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

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I. INTRODUCTION

Under traditional fisheries management, fishermen race to catch as much of the total allowable catch (TAC) as possible before the season is closed. The 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 for 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 securitized, their owners have incentives for stewardship and cost reduction, neither of which exists in the traditional “race-to-fish”. The most widespread, and

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widely heralded version of rights, is the “individual transferable quota” (ITQ), which grants the individual owner a secure right to a portion of each season’s TAC. Efficiency gains from ending the race to fish can also be achieved by assigning harvest rights to firms or to harvester cooperatives, however, and this option can yield additional benefits by facilitating the coordination of fishing effort.

In this paper we highlight the potential efficiency gains from coordinating fishing effort. Forming an association of harvesters whose members agree to have a central manager coordinate their effort in return for a suitable quid pro quo is one option for realizing these efficiency gains. In what follows we focus on one particular type of association, a profit-sharing fishery cooperative. The most obvious source of efficiency is ending the race to fish induced by the TAC and season closure form of regulation. Additional gains from coordination may be forthcoming, however, and these 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 stock that is biologically homogeneous, different portions may be heterogeneous in economic value due to their locations or times of availability. This can induce a race to catch the most profitable fish even if the right to harvest a specific portion of the TAC is secure. Additionally, fishermen generally devote costly effort to search because stock locations are not observed. When searching, the fisherman cannot easily know which locations have already been searched or what was found, so some search effort will generally be redundant. These two sources of waste can be eliminated by coordinating effort across harvesters.

While our focus is on efficiency, harvesting cooperatives may also have 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. If the only assignment of rights is to a voluntary co-op, however, these traditional “highliners” might reason that they can avoid losses by choosing not to join. Also, the ability to opt out may defuse arguments by any who would claim that their traditional right to fish is being

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3 Scott, supra note 2; Costello and Deacon, supra note 2. This is not the only way to achieve efficiency gains, however. Costello and Deacon, supra note 2, note that these inefficiencies could be eliminated if ITQs were defined more completely over time and space.
usurped—as they might well claim with an ITQ system. Further, it may be easier to negotiate a single TAC division to a co-op than a detailed assignment of quotas to scores of individual harvesters.4

The fishery we examine empirically was originally managed with 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. 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.5 These and similar insights are in agreement with conclusions from a small but growing literature on the economics of fishery cooperatives.6

We make three contributions to this literature. First, we examine how the characteristics of permit holders who voluntarily join cooperatives will differ from the characteristics of those refusing 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 will

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4 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 and Fred Inaba, Fishery Cooperatives as an Alternative to ITQs: Implications of the American Fisheries Act, MARINE RESOURCE ECONOMICS (16), 1-16 (2001).

5 These basic tradeoffs resemble those articulated by Coase (Ronald Coase, The Nature of the Firm, ECONOMICA 4(3), 386-405 (1937)) in his analysis of the costs and benefits of using firms to organize production (instead of individual contractors). 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 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 (1937) classic discussion of these points.

change 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 the cooperative ventures are likely to generate the largest efficiency gains relative to independent fishing regimes. In addition, we examine whether or not 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 section presents a brief literature review. Section 3 presents our theory of cooperative formation within a fishery having heterogeneous economic value. We use game theoretic arguments to characterize which permit holders will choose to join a co-op and, given this decision, how they will subsequently choose to deploy effort. In section 4 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. The Chignik cooperative is an ideal empirical case study because the economic value of salmon varies considerably across time and space as the fish migrate towards their home stream to spawn. The Chignik cooperative is also interesting because a subset of non-joiners filed the lawsuit ending the cooperative. In light of this, part of our analysis is directed toward uncovering the features of a voluntary co-op that may cause some fishermen to lose, even if membership is voluntary. Finally, in section 5 we highlight lessons for policymakers wanting to encourage fishing cooperatives.

