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Collective Rights–Based Fishery Management: A Path to Ecosystem-Based Fishery Management*

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Abstract

Fishery rents may be dissipated across margins not well defined or controlled by an individual transferable quota system. Collective rights–based fishery management (CRBFM), where catch rights are held by a group, can sometimes generate greater benefits and can also address external impacts of the fishery. I discuss potential failures of individual quotas and how these problems were addressed by CRBFM institutions. I then focus on the role of CRBFM in addressing environmental and social impacts external to the group of fishers, such as bycatch, habitat impacts, and spatial conflicts. The review suggests that CRBFM can effectively address both intrafishery and external impacts, provided there is sufficient incentive to do so, including maintaining access to preferred markets or the threat of further regulation. However, CRBFM can create moral hazard and adverse selection problems, and successful CRBFM institutions generally have homogeneous membership with well-aligned interests and/or formal contracts with monitoring and enforcement provisions.

INTRODUCTION

It has long been recognized that a failure to limit access to fisheries will lead to dissipation of economic rents and potentially to depletion and collapse of fish stocks (Gordon 1954). Gordon recommended the assignment of property rights[1] to the fishery as a means to internalize the stock externality[2] that leads to excessive effort and rent dissipation. Scott (1955) argued that a sole owner of a fishery would be incentivized to harvest efficiently and conserve the fish stock to maximize the stream of rents it would generate over time, but sole fishing rights have historically been rejected by governments (Johnson & Libecap 1982). Christy (1973) proposed a more politically practical means of operationalizing a rights-based approach that assigns rights to a share of the catch from a fish stock to individuals as individual transferable quotas (ITQs). ITQs and other rights-based fishery management approaches have been widely adopted in industrialized countries and have been shown to promote both profitability and conservation (Birkenbach et al. 2017, Bonzon et al. 2010, Brinson & Thunberg 2016, Costello et al. 2008, Thunberg et al. 2015).

ITQs are not the only practical means to conserve fishery rents. Collective[3] rights–based fishery management (CRBFM) approaches, under which catch rights are assigned collectively to a group (e.g., a fishing cooperative or community), have been found to be effective and potentially more practical in some cases (Ostrom 1990, Ostrom et al. 1994). Bonzon et al. (2010) found that approximately 10% of rights-based fishery management programs allocate allowable catch to a group, and CRBFM approaches have been used for centuries in Oceania in the form of customary access limits (Ruddle et al. 1992). CRBFM sometimes involves allocation of exclusive rights of harvest in a specified area to a cooperative or community. These territorial use rights (TURFs, a term coined by Christy 1982) have been particularly prevalent in developing countries where governments lack the resources to manage and regulate fisheries directly. In most of these cases, the primary function of the collectives has been to limit and allocate catch among members and exclude other parties (Deacon 2012).

CRBFM may have relative advantages over ITQs in some cases. Collectives can address problems not corrected by ITQs alone, and fishers have sometimes opted for CRBFM over ITQs or have voluntarily layered collective management instruments on top of ITQs to address problems or realize benefits that require collective action (Holland & Wiersma 2010). As the responsibilities of fishers and managers broaden to encompass external impacts of fisheries on nontarget species, habitat, and communities, CRBFM can facilitate Coasian bargaining[4] (Coase 1960) between fishers and managers or other stakeholders that can identify more efficient and effective solutions more quickly than through government-led regulation.

There is an extensive literature on externalities not resolved by ITQs, and two relatively recent reviews on CRBFM address these intrafishery externalities (Deacon 2012, Wilen et al. 2012). I

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[1] Here and throughout this review I refer to an economic concept of property rights rather than a legal one. In this context, property rights can be defined as an enforceable right to undertake specific actions (e.g., land a specific quantity of fish from a designated area). In the United States, such rights are referred to as privileges and are legally revocable without compensation.

[2] The cost imposed on other fishers by reducing the fish stock that may include both increased unit harvest costs and decreased resource productivity.

[3] Merriam-Webster Dictionary defines a collective in a number of ways that are applicable here: (*a*) denoting a number of persons or things considered as one group or whole; (*b*) involving all members of a group as distinct from its individuals; (*c*) marked by similarity among or with the members of a group; (*d*) collectivized or characterized by collectivism; and (*e*) shared or assumed by all members of the group.

[4] Coase (1960) hypothesized that two self-interested parties will bargain to a mutually advantageous, Pareto-optimal level of an externality regardless of initial unilateral property right entitlements. However, Coase also noted that high transaction costs could impede such bargains and that the nature of property right assignments could have important impacts on transaction costs.

briefly review this literature, but I mainly focus on the role of CRBFM in addressing environmental and social impacts external to the group of fishers. I use examples from fisheries in several countries to illustrate the motivations, benefits, and complications of CRBFM, with specific focus on collectives managing external impacts of fisheries such as bycatch, habitat impacts, and spatial conflicts between user groups. The examples presented are primarily cases where secure catch rights (or privileges) were assigned collectively to groups or where collectives were formed within or on top of ITQ systems, though groups of fishers without secure rights have also addressed external impacts. From these examples, I identify a number of common problems and draw some general insights about effective design of CRBFM institutions focused on external fishery impacts and on oversight of these institutions.

