2002

Property Rights and the Management of Multiple Use Fisheries

Keith R. Criddle
Utah State University

Economic Research Institute Study Paper

ERI #2002-04

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

by

KEITH R. CRIDDLE

Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530

February 2002

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

Keith R. Criddle, Professor

Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530

Information on other titles in this series may be obtained from: Department of Economics, Utah State University, 3530 Old Main Hill, Logan, Utah 84322-3530.

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

Keith R. Criddle

ABSTRACT

Arguments in favor of adopting rights-based management strategies have been developed primarily in the context of commercial fisheries and have focused on increasing the profitability of catcher vessel operations and reducing the incentive to deplete fish stocks. Relatively little attention has been given to the effects that alternative management regimes could have on the profitability of processing and support service businesses, consumer surplus, or to the interface between commercial fishing, sport fishing, and other use and nonuse demands for fishery resources. Although there is often congruence among users with respect to stock management and rule enforcement objectives, other objectives are mutually incompatible. This paper begins with a simple conceptual analysis of the effects of alternative regimes for management of a charter-based recreational fishery on the magnitude of net benefits in the sport fishery and in an associated commercial fishery. A theoretical framework for identifying the optimal commercial-sport allocation and the optimal sustainable yield is developed in the subsequent section. The final section reports the results of an empirically based comparative static simulation of commercial and charter-based sport fishing for halibut off Alaska.

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

The collapse of fished stocks and the depressed economic condition of commercial fisheries have been attributed to an incongruence between individually rational decisions and globally optimal outcomes, an incongruence that arises from the perverse institutional structures that govern access to and ownership of fishery resources. Traditional approaches to fisheries management have been predicated on regulatory structures that attempt to control the opportunity to catch too many fish; these approaches have been expensive and have failed to protect fish stocks or to improve the economic performance of fisheries. In contrast, rights-based approaches to fisheries management are based on the observation that rational self-interest can promote socially optimal outcomes when the bundle of entitlements and obligations pertaining to ownership are clearly defined and comprehensive and when all interested parties are eligible to negotiate mutually agreeable transactions. Consequently, rights-based approaches focus on the design of institutional structures that define property rights in fish or fishing areas. Theoretical and empirical analyses have demonstrated that sole ownership (e.g. Gordon 1953, 1954; Scott 1955), individual quotas (e.g. Moloney and Pearse 1979; Pearse 1980; Morey 1980; Wilen 1985; Scott 1988; Johnson and Libecap 1982; Keen 1983; Gauvin et al. 1994; Casey et al. 1995; Wang 1995; NRC 1999), territorial use rights (e.g., Agnello and Donnelley 1975; Christy 1982; Berkes 1986; Acheson 1988; Ruddle 1989; Seijo 1993; McCay 1998; Criddle et al. 2001), corporate fishing or fishing cooperatives (Townsend 1995; 1997; Larkin and Sylvia 1999; Criddle and Macinko 2000; Felthoven 2001; Matulich, Sever, and Inaba 2001), and common property management regimes (e.g., Olson 1965; Ostrom 1990; Stevenson 1991; Ostrom et al. 1994; McCay and Acheson 1987; Berkes 1989; and Bromley 1992) can promote biologically sustainable and economically profitable fisheries.

Nevertheless, implementation of rights-based solutions has met with resistance, due in part to concern about the mechanisms used to initially allocate ownership, concern about impacts on entities that are excluded from holding comprehensive or partitioned property rights, and concern about the compatibility of private property rights with the Public Trust character of fishery resources. In the US, the initial allocation problem arises from provisions in the Fisheries Conservation and Management Act (FCMA) that have been interpreted as a prohibition against market-based initial allocations. Because initial allocations have been based on political-procedural rules related to past participation, the rule setting process has engendered economically wasteful rent-seeking activities and induced speculative entry that has increased the number of participants and level of fishing effort in periods immediately preceding program implementation (Stollery 1986, Anderson and Hill 1990). The same political processes have resulted in restrictions on who is eligible to own fishing rights. Those who are excluded from the initial allocation or prohibited from subsequent acquisition of fishing rights argue that they have been deprived of their presumptive entitlement and that total net benefits have been reduced by their exclusion (see e.g., NRC 1999; Matulich et al. 1999; Matulich and Sever 1999). In addition, the Public Trust character of fishery resources limits the conditions under which exclusive use rights can be conveyed to individuals (McCay 1998; Macinko 1993).

Recommendations favoring adoption of rights-based management strategies have been developed primarily in the context of commercial fisheries and have focused on increasing the profitability of catcher vessel operations and reducing the incentive to deplete fish stocks. Relatively little attention has been given to the effects that alternative management regimes could have on the profitability of processing and support service businesses, consumer surplus, or to the interface between commercial fishing, sport fishing, and other use and nonuse demands for fishery resources. Insouciance about consumer surplus can be attributed to the implicit assumption that the demand for any particular fish stock is perfectly elastic, an assumption that is not supported in empirical analyses. It is similarly unreasonable to focus exclusively on the commercial fishery in as much as most fish stocks support a variety of commercial, sport, and other use and nonuse services, the provision of which may be subject to different management regimes, and the benefits of which accrue to different beneficiaries. Although there is often congruence among users with respect to stock management and rule enforcement objectives (Merritt and Criddle 1993), other objectives are mutually exclusive or are mutually unreachable, especially when the stock is stochastic or when there are lags in the feedback between information generating processes and the implementation of controls (Criddle and Streletski 2000). An example of the interface between commercial and sport fisheries will be explored in the following sections. The first section provides a simple conceptual analysis of the effects of alternative regimes for management of a charter-based recreational fishery[1] on the magnitude of net benefits in the sport fishery and in an associated commercial fishery. The subsequent section develops a theoretical framework for identifying the optimal commercial-sport allocation and the optimal sustainable yield. The final section reports the results of an empirically based comparative static simulation of commercial and charter-based sport fishing for halibut off Alaska.

1. A Conceptual Analysis of the Interface Between Commercial and Sport Fisheries

This section examines the economic consequences of four alternative management regimes for commercial and charter-based sport fisheries. It will be assumed that the target species is not caught in any other fishery (e.g. subsistence, self-guided sportfishing, bycatch)[2], that nonuse values are inconsequential, that trophic interactions with other species are insignificant, and that the fishery is governed by a management entity that establishes and enforces a binding overall cap on the sum of commercial and sport catches. It will also be assumed that landed catches in the sport fishery are a constant multiple of the number of sportfishing trips taken and that the nonpecuniary attributes of sportfishing trips are immutable. That is, charter service providers are assumed to compete through price alone; trip length and amenities are assumed to be identical across charter services.

1.1 Regulated Open Access Commercial Fishing and Open Access Sport Fishing

The archetypal form of interaction between commercial and sport fisheries involves a commercial fishery subject to an overall catch quota but without efficacious constraints on fishing capacity and a sport fishery that lacks binding constraints on catch and fishing capacity. While the economic consequences of regulated open access management of the commercial fishery are explored in for example, Homans and Wilen (1997) and Wilen and Homans (1998), the interaction with a sport fishery has not been examined. It will be assumed that anticipated increases in the demand for sportfishing trips will invariably be accommodated through reductions in the overall commercial quota. Because the number of charter operators is large and barriers to entry are relatively small, charter operators will be assumed to behave as perfect competitors. Thus the market supply of sportfishing trips (the sum of n homogeneous individual firm supply functions) is perfectly elastic and individual firms face a perfectly elastic demand for their services. The short- and long-run consequences of an increase in the demand for sportfishing trips can be represented by:

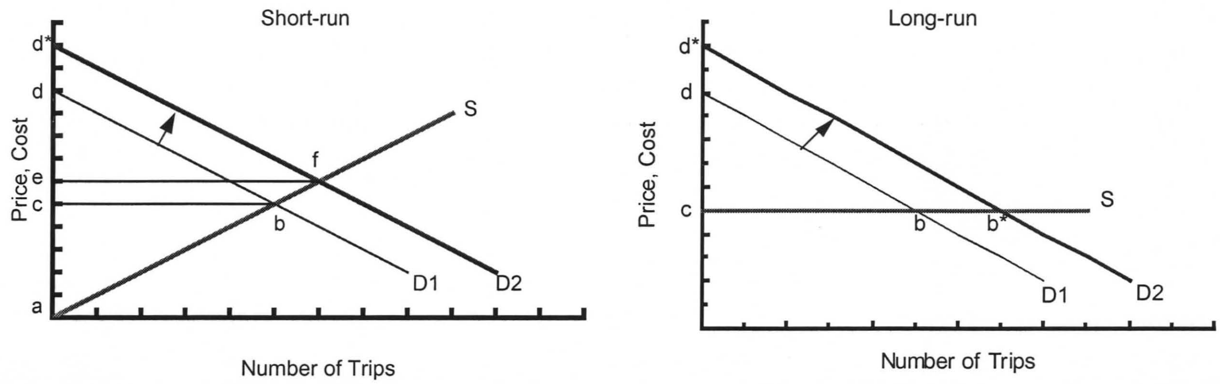

Figure 1. Short- and long-run net economic benefits in an open-access sport fishery in response to an increased demand for sportfishing trips.

