Defining and Designing Property Rights in Marine Fisheries

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Executive summary

Many of the world's fisheries are in a state of ecological collapse, and stock levels are projected to continue to decline (Worm et al, 2006). There is a growing consensus in the scientific community that management of the world's fisheries has failed (e.g., Arnason, et al, 2008; Hilborn, 2007; Melnychuk et al, 2011). Economists have long advocated a property rights-based approach to managing common pool resources such as fisheries (Gordon, 1954), but there is often resistance to rights-based management due to distributional concerns. Catch shares, the most common form of fisheries property rights, have been introduced in a variety of fisheries around the world, and evidence suggests that catch shares can have positive ecological as well as economic effects (e.g. Grafton, Squires and Fox, 2000; Costello, Gaines and Lynham, 2008). But while there has been an increase in the number of fisheries managed by catch shares, there has been significant variation in the structure of these programs, and policymakers face an array of choices in the design of these institutions. This paper provides an overview of the design of property rights in fisheries and discusses the efficiency and distributional implications of alternative design choices.

Introduction

There is compelling evidence and a legitimate concern that many of the world's fisheries are collapsing (Worm et al, 2006). Advances in fishing technology coupled with increasing demand for fish due to population and income growth have led to overexploitation of many marine fish stocks. There is a growing consensus in the scientific community that management of the world's fisheries has failed (e.g. Hilborn, 2007; Melnychuk et al, 2011). In many fisheries, there are too many boats racing to harvest an increasingly scarce resource. This is harmful for the resource, and it also represents a significant economic loss due to poor management (Arnason, Kelleher, and Willmann, 2008). In cases where the harvest can be controlled through traditional command-and-control regulations (such as limited entry and an overall harvest quota), the "race for fish" in most cases has led to a dissipation of economic returns. And in many fisheries, overexploitation is pushing stock levels toward collapse. Natural resource economists have long advocated the introduction of property rights in fisheries as a solution to the common pool resource problem, yet there is often significant resistance to market-based management of fish stocks because of concerns about who would win or lose in the transition to new management. This paper discusses equity-efficiency tradeoffs of alternative designs of catch share programs in the United States.[1]

Catch shares, which give individuals the right to a share of the overall harvest, are the most common form of property rights-based management. The most basic form of a catch share gives the holder the right to harvest a given proportion during a season. Depending on how the catch-share right is defined, that share can generally be transferred permanently or leased annually to another fisherman. In practice, there are often restrictions imposed on the catch share as an asset, and these restrictions can change economic incentives and lower the value of these assets.

The design features of these property rights-based management systems can be categorized in many ways. Arnason (2012) discusses four main characteristics of a catch share as a property right: exclusivity, security, durability, and transferability. Exclusivity is the ability of the holder to use his property and exclude others from infringing upon his rights. Security refers to the protection of property rights against illegal harvest or government takings. Durability refers to the duration of the property right, with longer horizons leading to greater durability. Finally, the transferability of the right is the ability of the owner to lease or sell the right. These four characteristics together can be used to define a catch share program.[2]

When considering a change to a catch shares system, a regulator faces many decisions in determining how a catch share right will be defined. While the main characteristics of a catch share may remain, a regulator could impose restrictions on sales, leases or consolidation; allocate to other sectors, communities or groups; define so-called "sunset provisions", where a right may expire; bundle the asset to vessels or other capital; or otherwise limit the rights of a shareholder. Each of these choices is meant to achieve some distributional goal, but there could be some efficiency costs of these restrictions.

While catch shares may represent a significant improvement over the status quo, there are other approaches that may be more appropriate or desirable in some cases. The focus of the analysis and literature review is individual

[1] For another recent paper that discusses the economics of design restrictions, see Kroetz and Sanchirico (2010). Their paper also provides an excellent overview of design restrictions in other catch share fisheries worldwide.

[2] Arnason uses these four characteristics to construct a "Q-value", a measure of the quality of a property right.

transferable quotas (ITQs), but there are other types of rights-based management that have been well-studied. Spatial property rights, such as territorial user rights in fisheries (TURFs), have been successfully implemented in several instances. And cooperatives, which create incentives for individuals to operate as a single firm, will be briefly discussed.[3]

This paper discusses the economics of defining and designing property rights-based management programs in marine fisheries. It also summarizes the equity/efficiency tradeoffs inherent in designing these property rights. I begin with a brief background on fisheries managed by catch shares. I then discuss the various design considerations, and when possible, use the economics literature to highlight the potential efficiency costs of restrictions in the catch share program. I then discuss, through several examples, how managers may design a catch share program to balance competing goals.

The economics of ITQs

In an introduction to the design of property rights in fisheries, the most common form of fisheries property right will be discussed: the Individual Transferable Quota (ITQ).[4] The first step in designing an ITQ system involves first setting an overall quota (the Total Allowable Catch, or TAC) for the fishing season. Which areas and sectors are covered by the overall quota depends on the specific application. In principle, the TAC could cover multiple sectors, vessels, gear types, or management areas, but the simplest form of ITQ generally involves setting an area-specific TAC for a single commercial sector.