THE ROLE OF COLLECTIVE ACTION IN ADDRESSING INTRAFISHERY EXTERNALITIES

Fishery rents may be dissipated across margins that are not well defined or controlled by a standard ITQ regime, and collective action may be the most effective means to address some of these issues. For example, the stock externality may not be fully internalized by an ITQ system when seasonal depletion occurs (Bisack & Sutinen 2006, Boyce 1992, Clark 1980, Holland 2011), and some other mechanism to order the intra-annual distribution of catch may be necessary to prevent rent dissipation. A similar problem can result from spatial heterogeneity in unit harvest costs and/or resource productivity (Holland 2004, Johnson & Libecap 1982). Sanchirico & Wilen (2005) demonstrated the loss of rent that can occur with a spatially heterogeneous resource when an individual quota or optimal tax is applied to the overall resource versus optimal controls on each patch. Vernon Smith (1969) illustrated the potential for rent dissipation from congestion externalities, and Clark (1980) showed that congestion externalities could indeed lead to rent dissipation in an ITQ fishery. Platteau & Seki (2000) found that reducing congestion externalities in preferred fishing areas was a primary motivation for implementing revenue pooling in a Japanese shrimp harvesting cooperative. Smith also noted that rents might be dissipated by suboptimal age selection, which will reduce the potential productivity of the stock. While this might be addressed through technical restrictions (e.g., larger mesh size) in an ITQ fishery, catch or incidental mortality of smaller fish may not be completely avoided. It is well known that ITQs can create incentives for high grading (discarding of less valuable catch), which can reduce the productivity of the fishery (Anderson 1994, Arnason 1994). If there is spatial heterogeneity across age classes together with imperfect selectivity, spatial organization of fishing effort may be the most effective way to optimize the age composition of catch (Deacon 2012, Deacon et al. 2008).

When efficient production (or conservation) requires organization and coordination of the activities of individual actors, firms can often achieve greater efficiency with lower transaction costs than can be achieved by indirect incentives, e.g., Pigovian taxes or subsidies (Coase 1937). Collectives can have many of the advantages that firms have at organizing activities in efficient ways. Potential benefits of collective action go beyond addressing the externalities discussed in the previous paragraph. Neither the cost of fishing nor the value of fish is determined exogenously. The value of catch is often a function of how it is handled and marketed. Costs are a function of technology, which is constantly changing, often as a result of innovation by fishers who are responding to the incentives created by the management approach among other things. Individuals might not have sufficient incentive to invest in market or technology development while the group does. Collective action has been used to reduce harvest costs through information sharing and technology development, to enhance fish stocks, and to increase the average quality and value of harvested fish (Deacon 2012, Mincher 2008, Townsend et al. 2008).

The limitations of ITQs are highlighted by the prevalence of commercial stakeholder organizations (CSOs) that are formed voluntarily by individual quota owners in many of New Zealand's ITQ fisheries. With the support of 50% of quota owners (by volume), CSOs can impose rules on all quota owners and fund their activities with commodity levies imposed on all quota holders [Fisheries Act 1996, New Zealand, Part 16, Section 305(b)]. There are more than 30 CSOs representing specific New Zealand fisheries or geographic regions (Harte 2008). Among other activities, CSOs carry out research, monitor seafood safety, run enhancement programs, and require members to shelve quota to keep catches below official allowable levels (Yandle 2008).[5] CSOs also participate in consultations with the government on behalf of quota owners and can ask regulators to enforce CSO management actions, such as stop-fishing orders, closed areas, and shelving of quota. The Challenger Scallop Enhancement Company is a seminal example of what a CSO can achieve. It implemented biotoxin monitoring, a reseeding and rotational harvest program, quota shelving, and daily and weekly catch limits to prevent a race for catch at the beginning of the season (Mincher 2008).

Another potential source of lost utility, if not rent, that is less prevalent in the fisheries economics literature is associated with financial risk. Fishing is a risky business in terms of both personal safety and income (Kasperski & Holland 2013). Fishers are sometimes perceived as risk seekers because of their choice of profession, but there is evidence that they often seek to reduce financial risk when they can. For example, fishers often diversify into a number of fisheries, which has been shown to reduce interannual variation in income (Kasperski & Holland 2013). Diversification is often reduced following implementation of rights-based management in the form of ITQs and fishery cooperatives as a result of consolidation (Holland et al. 2017). Collectives can provide additional means to reduce financial risk for members. This could be done through revenue pooling, which is done in a number of Japanese cooperatives to reduce variation in individual returns (Wilen et al. 2012). However, revenue sharing is uncommon in other countries and can present moral hazard issues (e.g., shirking) when the collective's members are not cohesive and homogeneous.