An increase in the demand for sportfishing trips from $D1$ to $D2$ leads to an increase in angler surplus from the area represented by bcd to the areas represented by efd^* in the short-run and cb^*d^* in the long run, where charter capacity is fixed in the short-run and unconstrained in the long run. Charter capacity expansion is induced by an ephemeral increase in charter operator surplus represented by $bcef$. The price of sportfishing trips rises from c to e in the short-run, but returns to c in the long run as charter service providers compete for clients. Thus the ultimate consequences of the expanded demand for sportfishing are an increase in the number of sportfishing trips taken, an increase in angler surplus, and an increase in charter capacity. Although sportfishing trip prices and charter operator profits increase in the short-run, they return to ex-ante levels in the long run.

Because the commercial fishery is constrained by an overall quota but the number of participants is unregulated, the ownership-by-capture rule leads to the adoption of cost-increasing technologies so that in equilibrium, the marginal harvester earns a normal return. The short- and long-run consequences of increased demand for sportfishing trips on profitability and post-harvest surplus in a regulated open-access commercial fishery can be represented by:

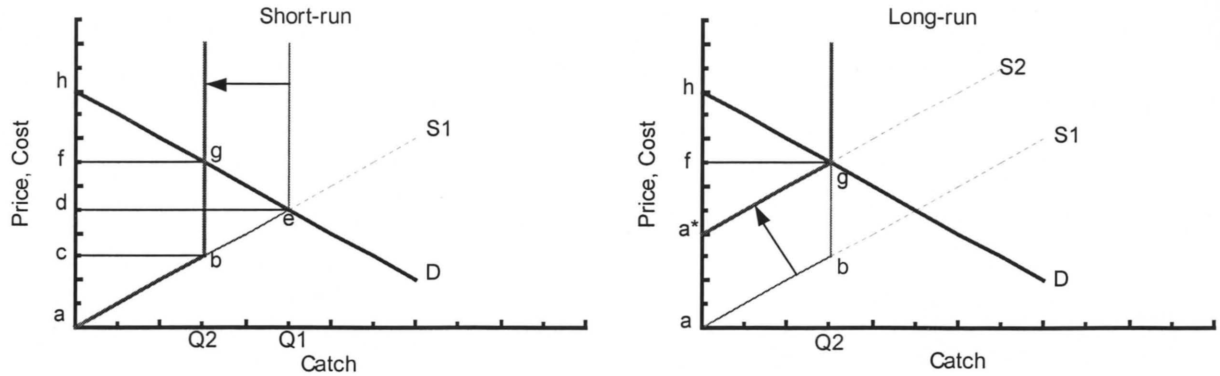

Figure 2. Short- and long-run changes in net economic benefits in a quota constrained open-access commercial fishery in response to an increased demand for sportfishing trips.

In this example, increased demand for sportfishing trips is accommodated by a reduction of the overall commercial quota from $Q1$ to $Q2$. Before the overall quota is reduced, exvessel price is d, fleet-wide producer surplus is ade and post-harvest surplus is deh. The immediate consequences of the quota reduction are an increase in the exvessel price to f and a reduction in post-harvest surplus to fgh. The short-run change in exvessel net revenue to $abfg$ could entail an increase or a decrease depending on the elasticities of demand and supply. In either case, the quota reduction and concomitant price increase results in above normal profits represented by $bcfg$. The presence of above normal profits attracts increased effort (additional boats or an intensified race for catch among existing boats) that leads to upward shifts of the supply function from $S1$ to $S2$ until the marginal harvester earns no more than a normal return. The race for catch dissipates a portion of the exvessel net revenues (aa^*bg), leading to a long-run decline from ade to a^*fg. Thus in the long-run, accommodation of increased sportfishing demand increases exvessel price, reduces exvessel net revenues, and reduces post-harvest surplus, irrespective of the elasticity of supply or demand.

1.2 IFQ-Based Commercial Fishing and Open Access Sport Fishing

Economists have long argued that a well-designed IFQ program can increase the profitability of commercial fishing and possibly reduce the incentive to over harvest fish stocks. However, little attention has been given to the interface between an IFQ managed commercial fishery and other fisheries that exploit the same stock. In this and subsequent examples, it will be assumed that the commercial fishery is subject to an IFQ regime wherein individual harvesters hold exclusive rights to harvest of a percentage of an overall quota set by the management authority. It is assumed that the sport fishery lacks meaningful constraints on catch and fishing capacity and that the management authority will invariably accommodate anticipated increases in the demand for sportfishing trips through reductions in the overall commercial quota that lead to proportionate reductions in the annual realization of the IFQs. Because assumptions about the sport fishery are unchanged from the previous example, the short- and long-run effects on the sport fishery of an increase in the demand for sportfishing trips are also unchanged. However, because the commercial fishery is IFQ-based, the effects on the commercial fishery are markedly different from those in the previous example. The following pair of graphs represents these short- and long-run consequences:

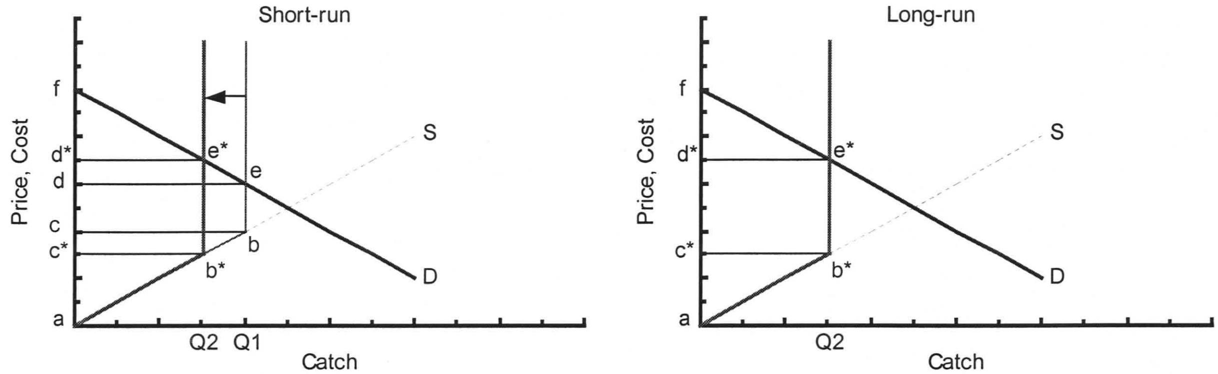

Figure 3. Short- and long-run changes in net economic benefits in an IFQ-based commercial fishery in response to an increased demand for sportfishing trips.

Before the quota reduction, the exvessel price is d, exvessel net revenue is $abde$, and post harvest surplus is def. The exvessel net revenue includes a single-period quota share value of $bcde$. Immediately following the commercial quota reduction (from $Q1$ to $Q2$) required to accommodate the increased demand for sportfishing trips, exvessel price rises to d^*, post-harvest surplus declines to d^*e^*f, and exvessel net revenue changes to $ab^*d^*e^*$. Although the change in exvessel net revenue could be positive or negative depending on the magnitude of the commercial quota and the elasticity of exvessel demand, the total net benefits of commercial fishing are unambiguously reduced because ab^*e^*f is strictly less than $abef$. In contrast with the previous example, there is no difference between the long-run and short-run consequences of an increase in the demand for sport fishing trips. Moreover, the long-run reduction in commercial fishing net benefits is smaller under IFQ management than it is under regulated open access (Figure 2). That is, IFQ-based management helps the commercial fishery mitigate the adverse impacts of increased allocations to the sport fishery.