II. The Literature on Fishing Cooperatives

There is now 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 can coordinate the activities of individual members. Scott relies on this basic reasoning in arguing that fishery governance by harvester-based organizations are a logical next step (beyond ITQ regulation) in the development of fishery management. He attributes these coordination benefits to the public good aspects of regulatory enforcement, the collective benefit of sharing information on fish stocks and the fact that a wasteful race to catch the ‘best’ fish may persist even under an ITQ regime. Townsend sees the move to self-governance arising from recognition that government-centered regulation has failed and that the resulting antagonism

9 Anthony Scott, Obstacles to Fisheries Self Government, MARINE RESOURCE ECONOMICS 8, 187-199 (1993); Scott, supra note 2.
between harvesters and regulators has been destructive. 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 makes a tighter link between initial sacrifices and future rewards. Leal describes the advantages of private harvesting agreements versus traditional government regulation as arising from reduced transactions cost, better monitoring incentives and a reduced role for regulatory oversight.

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 US. Kitts and Edwards describe how recent regulatory changes have affected the viability of harvester cooperatives, summarize the history of relevant regulation and anti-trust policy toward co-ops and describe recent experience in the US.

The commercial stakeholder organization (CSO) is a specific form of private harvester agreement now common in New Zealand. 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. 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. This CSO shares information on stock

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13 Kitts and Edwards, supra note 8. Sullivan (J. M Sullivan, Harvesting Cooperatives and US Antitrust Law: Recent Developments and Implications, at: http://oregonstate.edu/Dept/IIFET/2000/papers/sullivan.pdf (2000)) discusses transaction cost and enforcement advantages that harvester cooperatives may have over ITQ policies, but concludes that harvester coops may be less durable than ITQ systems since they exist at the pleasure of their members.
locations, provides enforcement of size limits, funds stock enhancement and allocates effort across space to avoid competition for heterogeneous stocks.

A number of theoretical questions remain to be addressed. How do such harvester agreements form? How is their behavior shaped by their institutional structure? What are their efficiency advantages, if any, and what factors determine the likely magnitudes of such gains? How do members sort themselves into voluntary cooperatives, where profits are shared and membership is not compulsory? In the next section we develop a model that helps answer these questions.

III. 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. Our focus is 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 or not the TAC is optimal. We further assume the price per fish is fixed.

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 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 costs for travel and search. Costs also depend 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 effort is specified to be $\alpha_i + d_i$, where the parameter $\alpha_i$ 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 distance zone.17

When a unit of effort is applied it catches a fixed fraction of the stock. The catch resulting from a unit of effort is therefore proportional to the stock not

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17 This implies that the fish stock resides in a zone for the duration of any individual’s harvest.
already caught by others. An individual who encounters the stock before others have exploited it by fishing at an advantageous time or location obtains a commensurately larger catch. A common regulatory regime involves opening the season and allowing licensed harvesters to fish as they wish until the TAC is filled, at which time the fishery is closed. The resulting incentive induces the familiar race to fish and the rent dissipation that accompanies it is well known. 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.18

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.19 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 this, each member will prefer a policy that maximizes total coop profit. Co-op revenue

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18 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 and Costello, supra note 15. We assume that the number of fishing permits issued is more than sufficient to harvest the entire TAC, if all harvesters apply maximal effort.

19 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.
equals the exogenous price times the TAC the regulator assigns to the co-op.\textsuperscript{20} Co-op revenue is consequently determined by factors exogenous to the members’ decisions and the optimal policy is therefore 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.

\textbf{B. Behavior in the independent sector}

To build intuition consider the case in which fishing can take place at only two distances, 0 and \( d \). 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 \( \theta \) 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 \( S \theta \), the second unit catches the same fraction of the stock that escaped the first unit of effort, \( S(1 - \theta) \), 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 \( d \), so each incurs a transportation cost of \( d \). 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 \( d \), 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

\textsuperscript{20} Later we consider the implications of allowing price to depend on harvesters’ actions to the extent that those actions affect the quality of harvested fish.
is sufficiently large and/or the outside distance is sufficiently small.\textsuperscript{21} The same condition implies that individuals have no incentive to fish at any distance closer to port than $\overline{d}$; this is true 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, $\overline{d}$; 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.\textsuperscript{22}

This setup gives rise to the following result: All independent fishermen electing to fish outside (at the maximum distance $\overline{d}$) 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 $\overline{d}$, 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 on 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 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.