Pooling of catch rights rather than revenues could also be beneficial for reducing risk. For example, if members of a collective do not have diverse portfolios of catch rights (e.g., different species or spatial stocks), but the collective as a whole does, the collective might facilitate transfers among members to create more diverse or balanced portfolios—perhaps through barter—avoiding the need for individuals to seek financing for quota acquisition. Collectives in multispecies fisheries may also help reduce difficulties of individual fishers balancing catches with quota. When many fish species are harvested jointly and there is random variation in relative catch rates, ITQ markets may not function efficiently at redistributing quotas to match realized catches at the vessel level (Holland 2016). This creates risk that fishers will be unable to acquire needed quota to rebalance quota portfolios during the year and could be forced to cease fishing before fully utilizing other species quotas. Collective institutions can redistribute quotas to help vessels rebalance quota portfolios and continue fishing. Sector managers in New England groundfish cooperatives play this role, brokering quota trades within and between cooperatives (Holland et al. 2015, Kitts & Demarest 2013).

[5] Many CSOs have required members to shelve a portion of their quota to maintain catch levels below the official allowable catch. This is sometimes done to avoid a cut in the official allowable catch that can be hard to reverse but has also allowed CSOs to choose overall catch levels that provide greater economic benefits while meeting the government's sustainability criteria.

THE ROLE OF COLLECTIVE ACTION IN ADDRESSING EXTERNAL IMPACTS OF FISHERIES

The focus of fishery management has traditionally been on preventing overfishing, allocation among user groups, and increasing efficiency and net benefits from fisheries. More recently, fishery managers and the broader public have begun to demand accountability from fishers for environmental impacts such as bycatch and habitat damage and for social impacts such as loss of access and employment for communities that are dependent on fisheries. Increasingly, fisheries and other users of public trust natural resources must have a "social license to operate" (Joyce & Thomson 2000). The idea of a social license originated in response to a perceived threat to the mining industry's legitimacy as a result of environmental disasters in the late 1990s (Thomson & Boutilier 2011), but it is relevant in other industries (e.g., farming, fisheries, renewable energy) (Parsons et al. 2014). The rationale of a social license to operate is that, in addition to legal permission to harvest a fish stock, the industry also requires social permission. Failure to operate in a socially responsible way may invite retaliation in the market place or legal action if not direct regulation. The new paradigm of ecosystem-based fishery management, which is gaining acceptance in many countries, also requires fisheries to take broader account of their impacts on ecosystems, for example, by minimizing bycatch and habitat damage and requiring forage stocks to be maintained at levels sufficient to support natural predators as well as human harvest (Essington & Punt 2011, Fluharty 2005, Link 2002, Rice 2011).

The role of CRBFM in addressing external impacts of fisheries has received little attention. In the next section, I discuss examples relating to managing bycatch, habitat impacts, and resolving conflicts between user groups. In some cases, the effort arose as means to forestall additional regulation or in response to market pressures. In others, they were a response to a regulatory action, for example, bycatch caps imposed on the group or on individuals that threatened the profitability of the industry or created unacceptable risks for individual fishers.

Examples of CRBFM: Bycatch Management and Risk Pools

Reduction of bycatch and discards in fisheries has been a concern of fishery managers, environmental NGOs, and increasingly, the broader public for over two decades. The Code of Conduct for Responsible Fisheries (FAO 1995) advocates the reduction of discards and bycatch, and requirements to reduce bycatch are included in national legislation or policies in a growing number of countries. In the United States, National Standard 9 of the Magnuson Act states that "conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch." Campaigns by NGOs have been successful at bringing consumer pressure to bear on the issues, most famously with the development of the dolphin-safe label for tuna, which led to global changes in tuna fishing methods to reduce dolphin bycatch (Teisl et al. 2002, Ward 2008). In Europe, in an effort to control bycatch and discards, the Common Fisheries Policy (EU 2013) imposes a wholesale ban on discards (though implementation will be phased in slowly). The adoption of the discard ban appears to have been due in part to a petition signed by more than 650,000 people calling for discards to be banned following a series of programs by television chef Hugh Fearnley-Whittingstall (De Vos et al. 2016).

In addition to these national and international mandates to reduce bycatch, fishery managers often face pressure from user groups whose target species is the bycatch of another group. This is the case in a number of fisheries off the Pacific coast of the United States and Alaska. The fishery management councils in these regions have responded by imposing caps on bycatch of particular species in trawl fisheries. I discuss four cases where industry-led cooperative approaches to bycatch management were implemented in response to bycatch caps: two in Alaska and two on the Pacific coast. In some of these cases, the catch rights for the species targeted in the fisheries were assigned to cooperatives (Bering Sea pollock and multispecies bottom trawl fisheries and at-sea Pacific whiting fisheries), while in other cases (West coast bottom trawl fishery and shore-based Pacific whiting fisheries) catch rights were assigned to individual firms as ITQs. In all of these cases, a cooperative approach was used (by at least part of the industry) to manage bycatch as an alternative to reliance on individual bycatch quotas or a competitive race-for-bycatch. These examples are instructive, as they illustrate how collectives can adapt cooperative strategies for bycatch management to the specific characteristics of the fishery, the industry structure, and the demands and constraints imposed by managers. In most cases, the collectives attempted to reduce financial risk for individual vessels through some type of bycatch pooling arrangement while simultaneously addressing the moral hazard issues that created. These collectives also attempted to foster cooperation between vessels in avoiding bycatch.