1.3 IFQ-Based Commercial Fishing and Regulated Open Access Sport Fishing

In the first two examples, it was assumed that the management authority is incapable of or unwilling to control the total magnitude of sportfishing catches. However, in fact, management agencies employ a variety of gear restrictions, bag, possession, and retention limits, size restriction, and seasonal and diurnal closures that influence the magnitude of sportfishing catches. In this example, it will be assumed that some combination of these instruments can be used to limit total sportfishing catches. In the previous examples, increased demand for sportfishing trips induced an expansion of charter capacity such that current and new operators adopted profit-maximizing combinations of inputs and services. However, because the charter service providers were assumed to be homogenous and to operate in a perfectly competitive market, they earned normal profits in the long run. In a quota constrained sport fishery, charter service providers compete to provide a limited number of trips (recollect that landed catches were assumed to be a constant multiple of the number of sportfishing trips taken). Competition for clients creates a pressure to increase the "quality" of services offered (at a given price) or to reduce the price per trip (of a given quality). These effects can be represented graphically:

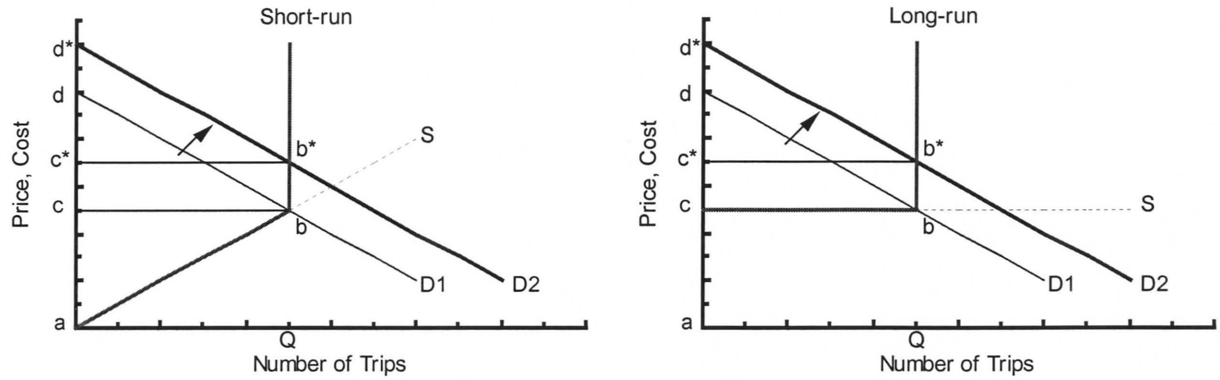

Figure 4. Short- and long-run changes in net economic benefits in a quota constrained charter-based sport fishery in response to an increased demand for sportfishing trips.

If the charter fleet is comprised of small homogeneous operators, in the short run, an increase in the demand for sportfishing trips results in an increase in trip prices from c to c^* and creation of above-normal profits for charter operators (ab^*cc^*). Despite the increase in trip prices, angler surplus is unaffected because $b^*c^*d^*$ is equal to bcd. In the long run, the above normal profit induces competition among charter operators that leads to trip price decreases (to c) and eventually transfers the value of the above normal profits from the charter operators to their clients. These results will hold even if the number of charter operators is capped, as long as there is latent capacity, because each charter-operator has an incentive to add services or lower prices to attract additional clients. Consequently, the long-run consequence of the expanded demand for sportfishing under a quota-constrained charter fishery is an increase in angler surplus and in social welfare as the number of charter operations does not increase to the point that congestion and localized depletion externalities serve to reduce the value of trip attributes to the charter customers. Although sportfishing trip prices and charter operator profits increase in the short run, they ultimately return to their ex-ante levels. Increases in the demand for charter trips do not affect the commercial fishery in this example because the charter fleet is quota constrained.

1.4 IFQ-Based Commercial and Sport Fishing

The preponderance of experience suggests that allocations between commercial, sport, and other use and nonuse activities are unlikely to be definitively settled by any single management decision. Instead, the allocation battle is reprised whenever a user group perceives that its negotiating position has improved. If by some fortuitous circumstance, the political processes arrive at an optimal allocation, the optimality will prove short-lived because it is conditional on constant exvessel price, factor costs, stock abundance, recreation trip costs, the opportunity cost of alternative recreational activities, angler success, etc. The conceptual appeal of an integrated sport-commercial IFQ management regime is that it would rely on voluntary market transactions to continuously adjust the allocation such that marginal net benefits are equated across uses and to ensure that quota share buyers compensate sellers for the private value of their IFQs. If the distribution of IFQ between the charter and commercial fisheries is initially in equilibrium, the short- and long-run consequences to the sport fishery of an increase in the demand for sportfishing trips can be represented by:

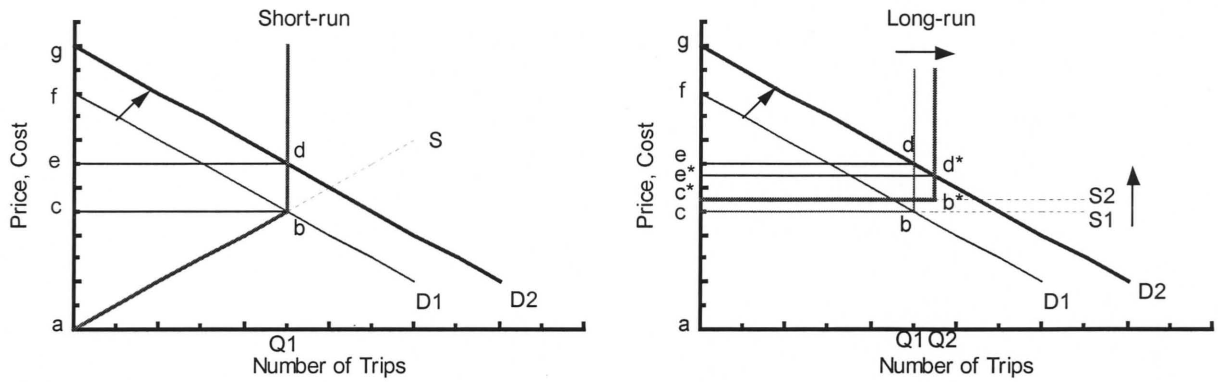

Figure 5. Short- and long-run changes in net economic benefits in an IFQ-based charter fishery in response to an increased demand for sportfishing trips.

In the short run, an increase in the demand for charter trips from *D1* to *D2* leads to an increase in trip price from *c* to *e* and an increase of *bcde* in charter operator surplus. Angler surplus is unchanged in the short run because area *deg* is equal to area *bcf*. In the long run, charter operators will purchase additional quota shares, increasing the quantity of trips supplied from *Q1* to *Q2*. The purchase of additional IFQs leads to an increase in the average operating cost from c to c^*. Recreational anglers are willing to pay e^* for *Q2* trips. Charter service providers will purchase the additional IFQs as long as area $b^*c^*d^*e^*$ is at least as great as *bcde*. If charter operators purchase additional IFQs, the angler surplus increases from *deg* to $d^*e^*g^*$. Because the opportunity cost of holding the additional IFQs is $b^*c^*d^*e^*$, charter operators continue to earn normal profits in the long run. Thus the overall effect of an increase in the demand for charter-based sportfishing trips is an increase in angler net benefits and a conservation of normal profits for charter operators.

There is no short-run effect on the commercial fishery, because the sport fishery is initially constrained by ex-ante IFQ holdings. In the long run, the charter service providers can purchase additional quota shares from the commercial fishery. The key difference between this example and the immediately preceding (Figure 4) is that, in the present example, the commercial fishery must agree to the transfer and will only do so if the marginal value of an additional unit of quota share is worth more to the charter service providers than it is to commercial harvesters. The results are represented graphically in the following pair of graphs:

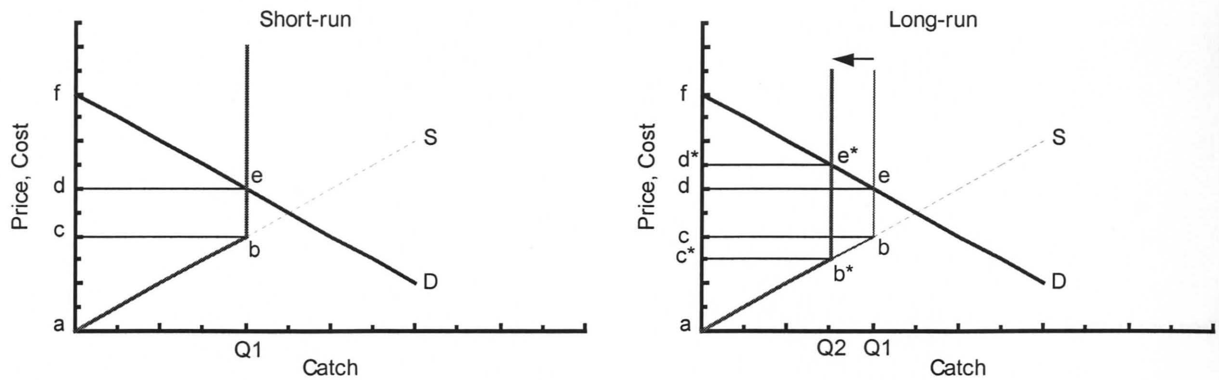

Figure 6. Short- and long-run changes in net economic benefits in an IFQ-based commercial fishery in response to an increased demand for sportfishing trips.

If the commercial fishery sells IFQs into the charter sector, the total commercial quota will decline from $Q1$ to $Q2$ causing exvessel price to rise from d to d^* and reducing post-harvest surplus from def to d^*e^*f. If the market for IFQs was initially in equilibrium, the reduction of commercial quota will result in a decrease in exvessel net revenue. However for the transfer to be consummated, the charter operators would have had to pay enough to offset the present value of foregone future exvessel net revenues.