\textbf{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 $N\overline{d}$, where $N$ is the number of non-joiners. Second, the co-op deploys only its most efficient units while all non-joiners deploy maximal effort until the season closes. Unless all non-joiners have identical cost parameters, this results in inefficiency and, loosely speaking, the degree of inefficiency is greater the more diverse are the non-joiners’ cost parameters. Finally, the co-op fishes over a longer season than the independent fishery. Because product quality generally declines when fishing and

\textsuperscript{21} The comparison also depends on $\theta$, the TAC and the stock size.

\textsuperscript{22} 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.
handling of the catch are rushed, the per unit value of the independent group’s catch will be lower than the co-op’s which is an additional source of inefficiency.

D. Who will join?

The decision faced by each fisherman is 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. The logical criterion for joining is that a fisherman would gain greater profit in the co-op than in the independent fishery. 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, which is 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. This implies that the fishermen who choose to join the co-op have the highest cost parameters (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 be also be a loss, however, because $i$ will be joining and sharing costs with a relatively high cost (low skill) group. As co-op 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 $\alpha$) 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

\[ \text{To obtain a richer set of conclusions, we later allow differences in maximal effort.} \]
cost to these cost parameters gives the cost of a marginal unit of effort in the independent sector. If only 1 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 \( \lambda^* \) 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 has yielded 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.

P.5 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 answering that question, we must determine how one’s \( E_i \) affects the decision of which sector to enter. It turns out that a fisherman’s choice of whether to join the cooperative will depend on both maximal effort \( E_i \) and the efficiency of harvest (\( \alpha_j \)). 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 $k$ who finds that he will maximize profits by joining the independent fleet. How will $k$’s profits compare to his profits before the institutional change that permits a co-op to form? To make the comparison concrete, let $k$ be a high efficiency (low $\alpha_k$), 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:

P1. If the $E_i$ 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).

In the next section we assemble an empirical case study, based on a voluntary salmon fishing cooperative in Alaska, to test these predictions.

IV. 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. Typically, about 100 purse seiners had competed for harvest shares in any given year. 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 independent harvest system does not allow for real improvements in product quality or flexibility in competing with farmed salmon”\(^\text{25}\). The Board approved the request in 2002, and the majority of seine operators chose to join. 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

\(^{24}\) This Chignik fishery is one of Alaska’s oldest commercial fisheries dating back to the 1880s. Maps of the Chignik Management Area are provided in an appendix.

\(^{25}\) Grunert v. State, supra note 7, at 927
Alaska’s limited entry law. This section tests our theory against available data from the Chignik experiment.

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. 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. The remaining 30.7 percent was allocated to those permit holders who had not joined the co-op. 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 anticipation of higher joining rates among fishermen with lower catch histories. The co-op and the independent fleet fished separate openings as determined by the Board of Fisheries.

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. 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 2002 through 2004 decline in Chignik permits fished was caused by the co-op’s decision to retire the majority of vessels in its fleet. Per the terms of the co-op’s annual agreements, typically 20 vessels fished each year on behalf of the 77 to 87 co-op members. The co-op paid salaries to the active fishermen and all members earned an equal share of 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.

See Grunert v. State, supra note 7. A constrained version of the co-op was allowed to operate during 2005. The constraint was that all co-op members were required to spend time at sea aboard fishing vessels. This requirement raised the co-op’s costs and eliminated many of the advantages to joining.


28 Knapp and Hill, supra note 8. 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 Gary L. Libecap and S. N. Wiggins, Oil Field Unitization: Contractual Failure in the Presence of Imperfect Information, with S. N. Wiggins, AMERICAN ECONOMIC REVIEW, Vol. 75, No. 3 (June 1985).
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 20 co-op vessels had marked equipment advantages over the remainder of the fleet (see below). 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 mid-season 2007. Over this 18-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 from 2005 to 2007 as cooperative fishing in Chignik ended.

