

Strategies for Enhancing Rent Capture in ITQ Fisheries

Robert T. Deacon and Christopher Costello

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Abstract

An ITQ system that relies on a single price to allocate harvest rights will not be fully efficient unless the stock in question is uniform in terms of its economic value. Variations in the location or density of portions of a stock can give rise to corresponding variations in value, leading harvesters to compete for the *best* portions of the stock. The size of the waste that can arise from this competition is governed in part by the degree of heterogeneity—greater heterogeneity leads to greater losses. Similar losses can arise from inefficient search in cases where rights are not spatially delineated. We argue that these potential losses can be eliminated either by *fully* delineating ITQ harvest rights or by coordinating the fishing effort expended by quota holders. Evidence on practices adopted by harvesters operating under ITQ and other forms of regulation indicate that the issues we raise have practical relevance.

1 Introduction

Dissatisfaction with traditional management regimes on both economic and ecological grounds has led to the increasing adoption of individual transferrable quotas (ITQs) as a management approach over the last 20 years. Under traditional management approaches, the harvests of individual firms are effectively based on the rule of capture, which leads to a *race* to fish. Regardless

of whether harvesters are constrained by limits on total allowable catch (TAC), by limitations on entry, or by no limits other than licensing requirements, the success of an individual fisherman in such systems is determined by the ability to catch fish before one's rivals. This leads to over-capitalization, shortened seasons, and lowered product quality, as the literature has amply documented. The ITQ approach seeks to eliminate such inefficiency by establishing ownership to portions of the uncaught stock. It gives the quota holder a secure right to catch a unit of the stock, making it unnecessary to race to capture it.

Overall experience with ITQs has been positive. Enhanced fishery rents are evident in positive prices for quota allocations and in higher unit values for fishery products. Improved catch per unit effort and longer fishing seasons provide indirect evidence of improved efficiency. Yet an ITQ only establishes the right to catch some number of units from the stock and does not generally specify *which* units. This seemingly insignificant detail can have important consequences for two reasons. First, fishermen may not be indifferent to which portions of the stock they capture, or to where or when this capture takes place. In a stock that is biologically homogeneous, different portions may be heterogeneous in economic value due to their locations or times of availability. In such cases there remains an incentive to compete, or race, to catch the most profitable fish even if one's right to harvest a specific number of units is secure. Wilen (2006) make 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. Second, when the locations of stocks are uncertain, fishermen need to devote costly effort to search. When searching, the individual cannot know which locations have already been searched or what was found, so some search effort will generally be redundant. This redundant effort is a second source of rent dissipation that a standard ITQ policy will not eliminate.

Beyond describing these phenomena, our contributions in this chapter are threefold. First, we demonstrate that the inefficiencies we describe can be eliminated either by delineating rights more precisely or by coordinating fishing effort. Second, we identify factors that determine whether the degree of rent dissipation resulting from competition for the best fish or from redundant search will be large or small. Third, we demonstrate that these sources of inefficiency should be taken into account when determining the total allowable catch (TAC) in an ITQ fishery. In general, we find that catches should be smaller and steady state stocks larger in circumstances where rent dissipation is high.

2 Literature review

The basic questions we examine have been addressed in varying levels of detail by others. Boyce (1992) has questioned the within-season efficiency of ITQ regulation in circumstances where a firm's effort interferes with others in the industry, either by congesting the fishing grounds or simply by increasing the catch costs of others as a consequence of depleting the stock. He finds that a

standard ITQ policy will necessarily do better than open access, but concludes that it is not fully efficient if either of the two sorts of ‘interference’ mentioned above are present. Clark (1980) reached the same conclusion regarding the inefficiencies due to congestion on the fishing grounds, but does not agree that the simple stock depletion effect on cost is a source of inefficiency under ITQ regulation.

Wilson (1990) examines the process of search in fisheries where the movements of stocks are unknown. He characterizes the social gains from sharing and creating knowledge, the perverse private incentives to hide and distort it, and the gains from a coordinating institution that would facilitate knowledge sharing. Wilson (1990) describes conditions under which precise, timely information on stock locations is particularly valuable, but does not develop specific management regimes.