Note however that because the charter operators and commercial harvesters do not benefit from angler surplus or post-harvest surplus, they will not consider the effect of quota transfers on the magnitude of those net benefits. Consequently, although an integrated sport-commercial IFQ management regime will ensure efficiency from the perspective of commercial harvesters and charter operators, it is unlikely to ensure welfare maximization.

2. A Theoretical Model of Optimal Sport-Commercial Allocations in the Halibut Fishery

The overall management objective for an integrated commercial and sport fishery can be characterized as a constrained maximization of the net present benefits of commercial and sport fishing over time:

$$\text{Maximize } NB = \sum_{t=t_0}^{T} \delta^t f\left(NB_{c,t}, NB_{s,t}\right) \tag{1}$$

$$\text{subject to } x_t = f\left(x_{t-1}, h_{c,t-1}, h_{s,t-1}\right), \tag{2}$$

where $NB_{c,t}$ and $NB_{s,t}$ are the net benefits of commercial and sport fishing, x_t is the biomass of the target species, $h_{c,t}$ and $h_{s,t}$ are the commercial and sport fishing catches, and δ is the discount factor. Expanding on a commercial sector model developed in Criddle (1994), a sport fishery model based on Herrmann et al. (2001), and an approximate model of population dynamics introduced in Criddle and Havenner (1991), the net benefits of commercial and sport fishing, and the stock dynamics can be described by:

$$NB_{c,t} = TR - TC + CS = ah_{c,t} - \tfrac{1}{2}bh_{c,t}^2 - c\alpha h_{c,t}^{\beta_1}x_t^{\beta_2} + bh_{c,t}^2 = ah_{c,t} + \tfrac{1}{2}bh_{c,t}^2 - c\alpha h_{c,t}^{\beta_1}x_t^{\beta_2} \tag{3}$$

$$NB_{s,t} = \phi \ln(h_{s,t} + 1) \tag{4}$$

$$x_t = \gamma_0 + \gamma_1 x_{t-1} + \gamma_2 x_{t-1}^2 - h_{c,t-1} - h_{s,t-1} \tag{2'}$$

where TR, TC, and CS are the total revenues, costs, and post-harvest surpluses associated with commercial harvests, and a, b, c, α, β_1, β_2, ϕ, γ_0, γ_1, and γ_2 are estimated parameters. Based on these relationships, and imposing sustainability on the stock dynamics constraint, the model can be rewritten:

$$\text{Maximize } NB = \sum_{t=t_0}^{T} \delta^t \left(ah_{c,t} + \tfrac{1}{2} bh_{c,t}^2 - c\alpha h_{c,t}^{\beta_1} x_t^{\beta_2} + \phi \ln(h_{s,t} + 1) \right) \tag{1'}$$

$$\text{subject to } h_t = h_{c,t} + h_{s,t} = (\gamma_1 - 1) x_t + \gamma_2 x_t^2 . \tag{2'}$$

The solution to this problem can be obtained from the solution to a related, but unconstrained problem:

$$\text{Maximize } L = \sum_{t=t_0}^{T} \delta^t \begin{pmatrix} ah_{c,t} + \tfrac{1}{2} bh_{c,t}^2 - c\alpha h_{c,t}^{\beta_1} x_t^{\beta_2} \\ + \phi \ln(h_{s,t} + 1) \end{pmatrix} + \lambda_t \left(h_{c,t} + h_{s,t} - (\gamma_1 - 1) x_t + \gamma_2 x_t^2 \right) \tag{5}$$

The derivatives of this Lagrangian with respect to the control variables ($h_{c,t}$ and $h_{s,t}$) and Lagrange multipliers (λ_t) provide a set of necessary conditions for an optimum:[3]

$$\frac{dL}{dh_{c,t}} = \delta^t \left(a + bh_{c,t} - c\alpha\beta_1 h_{c,t}^{(\beta_1 - 1)} x_t^{\beta_2} \pm \frac{c\alpha h_{c,t}^{\beta_1} \beta_2 x_t^{(\beta_2 - 1)}}{\sqrt{(\gamma_1 - 1)^2 + 4\gamma_2 (h_{c,t} + h_{s,t})}} \right) + \lambda_t \doteq 0 \tag{6}$$

$$\frac{dL}{dh_{s,t}} = \delta^t \phi \left(\frac{1}{h_{s,t} + 1} \right) + \lambda_t \doteq 0 \tag{7}$$

$$\frac{dL}{d\lambda_t} = h_{c,t} + h_{s,t} - (\gamma_1 - 1) x_t + \gamma_2 x_t^2 \doteq 0 \tag{8}$$

The total net benefits of commercial and sport fishing are maximized when the marginal net benefits of commercial fishing are equated with the marginal net benefits of sportfishing.

3. An Empirical Model of Optimal Sport-Commercial Allocations in the Halibut Fishery

Allocation of catch among competing user-groups is a contentious and perennial issue; the oft-rancorous disputes can place paralyzing demands on management agency time. Under IFQs, voluntary market transactions replace the regulatory allocation process. While IFQs have been implemented in several commercial fisheries, IFQs have not yet been implemented in a US sport fishery. Issues related to the implementation of IFQs in commercial fisheries and the magnitude and distribution of benefits among initial IFQ recipients, subsequent purchasers of IFQ, processors, consumers, and regional economies remain controversial (NRC, 1999). In addition to raising many of the same implementation and distribution issues associated with commercial fishery IFQ programs, sport fishing IFQs raise issues related to the Public Trust.[4]

The halibut fishery off Alaska is the only US fishery with an IFQ-based commercial sector and a large sportfishing component.[5] Moreover, both fisheries are economically significant to the Pacific Northwest region. Gross exvessel revenue from commercial sales of halibut was $135 million in 2000 (Hiatt et al. 2001). Herrmann et al. (2001) estimate that over $19 million in compensating variation was generated by halibut sportfishing trips in Lower and Central Cook Inlet during 1997. Halibut are managed under the Halibut Convention of 1923, a bilateral agreement between the U.S. and Canada. The treaty established the International Fisheries Commission (now the International Pacific Halibut Commission), a scientific body with responsibility for conducting stock assessments and recommending conservation measures for halibut in the Pacific Northwest, Gulf of Alaska, Aleutian Islands, and Eastern Bering Sea. In 1976, the Commission's management authority was extended to the 200-mile fisheries conservation zones established pursuant to the US Fisheries Conservation and Management Act (FCMA) and equivalent Canadian legislation. Canadian and US halibut fishers were excluded from each other's territorial and extended jurisdiction waters in 1978. Although the IPHC retains authority to establish area specific harvest limits, each nation is individually responsible for allocating catches within its national and extended jurisdiction waters such that the sum of commercial, sport, and other removals does not exceed the IPHC catch limits.

Access to the commercial fishery was unrestricted prior to the passage of the FCMA. Immediately following implementation of the FCMA in 1976, the North Pacific Fisheries Management Council (Council) proposed a limited entry program. The proposal was shelved in late 1978 during negotiations over the US-Canada Halibut Convention. The Council next approved a 1-year moratorium on entry for 1982, but because the action was conditional on passage of an amended North Pacific Halibut Act and because the amended Act was not passed until after the start of the 1982 fishing season, no action was taken. In early 1983, the Council approved a 3-year moratorium, however the NOAA administrator disapproved the action and suggested that the Council instead investigate a permanent limited entry system. The Council began consideration of IFQs for the commercial fishery in 1988. The final rule creating halibut and sablefish IFQs was published in the Federal Register in 1993 and implemented in 1995 (Pautzke and Oliver, 1997).

The Council sets a Total Allowable Catch (TAC) limit for the commercial fishery by subtracting a bycatch allowance and expected non-commercial (sport and subsistence) catches from the annual IPHC catch limit.[6] Halibut bycatch mortality has been capped at about 18% of the IPHC catch limit in recent years. Subsistence and personal-use halibut catches are small (less than 0.2% of the IPHC catch limit). The share of halibut caught by sport fishers, particularly in the Central Gulf of Alaska Region (Area 3A: Prince William Sound, Resurrection Bay, Kodiak, Yakutat, Cook Inlet, and adjacent portions of the Gulf of Alaska), has increased from less than 2% of total removals in the late 1970's to over 18% in the 1990's (IPHC 1999, Howe et al. 1998). Even before implementation of IFQs, commercial fishers were concerned that unchecked expansion of the sport fishery would reduce commercial fishing opportunities, particularly in periods of declining halibut biomass. That concern increased substantially after IFQs were implemented. Not only do sportfishing catches reduce the quantity of fish available to individual commercial fishers in any given year and thus reduce commercial net revenues, expansion of sportfishing reduces the wealth of IFQ holders because the asset value of the IFQ is a function of the discounted stream of future profits and thus a function of current and expected future catches.