The first example concerns bycatch management in the multispecies bottom trawl fishery in the Bering Sea and Aleutian Islands (BSAI). This is a large fishery (in value and volume) prosecuted by a relatively small number of catcher-processors (currently between 18 and 22 participate annually) (M. Fina, personal communication). Until 2011, the fishery was managed with competitively fished total quotas of target species and bycatch caps for Pacific halibut, red king crab, opilio (snow) crab, and bairdi (tanner) crab. These caps were sometimes binding on the fleet, leading to premature fishery closures before target species quotas were harvested (Holland & Ginter 2001). In 1995, some, but not all, of the vessel owners formed a cooperative with the primary focus of reducing bycatch to avoid premature fishery closures. A key strategy used by the cooperative was information sharing about bycatch hotspots accomplished through a third-party company called Sea State Inc., which collected and collated bycatch information from the observers on the vessels and produced maps of bycatch hotspots. The success of the system was limited, in part due to defection from the avoidance strategies toward the end of fishing seasons, and the fishery remained constrained by premature closures triggered by reaching halibut bycatch caps (Abbott & Wilen 2010, Holland & Ginter 2001).

In 2011, under Amendment 80 of the BSAI groundfish fishery management plan, secure allocations of both target and bycatch species were given to two cooperatives, which enabled a more effective bycatch management approach to be implemented. Although the cooperative still utilizes information sharing and hotspot designations facilitated by Sea State, a number of other practices were introduced, including halibut excluders on nets and deck sorting of catch (to increase the percentage of halibut returned to the sea alive, reducing mortality counted against the cap). Vessels are also required to meet halibut bycatch rate standards or face monetary penalties imposed by the cooperative itself.

Notably, halibut mortality has remained well below caps since 2011, which has enabled the fleet to harvest the vast majority of its target quotas of yellowfin and rock sole in all years since Amendment 80 was implemented (Abbott et al. 2015; M. Fina, personal communication). Fina notes that keeping halibut bycatch well below caps and making demonstrable efforts to minimize bycatch (including considerable research expenditures by the cooperative) have likely been key to the regulators not imposing stricter bycatch caps when the allowable catch for the directed halibut fishery was decreased in recent years.

The second example of bycatch-related CRBFM concerns the BSAI pollock fishery, which has been managed since 1999 with allocations of catch rights to cooperatives in three sectors: catcher-processors, motherships and associated vessels, and shore-based catcher vessels. Regulators implemented caps on bycatch of chinook salmon in 2011 in response to a spike in chinook bycatch in 2007. A lower hard cap of 47,591 chinook salmon per year was imposed and allocated among sectors and cooperatives in proportion to pollock allocations. However, cooperatives that participate in an incentive plan agreement (IPA) that is deemed to provide continual incentives to minimize bycatch even when the cap may not be binding can catch up to their share of a higher 60,000 chinook salmon per year cap as often as 2 out of every 7 years.

IPAs for the three sectors have many similarities but also differences that reflect varied coordination and control of the fleets. All three sectors use Sea State to collate catch and bycatch information collected by onboard observers and determine dynamic hotspot closures where fishing is prohibited (Gruver 2017, Madsen & Haflinger 2016, Mize 2017). To create incentives for vessels to avoid salmon bycatch even when the caps are not expected to be binding, unused bycatch credits (essentially bycatch quota) can be carried forward to the next year, though at a discount. The catcher-processor sector has chosen to pool bycatch and rewards vessels with low bycatch rates by allowing them to continue fishing in "salmon savings" areas with higher bycatch risk where other vessels are prohibited. The IPA for the mothership sector, which is organized by fleets that deliver to individual motherships, allocates bycatch credits at the fleet level because the mothership organizes the fishing activities of the fleet of vessels delivering to it. The IPAs for the shore-based sector create incentives at the vessel level by assigning credits to individual vessels. Transferability is allowed to account for the lumpiness and randomness of bycatch, and vessels contribute to and can access a pool of credits if they are unable to purchase them from another vessel. This improves liquidity in the market but is designed to be a costly option. Vessels must also adhere to rolling hotspot closures, and only vessels that have maintained low bycatch rates can access salmon savings areas. Since the IPAs were implemented, the pollock fleet has been successful at keeping chinook salmon bycatch under the lower hard cap in every year from 2011 to 2017.