We advance this literature by pointing out that inefficiencies of the type explored by Boyce (1992) may be present under ITQ regulation even with homogeneous fishermen, no stock externalities and no congestion externalities. The key to this result is recognition that the stock regulated by a single ITQ system may be composed of economically heterogeneous components. In such circumstances, rent capture will benefit from either a more refined assignment of property right or from a degree of centralized coordination that ITQ policies do not achieve. Applying the same reasoning to the problem of search in fisheries, we find that similar benefits from ITQ refinements may be available when there is uncertainty over the locations of stocks.¹

3 Gains from delineating rights or coordinating effort

We employ two examples of undelineated rights to illustrate the general principle and then summarize our key results as general propositions. Formal proofs of the propositions are available in a companion paper.² We then present our argument concerning duplicative search, and explain how efficiency could be restored either by spatially delineated rights or by coordinating search areas or sharing search information. Lastly, we examine implications for the optimal catch level.

An N-patch fishery example

Trawlers based at the village of *Home Port* harvest pollock found in several offshore patches. Patch geometry is scaled so that each patch supports a harvestable stock of 1 unit per season. All fish on these patches are biologically identical.

The net profit that can be earned from harvesting these stocks varies over the fishing season for several reasons. Due to seasonal weather conditions, the cost of fishing is higher in winter months than during the summer. There is also

¹ We do not examine the costs of reaching agreement on coordinated actions, a question addressed by Johnson and Libecap (1982).

² See Costello and Deacon (2006).

seasonal variation in demand and in harvests of substitute species, leading to seasonal variation in the exvessel price. Finally, pollock biology and human tastes dictate that the quality of the harvest is higher at some times of the year than at others. We capture the net effect of these variations by assuming that the profit harvesters can earn from harvesting a unit of stock from any patch is a continuous function of time. We make no other assumptions about this function other than that it achieves a unique maximum at some date after the start of the season and that the profit from harvesting on the first day of the season is sufficiently low.³

Because the stocks on different patches are biologically identical it is plausible (though not necessary for our argument) that the within-season profit profiles for different patches all have the same shape. The profiles for different patches will typically have different levels, however, because some are closer to port and thus less expensive to catch than others. Figure 1 shows an example of profit profiles for a 4 patch fishery. In this case the profit maximizing harvest date, t^* , is the same for each patch. Imagine that the biologists (and possibly economists) who manage this fishery have decided that the appropriate total allowable catch (TAC) is 3 units. This total can be filled by harvesting the stocks found on exactly 3 patches. Clearly, the profit maximizing policy in this case is to fill the TAC by harvesting from patches 1, 2, and 3 and to harvest these stocks at date t^* .

A regulatory agency could achieve this first-best outcome by assigning patch-specific harvest rights for these 3 patches, a policy we refer to as *fully delineated* harvest rights. Any harvester j holding a secure right to harvest from patch 1, for example, will rationally wait until date t^* to exercise it. There is no possibility that stock 1 will be fished out before j arrives because the number of patch 1 rights issued equals the available stock from that patch. Harvesters holding rights to harvest on other patches will behave similarly and total profits will be maximized as a result. Under this policy the total profit captured for a TAC of 3 units equals the maximum profits from harvesting patches 1, 2 and 3.

Keeping the same TAC, suppose the regulator simply issued individual harvest rights that the holder can exercise on any patch. We refer to this policy as an *undelineated* harvest right and note that this is the common circumstance in ITQ regimes. It is easy to show that the efficient policy of harvesting all stocks at date t^* is no longer an equilibrium. For example, any harvester who would have been assigned a right to harvest stock 3 under a fully delineated regime would now prefer to exercise that right on stock 1 instead. With all harvesters having similar incentives, stock 1 will clearly be over-subscribed. It is likely that this mismatch between desired harvests and the available stock on patch 1 will be resolved in favor of those who are the first to arrive on patch 1. The early arrivers are likely to enjoy a competitive advantage because they encounter denser, easier to catch stocks than those who follow and because they avoid the possibility that the patch has been entirely depleted by others before they start fishing.

³ The precise meaning of “sufficiently low” is explained in Costello and Deacon (2006).