In response to the intensified allocation conflicts between commercial and sport interests, the Council approved establishment of a cap on charter-based sportfishing catches (NPFMC 2000). The cap, called a guideline harvest level (GHL), was set equal to the 1995-1999 average charter-based sportfishing harvest with provisions for a reduction in the GHL if stock biomass declines. Under the GHL, subsistence harvests and harvests by sport fishers who do not hire guide/charter services will continue to be deducted from the commercial TAC. If approved by the Secretary of Commerce, the GHL will be implemented in 2002. The Council regards the GHL as a stopgap measure because it fails to directly limit expansion of the charter fleet and because there is little confidence that traditional sport fishery management measures can effectively constrain catch. Consequently, in April 2001, the Council approved a fishery management plan to establish an IFQ program for the charter sector (NPFMC 2001). If approved by the Secretary of Commerce, the charter IFQ program will replace the GHL in 2003.

The following results are based on an empirically based deterministic discrete-time comparative static simulation-optimization of equations (1') and (2') derived in Criddle (2002). The results characterize the net economic benefits of the set of feasible sustainable commercial-sport allocations of halibut in Alaska. Considered independently, the sustainable net benefits of commercial and sport fishing can be represented by:

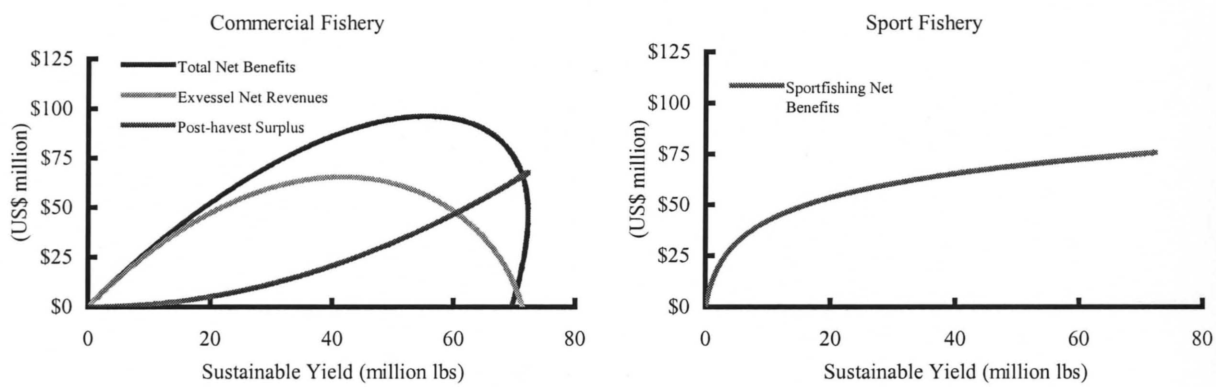

Figure 7. Sustainable exvessel net revenue, post-harvest surpluses, commercial net benefits, and angler net benefits.

Exvessel net revenues are maximized at a sustainable yield of 42 million lbs. and a corresponding biomass of 537 million lbs. The solution that maximizes the net benefits of commercial fishing is a sustainable yield of 54 million lbs at a biomass of 490 million lbs. The net benefit maximizing harvest level exceeds the level of harvests that maximizes exvessel net revenue because post-harvest surplus is strictly increasing in catch. That is, when benefits to the purchasers of halibut are treated on an equal footing with benefits to harvesters, the optimal harvest level differs from the level that would be optimal from the perspective of a sole-owner or a group of IFQ rights-holders who behave as though they were a sole-owner.

In a purely recreational fishery, the model suggests that angler surplus is maximized under a maximum sustainable yield management strategy. However, because marginal utility is a declining function of sport catches, the incremental net benefits of catches greater than about 20 million lbs. are quite small.

Independent optimization of commercial and sport fishing net benefits fails to provide a mechanism for partitioning the sustainable yield and fails to ensure welfare maximization because it does not equate the marginal net benefits of commercial and sport fishing. Following Criddle (2002), the feasible set of optimal sustainable commercial-sport allocations and net benefits can be represented by:

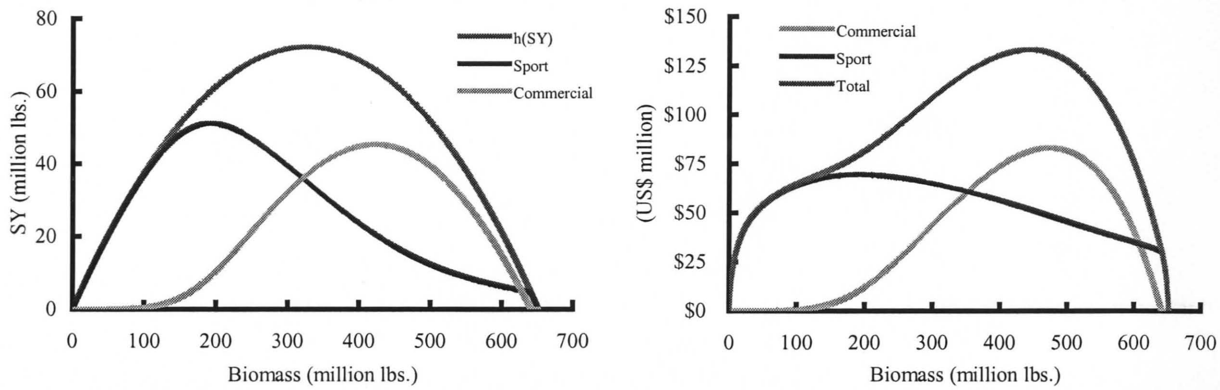

Figure 8. Optimal allocation of the sustainable yield and sustainable net benefits of halibut to sport commercial fisheries (Criddle 2002).

Because the marginal net benefits of sport fishing exceed the marginal net benefits of commercial fishing at low sustainable yields, most of the sustainable yield is initially allocated to the sport fishery.[7] As the quantity of fish allocated to the sport fishery increases, the marginal net benefit of additional sport fish catches declines. At intermediate levels of biomass, the marginal net benefits of commercial fishing exceed the marginal net benefits of additional allocations to the sport fishery and it is optimal to allocate an increasingly large share of the sustainable yield to the commercial fishery. At very high biomass levels, the sustainable yield is small and it is again optimal to allocate most of the sustainable yield to the sport fishery. The overall optimal solution is to manage for a biomass of 444 million lbs and to allocate 71% of the 63 million lbs sustainable yield to the commercial fishery, with the balance allocated to sportfishing. The overall optimal is solution provides $55.2 million in net revenue to commercial harvesters, $26.2 million in post-harvest surplus to the purchasers of commercial catches, and $51.9 million in angler surplus.

Because the social welfare maximizing solution is suboptimal with respect to the private net benefits that accrue to different stakeholders, the actual solution may closely reflect the preferences of the politically empowered. Table 1 reflects solutions that independently maximize exvessel net revenues, post-harvest surplus, the net benefits of commercial fishing, and angler surplus by allocating the entire sustainable yield to either the commercial or sport fishery. The maximum sustained yield and open access solutions are also represented.

Table 1.—Characteristics of alternative management regimes independently optimized for commercial or sport fishing.

	Open Access	Max(SY)	Max(NR_c)	Max(CS_c)	Max(NB_c)	Max(NB_s)
Biomass (million lbs.)	444.5	326.1	536.5	326.1	490	326.1
Commercial catch (million lbs.)	62.7	72.3	42.2	72.3	54.0	0
Sport catch (million lbs.)	0	0	0	0	0	72.3
Exvessel price ($)	$1.12	$1.42	$2.21	$1.42	$1.90	-
Commercial effort (million skates)	0.167	0.381	0.055	0.381	0.100	0
Exvessel net revenue ($ million)	0	-$41.9	$72.0	-$41.9	$64.4	0
Post-harvest surplus ($ million)	$51.1	$67.8	$23.1	$67.8	$37.9	0
Commercial net benefits ($ million)	$51.1	$25.9	$95.1	$25.9	$102.2	0
Angler surplus ($ million)	0	0	0	0	0	$75.7
Total net benefits ($ million)	$51.1	$25.9	$95.1	$25.9	$102.2	$75.7

The open access solution represents a fishery managed without consideration of benefits to commercial consumers or sport fishers and where the commercial fishers are unable to agree to behave like a sole owner. While the open access solution does not provide positive net revenue to commercial fishers or positive angler surplus to sport fishers, it provides substantial ($51 million) net benefits to the purchasers of commercially harvested fish. Post-harvest surplus is reduced under management regimes that maximize exvessel net revenues (sole-owner or fully efficient IFQ) or maximize the net benefits of commercial fishing. This result provides an explanation for why processors often oppose the implementation of rights-based fishery management programs. In a purely commercial fishery, maximization of the sustained yield generates $68 million in post-harvest surplus and results in net operating losses of $42 million for commercial fishers. Consequently, it is extremely unlikely that commercial fishers would voluntarily harvest the MSY. Angler surplus is maximized when commercial fishing is disallowed and catches approximate MSY. A sole owner of an exclusively commercial fishery would choose to harvest a sustainable yield of 42 million lbs, earning $72 million in exvessel net revenues and coincidentally providing $23 million in post-harvest surplus. If fishery managers were interested in maximizing the total net benefits of commercial fishing, they would set the TAC equal to 54 million lbs and implement regulations to induce commercial harvesters to behave like a sole owner. In so doing, the commercial fishery would generate total net benefits of $102 million comprised of $64 million in exvessel net revenue for harvesters and $38 million in post-harvest surplus.