The third bycatch example is drawn from the Pacific whiting fishery operating off the US Pacific coast. Similar to the pollock fishery (with which there is substantial overlap in participants), this fishery has shore-based, catcher-processor, and mothership sectors. The catcher-processor and mothership sectors are managed under cooperatives, while the shore-based vessels are managed with an ITQ system. However, most shore-based vessels (though not all) joined a "risk pool" cooperative to manage bycatch. Along with their allocations of whiting, the cooperatives and the ITQ holders were allocated small quotas of several rockfish species that are taken as bycatch. Both the shoreside and at-sea sectors of the fishery share the same problem: how to ensure that bycatch limits are not reached and to shut down the fishery before the quota of Pacific whiting has been harvested.

As in the pollock fishery, there are similarities and differences in the approaches the various sectors use to avoid bycatch. All three sectors use Sea State to collate and relay information on bycatch rates collected by on-board observers, and all three sectors also designate both year-round and dynamic hotspot closures. Each cooperative's manager can use observer data to monitor compliance with closures and other fishing rules and can penalize noncompliance with fines. While the catcher-processor sectors allocate both whiting and bycatch quotas to individual members, the other sectors pool bycatch quota, although vessels have individual allocations of whiting. The whiting mothership cooperative requires vessels to follow a number of operational rules including precautionary closures of past bycatch hotspots and in-season hotspot closures, restrictions on fishing at night, and mandatory relocation if a mothership fleet's bycatch rate exceeds specified rates. The shore-based risk pool has similar fishing restrictions but has also implemented a system of premiums, deductibles, copayments, and penalties that attempt to limit adverse selection and moral hazard (D. Frazer, personal communication). In addition, a funding mechanism enables the risk pool board to purchase additional bycatch quota to supplement the risk pool reserve account if necessary.

It is difficult to assess how successful Pacific whiting cooperatives have been at avoiding bycatch. There have been instances of seasonal pools for the mothership cooperative exceeding bycatch quotas and shutting down, but there have not been any cases of noncompliance with the cooperatives' rules according to their annual reports. Analysis of fishing behavior confirms increased bycatch avoidance in the form of test-towing and move-on behavior for the mothership fleets. For the shore-based fleet, there is evidence of reduced tow duration after bycatch events following implementation of its risk pool.

The last example relating to bycatch management is the development of risk pools in the bottom trawl sector of the Pacific groundfish trawl fishery. An ITQ system was implemented for this sector in 2011. Individuals were allocated ITQs for 28 groundfish stocks as well as individual bycatch quotas for Pacific halibut. The ITQ system requires vessels participating in the fishery to balance all catches with quota whether the catch is retained or discarded. Full accounting for all catches is ensured by human observers on all vessels. One of the biggest challenges fishermen face is to limit catches of several rebuilding rockfish species for which catches are rare, highly variable, and highly uncertain (Holland & Jannot 2012). Fishermen must cease fishing and face penalties if they exceed their quotas. This led to formation of risk pools under which individual fishermen would collectively pool their quotas of the bycatch species. The motivation for these risk pools was primarily to mitigate the financial risk for individual fisherman associated with the availability and cost of acquiring quota to balance bycatch and avoid shutdown.[6] Holland (2010) showed that, when bycatch is highly uncertain, even small risk pools of 5–10 vessels could substantially reduce financial risk for vessels associated with premature shutdown or for having to pay high-quota acquisition cost for bycatch quota.

Risk pools are not regulated entities, and consequently, information on them is limited. However, at least one formal risk pool was created by a coalition of fishers from three California ports and the Nature Conservancy, which controlled a substantial amount of bycatch quota as a result of fishery permits it had purchased prior to the ITQ (Kaufman 2011). Risk pool members can access the risk pool's bycatch quotas, in return for adhering to the spatial fishing plans and using an electronic logbook system to share catch information on the location of overfished species catch (Labrum & Oberhoff 2014). The Ilwaco Fishermen and Marketing Cooperative in Washington State reportedly formed a risk pool as well (L. Walton, personal communication), although details on its operation are not available. There are anecdotal reports of other risk pools operating in Oregon and Washington, but details on their operations have not been made public.

Overall, it appears that the risk pools have been successful at controlling bycatch, as there has been only one instance of a total quota for any species being exceeded since the ITQ was implemented. The industry as a whole continues to underutilize many of the quotas, but it is unclear whether this is due to quota constraints of rockfish or market constraints.

Examples of CRBFM: Spatial Conflicts and Habitat Protection

Area closures and spatial restrictions on particular fisheries, gear, or classes of vessels are widely used to reduce bycatch, protect juvenile fish or spawning areas, and protect sensitive habitat (Gell & Roberts 2003, Kaiser & de Groot 2000, Lindeboom 2000). They are also used to address user conflicts, for example, to prevent local depletions by larger vessels in inshore areas fished by small vessels or recreational fishers or to prevent gear conflicts (Kaiser et al. 2000). While area

[6]This statement is based on observations of industry members discussing the formation and design of risk pools at a meeting held at the law office of Mundt MacGregor L.L.P. on October 28, 2010.

closures can be an effective means of addressing these issues, they are often not designed in the most effective and efficient way, and they can be very contentious. Area closures are often strongly resisted by industry groups that would lose access to profitable fishing areas, but two examples from New Zealand illustrate that fishery rights holders collectively may be motivated to identify with and voluntarily agree to area closures that address concerns over habitat impacts or spatial conflicts over resources. Another example from British Columbia discusses a novel approach to reduce habitat impacts based on a combination of cooperatively designed closures and quotas for coral and sponge bycatch.