Following this reasoning, any combination of individual harvest dates that yields different profits on different patches for any harvester cannot be an equilibrium. Any harvester catching fish on a low profit patch could gain by redirecting effort to a higher profit patch and arriving slightly before the competition. It is easy to show that an equilibrium outcome for an undelineated ITQ regime (assuming a TAC of 3 units) involves harvesting stock 3 at date t^* , harvesting stocks 1 and 2 at the earliest dates that yield the same profit as stock 3, and leaving unharvested any stock yielding maximal profit lower than that of stock 3.⁴ Equilibrium dates for the three stocks harvested are shown in Figure 1 as \hat{t}_1, \hat{t}_2 and t^* , respectively. Generalizing from this example, the profit earned by harvesting a TAC of k with fully delineated rights equals the maximal profits for the k most profitable stocks, whereas the profit earned with undelineated rights only equals k times the maximum profit for the k^{th} least profitable stock harvested.

Figure 2 shows rent capture and rent loss in an undelineated ITQ regime, where TAC=3. With fully delineated rights, an ITQ policy would capture the entire area under the step function (solid and dotted areas) out to the TAC of 3 units. In an ITQ system with undelineated rights, rent capture is the solid area only; the dotted area is lost. Notice how an increase in the TAC to 4 units would affect rent capture. With fully delineated rights, rent would increase by the area beneath the step function between units 3 and 4. With undelineated rights, a TAC of 4 units would yield rent equal to 4 times the rent for the 4th stock. (This equals the area of a rectangle 4 units wide, with height equal to the rent on the 4th stock.) As represented in Figure 2, rent capture is *smaller* with a TAC of 4 units than with a TAC of 3 units. Expanding the TAC to 6 units would reduce the rent captured drastically, to nearly nothing. This suggests a general principle: For any given TAC, an undelineated ITQ system will capture a fraction of the rent available with fully delineated rights, and that fraction equals the ratio of marginal to average potential rent for the stocks harvested.⁵ Accordingly, the magnitude of rent loss under an undelineated rights system will be large when there is large variation in the potential rents that different stocks can generate.

⁴ This outcome is a Nash equilibrium to a game defined in Costello and Deacon (2006). While not generally unique, this equilibrium turns out to be the Nash equilibrium that preserves maximal rents. All other Nash equilibria return lower economic performance.

⁵ By ‘marginal rent’, we mean the rent on the least valuable stock harvested under the TAC. To see the result, suppose the potential rents on J stocks are denoted $R_j, j=1, \dots, J$, and assume the stocks are arranged in decreasing order of rent. Total rent with a fully delineated ITQ system equals $\sum_{j=1}^J R_j$ and total rent with undelineated rights equals $J \cdot R_J$. Forming the ratio of these two terms gives the result in the text.

An example with N migrating sub-stocks

The same principle can be illustrated with migratory stocks. Consider salmon that migrate toward N different rivers located in fjords in Southeast Alaska. Aside from the location of their spawning streams, the N sub-stocks are biologically identical. The stocks are intercepted by purse seiners operating out of the town of *Safe Harbor*, which is located near the mouth of river 1. As the fish migrate toward their respective rivers they become concentrated and easier to catch. Once they enter the fjords, however, their quality and accessibility decline. Over time, then, their values first increase as they approach their respective fjords, and then decrease after the fjords are entered. The potential rent from harvesting each stock is greatest on the day it enters its fjord, and is lower for both earlier and later harvest dates. Plotting rent as a function of time for each stock, there is a unique rent-maximizing date (and corresponding rent-maximizing location) for harvesting each.

The rivers toward which the salmon migrate are indexed in order of distance from *Safe Harbor*; that is, the mouth of river 1 is closest to the port, the mouth of river 2 is farther away, the mouth of river 3 is yet farther away, and so forth. These differences in proximity to the fishing fleet's base gives rise to corresponding differences in catch costs. Salmon running to streams that are farther away from port involve higher catch costs and hence are less valuable than those that enter streams closer to port. Accordingly, higher indexed stocks have a lower maximum value, i.e., can generate less potential rent, than lower indexed stocks.