The results reported Table 2 maximize net benefits to various stakeholders conditional on the optimal allocation of sustainable yields between the commercial and sport fisheries.

Table 2.—Characteristics of alternative management regimes jointly optimized for commercial and sport fishing.

	Max(SY)	Max(NR_c)	Max(CS_c)	Max(NB_c)	Max(NB_s)	Max(NB)
Biomass (million lbs.)	326.1	512.1	422.5	474.5	192.3	443.5
Commercial catch (million lbs.)	37.1	37.4	45.3	42.7	8.9	44.9
Sport catch (million lbs.)	35.2	11.4	20.6	14.6	51.2	18.0
Exvessel price ($)	$2.34	$2.33	$2.12	$2.19	$3.07	$2.13
Commercial effort (million skates)	0.136	0.066	0.117	0.089	0.048	0.107
Exvessel net revenue ($ million)	$34.9	$61.9	$51.7	$59.5	$9.2	$55.2
Post-harvest surplus ($ million)	$17.8	$18.1	$26.7	$23.6	$1.0	$26.2
Commercial net benefits ($ million)	$52.8	$80.0	$78.4	$83.1	$10.2	$81.4
Angler surplus ($ million)	$63.3	$44.3	$54.2	$48.5	$69.7	$51.9
Total net benefits ($ million)	$116.1	$124.3	$132.6	$131.6	$80.0	$133.3

It is notable that the overall optimal solution suboptimal from the myopic perspective of commercial harvesters, the purchasers of commercial harvests, and recreational anglers. From the perspective of commercial fishers, the solutions that maximize exvessel net revenues, commercial net benefits, and even post-harvest surplus are all preferred to the solution that maximizes overall net benefits. Similarly, sport fishers prefer solutions that maximize angler surplus, maximize sustainable yields, or maximize post-harvest surplus. Another important result presented in Table 2 is that consideration of the joint benefits of commercial and sport fishing provides larger overall net benefits than are generated when the goal of fishery management is solely motivated by an interest in maximizing net benefits to commercial or sport fishers alone (Table 1). The results also emphasize the importance of considering post-harvest surplus.

Because the solutions that maximize overall net benefits, maximize post-harvest surplus, or maximize the net benefits of commercial fishing produce similar levels of overall net benefits, there are multiple nearly equally efficient solutions with differing distributional consequences. Consequently, even if all of the stakeholders agree to abide by a solution that maximized net benefits across uses, they will probably contest specific allocation decisions if political-regulatory processes are used to effect the allocation.

Because changes in the demand or supply functions in the commercial fishery, changes in the willingness to pay or cost of participating in the sport fishery, and changes in ocean productivity affect the optimal sustainable yield and the optimal allocation of the optimal sustainable yield, any initially optimal allocation will be suboptimal in subsequent periods. Consequently, to maximize net benefits, allocations need to be revised whenever the economic or biological conditions change. When allocations are determined in a political process, interest groups have an incentive to overstate the marginal value of additional shares. An integrated commercial-sport IFQ management regime shifts the allocation decision from the management arena into the market place. However, the mere act of adopting an integrated commercial-sport IFQ regime will not by itself ensure that overall net benefits are maximized unless the rights are defined in a way that causes the value of post-harvest and angler surplus to be expressed in the market price for quota shares. Indeed, failure to account for post-harvest surplus could be considered to be the basis for the opposition by processors to harvester-only IFQ programs (Matulich et al. 1999, Matulich and Sever 1999, NRC 1999). Similarly, to the extent that restrictions on ownership and transfer of IFQs exclude interested parties, efficiency is squandered and political opposition is fomented. The challenge then is to devise a rights-based regime that will encourage expression of the full suite of use and nonuse values. While it is possible that elimination of ownership restrictions might be sufficient to eliminate the inefficiency of harvester-only rights in the simple case examined in this paper, it is unlikely that such a simple prescription will allow expression of other use and nonuse values.

4. Conclusions

In commercial fisheries, ownership by capture rules lead harvesters to dissipate net revenues and encourages uneconomic and biologically unsustainable harvest levels. In sport fisheries, the lack of effective limits on the number of sport fishers and magnitude of sportfishing catches has led to substantial reductions in the commercial TACs and may have reduced overall net benefits to society. Although theoretically possible, the knowledge and control needed to maximize overall net benefit through political-regulatory management regimes is overwhelming and such systems have consistently failed to sustain overall net economic benefits or the resource base on which they depend. When political muscle is the basis for allocating TAC among commercial, sport, and other users, the resultant allocations cannot be expected to maximize overall net economic benefits. The appeal of rights-based management systems lies in their potential to channel rational self-interest in a way that coincidentally maximizes overall net benefit. Because they exploit an alignment of individually rational actions and socially optimal outcomes, rights-based management is potentially self-regulating. If rights can be defined in a way that is meaningful across use and nonuse values and to the extent that all use and nonuse values can be fully captured, self-interest and transferability will encourage the movement of use rights to the use/nonuse that generates the greatest marginal net benefit, ensuring the maximization of overall net benefits.

With the apparent advantages of rights-based management systems, it seems reasonable to wonder why IFQs, Co-Ops, and TURFs have not been warmly embraced and uniformly adopted. The answer is that the creation and enforcement of rights is not costless and that the rights systems that have been proposed often exclude interested parties for owning rights, are not structured in a way that is capable of reflecting post-harvest surplus, angler surplus, or other use and non-use values, and do not eliminate the opportunity to freeride on the benefits (costs) of individual stewardship. Because it can be costly to change the legal and social institutions that have been developed to support current fishery management systems and because it can be costly to monitor and enforce quota shares or spatial use rights, especially when there are numerous rights-holders, rights-based management systems will be less prevalent than might otherwise be anticipated (Anderson and Hill 1975; Dennen 1976).

5. References:

Acheson, J. M. 1988. *The Lobster Gangs of Maine*. University Press of New England, Hanover NH.

Agnello, R. J., and L. P. Donnelley. 1975. Property Rights and Efficiency in the Oyster Industry. *Land Economics* 18:521-533.

Anderson, T. L., and P. J. Hill. 1975. The Evolution of Property Rights: A Study of the American West. *Journal of Law and Economics* 18:163-179.

Anderson, T. L., and P. J. Hill. 1990. The Race for Property Rights. *Journal of Law and Economics* 33:177-197.

Berkes, F. 1986. Local-Level Management and the Commons Problem: A Comparative Study of Turkish Coastal Fisheries. *Marine Policy* 10:215-229.

Berkes, F., editor. 1989. *Common Property Resources: Ecology and Community-Based Sustainable Development*. Bellhaven Press, London.

Bjørndal, T. 1988. The Optimal Management of North Sea Herring. *Journal of Environmental Economics and Management* 15:9-29.

Bromley, D. W., editor. 1992. *Making the Commons Work: Theory, Practice, and Policy*. Institute for Contemporary Studies, San Francisco CA.

Casey, K. E., C. M. Dewees, B. R. Turris, and J. E. Wilen. 1995. The Effects of Individual Vessel Quotas in the British Columbia Halibut Fishery. *Marine Resource Economics* 10:211-230.

Christy Jr., F. T. 1982. Territorial Use Rights in Marine Fisheries: Definitions and Conditions. FAO Fisheries Technical Paper 227: FIPP/T227. Food and Agriculture Organization, Rome, Italy.

Cook, B. A., and P. Copes. 1987. Optimal Levels for Canada's Pacific Halibut Catch. *Marine Resource Economics* 4:45-61.

Criddle, K. R. 1994. Economics of Resource Use: A Bioeconomic Analysis of the Pacific halibut Fishery. Pages 37-52 *in* D. Shaw, editor. *Proceedings of the Fourth International Symposium of the Conference of Asian and Pan-Pacific University Presidents*, University of Alaska Sea Grant College Program, Fairbanks AK.

Criddle, K. R. 2002. Finding Economic Incentives to Support Fisheries Sustainability. In, D. D. MacDonald and E. E. Knudson (editors), *Fisheries Sustainability*, American Fisheries Society.

Criddle, K. R., and A. Y. Streletski. 2000. Multiple Criterion Management of a Sequential Fishery. *Annals of Operations Research* 94: 259-273.

