” time and place and eliminating part of the economic rent the resource would otherwise generate. Limiting licenses and closing the fishery once the TAC is reached will not end this rent dissipation, as is well known. An ITQ policy, though clearly superior to licenses and season closures, may not end the rent dissipation either because it fails to assign rights to harvest fish at precise times and places. The individual quota holder therefore has an incentive to deploy gear at a time and place that gives an advantage over other quota holders in the competition to capture the best fish.

Our analysis demonstrates that these losses from incomplete assignment of property rights can be substantially diminished by allowing fishermen to form a private harvesting association, effectively ceding to the association the right to direct their effort in a coordinated way. We focused on a cooperative association that shares profits because the case we studied empirically has this feature, making data readily available, but other organizational forms clearly are possible. More importantly, perhaps, voluntary associations are of interest because any attempt to force individual fishermen to deploy gear at specific times and places, under the direction of government, would surely be fought politically or in the courts, with even more fire than was launched at the Chignik co-op.

Fortunately, it appears that significant gains can be achieved without the use of force. In the Chignik case the co-op achieved a remarkable degree of efficiency in harvesting its assigned share of the TAC. The evidence reviewed indicates that the co-op allocated effort efficiently among its members, improved the spatial allocation of effort, and stretched fishing over a longer time horizon than with competitive fishing, thereby improving the value of the final product.⁷⁶

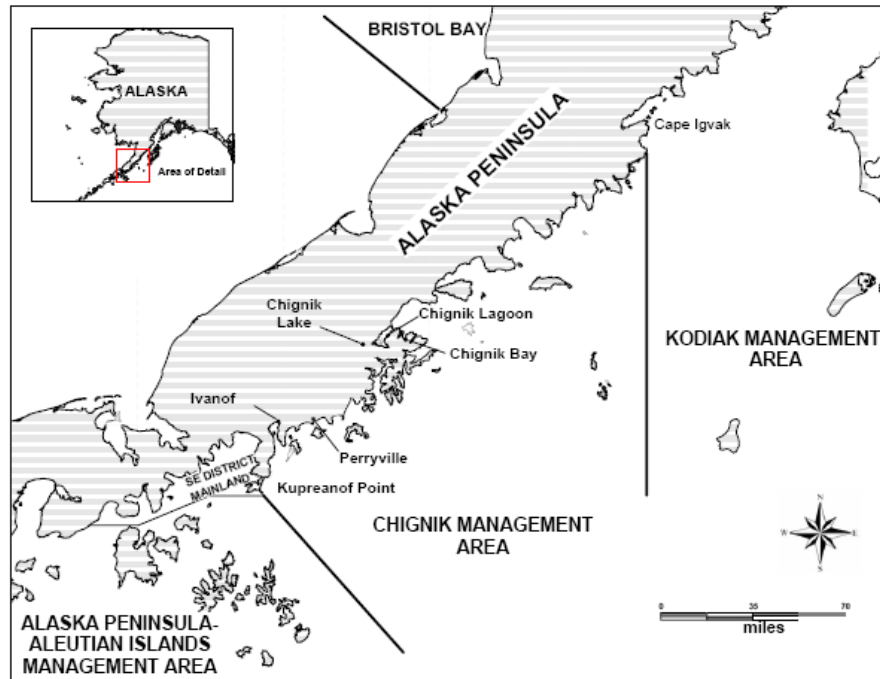
Our model indicates that the success of allowing voluntary co-ops to form is directly related to the proportion of the fleet that joins, which in turn is directly related to the degree of homogeneity in the skills of the harvesters. In the Chignik case roughly three-fourths of the permit holders joined the co-op; those not joining appeared to be high efficiency harvesters who were deterred by the prospect of sharing profits with less efficient members. Another possibility, one we have not explored in detail, is that even greater gains might be attainable by allowing more than one voluntary co-op to form. Our analysis indicates that the key to expanding membership in voluntary co-ops is to make their membership more homogeneous. Greater homogeneity might be accomplished by specifying that all members joining a particular coop meet a minimum efficiency requirement, e.g., in terms of their historic catch per season. Arguably, this possibility deserves further study.