The fishery just described could be represented by a variant of Figure 1. If the N sub-stocks migrate at different times, their rent maximizing harvest dates would generally be different. In other respects, however, this situation is economically the same as the N -patch fishery described earlier. An efficient (rent maximizing) outcome would result from a fully delineated ITQ system, one that assigns distinct harvest rights to the stocks that approach each stream. Under an undelineated ITQ system, a single set of rights would be created for harvests from *any* of the sub-stocks. This would induce competition for the most valuable sub-stocks, i.e., those approaching the lower indexed streams. Empirically, this competition would cause harvests of stock 1 to take place well offshore, rather than near the port as efficiency would dictate. Other low indexed stocks would experience the same phenomenon to lesser degrees. As just mentioned, this inefficient outcome could be avoided by defining rights to each sub-stock. If this were impossible, the same end could be achieved by coordinating effort among fishermen. The required coordination would involve rules against contacting stocks in offshore waters, and would require some method for rationing access to the most valuable stocks.

Gains from more efficient search

Fishermen seldom know the precise locations of fish stocks. When many harvesters are pursuing the same stocks the problem is magnified. Even if the

locations of sub-stocks were known to all at the beginning of the season, a lack of information on where others have fished would render the locations of unexploited stocks uncertain to each individual. To fix ideas, imagine a situation in which N stocks are located at N known locations at the beginning of the season. As the season progresses, identical individual harvesters deploy gear randomly at these known locations and harvest any stocks encountered. At the beginning of the season, when aggregate harvest is still small, it is unlikely that any individual will choose to fish at a location that has already been depleted by others. As the season progresses, however, the possibility of visiting a site that someone else has already exploited grows at an increasing rate.⁶

The consequence of this is that search cost per unit harvested grows at an increasing rate as the TAC gets larger in a system where search is not coordinated. An undifferentiated ITQ system will not accomplish the needed coordination. Either a spatially delineated ITQ system or a rule that search information is to be shared could achieve efficiency, however. In a spatially delineated system, the right to harvest in a specified location would be assigned to an individual fisherman or to a cooperative group that shares information internally. Each fisherman might hold rights to several locations or only one. The key is that each individual would know that the sites assigned to him or her have not been fished in the past, and hence would know the exact locations of stocks in the assigned areas.

It might prove difficult to implement a spatially delineated scheme in practice. If the stock sizes on individual patches are not known precisely, the regulator would be unable to assign secure harvest rights to them. An alternative would be to coordinate effort to reduce or eliminate redundant search. One simple method would be to require that all fishermen announce the results of search and harvest efforts experienced on all sites visited. Since the information is a public good, capable of benefiting all harvesters simultaneously, making it freely available to all would enhance efficiency. Of course, individual harvesters may be unwilling to reveal this information freely unless they receive some guarantee that others will reciprocate.

Optimal TAC and stocks with undelineated rights

Our results on rent capture indicate that the within-season social gain from increasing the TAC in an undelineated ITQ system is less than an ITQ system with *fully* delineated rights could achieve. With undelineated rights, the rent earned from each sub-stock harvested is driven down to the rent earned from the least profitable sub-stock allowed under the TAC. With fully delineated rights no such rent dissipation occurs. Figure 3 illustrates this phenomenon. It suggests that the optimal TAC with undelineated rights is likely to be lower than the optimal TAC with fully delineated rights.⁷ A lower optimal TAC, in turn, generally

⁶ See Costello and Deacon (2006).

⁷ Showing this result rigorously requires accounting for the dynamic effects of a larger TAC.

translates into a larger stock with undelineated rights.⁸ Intuitively, all portions of the harvested stock have lower economic value when harvest rights are imperfectly assigned; it is, therefore, not efficient to harvest as extensively as one would if harvest rights were fully delineated.

4 Evidence on gains in actual fisheries

Although ITQ instruments have clearly achieved gains over the last 20 years, our analysis suggests that even greater rent capture may be possible. These gains could be achieved either by coordinating harvest effort among quota holders or by more finely delineating ITQ rights, e.g., to specific sub-stocks. If our claims are accurate we would expect to see ITQ participants altering their practices in ways suggested by our analysis in order to reap these gains. Such behavior would be exemplified by rules among ITQ harvesters on how effort will be allocated spatially or temporally, or cooperative agreements to achieve the same ends by coordinating effort.

In this section we present some anecdotal evidence of such behavior. We report on experience in two fisheries, one of which is managed by an ITQ regulatory framework. The management regime in the other case was a limit on entry and TAC constraint, onto which a voluntary association grafted a framework for coordinating effort. Both cases illustrate the presence of gains from more finely delineating harvest rights and from sharing information.