Criddle, K. R., and S. Macinko. 2000. A Requiem for the IFQ in US Fisheries? *Marine Policy* 24:461-469.

Criddle, K. R., M. Herrmann, and J. A. Greenberg. 2001. Territorial Use Rights: A Rights Based Approach to Spatial Management. Pages 573-590 *in* M. Dorn, S. Hills, G. Kruse, and D. Witherell, editors. *Proceedings of the International Symposium on Spatial Processes and the Management of Fish Populations*, Alaska Sea Grant College Program, Fairbanks AK.

Criddle, K. R. 1993. Optimal Control of Dynamic Multispecies Fisheries. Pages 609-628 *in* G. Kruse, D. M. Eggers, R. J. Marasco, C. Pautzke, and T. J. Quinn II (Editors), *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations*, University of Alaska Sea Grant College Program, Fairbanks AK.

Criddle, K. R. and A. M. Havenner. 1991 An Encompassing Approach to Modeling Fishery Dynamics. *Natural Resource Modeling* 5: 55-90.

Dennen, R. T. 1976. Cattlemen's Associations and Property Rights in Land in the American West. *Explorations in Economic History* 13:423-436.

Felthoven, R. 2001. Effects of the American Fisheries Act on harvesting capacity, capacity utilization, and technical efficiency of catcher-processors. Working paper. Alaska Fishery Science Center, National Marine Fisheries Service, Seattle WA.

Gauvin, J. R., J. M. Ward, and E. E. Burgess. 1994. Description and Evaluation of Wreckfish (*Polyprion americanus*) Fishery Under Individual Transferable Quotas. *Marine Resource Economics* 9:99-109.

Gonzalez, E. 1996. Territorial Use Rights in Chilean fisheries. *Marine Resource Economics* 11:211-218.

Gordon, H. S. 1953. An Economic Approach to the Optimum Utilization of Fishery Resources. *Journal of the Fisheries Research Board of Canada* 10:442-457.

Gordon, H. S. 1954. The Economic Theory of a Common Property Resource: The Fishery. *Journal of Political Economy* 62:124-142.

Hamel, C., M. Herrmann, S.T. Lee, K.R. Criddle, and H.T. Geier. 2002. Linking Sportfishing Trip Attributes, Participation Decisions, and Regional Economic Impacts in Lower and Central Cook Inlet, Alaska. *Annals of Regional* Science 36:xxx-xxx.

Hanna, S. 1998. Institutions for Marine Ecosystems: Economic Incentives and Fishery Management. *Ecological Applications* 8:23-32.

Hanna, S. and M. Munasinghe, editors. 1995a. *Property Rights in a Social and Ecological Context: Social and Ecological Issues.* The World Bank, Washington DC.

Hanna, S. and M. Munasinghe, editors. 1995b. *Property Rights in a Social and Ecological Context: Case Studies and Design Applications*. The World Bank, Washington DC.

Hannesson, R. 1983. Bioeconomic Production Function in Fisheries: Theoretical and Empirical Analysis. *Canadian Journal of Fisheries and Aquatic Sciences* 40:968-982.

Hannesson, R. 1993. *Bioeconomic Analysis of Fisheries*. Halstead Press, New York.

Herrmann, M. 1996. Estimating the Induced Price Increase for Canadian Pacific Halibut with the Introduction of the Individual Vessel Quota Program. *Canadian Journal of Agricultural Economics* 44:151-164.

Herrmann, M. 2000. The Individual Vessel Quota Price Induced Effects for Canadian Pacific Halibut: Before and After Alaska IFQs. *Canadian Journal of Agricultural Economics* 48:195-209.

Herrmann, M., S. T. Lee, C. Hamel, K. R. Criddle, H. T. Geier, J. A. Greenberg, and C. E. Lewis. 2001. An Economic Assessment of the Sport Fisheries for Halibut, and Chinook and Coho Salmon in Lower Cook Inlet: Final Report. University of Alaska Coastal Marine Institute/U.S. Mineral Management Service, Fairbanks AK.

Herrmann, M., S.T. Lee, K.R. Criddle, and C. Hamel. 2001. A Survey of Participants in the Lower and Central Cook Inlet Halibut and Salmon Sport Fisheries. *Alaska Fishery Research Bulletin* 8:xxx-xxx (forthcoming)

Hiatt, T., R. Felthoven, and J. Terry. 2001. Economic Status of the Groundfish Fisheries off Alaska, 2000. Appendix D in Status Assessment and Fishery Evaluation Report for the Groundfish Fisheries of the Gulf of Alaska and Bering Sea/Aleutian Islands Areas. Alaska Fishery Science Center, National Marine Fisheries Service, Seattle WA.

Homans, F. R. and J. E. Wilen. 1997. A Model of Regulated Open Access Resource Use. *Journal of Environmental Economics and Management* 32:1-21.

Howe, A. L., G. Fidler, C. Olnes, A. E. Bingham, and M. J. Mills. 1998. Harvest, Catch, and Participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-25, Anchorage AK.

International Pacific Halibut Commission (IPHC). 1999. Pacific Halibut Stock Assessment and Fishery Evaluation (SAFE). Appendix A in: Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. North Pacific Fisheries Management Council, Anchorage AK.

Johnson, R. N., and G. D. Libecap. 1982. Contracting Problems and Regulation: The Case of the Fishery. *American Economic Review* 72:1005-1022.

Keen, E. A. 1983. Common Property in Fisheries: Is Sole Ownership an Option? *Marine Policy* 7:197-211.

Knapp, G. 1996. Thalassorama: Alaska Halibut Captain's Attitudes Towards IFQ's. *Marine Resource Economics* 11:43-56.

Larkin, S., and G. Sylvia. 1999. Intrinsic Fish Characteristics and Intraseason Production Efficiency: A Management Level Bioeconomic Analysis of a Commercial Fishery. *American Journal of Agricultural Economics* 81:29-43.

Libecap, G. D. 1989. *Contracting for Property Rights*. Cambridge University Press, New York.

Macgillivray, P. 1996. Canadian Experience with Individual Fishing Quotas. In, Daniel V. Gordon and Gordon R. Munro, editors, *Fisheries and Uncertainty: A Precautionary Approach to Resource Management*. University of Calgary Press, Calgary, Canada.

Macinko, S. 1993. Public or Private? United States Commercial Fisheries Management and the Public Trust Doctrine, Reciprocal Challenges. *Natural Resources Journal* 32:919-955.

Matulich, S. C., and M. Sever. 1999. Reconsidering the Initial Allocation of ITQs: The Search for a Pareto Safe Allocation Between Fishers and Processors. *Land Economics* 75:203-219.

Matulich, S. C., R. C. Mittelhammer, and C. Reberte. 1996. Toward a more Complete Model of Individual Transferable Fishing Quotas: Implications of Incorporating the Processing Sector. *Journal of Environmental Economics and Management* 31:112-128.

Matulich, S. C., M. Sever, and F. Inaba. 2001. American Fisheries Act Cooperative Rationalization. *Marine Resource Economics* 16:1-16.

McCay, B. J. 1998. *Oyster Wars and the Public Trust: Property, Law, and Ecology in New Jersey History*. University of Arizona Press, Tucson AZ.

McCay, B. J., and J. M. Acheson, editors. 1987. *The Question of the Commons: The Culture and Ecology of Communal Resources*. University of Arizona Press, Tucson Az.

Merritt, M. A. and K. R. Criddle. 1993. Multiple criterion decision theory for judging management strategies and resolving conflict: a case study of the Kenai River recreational fisheries. Pages 683-704 *in* G. Kruse, D. M. Eggers, R. J. Marasco, C. Pautzke, and T. J. Quinn II, editors, *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations*, Alaska Sea Grant College Program, Fairbanks AK.

Moloney, D. G., and P. H. Pearse. 1979. Quantitative Rights as an Instrument for Regulating Commercial Fisheries. *Journal of the Fisheries Research Board of Canada* 36:859-866.

Morey, E. R. 1980. Fishery Economics: An Introduction and Review. *Natural Resources Journal* 20:827-851.

Muse, B., and K. Schelle. 1989. Individual Fisherman's Quotas: A Preliminary Review of Some Recent Programs. CFEC 89-1, Alaska Commercial Fisheries Entry Commission, Juneau AK.

National Research Council Committee to Review Individual Fishing Quotas (NRC). 1999. *Sharing the Fish: Toward a National Policy on Individual Fishing Quotas*. National Academy Press.

North Pacific Fishery Management Council (NPFMC). 2000. Draft environmental assessment/regulatory impact review/initial regulatory flexibility analysis for a regulatory amendment to implement management measures under a guideline harvest level and/or moratorium for halibut in areas 2C and 3A. North Pacific Fishery Management Council, Anchorage AK.