The second step, and often the most controversial, involves allocating shares of the TAC harvest rights to individuals. Catch shares can be allocated to individual fishermen based on historical harvests, by auctioning the rights, or by some other method. The initial allocation is a critical component of any catch share program because it largely determines the distribution of profits among individual fishermen. The allocation will be discussed in the next section. For now, we will gloss over this step and proceed under the assumption that the harvest rights have been allocated to some set of individuals.

Under this system, each individual owns the right to harvest his or her share of the overall quota. This share could be defined in terms of pounds or as a percentage of the overall harvest. Because environmental conditions may change, it may be desirable to allow for changes in the TAC from one year to next, and a right defined by a percentage of the TAC may be preferable.

Once the shares are defined, an ITQ system allows individuals to buy or sell their shares of the overall TAC. The most flexible forms of ITQ management also allow for leases on an annual basis.

When catch shares can be freely traded among fishermen, the market cost of quota shares should reflect the profitability of harvest. Put simply, the market allows quota shares to move from high-cost individuals to low-cost individuals. High-cost fishermen gain from selling some of their allocation because the market price exceeds how much they could earn from exercising their right and harvesting their share. Similarly, a low-cost individual gains from purchasing more allocation because at the margin an extra pound of harvest earns him more than the cost of purchasing additional quota shares.

In the market equilibrium, each fisherman has no incentive to buy or sell more allocation, and marginal profits are equated across individuals. That is, the next pound of harvest for each fishermen (in theory) would have the same value at the equilibrium harvest level. This fundamental result means that the overall costs of harvesting the TAC are minimized under an ITQ system.

There are some important lessons from the economics literature regarding ITQs. First, catch shares increase efficiency by allowing fishermen to buy and sell shares of the overall harvest. This allows the harvest rights (at the margin) to move to the most efficient fisherman. Flexibility to buy and sell allocation under this program leads to a cost-effective harvest, regardless of the initial allocation. Fishermen with the lowest marginal extraction costs are those who will harvest the most. Second, individuals who exit the fishery (or who sell some allocation to others) do so voluntarily and at the market's valuation. If an individual chooses *not* to sell his allocation, he can continue operating in the fishery. However, if the market price of quota is high enough, individuals have a great incentive to sell their quota shares as the opportunity cost of holding a share can be high. Thus consolidation may occur under ITQs, but this leads to an increase in overall efficiency in the fishery. Moreover, under this system trades are entered into voluntarily through the market for allocation.

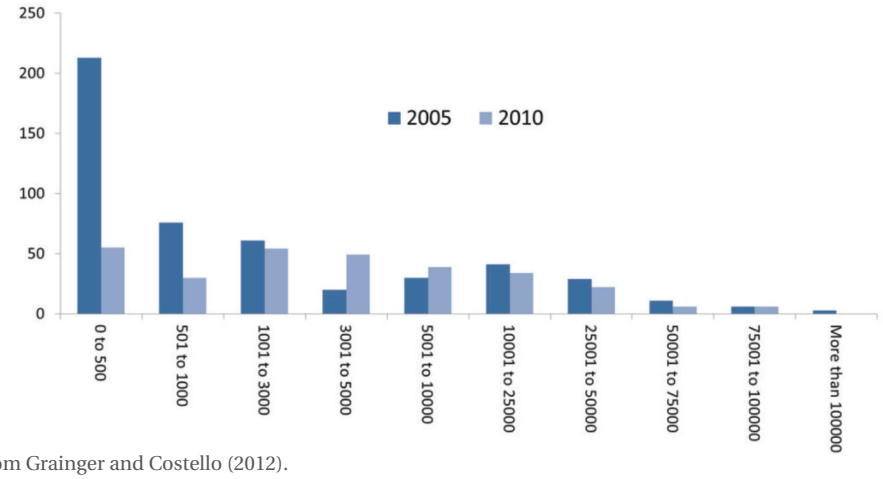
ITQ shares are generally defined as perpetual rights to fish, so the asset's value would be determined by how profitable an *annual* share is. The value of a pound of allocation would be equal to the expected present value of the stream of income generated by owning that asset. Indeed, in a well-functioning ITQ system like New Zealand, the implied discount rate in these markets has been roughly 8–10% (see for example Newell, Sanchirico and Kerr, 2005).

[3] See Wilen, et al (2012) for an overview of the economics of TURFS, and Deacon (2012) for a nice overview of cooperatives as a management tool in fisheries.

[4] A simple mathematical model of an ITQ fishery is shown in Appendix B.

FIGURE 1

Harvest distribution pre- and post-ITQ in red snapper fishery



Notes: Figure is taken from Grainger and Costello (2012).

Design restrictions and ITQs

In practice, the design of catch shares often strays somewhat from the simple ITQ system described above. Concerns about potential adverse distributional consequences often dominate the policy debate surrounding management change in fisheries, and the debate is often particularly heated when catch shares are discussed. This section provides an overview of the types of distributional concerns that are generally raised, how managers may choose to address some concerns, and how design restrictions may affect the efficiency of a catch share program. One key insight is that many of the distributional concerns that arise could be dealt with within the catch shares program design, but introducing restrictions on the property right could be costly in terms of efficiency. The inevitable question facing resource managers is how much efficiency they are willing to sacrifice in order to achieve other distributional goals.