Chignik Salmon Cooperative

Except for a brief period, the sockeye salmon harvest in the Chignik region of Alaska on the southern side of the Alaskan Peninsula has been regulated by limited-entry with a fishery-wide TAC. Typically, about 100 purse seiners operate in any given year. This regulatory regime evidently preserves some rent as the permits, which are transferable, generally trade at a price of about \$200,000 (Alaska Board of Fisheries, 2003). In 2002 a group of Chignik purse seiners obtained permission from the Alaska Board of Fisheries to form a cooperative, which permit holders could voluntarily join. Roughly three quarters of the 100 permit holders did elect to join, while the others remained independent, and the Alaska Board of Fisheries divided the TAC between these two groups approximately in proportion to their numbers. The two groups fished separate openings (Knapp and Hill, 2003).

While it operated, the coop coordinated effort across space in a sophisticated fashion. One member of the coop was designated the ‘fleet director’ and was provided real time information on stock concentrations at all locations while the harvest was taking place. This individual then directed effort over the fishing grounds to avoid opportunistic races to catch fish at locations or times that were privately advantageous. Late in 2002, members of both groups were

⁸ Actually, the outcome for the stock depends on whether the equilibrium occurs on the upward sloping or downward sloping portion of the yield-effort curve.

surveyed. Those in the cooperative reported significant financial advantages from cooperation, due to decreased harvest costs and increased product quality. Most coop members expressing an opinion found the fishing experience to be less competitive and more enjoyable than was the case normally. Despite its financial success and the positive reports from coop members, this arrangement was eventually ruled to be illegal by the Alaska Supreme court and was subsequently banned in Alaska.⁹

New Zealand paua

The New Zealand *paua*, known as abalone elsewhere, is a univalve shellfish found in rocky coastal areas. It has been managed under New Zealand's ITQ quota management system since 1986. As of 2003, the market value of *paua* quota allocations, which represent perpetual harvest rights, was roughly \$325 million. Since 2000, annual exports have been in the \$50-\$80 million range. In 2002 a commercial stakeholder group consisting of harvesters operating on the eastern side of the South Island (Paua region 3) initiated a voluntary arrangement to coordinate harvesting activity. A major goal was to manage effort spatially in order to redirect intense competition for stocks in highly accessible areas in the North toward stocks in less accessible areas in the South. The coop accomplished this by subdividing the management region into 4 zones and, in effect, subdividing the quota allocations for the overall region into allocations for each zone. Although this arrangement was never codified contractually, the group reports an extremely high rate of voluntary compliance.

According to a recent assessment, the reduced pressure in more accessible zones produced benefits; catch per unit effort in the entire region (catch per diver per day) was increased after the program was implemented.¹⁰ This group also cooperates on sharing information on diving conditions and stocks, on efforts to reseed depleted grounds, and on controlling poaching. The same group has proposed a diver accreditation plan, intended in part to reduce incidental harvesting mortality, and has implemented voluntary size limits in certain areas.

Other evidence

Brief accounts from other fisheries serve to indicate that the two cases described above are not isolated phenomena. According to Schalger, et al (1994), cooperative organizations play an important role in fisheries management in several regions of the world. After surveying the structure of such arrangements, they found that rules limiting competition for the best fishing spots or times are among the most common types of agreements reached. A typical allocation arrangement specifies that individual fishermen rotate through the best fishing

⁹ According to the court ruling, it is illegal for a harvester to profit from a right to fish if the individual does not actually engage in fishing.

¹⁰ The following information was taken from:
<http://www.seafood.co.nz/doclibrary/industryorgs/paua>.

spots in a strict order, or assigns individual time slots for fishing certain areas. Also common are rules governing periods during the year when fish may be taken or the size of fish that may be kept. Along the same lines, Hannesson (1988) describes assignment rules that limit competition for the best fishing grounds in Turkish fisheries.