North Pacific Fishery Management Council (NPFMC). 2001. Draft environmental assessment/regulatory impact review/initial regulatory flexibility analysis for a regulatory amendment to incorporate the charter sector into the commercial individual fishing quota program for Pacific halibut in Areas 2C and 3A. North Pacific Fishery Management Council, Anchorage AK.

Olson, M. 1965. *The Logic of Collective Action*. Harvard University Press, Boston MA.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, Cambridge U.K.

Ostrom, E., R. Gardner, and J. Walker. 1994. *Rules, Games, and Common-Pool Resources*. University of Michigan Press, Ann Arbor MI.

Pautzke, C. G., and C. W. Oliver. 1997. Development of the Individual Fishing Quota Program for Sablefish and Halibut Longline Fisheries off Alaska. North Pacific Fisheries Management Council, Anchorage AK

Pearse, P. H. 1980. Property Rights and the Regulation of Commercial Fisheries. *Journal of Business Administration* 11:185-209.

Pearse, P. H., and J. E. Wilen. 1979. Impact of Canada's Pacific Salmon Fleet Control Program. *Journal of the Fisheries Research Board of Canada* 36:764-769.

Schellberg, T. 1993. The Problem on Nonmalleable Capital Revisited: A Study of the Pacific Halibut Fishery. *Natural Resource Modeling* 7:245-277.

Schlager, E., and E. Ostrom. 1992. Property Rights Regimes and Natural Resources: A Conceptual Analysis. *Land Economics* 68: 249-262.

Scott, A. D. 1955. The Fishery: The Objectives of Sole Ownership. *Journal of Political Economy* 63:116-124.

Scott, A. D. 1988. Development of Property in the Fishery. *Marine Resource Economics* 5 289-311.

Seijo, J. C. 1993. Individual Transferable Grounds in a Community Managed Artisinal Fishery. *Marine Policy* 18:78-81.

Stevenson, G. G. 1991. *Common Property Economics: A General Theory and Land Use Applications*. Cambridge University Press, New York.

Stollery, K. R. 1986. A Short-Run Model of Capital Stuffing in the Pacific Halibut Fishery. *Marine Resource Economics* 3:137-154.

Townsend, R. E. 1995. Fisheries Self-Governance: Corporate or Cooperative Structures? *Marine Policy* 19:39-45.

Townsend, R. E. 1997. Corporate Management of Fisheries. Pages 195-202 *in* J. Boreman, B. S. Nakashima, J. A. Wilson, and R. L. Kendall, editors. *Northwest Atlantic Groundfish: Perspectives on a Fishery Collapse*. American Fisheries Society, Bethesda MD.

Wang, S. D. 1995. The Surf Clam ITQ Management: An Evaluation. *Marine Resource Economics* 10:93-98.

Wilen, J. E. 1979. Fisherman Behavior and the Design of Efficient Fisheries Regulation Programs. *Journal of the Fisheries Research Board of Canada* 36:855-858.

Wilen, J. E. 1985. Towards a Theory of the Regulated Fishery. *Marine Resource Economics* 1:369-388.

Wilen, J. E., and F. R. Homans. 1998. What do Regulators do? Dynamic Behavior of Resource Managers in the North Pacific Halibut Fishery. *Ecological Economics* 24:289-298.

Endnotes:

[1] The type of sport fishery that will be modeled is one in which anglers hire the services of a vessel and vessel operator for a single trip (8-hour) with a single target species. The vessel operator provides all of the required fishing gear, selects the fishing location, provides recommendations with respect to angling technique, and provides ancillary services related to landing and processing of catch. Providers of these types of sport fishing services are variously described as "charter-" or "head-boat" operators, or sportfishing "guides."

[2] This assumption could be relaxed to allow constant levels of bycatch, subsistence catches, and unguided sportfishing catches by specifying that the commercial and charter-based sport fisheries are allocated αOSY where $0 \leq \alpha \leq 1$.

[3] See e.g., Clark (1976, 1985); Hannesson (1983, 1993); Bjørndal (1988); Criddle (1993).

---

[4] The legal definition of property rights in the United States and many other nations is based on Roman civil law. Under Roman law, certain waters, the lands beneath those waters, and the living resources within those waters were considered to be common property outside private ownership but subject to acquisition through capture. Because the public's usufruct was established in law, the State was considered to have a trusteeship responsibility for common property resources. Common law in the various US states is a derivative of Roman common law and has been interpreted to recognize a similar set of rights and responsibilities with respect to common property resources. This body of common law has come to be referred to as the Public Trust Doctrine. In *Illinois Central R.R. Co. v. Illinois*, 146 U.S. (1892), a landmark application of the Public Trust Doctrine, the U.S. Supreme Court found that:

> *"The State can no more abdicate its trust over property in which the whole people are interested, like navigable waters and the soils under them, so as to leave them entirely under the use and control of private parties than it can abdicate its police powers in the administration of government and the preservation of the peace."*

Because public trust resources are held on behalf of the citizens, the State may be precluded from transferring comprehensive ownership rights to individuals. In general, conveyance of public trust resources to private ownership is a usufruct that does not terminate the State's right to capital or right to manage the resource. Consequently, when a right to harvest fishery resources is conveyed to individuals, the State continues to have responsibility for safeguarding the sustainability of those resources. The Endangered Species Act (ESA), the FCMA, and international treaties reinforce the stewardship responsibilities implicit in the Public Trust Doctrine. McCay (1998) provides an extensive discussion of the application of the Public Trust Doctrine to US fisheries. Macinko (1993) examines the relationship between the Public Trust Doctrine and IFQs. Although the legality of privatizing charter-based recreational fishing has not yet been established, there may be precedence in the regulation and licensing of guided hunting opportunities.

Another option that could be useful in some sport fisheries would be to adopt an annual lottery based allocation such as that used for many big-game hunting opportunities. Because every applicant has an equal probability of receiving a permit and because the number of permits is set to avoid overexploitation of the stock, a lottery would be unlikely to conflict with interpretations of the Public Trust doctrine. If lottery winners are permitted to auction their permits, individuals who place the greatest value in sportfishing for a particular species at a specific location will be able to obtain permits. Equity concerns are at least partially satisfied by the fact that every applicant has an equal opportunity of being drawn and that permit sales are voluntary.

[5] IFQs are being considered for use in other US commercial fisheries where there is also a substantial sport fishery, e.g., Gulf of Mexico red snapper. Although the State managed lake trout and yellow perch resources in Wisconsin's portions of Lake Superior and Green Bay in Lake Michigan are subject to high levels of sportfishing and include IFQ-based commercial fisheries (Muse and Schelle, 1989), the commercial sector is very small and may not provide a good example of the interaction that can be expected between an IFQ-based commercial fishery and a competing sport fishery.

[6] Bycatches are the incidental catches of halibut in non-target fisheries that arise from the imperfect selectivity of the harvest technology. In order to preclude surreptitious targeting, all bycatches of halibut must be discarded unless taken with hook and line gear by individuals with permits to retain halibut. The sablefish fishery is an IFQ-based hook and line fishery. Many fishers hold IFQ for both species and can consequently retain bycatches up to the limit of their quota share.

[7] It is important to acknowledge that while this result is probably reasonable at high levels of biomass, the data available for estimating angler surplus did not allow for estimation of the relationship between average trip costs and halibut abundance. Because it is likely that the cost of catching a halibut increase as population size declines, marginal angler surplus is probably overstated at low abundance levels.

Economic Research Institute Study Paper

ERI #2002-04

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

by

KEITH R. CRIDDLE

Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530

February 2002

PROPERTY RIGHTS AND THE MANAGEMENT OF MULTIPLE USE FISHERIES

Keith R. Criddle, Professor

Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530

Information on other titles in this series may be obtained from: Department of Economics, Utah State University, 3530 Old Main Hill, Logan, Utah 84322-3530.

PROPERTY RIGHTS AND THE MANAGEMENT OF

MULTIPLE USE FISHERIES

Keith R. Criddle

ABSTRACT

Arguments in favor of adopting rights-based management strategies have been developed primarily in the context of commercial fisheries and have focused on increasing the profitability of catcher vessel operations and reducing the incentive to deplete fish stocks. Relatively little attention has been given to the effects that alternative management regimes could have on the profitability of processing and support service businesses, consumer surplus, or to the interface between commercial fishing, sport fishing, and other use and nonuse demands for fishery resources. Although there is often congruence among users with respect to stock management and rule enforcement objectives, other objectives are mutually incompatible. This paper begins with a simple conceptual analysis of the effects of alternative regimes for management of a charter-based recreational fishery on the magnitude of net benefits in the sport fishery and in an associated commercial fishery. A theoretical framework for identifying the optimal commercial-sport allocation and the optimal sustainable yield is developed in the subsequent section. The final section reports the results of an empirically based comparative static simulation of commercial and charter-based sport fishing for halibut off Alaska.