Perhaps the most common concern regarding catch shares is the impact on coastal communities. Many small fishing communities have an intimate connection to their fisheries, with many residents either directly employed in fishing or a related industry. There is often a concern that moving to a market-based management program will lead to consolidation and a loss of jobs in that sector. While real incomes in most US fisheries are low for the majority of fishermen, residents may place a high value the cultural significance of the fishery in coastal communities.

A second type of concern regards equity across individuals or groups of fishermen. In the introduction of catch share programs, there is invariably some group that would benefit from an alternative allocation scheme. The initial allocation in a catch share system may be viewed as unfair to some individuals or groups. These concerns could be motivated by concerns of fairness within the current fishing community or concerns about the costs that a catch share system would impose on future entrants into the fishery.[5]

A third main type of distributional concern is between sectors. For example, processers may be concerned about an allocation system that gives rights exclusively to harvesters. Similarly, there are often tensions between gear sectors or between commercial and recreational interests. Most of the distributional concerns can be dealt with by altering the catch share program, either through changes in the method of allocating the initial rights, or through placing restrictions on how the catch share program operates. This section discusses the main ways that a catch share could raise distributional concerns as well as how the program could be altered to address those concerns.

Allocation and distribution

In theory, the initial allocation of quota shares in an ITQ program could take place in many possible ways, but in practice there are a few methods that have historically dominated the debate. These are free allocation ("grandfathering"), auctioning the rights, or some combination of the two.

Free allocation has been the default method of allocating quota shares in new ITQ programs in the United States. The eligibility for quota is generally determined by an individual fisherman's harvests during some historical period.[6] Choos-

[5] These intergenerational concerns could also be framed in terms of the impact of current management on the state of the future resource.

[6] To prevent inducing a new "race for allocation", it is inadvisable to choose a *future* period for this process.

ing the eligibility window is difficult, but once chosen, the rights are generally proportional to harvests during that period. For example, if an individual harvested 1% of the overall catch in during the allocation period, he would be granted 1% of the harvest rights under an ITQ program. Unsurprisingly, the baseline allocation period is a contentious choice, as each individual would prefer a period when their harvest levels were highest in order to maximize their own allocation under ITQs.

Auctioning is often proposed by economists, but in practice auctions are rarely used for allocating quota shares due to political opposition. Freely grandfathered allocation represents a transfer of rents to fishermen receiving an allocation of shares, so most fishermen would oppose any mechanism forcing them to pay for the right to harvest. Some have argued that grandfathering has efficiency effects as well (Anderson, Arnason and Libecap, 2011), though empirical evidence is lacking due to a lack of auctions in fisheries.

Importantly, there is often significant heterogeneity in harvest prior to the adoption of catch shares. Even after catch share management is implemented, there can be substantial variation in harvest. Figure 1 below shows the distribution of harvest by individuals pre- and post-ITQ in the Gulf of Mexico Red Snapper Fishery.

In addition to allocating to individuals, some fisheries (in particular in Alaska) have also included a Community Development Quota (CDQ) in the allocation process. In that case, some quota shares can be allocated to communities to ensure the long-run viability of the fishing sector. Restricting the tradability of shares across communities or individuals may have efficiency costs, but depending on the distributional goals of the program, community-based allocations may be an attractive policy option.

Consolidation caps

Concerns about consolidation are prevalent in the discussion about catch shares. While some cite maintaining a viable fishing community as the main reason, others have raised concerns about market power arising due to consolidation. One way to address concerns about consolidation is to simply put a cap on the amount of quota allocation that can be owned by an individual or firm.

In practice, there is a wide range in the use of consolidation caps. For example, the Red Snapper fishery in the Gulf of Mexico has a consolidation cap equal to the maximum percentage issued to a recipient at the time of the initial allocation. This prevents the 'largest' harvester (proportionally to the TAC) from becoming any larger under ITQ management. In the Alaskan Halibut fishery, the restriction is approximately 0.5-1.5% of the overall quota, while New Zealand stocks managed by ITQs have consolidation caps of up to 45% (Bonzon, et al, 2010).

The economics literature does not generally support the use of consolidation caps due to concerns about market power, as the evidence suggests that market conditions are not usually conducive to monopolistic behavior in fisheries. Anderson (2008) addresses the possibility of market power by demonstrating the conditions under which monopolistic behavior could arise;[7] in most circumstances, consolidation caps are not necessary to prevent market power in fisheries, though these caps could address equity concerns. Concerns about other distributional concerns, such as maintaining fishing communities or some notion of equity, though, need to be analyzed on a case-by-case basis to determine the inherent tradeoffs in such choices.

Ex ante analyses generally predict that consolidation would be a major driver of the cost savings of catch share management (e.g., Lian et al, 2010; Weninger, 2008; Weninger and Waters, 2003). These studies predict that the implementation of catch shares would lead to fewer inefficient vessels, and *ex post* studies of the effects of catch shares also find significant cost savings due to consolidation (e.g., Grafton, Squires and Fox, 2000).