As noted above, the Challenger Scallop Enhancement Company in New Zealand addresses a number of intrafishery externalities, but it has also played a role in addressing external impacts of the fishery. It negotiated an agreement with recreational scallop harvesters that allowed recreational harvesters access to areas that were voluntarily closed to commercial harvesting (Mincher 2008). The agreement created a consultation process sharing responsibility for management with the recreational group, granting the chairman of the recreational group a permanent observer seat on the Challenger board.

Another New Zealand CSO, the Deepwater Group Ltd., which represents quota owners in New Zealand's major offshore fisheries, proposed and developed an initiative that closed over one-fourth of New Zealand's 4-million-square-kilometer exclusive economic zone (EEZ) to bottom trawling and dredging (Helson et al. 2010). The initiative addressed concerns raised by environmental NGOs about the lack of habitat protection in deep sea areas. In 2001, 18 areas in the EEZ outside territorial waters totaling over 81,000 square kilometers were closed to trawling to protect seamounts under authority of the Fisheries Act. The prospect of additional closures may have been the impetus for the Deepwater Group's initiative to designate benthic protection areas. The closures, though extensive, were focused mainly on areas that had not been fished and still had pristine habitat. In addition, fishing in these areas with pelagic trawls is allowed provided that vessels carry two observers (paid for by industry) and do not allow fishing gear to come within 100 m of the seabed (subject to fines up to NZ$100,000 per offense). Although there was some criticism by environmental NGOs that most of the closures were in areas that would not be fished anyway, they were more extensive and implemented more quickly than could have been achieved with a statutory process under the Fisheries Act (Helson et al. 2010).

The final example of the use of CRBFM to address spatial or habitat externalities is a novel habitat protection scheme implemented in the British Columbia groundfish trawl fishery, which has been managed with ITQs since 1997. Quota holders do not operate under a formal cooperative that can bind the actions of its members, but they have participated actively in research and management of their fishery through the Canadian Groundfish Research and Conservation Society (CGRCS) and the Deep Sea Trawlers Association, both of which are industry-funded organizations. In 2012, these organizations negotiated a novel habitat protection strategy with environmental NGOs. Impacts of the British Columbia groundfish trawl fishery on deepwater corals and sponges had arisen as an issue of growing concern to conservation NGOs, but Canadian legislation did not provide a legal mandate to implement this protection through regulation. The industry was, however, sensitive to criticism about these impacts. Under pressure from environmental NGOs, in particular the Monterey Bay Aquarium, the major buyers of British Columbia groundfish had threatened to turn to other sources of fish, forcing the industry to find an acceptable solution to the problem (Wallace et al. 2015). The industry and conservation organizations, represented by the David Suzuki Foundation and Living Oceans Society, worked collaboratively to develop the system over three years, culminating in implementation in 2012 as part of the Integrated Fisheries Management Plan (Wallace et al. 2015).

The agreement includes some area closures in particularly sensitive areas but also a novel habitat conservation bycatch limit in the form of individual transferable quotas for corals and sponges. A cap-and-trade system for fishery habitat impacts and biodiversity protection had been previously proposed in the literature (Holland & Schnier 2006a,b). However, it had envisioned using a proxy for habitat impacts based on monitoring vessels' fishing locations relative to a virtual habitat stock that would be updated over time in response to fishing activity and expected habitat impacts and regeneration. This British Columbia system created quotas for actual benthic material brought up in nets. This is still somewhat of a proxy for habitat damage because not all impacted organisms would be expected to come up in the net. However, the catches can be compared to baseline catch levels before the program was implemented with a total quota set to ensure a reduction in damage relative to prior levels. Enforcement of the system is made possible by 100% human observer coverage on the fishing vessels: Observers were already in place as part of the compliance system for the ITQ system.

Notably, the actual catch of corals and sponges has remained far below the total quotas since the program was implemented and also well below average levels prior to the agreement. This was by design. The program set a target of 884 kg of coral and sponge catch, but as a total quota divided among vessels, this would have been insufficient to cover even a moderate encounter. A single unforeseen large catch of corals and sponges could even exceed the total industry target (Wallace et al. 2015). The agreement set a higher total quota of 4,500 kg to provide a risk buffer for individual vessels and the industry but with a tacit understanding that the industry would take steps to keep catch below the lower target of 884 kg. These steps included an encounter protocol in the event of a large catch of corals and sponges in a single tow. The protocol required the vessel to inform the fleet of a potential high-risk area within the fishable areas of the fishery and could lead to closure of that specific area (Wallace et al. 2015).