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. These results are consistent with theoretical prediction 3 regarding fishing location, but there are caveats to consider. Unlike co-op fishermen, independent fishermen also held permits to harvest salmon species that were not sockeye. This fact could 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. Second, independent openings were shorter than co-op openings. Independent openings usually ranged from 1 to 3 consecutive days, while co-op openings often exceeded 7 consecutive days. Thus, there was generally less time for independent fishermen to move vessels “outside” for fishing.

C. Quality of Fish and Harvest Costs

Our theory predicts the co-op will fish over a longer season than the independent fishery, and this should improve product quality by slowing the rate at

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29 The independent fleet’s proportion of inside catch was 1.00 in 2004, the year that co-op membership peaked at 87 (see table 2).
30 Knapp and Hill, supra note 8
31 See e.g., Bouwens and Poetter, supra note 27
which fish are handled and processed. Figure 6 shows the sockeye season length for the Chignik fishery from 1990 through 2005. The average length over this 16-year period was 69 days compared to an average of 86 days during the co-op years. 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 22,890 compared to an average of 10,992 during the co-op years. The catch per fishing day dropped dramatically from 26,993 in 2001 to 11,673 when the co-op was formed in 2002.

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. The co-op on occasion even released live fish from capture when processing capacity was insufficient.32

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.33 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 prediction 4. Note that salmon prices in the other fisheries were mostly stable during the cooperative years.

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.34 conducted an extensive survey of joiners and non-joiners to assess their opinions about changes in the Chignik fishery. Results from the survey indicate that a strong majority of co-op members believed they were better off financially because they had joined. In addition, 100 percent of the co-op members who fished thought the quality of fish was improved because of how the cooperative paced their fishing effort; again, this result is consistent with theoretical prediction 4.

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33 We interpret gross earnings per pound to be the average unit price.
D. Characteristics of Joiners and Non-Joiners

Our theory of co-op formation implies the 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.\textsuperscript{35} to relate harvest levels prior to 2002 to the decision to join the co-op. 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 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.\textsuperscript{36}

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.

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.\textsuperscript{37} Second, the variation in horsepower is higher among joiners than it is among non-joiners. Owners of the 20 boats with the greatest horsepower all joined the co-op, while owners of 17 of the 20 boats with the lowest horsepower also joined. Recalling the co-op hired about 20 boats to fish on behalf of all members, these results may


\textsuperscript{36} 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.

\textsuperscript{37} 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.
indicate that highliners joined the co-op to earn the annual salary. The empirical evidence on prediction 5 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.

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. 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. The Supreme Court disagreed with this contention of Grunert stating in their 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. (Grunert v. State, p. 930).

The Supreme Court, however, did agree with Grunert in the contention that the co-op regulation contradicts the intended purposes of the Limited Entry Act (of 1973) because the Act requires “present active participation” of permit holders. Under the Limited Entry Act, the Commercial Fisheries Entry Commission (“CFEC”) determines who is eligible to take fish. 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.”

The majority opinion also cites an earlier Alaska case (Johns v. Commercial Fisheries Entry Commission) in which the Court points out that, under the Limited Entry Act, a “person” cannot be defined as a corporation,

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38 The Act is codified as the Limited Entry Act, AS 16.43.010 et. seq.
39 Limited Entry Act, supra note 38.
partnership, firm, association, organization, or any other legal entity other than a natural person. This provision reinforces the Court’s earlier interpretation from *Johns* that the legislature intended the number of permits issued to reflect the number of permits that are 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.

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 tendering and processing operations at Chignik. Because of these and related reasons, the Knapp et. al.\textsuperscript{42} survey indicates that 83 percent of independent fisherman respondents felt negatively about the co-op generally. And additional groups in the Chignik area may have also felt negatively affected. These include Chignik salmon processors and tender operators that were not able to do business with the co-op, and Chignik-area residents that may otherwise have been hired as crew by retired co-op boats.\textsuperscript{43}

**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 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

\textsuperscript{40} Johns v. Commercial Fisheries Entry Commission, 758 P.2d 1256, 1262 (Alaska 1988)

\textsuperscript{41} Grunert v. State, *supra* note 7, at 936

\textsuperscript{42} Knapp et. al., *supra* note 34

\textsuperscript{43} Knapp and Hill, *supra* note 8
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, but other organizational forms clearly are possible. We focused on voluntary associations rather than institutions mandated by government in part because the Chignik co-op was voluntary. 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.