Without a cap on consolidation, the market price of quota shares determines the distribution of harvest. High-cost individuals in an ITQ fishery have an incentive to sell to fishermen with low harvest costs. Once a consolidation cap is introduced, the individuals with the highest harvest may be forced to harvest less, which shifts their excess harvest rights to fishermen with higher costs. That is, preventing the lowest-cost fishermen from harvesting more can only lead to higher overall costs for harvesting the TAC. This increase in costs moves the fishery away from the cost-effective harvest, and it leads to a reduction in the overall value of the fishery.[8]

Banking, borrowing and deemed value

ITQs give the holder the right to harvest his or her share of the overall quota each year. The system could be designed so that individuals who harvest more than their allotted allocation in one year can deduct that overage from the following year's allocation. Similarly, individuals that underharvests this year could increase their allowance for next year by the difference between this year's harvest and allocation.

Banking and borrowing in catch share programs could be allowed in order to add flexibility to the system, but while such "carry-forward" or "carry-back" provisions have been

[7] A more general model of market power in cap-and-trade programs is in Hahn (1984).

[8] A simple example in the context of a mathematical model is shown in Appendix C.

used in other countries (Kroetz and Sanchirico, 2010), they are uncommon in the United States.[9]

A related innovation is New Zealand's "deemed value" policy. If an individual's harvest exceeds his annual allocation, he can pay the "deemed value" for the overage. This amounts to a fine or tax, and if not set properly, the incentives can change. For example, if the deemed value is set too low, an individual may decide to target that species even if he does not own quota because it could be profitable with a low per-kilogram fine. Similarly, if the deemed value per-kilogram is set too high, an individual who is at risk of exceeding his allocation could have the incentive to discard fish at sea. When implemented properly, a deemed value policy does not incentivize overharvesting or discarding caught fish.

Sunset provisions

In the United States, some concern surrounding catch shares is the notion that a public natural resource is being given (or sold) to individuals permanently. In response to this concern, some councils have considered so-called sunset provisions. A sunset provision effectively makes the catch share right into a temporary right with an expiration date (or a renewal date).

Some concern has been raised among resource economists regarding limiting the tenure of such property rights-based systems. For example, catch share program with a sunset provision are believed to take away the incentives for long-run stewardship of the resource (e.g., Costello and Kaffine, 2008).

These concerns are grounded in real-world definitions of these rights. In the United States, ITQ shares are explicitly not considered property. Quota shares "shall be considered a permit"; "may be revoked, limited, or modified at any time"; "shall not confer any right of compensation to the holder...if it is revoked, limited, or modified"; "shall not create, or be construed to create, any right, title, or interest in or to any fish before the fish is harvested by the holder"; and "shall be considered a grant of permission to the holder of the quota share to engage in activities permitted by such...quota share."[10]

The New Zealand quota management system differs in many ways from the catch share programs in the United States, but perhaps the most striking is the nature of the property right. In New Zealand, quota shares are explicitly considered property, and quota owners can easily use their holdings as collateral in obtaining credit. Another striking difference is the relative availability of information about the quota markets. Trades are brokered through a central clearinghouse that tracks prices, in contrast to the decentralized (and nontransparent) quota markets in the United States. In a working paper, Grainger and Costello (2011) study the effects of insecure property rights on ITQ asset prices. They examine fisheries in New Zealand, the United States, and Canada, and they test whether a fishery's property rights security affects its lease-to-sales price ratio (i.e., the dividend price ratio). They provide evidence that the resolution of a high-profile dispute in New Zealand led to an increase in asset values and that fisheries in countries with stronger property rights had higher asset values than comparable fisheries in countries with weaker property rights.

Regarding investment incentives, the impact of a sunset provision is immediate. If an asset can be taken away at some point in the future, the willingness to pay to hold that asset should decrease. But perhaps more importantly, if long-run ownership of the asset is in question, individuals could have a greater incentive to lobby for a higher TAC now, regardless of what the longer-run consequences are for the resource.

Restrictions on trades/leases

Several concerns arise that have led to restrictions on permanent trades or leases. One concern is that quota shares will act as an investment vehicle, where a distant investor purchases a quota and leases it back to fishermen in the community. A second concern is that a lack of information (or asymmetric information) among fishermen will allow some fishermen to sell their quota shares at below-market prices.

These concerns can be dealt with by outlawing leasing or requiring that asset owners also operate the vessel. Other restrictions of this type include an all-out ban on trades or only allowing the transfer of a portion of the catch share. The literature on this type of restriction in ITQ markets is thin, but any decrease in flexibility regarding the asset could decrease the share's value.

To my knowledge, the academic literature on this topic is thin. The Pacific groundfish fishery placed a two-year moratorium on transfers in order to allow price discovery among its participants. After the initial two year phase-in, shareowners will be allowed to freely transfer their quota shares.

Environmental participation clauses

A common concern regarding the introduction of market-based management programs is the possibility for non-use groups to participate in the market. This participation could take the form of an environmental organization purchasing pollution rights in a cap-and-trade program; an environmental organization buying catch shares and retiring them in an ITQ program; or an outside investor purchasing a catch share right and leasing back that right to individual fishermen.

Economists would generally favor flexibility in market-based programs such as ITQ fisheries, as it allows people

[9] An excellent review of the literature on banking and borrowing in cap-and-trade markets can be found in Fell and Morgenstern, 2009.

[10] 16 U.S.C. 1801, 1996. Also quoted in Grainger and Costello, 2011.