ADVANTAGES AND CHALLENGES OF CRBFM

Rights-based fishery management has been implemented in various forms (ITQs, TURFs, CRBFM) in nearly every type of fishery and region in the world—in developed and developing countries, in small-scale and industrialized fisheries, and with sessile and highly migratory species. The type and specific characteristics of the rights-based approaches implemented depend on the characteristics of the fisheries, the objectives of stakeholders and managers, and the capabilities of regulators or participants to monitor and enforce rights and regulations (Holland 2015). An important choice when designing a rights-based management approach is whether rights are allocated to individuals or groups. Even when rights are allocated to individuals, collective institutions may still form, but their emergence and effectiveness may depend on the support of regulators. The aforementioned examples illustrate that CRBFM institutions can often address problems and exploit opportunities that ITQ systems do not. The examples also illustrate the problems CRBFM institutions can face and how they can be tailored to address these problems.

Though internalizing the stock externality was the initial focus of fishery economists when proposing rights-based management, it has become clear that this will not necessarily ensure that value from the fishery is maximized even if overall catch rates are set at what regulators perceive as optimal levels. Rents can be dissipated over a number of margins requiring either additional regulatory instruments or institutional arrangements that enable and incentivize rights holders to resolve remaining inefficiencies. Technology and market value, and even the productivity of the resource itself, are often dynamic and dependent on how a fishery is managed and fished. In such cases, cooperation of rights holders, either though formal cooperative institutions or informally, can often increase the net value generated by the resource, sometimes in ways that regulators would not have envisioned or been able to implement (Deacon 2012, Townsend et al. 2008, Wilen et al. 2012).

From a societal standpoint, the value of fisheries and marine ecosystems can also be dissipated across margins that fishers individually or collectively may have little internal incentive to address. Prominent examples of these third-party externalities include bycatch and habitat impacts or spatial patterns of harvest or delivery of catch that affect other stakeholders or communities. As the examples in the prior section show, fishers are increasingly being required to address these externalities directly or are pressured to do so by buyers who are responding to pressure from NGOs and consumers.

Fishers can often address external impacts more effectively and efficiently than regulators through cooperation if they are incentivized to do so. By capitalizing on private information, they can devise restrictions on their own fishing that mitigate these issues more cost-effectively than methods devised by regulators (Little et al. 2015). Collectives can tailor contracts and structure incentives to the specific situation and parties involved (as demonstrated by the variation in approaches by different sectors within a single fishery detailed in the bycatch avoidance examples). Collectives members may be able to monitor each other more effectively and cheaply than can the regulator (Hoefnagel & de Vos 2017). They can adjust rules quickly (e.g., dynamic area closures or variable financial incentives or fines), while regulators typically must utilize a lengthy and often contentious public rule making process. Collectives can quickly discipline noncompliance and can generally exclude anyone that does not follow the rules, which can greatly decrease the risk of noncompliance. Collectives can also create and rely on social pressure and social norms to ensure compliance with collective strategies and rules. Finally, a collective may invest in research to develop new technologies that reduce bycatch and habitat impacts—investments that might not make financial sense for an individual firm but do for the group.

Collectives of fishery rights holders, whether created through the official allocation of catch rights or formed voluntarily by groups of rights holders, can also facilitate Coasian bargaining to address problems important to societal groups external to the fishery. Rather than sue or pressure regulators to address their concerns, environmental NGOs and consumers can incentivize fishing collectives to address environmental impacts by limiting or enabling their access to preferred markets. NGOs sometimes take an active role in negotiating an acceptable solution. The habitat quota system in the British Columbia groundfish fishery is a clear example of this, but it is not unprecedented. Fishery certifications by groups such as the Marine Stewardship Council are increasingly focused on the external impact of fisheries, such as bycatch and habitat impacts rather than simply sustainable catch levels (Christian et al. 2013, Martin et al. 2012). Coasian bargaining is not limited to rights-based fisheries organized into collectives; there are many examples of fisheries that are not managed with rights-based systems seeking fishery certification or engaging with NGOs in addressing external problems (e.g., bycatch in tuna fisheries). Groups of fishers in competitive fisheries have successfully negotiated voluntary partitioning of fishing areas to avoid gear conflicts (e.g., Kaiser et al. 2000). However, the existence of secure catch rights, particularly rights with a long duration, can greatly increase the incentives for fishery collectives to engage in bargaining or undertake costly activities to address external impacts voluntarily, simply because of the substantial wealth they have tied up in their catch rights. The cost of having those catch rights taken away or devalued by additional regulation or loss of access to markets is higher, as the stream of potential reductions in value is capitalized in the catch right.