Information sharing among groups of purse seine skippers in inland salmon fisheries in southeast Alaska has been documented by Gatewood (1984). Because salmon movements are unpredictable in the short run, up to the minute information is extremely valuable before openings. Small groups of skippers meet to search out fishing sites for stock locations. The areas to be searched are negotiated a day or two before the opening. Skippers then meet again to share information just before fishing begins. Of course, members must be relied on to provide accurate information and to keep the group's information secret from outsiders. These groups are often based on kinship ties. While the fishery involved is not managed under ITQs, this case does illustrate how coordinating effort cooperatively can enhance efficiency.

Certain aspects of the Bering Sea pollock fishery suggest the presence of economic heterogeneity, implying potential gains from coordinating effort. Wilen's (2002) account of experience in this fishery after the formation of cooperatives in 1998 points out that the roe content of female pollock varies over time during the season and even varies according to position within a migrating mass of fish. This induces economic heterogeneity within the stock, as the unit value of pollock is increased by higher roe content. An incentive to compete for the highest valued sub-stocks may therefore be present and, absent coordination, a portion of the stock's potential rent could be dissipated under an undelineated ITQ system.

Finally, Wilen's (2006) description of TURFs in Japan and Chile documents the role of effort coordination in achieving efficiency. In Japan, one of the major tasks accomplished by TURFs is coordination of effort over space, to reduce excessive competition for hot spots. This is often accomplished by rotating fishing opportunities on hot spots among individuals or by sharing of harvest proceeds.¹¹ These groups also coordinate temporally, to avoid market gluts and depressed prices, and to collectively take advantage of predictable surges in demand such as occur on holidays. TURF groups in Chile and Japan often undertake stock enhancement as well.

5 Conclusions

The rise of the ITQ as an instrument for regulating fisheries has brought enormous gains, by shifting attention away from limiting entry and toward implementing secure rights and market exchange in the unowned biomass. The previous emphasis on limiting effort as a means to capturing rent, seemingly implied by Gordon's (1954) fundamental analysis of the over fishing problem, is

¹¹ Wilen (2006) discusses the potential shirking problem associated with revenue pooling and describes how the coops deal with it.

now known to have been misplaced. Attempts to limit effort have been undone by the ingenuity of the industry and the malleability of effort, despite the best attempts of regulators.

In the examples we found, the finer delineation of rights or centralized coordination of effort was undertaken by harvester cooperatives, rather than by government regulators. Wilen (2006) points out that such groups have incentives to undertake artificial enhancement of stocks or habitat preservation, assuming the transactions costs associated with collective action can be overcome. A case in point, the same industry group that instituted spatial harvesting rights for the New Zealand paua has adopted voluntary minimum and maximum size limits and conducted reseeding trials. According to Wilen (2006), the recent rise of harvester coops as the policy approach of choice in Alaska has been in response to distributional disputes over the assignment of ITQ rights. Our analysis and the experience cited indicates that the rise of harvester coops may bring efficiency gains as well.

Our central message emerges from the observation that the biomass may be complex and multidimensional, and its economic value may vary over time and space. When such complexity is present, no simple assignment of undifferentiated rights to harvest can capture all the rent the resource is capable of generating. An undifferentiated ITQ system results in a single scarcity price applied to all units of the stock. When different portions of the stock have different values, agents will naturally seek to exercise their quota shares on the most valuable portions. This can lead to competition that dissipates part of the resource's rent. In such circumstances, wasteful competition can potentially be forestalled by adapting the policy to recognize resource heterogeneity. The adaptations we propose are more precise delineations of harvest rights, possibly temporally or spatially, or actions to coordinate the effort decisions of individual harvesters. As Wilen (2002) notes, the rents fisheries can generate are complex and their levels are determined by interactions among fishermen along several dimensions. Our analysis indicates that efficiency gains can be achieved by recognizing this complexity, and by adapting the design and operational details of ITQ systems to prevent harvesters from exploiting it.

References

- Alaska Board of Fisheries, 2003. *Chignik Salmon Purse Seine Fishery: Permit Transfer Statistics, 1992-2003*. Technical report, State of Alaska, Commercial Fisheries Entry Commission.
- Akimichi, T. 1984. "Territorial regulation in the small-scale fisheries of Itoman, Okinawa", *Senri Ethnological Studies*, Vol.17, 89-120.
- Boyce, J. (1992). "Individual transferable quotas and production externalities in a fishery", *Natural Resource Modeling*, Vol 6(4) 385--408.