TABLE 1

Design features of current U.S. catch share fisheries

Fishery	Program reevaluation	3rd party harvest	Consolidation cap	Transfer restrictions	Owner/lessee restrictions	Nonuse clause
Delaware Commercial Black Sea Bass	X	X		X	X	
Maryland Black Sea Bass	X	X		X	X	
Maryland Striped Bass Pound Net	X			X	X	
Maryland Summer Flounder	X			X	X	
Pacific Coast Groundfish Limited Entry Trawl		X		X		
US Alaska Fixed-gear Commercial Halibut and Sablefish	X	X	X		X	
US Atlantic Sea Scallop			X		X	
US Atlantic Surf clam and Ocean Quahog	X			X	X	
US Bering Sea Aleutian Island Crab (King and Tanner)		X	X	X	X	
US Gulf of Mexico and South Atlantic Spiny Lobster Trap		X				
US Gulf of Mexico Commercial Grouper and Tilefish		X	X	X	X	
US Gulf of Mexico Commercial Red Snapper	X	X	X	X	X	
US Mid-Atlantic Golden Tilefish	X	X	X		X	
US South Atlantic Wreckfish		X	X		X	X
Virginia Black Sea Bass			X	X		
Virginia Commercial Striped Bass (Rockfish)	X		X	X	X	

(fishermen included) to participate in the market according to their marginal willingness to pay. In the example of an environmental organization participating, catch share management allows those groups to participate if they feel that the current management system is leading to overfishing. If they are able to outbid fishermen, and if fishermen are willing to sell their rights to environmental organizations, it would be socially optimal for the fishing right to trade hands. Because this is often unpopular among fishermen, one possible design strategy could be to explicitly restrict participation to groups or individuals who actively participate in the fishery.[11]

Two prominent examples of non-use participation may help shed light on this concern. First, a high-profile buyback of limited entry permits and vessels (TNC) in Morro Bay proved to be a successful way to achieve conservation in a marine environment. It was the first private purchase of Pacific permits for conservation purposes, and it is a valuable lesson in how market-based regulations can be used by private parties to achieve a mutually agreeable agreement to conserve a resource (Deacon and Parker, 2009).

Second, in an example from outside of fisheries, the acid rain program administered by EPA allows for the purchase and retirement of emissions permits for nonuse purposes. In some instances, individuals have participated to buy pollution rights in order to reduce the effective cap on emissions. Participation levels have been low, but in recent auctions environmental groups and individuals have successfully purchased permits. [12]

[11] Costello (2012) briefly discusses this phenomenon, and as he points out, the legality of non-use participation in catch share fisheries has not been resolved. The Alaskan Limited Entry Act (1973) prohibits individuals from profiting from the fishery's resources who do not actively participate in the fishery.

[12] See Maleug and Yates, 2006, for a discussion of the economics of non-use participation in environmental markets. EPA auction results are posted regularly on its website.

Other factors limiting exclusivity

In many cases, an ITQ program operates where that stock is affected by other sectors, jurisdictions or individuals. When recreational harvest is large and unregulated, for example, commercial fishermen may be concerned about potential impacts on the future stock. Similarly, if neighboring jurisdictions have poor management, the stock will be adversely impacted even if the ITQ program is properly designed. For example, Grainger and Costello (2011) find that non-constant illegal harvest activity has a significant impact on ITQ market prices.

Discussion

There is often a tradeoff between equity and efficiency in environmental policy, and catch shares in fisheries are no exception. This paper provides an overview of the distributional impacts of catch share management and how the programs can be altered to achieve different distributional goals. In order to properly balance goals of equity and economic efficiency, the tradeoffs need to be made explicit in designing the program. There are many channels through which management change can have distributional effects, but perhaps the most critical aspect in catch shares is the initial allocation of rights. While there are many possibilities in designing catch share programs, there are often efficiency costs when the rights are made less secure or where additional restrictions are put on the quota assets. Other factors include the duration of the right, the breadth of coverage of such a system, and additional restrictions on trade or ownership of the underlying assets. Additional research is needed to fully understand the impacts of design restrictions on both efficiency and equity in catch share programs.

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Appendix A: U.S. catch share fisheries and design considerations

This table may not be comprehensive. Information comes from the EDF Catch Share database and individual management plans for the fisheries listed here. Some entries are left blank due to a lack of information, though the program may have such restrictions.

Fishery	Program reevaluation	3rd party harvest	Consolidation cap	Sales restrictions	Owner/lessee restrictions	Nonuse clause
Delaware Commercial Black Sea Bass	Anytime in first 3 years, by established targets thereafter	49% for commercial harvest		• A maximum of one transfer per year per person. • Quota is sold with vessel unless otherwise specified	Eligibility for commercial permits based on activity 1988-1993.	
Maryland Black Sea Bass	Anytime in first 3 years, by established targets thereafter	• Without quota, 50 lb per day limit • 49% for commercial harvest		A permittee may annually transfer no more than 30 percent of his/her individual quota in a maximum of two transactions per year to another permittee	• Moratorium on new vessels: Eligibility for commercial permits based on activity 1988–1993. • The Department may approve a permanent transfer of a Maryland black sea bass landing permit to an individual who: Is not currently a permit holder; has a federally permitted vessel used for commercial black sea bass fishing; has not held a Maryland black sea bass landing permit for the prior 2 calendar years.	
Maryland Striped Bass Pound Net	Department may modify or close a season or catch limit or set a monthly catch limit or modify size limit by with published notification.			• Sales only from Mar 1-Mar 31 and Aug 1-Aug 31 A commercial tidal fish licensee may permanently transfer a striped bass authorization if: The transferor was authorized to harvest striped bass in each of the 3 immediately preceding years; • The transferee is a valid commercial tidal fish licensee	• An individual who is authorized to commercially harvest striped bass and participated in at least one striped bass fishery during the past 2 years is allowed to register to participate for the next striped bass fishery. A commercial tidal fish licensee may not possess or be assigned both a striped bass hook and line allocation permit and a striped bass pound net allocation permit.	