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.44

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. This 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 worsened by the ADFG’s 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 if imposed jointly to produce an undesired result. A restriction that prevents fishermen from traveling long distances in order to encounter unexploited stocks may well improve efficiency if no harvesting

44 The evidence on improved value is not entirely robust, however.
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 1
Average and marginal catch relationship

Figure 2
Determining the number of joiners
Figure 3
Efficiency losses in the competitive sector

Number of non-joiners, $N$

$N^*$
Figure 4
Proportion of Permits Fished in Alaska's Purse Seine Fisheries

Figure 5
Proportion of Chignik Area Sockeye TAC Caught 'Inside' 1990 to 2007
Figure 6
Total Days of Sockeye Fishing in Chignik Area
1990 to 2005

Figure 7
Total Sockeye Harvested per Fishing Day in Chignik Area
1990 to 2005
Figure 8
Gross Earnings per Pound for Alaska’s Limited Entry Purse Seine Fisheries

Figure 9
Percent of Joiners and Non-Joiners in Each Harvest Decile (1999-2001)
Table 1
Proportion of Sockeye Caught Inside by Co-op and Independent Fleets
(on days reserved exclusively for one of the two fleets)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Sockeye Harvested</th>
<th>Proportion of Fish Caught Inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>576,757</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>162,979</td>
<td>0.82</td>
</tr>
<tr>
<td>2003</td>
<td>757,974</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>334,330</td>
<td>0.79</td>
</tr>
<tr>
<td>2004</td>
<td>541,400</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>61,446</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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46 Bouwens and Poetter, supra note 27

Table 2
Fishing Season Lengths for Cooperative and Independent Fleet

<table>
<thead>
<tr>
<th></th>
<th>Cooperative fleet</th>
<th>Independent fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2002</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of members</td>
<td>77</td>
<td>22</td>
</tr>
<tr>
<td>Length of fishing season (days)</td>
<td>78</td>
<td>30</td>
</tr>
<tr>
<td>Average sockeye caught per day</td>
<td>9,274</td>
<td>10,667</td>
</tr>
<tr>
<td><strong>2003</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of members</td>
<td>77</td>
<td>24</td>
</tr>
<tr>
<td>Length of fishing season</td>
<td>89</td>
<td>37</td>
</tr>
<tr>
<td>Average sockeye per day</td>
<td>8,517</td>
<td>9,036</td>
</tr>
<tr>
<td><strong>2004</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of members</td>
<td>87</td>
<td>13</td>
</tr>
<tr>
<td>Length of fishing season</td>
<td>51</td>
<td>8</td>
</tr>
<tr>
<td>Average sockeye caught per day</td>
<td>11,868</td>
<td>11,681</td>
</tr>
</tbody>
</table>

48 Pappas and Clark, supra note 45
49 Bouwens and Poetter, supra note 27
50 Bouwens and Stichert, supra note 47
### Table 3
Comparison of Joiner and non-Joiner Groups

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Joiners (obs)</td>
<td>Non-Joiners (obs)</td>
<td>t-stat for diff</td>
</tr>
<tr>
<td>Local permit holder</td>
<td>0.4  (78)</td>
<td>0.74 (23)</td>
<td>2.*</td>
</tr>
<tr>
<td>Year of vessel</td>
<td>1983 (75)</td>
<td>1982 (22)</td>
<td>1</td>
</tr>
<tr>
<td>Vessel length (feet)</td>
<td>46.4 (76)</td>
<td>46.3 (22)</td>
<td>0.02</td>
</tr>
<tr>
<td>Vessel horsepower</td>
<td>779 (72)</td>
<td>531 (21)</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Notes: (*) differences are statistically significant at 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.
Figure A1
Map of Chignik Management Area on the Alaskan Peninsula

Source: Stichert, supra note 32, at 11
Figure A2
Map of Chignik Management Area with District Boundaries and Statistical Areas

Source: Stichert, supra note 32, at 12
Figure A3
Map of Chignik Bay and Near Vicinities
Source: Stichert, supra note 32, at 15