- Costello, Christopher, and Robert T. Deacon, 2006. "The efficiency gains from *fully* delineating rights in an ITQ fishery." Unpublished, Department of Economics, University of California, Santa Barbara.
- Gaspart, F. and E.~Seki, 2003. "Cooperation, status seeking and competitive behaviour: theory and evidence." *Journal of Economic Behavior and Organization*, Vol. 51, 51-77.
- Hannesson, Rognvaldur, 1988. *Fishermen's organizations and their role in fisheries management: Theoretical considerations and experiences from industrialized countries*. FAO Fisheries Technical Paper, Vol. 300, 1-27.
- Johnson, R., and Gary Libecap, 1982, "Contracting problems and regulation: The case of the fishery", *American Economic Review* 72(5) 1005-1022
- Knapp, Gunnar, and Lexi Hill, 2003. "Effects of the Chignik Salmon Cooperative: What the Permit Holders Say" University of Alaska Research Summary, No. 1, June, 2001.
- Lynham, John, 2006. "Schools of fishermen: a theory of information sharing in spatial search" Working paper, UCSB Department of Economics, 1-26.
- Schalger, Edella, William Blomquist and Shui Tan Tang, 1994. "Mobile flows, storage and self-organizing institutions for governing common-pool resources." *Land Economics*, Vol. 70(3) (1994) 294-317.
- Wilén, James, 2002. "Property rights and the texture of rents in fisheries," Paper presented at PERC's 13th Political Economy Forum. Property and Environment Research.
- Wilén, James, 2006. "TURFs and ITQs: Coordinated vs. Decentralized Decision Making," Paper presented at the Workshop on Advances in Rights-based Fisheries Management, Reykjavik, Iceland, August 1006.
- Wilson, J., 1990. "Fishing for knowledge", *Land Economics*, Vol 66(1) 12-29.