Useful lessons for policy design may be gleaned from the Chignik experience. Our analysis and the eventual fate of the co-op demonstrate that the ultimate success of this approach can hinge on the assignment of TAC shares to the co-op versus the independent fleet. Evidently, some harvesters in the independent fleet believed their fortunes were negatively impacted by the ADFG’s

76. The evidence on improved value is not entirely robust, however.

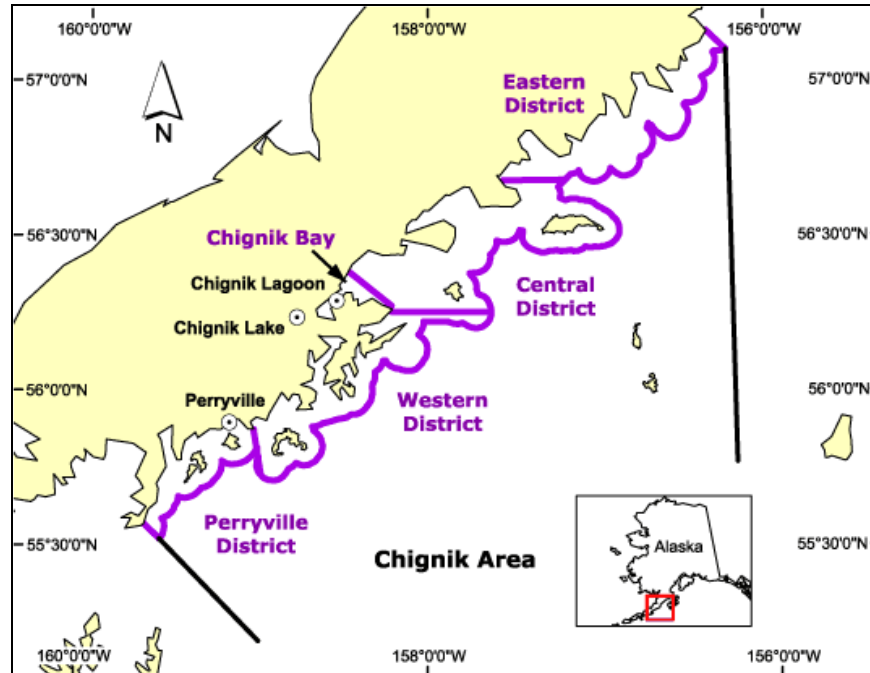
allocation, despite the fact that competition for the stock the independent fleet was assigned was substantially reduced. Because the co-op demonstrably improved efficiency, it seems clear that a different assignment of TAC shares could have produced an outcome favorable to both groups. A second lesson is that policies that are sensible in isolation may interact to produce an undesired result if imposed jointly. A restriction preventing fishermen from traveling long distances in order to encounter unexploited stocks may well improve efficiency if no harvesting association exists and management involves only a license requirement and season closure. Imposing such a restriction could be perverse, however, if harvesters have the option of joining a voluntary co-op that allocates effort efficiently. In this case, improving efficiency in the independent sector would undermine the incentive to join the co-op, thereby reducing its membership and diminishing the gains from coordinating effort. Finally, policies that encourage harvesters to coordinate effort can gain by providing public goods that benefit the entire group. Experience from CSO operations in New Zealand indicates that harvester co-ops can reap gains by cooperating on enforcing size limits, enhancing habitat and sharing information. In the Chignik case, the co-op achieved public good benefits by sharing information on the location of fish stocks and by installing fixed leads to concentrate fish for easier harvesting.