Fishery	Program reevaluation	3rd party harvest	Consolidation cap	Sales restrictions	Owner/lessee restrictions	Nonuse clause
Maryland Summer Flounder	The Secretary may modify or close a season or catch limit or set a monthly catch limit or modify size limit by with published notification.			The Department may approve the permanent transfer of a Maryland summer flounder landing permit to an individual who: • Has a license to fish for commercial purposes and has a license to fish for commercial purposes from the National Marine Fisheries Service; • Is not currently a permit holder; • Has not held a Maryland summer flounder landing permit for the prior 2 calendar years; and Meets one of the following conditions: • Is the permittee's spouse, daughter, son, stepchild, grandchild, stepgrandchild, parent, sister, brother, grandparent, father-in-law, mother-in-law, son-in-law, daughter-in-law, sister-in-law, or brother-in-law; • Upon death of the permittee, has been designated as an authorized representative of the permittee; • Has purchased a vessel with a federal permit used for commercial fishing from the Maryland permit holder; or Provides a notarized bill of sale for the purchase of equipment and assets with a minimum value of $2,000 and the commercial fishing business from the permit holder	An owner of a vessel with a permit from the National Marine Fisheries Service may obtain a Maryland summer flounder landing permit if the vessel or owner: • Has a license to fish for commercial purposes and has a license to fish for commercial purposes from the National Marine Fisheries Service; • Landed in the State at least 25,000 pounds of summer flounder in a year for at least 2 years of the period 1998—2003; • Held a Maryland summer flounder landing permit for at least 1 year during the period 1998—2003; and • Provides proof of eligibility to the Department.	
Pacific Coast Groundfish Limited Entry Trawl		Pacific Northwest Indian Tribe harvest		• Two year moratorium on trading quota • Further regulations on permit transferability are unclear.		
US Alaska Fixed-gear Commercial Halibut and Sablefish	Annual management measures may be added and modified through adoption by the Commission and publication in the Federal Register by the Assistant Administrator, with immediate regulatory effect	Subsistence fishing, community harvest permits	No person, individually or collectively, may use more than 3,229,721 units of sablefish QS, except if the amount of a person's initial allocation of sablefish QS is greater than 3,229,721 units, in which case that person may not use more than the amount of the initial allocation. No CQE may hold more than 3,229,721 units of sablefish QS on behalf of any single eligible community.		• Vessel owner must be a citizen • Only persons who are U.S. citizens are authorized to receive or hold permits, with the exception that an IFQ hired master permit or a CDQ hired master permit need not be held by a U.S. citizen. • Only persons who are IFQ crew members, or who were initially issued QS assigned to vessel categories B, C, or D, and meet the eligibility requirements in this section, may receive by transfer QS assigned to vessel categories B, C, or D, or the IFQ resulting from it.	

Fishery	Program reevaluation	3rd party harvest	Consolidation cap	Sales restrictions	Owner/lessee restrictions	Nonuse clause
US Atlantic Sea Scallop			• 2 percent of the TAC • may not have ownership interest in more than 5 percent of the TAC		A vessel is eligible to be issued an IFQ scallop permit if NMFS records verify that the vessel landed at least 1,000 lb (454 kg) of scallop meats in any fishing year between March 1, 2000, and November 1, 2004, and a general category scallop permit had been issued to the vessel during the fishing year in which the landings were made.	
US Atlantic Surf clam and Ocean Quahog	Annual Catch Totals (ACTs) may be established on an annual basis for up to 3 years at a time.			• The ownership of an allocation may be transferred in amounts not less than 160 bushels (5 cages) to any person eligible to own a documented vessel. • Transfers may not be made between 15 October and 31 December of each year.	• Within two calendar quarters of implementation of the quota system, allocation permits will be issued to owners and operators of permitted vessels which harvested surf clams or ocean quahogs between 1 January 1979 and 31 December 1988.	
US Bering Sea Aleutian Island Crab (King and Tanner)		Ten percent of the TAC in each fishery is held for the community development quota (CDQ) program.	Use caps limit the amount of QS and IFQ a person can hold, to prevent excessive share consolidation or control. The type of use cap that applies differs on the type of person that holds the QS or IFQ. Vessels use caps limit the amount of IFQ that can be fished on a vessel. Use caps are calculated by adding up all of the QS or IFQ held by that person and their percentage of direct or indirect ownership in any entity that holds QS or IFQ. This is called the "individual and collective" rule.	On the death of an individual who holds QS or PQS, the surviving spouse or, in the absence of a surviving spouse, a beneficiary designated pursuant to paragraph (g)(3) of this section, receives all QS, PQS and IFQ or IPQ held by the decedent by right of survivorship, unless a contrary intent was expressed by the decedent in a will.	A "Hired Master" is an individual who, at the request of an **IFQ Permit holder, and on approval by NMFS**, has been authorized to fish another person's specific IFQ permit. Some IFQ permit holders must use Hired Masters to fish their IFQ; some may use Hired Masters, and some types of IFQ may never be fished by Hired Masters, (i.e. the IFQ permit holder must personally be on board).	
US Gulf of Mexico and South Atlantic Spiny Lobster Trap		There is a 2-day special recreational fishing season in the EEZ off Florida on the last Wednesday and successive Thursday of July each year during which fishing for spiny lobster is limited to diving or use of a bully net or hoop net.				
US Gulf of Mexico Commercial Grouper and Tilefish		Recreational fishing also occurs in the fishery, it is unclear how it affects the cap.	No person shall own more IFQ shares than the maximum percentage issued to the recipient of the largest shares at the time of the initial apportionment of IFQ shares. The share cap(s) shall be calculated as separate caps for each type of share, plus a cap on total shares owned by any one person for the entire program	IFQ share transfers prohibited during the month of December to allow NMFS the time necessary for end-of-year program management.	• IFQ shares or allocation can only be transferred to commercial reef fish permit holders during the first five years of the IFQ program and all U.S. citizens and permanent resident aliens thereafter. • Restrict initial eligibility to valid commercial reef fish permit holders.	