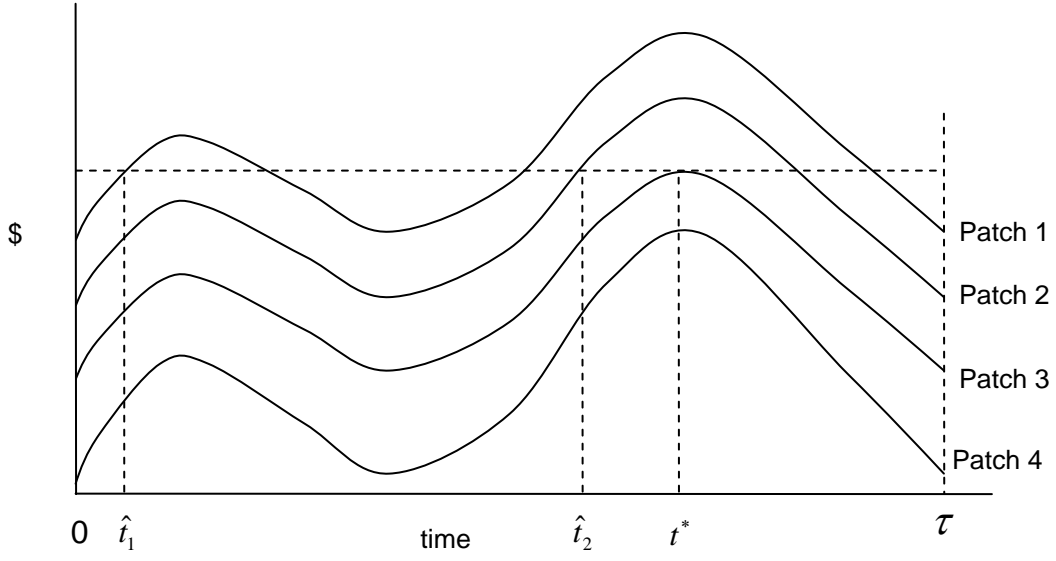


Figure 1. Seasonal pattern of harvest profits

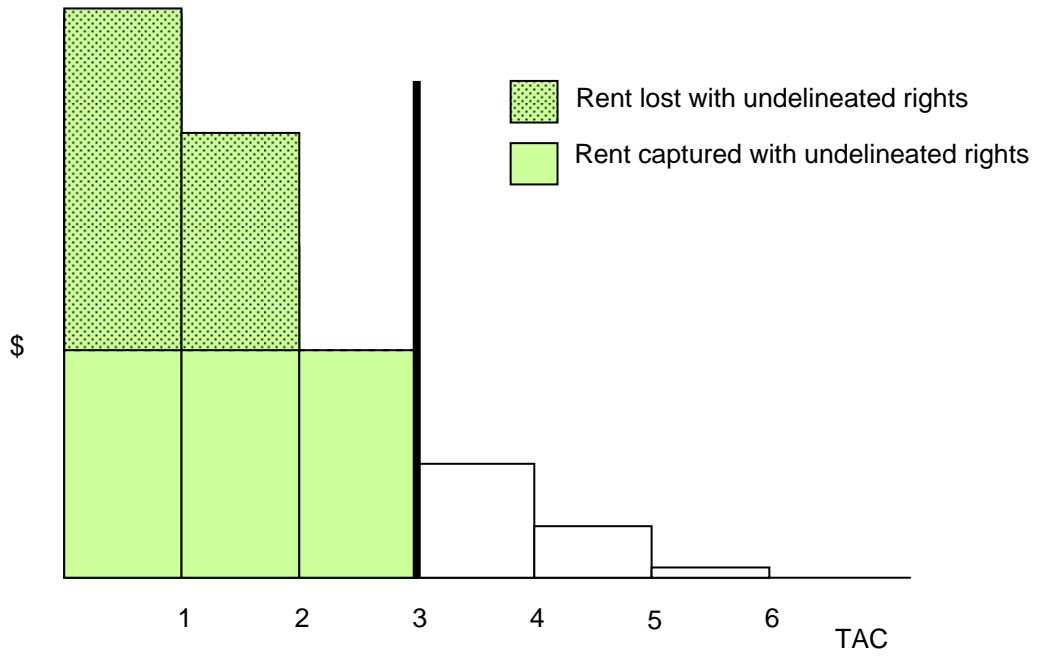


Figure 2. Rent capture with undelineated rights

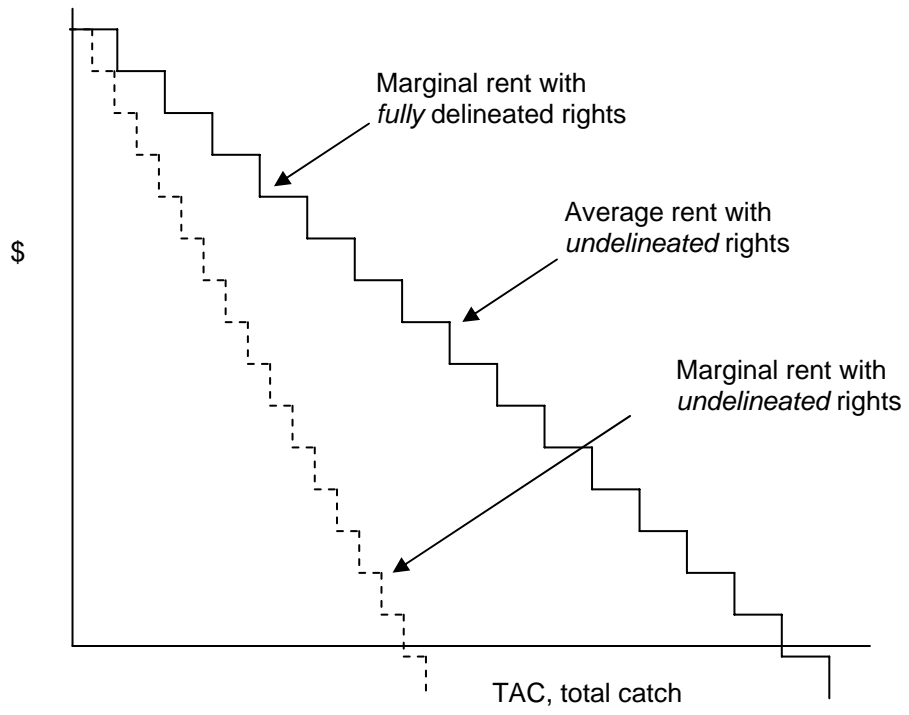


Figure 3. Rent capture with delineated vs. undelineated ITQs