Figure A1⁷⁷
Map of Chignik Management Area on the Alaskan Peninsula



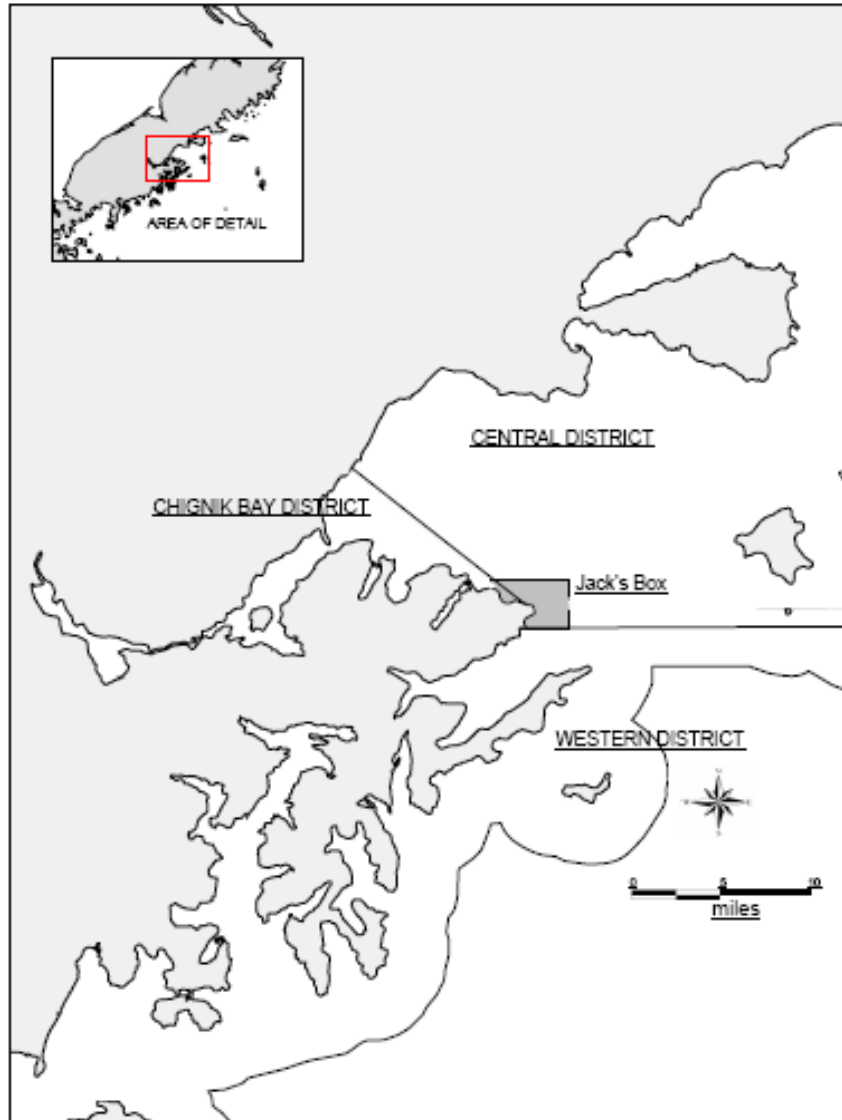
77. MARK A. STICHERT, ALASKA DEP'T OF GAME & FISH, 2007 CHIGNIK MANAGEMENT AREA COMMERCIAL SALMON FISHERY HARVEST STRATEGY, FISHERY MANAGEMENT REPORT No. 07-23, at 11 (2007), available at <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-23.pdf>.

Figure A2⁷⁸
Map of Chignik Management Area with District Boundaries



78. Div. of Commercial Fisheries, Alaska Dep't of Fish & Game, Salmon District Map, http://www.cf.adfg.state.ak.us/region4/finfish/salmon/maps/chig_all.php (last updated: Feb. 3, 2006).

Figure A3⁷⁹
Map of Chignik Bay and Near Vicinities



79. *Id.* at 15.