Fishery	Program reevaluation	3rd party harvest	Consolidation cap	Sales restrictions	Owner/lessee restrictions	Nonuse clause
US Gulf of Mexico Commercial Red Snapper	Require a program evaluation every 5 years	Commercial allocation 51%, recreational allocation 49%	For any single fishing year, no person shall own IFQ shares that represent a percentage of the total, which exceeds the maximum percentage, issued to a recipient at the time of the initial apportionment of IFQ shares (e.g., ~ 8 percent).	Transfers of IFQ shares and annual allocations would not be allowed during December to allow NMFS the time necessary for end-of-year program management.	• Restrict initial eligibility to persons who own a Class 1 or Class 2 license. Permanent resident aliens who currently own a Class 1 or Class 2 license will be included in the initial allocation subject to any other qualifications included in this IFQ program. • IFQ shares/allocations can be transferred only to individuals/ vessels with a valid commercial reef fish permit during the first 5 years of the IFQ program and U.S. citizens and permanent resident aliens thereafter.	
US Mid-Atlantic Golden Tilefish	• The tilefish commercial ACL may be established on an annual basis for up to 3 years at a time. • The Tilefish Monitoring Committee shall conduct a detailed review of fishery performance relative to the sector annual catch limits (ACLs) at least every 5 years.	For each fishing year, up to 3 percent of the TAL may be set aside for the purpose of funding research. Once a research amount, if any, is set aside, the TAL will first be reduced by 5 percent to adjust for the incidental catch. The remaining TAL will be allocated to the individual IFQ permit holders.	No person or entity may acquire more than 49 percent of the annual adjusted tilefish TAL		An owner of an IFQ allocation may permanently transfer the entire IFQ allocation, or a portion of the IFQ allocation, to any person or entity eligible to own a documented vessel	
US South Atlantic Wreckfish		5% of the Annual Catch Limit for wreckfish has been allocated to the recreational sector.	• No percentage share can be greater than 10% of the 100 available shares at the time of the initial allocation. • Limitations on the size of a percentage share held by an individual or business entity after the initial allocation are not thought to be necessary. • The council intends to monitor the concentration of shares over time, and may place restrictions on the concentration of shares if evidence of price-determining power or other detrimental effects are observed (Amendment under review: Establish a share cap as 49% of the total shares.)		• Initial eligibility includes those who can document wreckfish landings during the period beginning January 1 1989 and ending September 14 1990. Must be able to document landing at least an aggregate of 5,000 pounds (dressed weight) of wreckfish between January 1 1987 and September 24 1990. • Allow sale of percentage shares to anyone. Sale or lease of individual quota or portions of it can be to shareholders only. • To buy individual quota, a fisherman must hold a percentage share in the ITQ program, which means he will be one of the original eligible wreckfish fishermen, or he will have to purchase at least some portion of a percentage share from an individual in the program.	• The council will monitor use of individual quota over time and may take steps to require direct use in the future, if absentee ownership or other potential problems arise.
Virginia Black Sea Bass			No person permitted for the directed fishery may hold more than 20% of the annual directed fishery quota.	Commercial black sea bass shares of the directed fishery quota shall not be transferred in any quantity less than 200 pounds.		
Virginia Commercial Striped Bass (Rockfish)	Annually		No licensed, registered, commercial fisherman shall hold more than 2.0% of the total annual Chesapeake area commercial striped bass harvest quota or more than 11% of the total annual coastal area commercial striped bass harvest quota.	• Commercial striped bass shares shall not be transferred in any quantity less than 200 pounds • Transfers shall be prohibited during the period of December 1 through February 1.		

Appendix B. A simple model of ITQs

Individual Transferable Quota (ITQs) can be designed in many ways[13], but the most basic type can be explained succinctly in an economic model.[14] For a given management area and target stock (i.e., a "fishery"), a total allowable catch (TAC) is first set for some fishing season. Usually this consists of an overall fishing quota being set for a commercial fishing season. Fishermen are then allocated a share of the overall quota. This *catch share* could be allocated to individuals based on historical harvest levels, by auctioning the rights, or through some other method. The initial allocation is a critical component because it largely determines the distribution of profits across fishermen.[15] This step will be discussed in detail in the next section. For now suppose that by some allocation process individual fishermen $i = 1,\ldots,N$ have a right to some share of the harvest, h_i. Summing over all fishermen would give us the overall quota, H.

Under this system, individual i owns the right to harvest his share of the quota, h_i. Assume for simplicity now that each fisherman has linear marginal extraction costs[16], but there is some heterogeneity in skill that we will parameterize through the cost function.

In equilibrium, each fisherman has no incentive to buy or sell more allocation, and marginal profits across fishermen are equal. That is, the next pound of harvest for each fisherman would have the same value at the equilibrium harvest level. Because the market for quota allocation will equate the marginal profits across individuals, it also equates the marginal extraction costs of each person in the fishery.

Denote the annual harvest levels in equilibrium as $\{h_i^*\}_{i=1}^N$. If this right is fully transferable and divisible, the equilibrium lease value of a pound of quota will then be equal to the marginal profits of each fisherman. Formally, $\pi = P - c_i h_i^*$ for all i,where π is the lease price of a pound of quota, P is the market ex-vessel price per pound (assumed exogenous) and c_i is the marginal extraction cost for the ith individual. In equilibrium the lease price equals the marginal profits (or rents) in the fishery.

There are some important lessons that come out of this simple model. First, catch shares increase efficiency by allowing fishermen to buy and sell shares of the harvest. This allows the marginal harvest rights to move to the most efficient fisherman. Flexibility to buy and sell allocation under this program leads to a cost-effective harvest, regardless of the initial allocation. The fishermen who harvest the most under catch shares will be the individuals with the lowest marginal extraction costs. Second, while this simple model does not explicitly capture exit decisions, some individuals may find it profitable to sell their allocation to others with lower costs and then voluntarily exit the fishery. If an individual's marginal extraction costs are very high, he may decide not to stay in the fishery if the opportunity cost of holding quota shares is high. Thus consolidation may occur, and the number of individuals in the fishery may change.[17]

[13] For a practical guidebook to catch share design, see Bonzon, et al (2010).

[14] For simplicity, the dynamics of the stock are not modeled here. This type of model is common in the literature on the economics of ITQs. See Grainger and Costello (2012) for a more thorough introduction.

[15] This is true not only in catch shares, but in any market-based environmental regulation. The initial allocation of emissions rights in a cap-and-trade program is analogous to the catch share programs discussed here.

[16] The assumption is that the marginal unit of harvest costs more than the previous unit for each fisherman. For simplicity we will also assume that marginal extraction costs are zero when harvest is zero.

[17] See Weninger (2007), Weninger and Waters (2003) or Lian et al (2010) for ex ante analyses of catch shares including consolidation and exit decisions.

Appendix C. Consolidation restrictions: A dimple example

Because consolidation caps are meant to prevent some individuals from accruing quota, that constraint (if binding) would likely have reduced overall rents in the fishery.[18] A simple example building on the model above can help illustrate this principle. Suppose that there are three types of fishermen in a hypothetical fishery. Type A has high marginal extraction costs, Type B has medium marginal extraction costs, and Type C has low marginal extraction costs. Simplifying even further, suppose that there are only three fishermen in this hypothetical catch share fishery, one of each type. After the catch share program is introduced, fisherman A has marginal extraction costs given by the following: MECA(hA) = 3/8*(hA), where hA is A's annual harvest (in tons). Similarly, assume that MECB(hB) = 3/10*(hB) and MECC(hC) = 1/4*(hC).

The total harvest in the fishery is simply H= hA+hB+hC. Suppose that the ex-vessel price is determined exogenously by world markets at $5 per pound, and the total allowable catch in the fishery this year is set at 60,000 lbs.

If shares are divisible and transferable, the equilibrium allocation is that A harvests 8 tons, B harvests 10 tons, and C harvests 12 tons. The equilibrium lease price of a quota share is $2/lb, and the total annual rents in the fishery are $210,000.

Suppose now that management implements a consolidation cap, where each fisherman is allowed to harvest no more than 10 tons in a year. In that case, fisherman B still harvests 10 tons, but fisherman C is forced to reduce his harvest by 2 tons, and fisherman A will increase his harvest by 2 tons. For simplicity, suppose that fisherman C sells his annual right to fisherman A. In this example, there is no unique equilibrium price of the share in that transaction, but it is individually rational for C to sell his excess two tons because he cannot use them. Under these new rules, each fisherman will harvest 10 tons, but the catch share program is no longer cost effective. Total annual rents under ITQs with the consolidation cap in this example equal $207,500.

This example is highly stylized, but it helps illustrate a simple lesson: imposing restrictions (such as a consolidation cap) on a market-based policy such as catch shares can undermine the cost-effectiveness of the program.

18 Setting consolidation caps that are non-binding in equilibrium will not have direct efficiency consequences.