Whether they are addressed through regulation or voluntary agreements, solutions to external impacts of fisheries are unlikely to be optimal in terms of balancing costs and benefits (Segerson 2013). For example, the value of additional Pacific halibut bycatch to the Bering Sea bottom trawl fleet is probably much greater than the marginal value of the halibut landed in the directed fishery, and the same may be true of salmon bycatch in the pollock fishery and rockfish bycatch in the Pacific whiting fishery. However, regulatory approaches to managing impacts of fisheries, even incentive-based approaches using taxes or cap-and-trade programs, are also unlikely to maximize social welfare because they rely on regulators knowing the optimal level of damages and/or the cost of damage avoidance and how they change over time and with the level of avoidance. Furthermore, regulators may not even attempt to achieve these optimal levels as they balance efficiency with political concerns. In some cases, there may be important cultural values involved that are difficult to measure in monetary terms. Native Americans have strong cultural values (and treaty rights) for salmon and have argued persuasively and successfully to control chinook bycatch in the pollock fishery despite the high costs of the bycatch reduction efforts. Regulators, or the interested parties themselves, rarely have the information necessary to identify the most efficient solution, and the chosen solution is generally arrived at through negotiation and a political process (which may invite rent seeking). This is likely to be true both in regulatory and voluntarily negotiated cases.

Because the efficiency and efficacy of negotiated agreements are uncertain, rigorous evaluation of these collective approaches to managing environmental impacts of fishing is important. However, doing so can be a challenge. The uncertainty and variability of bycatch and even habitat impacts can make it difficult to know whether a change in realized impacts was a function of avoidance or luck (bad or good). In most cases, evaluations just examine how impacts changed after a program was implemented, but there is a need to apply more sophisticated program evaluation techniques to evaluate the effectiveness and cost and benefits of these programs (Ferraro & Hanauer 2014). This can be challenging when programs apply to small numbers of heterogeneous vessels and there is no good control group. However, as Reimer & Haynie (2018) illustrate, there are a number of techniques that can be applied in these cases, including difference-in-difference, propensity-score-weighted difference-in-difference (Heckman et al. 1997), and the synthetic control method (Abadie & Gardeazabal 2003, Abadie et al. 2010).

The challenges of organizing collectives can be substantial, particularly when gains to members are uneven or uncertain. Organizing a collective to voluntarily address impacts external to the group may present even greater challenges because the benefits of doing so may be less concrete and immediate. Case studies and meta-analyses of collectives formed to manage common pool resources led Ostrom (1990) to identify a number of design principles that can be critical in enabling formation and success of collectives. She found that an ability to exclude outsiders is critical and further that collective management often fails unless a government authority legitimizes the right to exclude outsiders from appropriating the resource. The same is true when the issue is a bycatch cap, as demonstrated by the initial failures of the BSAI groundfish cooperative to limit halibut bycatch before the cooperative was granted an exclusive share of the bycatch cap. Strong leadership and robust social capital have also been shown to be important for development and endurance of CRBFM (Gutiérrez et al. 2011, Little et al. 2015).

Collectives also face internal challenges. Collectivizing catch (or bycatch) rights can create free-rider problems that lead to shirking (Heintzelman et al. 2009), and some mechanism to combat this is likely to be necessary. Although Deacon et al. (2008) found increases in efficiency after implementation of a cooperative in the Chignik salmon fishery, Huang et al. (2015) found no appreciable increase in technical efficiency for cooperatives in the Northeast groundfish fishery. Policies that promote cooperation can also serve to offset free-rider problems in collectives (Segerson 2016). Estrada et al. (2017) found that that although collective catch rights granted to cooperatives in the Chilean sardine and anchovy fishery did not increase efficiency relative to a control group overall, collectives that harvested fish cooperatively did see increased efficiency.

With the exception of the British Columbia groundfish habitat quota program, the examples discussed in this review involve formal collectives with contractual agreements between the members that bind them to the agreed rules and actions. The British Columbia group appears to be somewhat of an anomaly in its ability to implement cooperative approaches (or at least cooperatively negotiate them). This group had also previously dealt with problems of low and binding choke stocks of some rockfish species (similar to the Pacific groundfish trawl case) through an informal risk pool in which fishers transferred quota to each other at nominal prices to cover unexpected bycatch events (Holland 2013). Though reciprocity at the individual level may not have been sufficient incentive for this behavior, research by Kranton & Minehart (2001) suggests that such cooperative norms can be sustained in a network of traders, and it is likely to be reinforced in this case because there is a fairly consistent group of quota owners over time with a long history of cooperation.

A cohesive group with a formal contract and monitoring and enforcement capabilities is likely to be more effective than a nonbinding group agreement relying on voluntary actions (Dawson & Segerson 2008, Little et al. 2015, Segerson 2013). Ostrom (1990) notes that, when a monitoring and enforcement system is designed and implemented by the cooperative itself, it is likely to be more effective than when penalties are imposed by outsiders. The cooperatives discussed earlier recognized that pooling bycatch would weaken incentives to avoid it and counteracted this with operational rules designed to reduce moral hazard, for example, the prohibitions on night fishing and fishing in particular areas imposed by the whiting cooperatives on their members with sanctions for noncompliance.

Much of the existing literature on collective institutions used in fisheries or other natural resources indicates a primary focus on access to or allocation of resources and on enforcement of internal allocation rules and exclusion of outside expropriators (Deacon 2012). The lack of preoccupation (or problems) with enforcement and allocation in many of the aforementioned examples is due in part to the fact that they are in developed and intensively monitored fisheries with exclusive catch rights granted to the cooperative or its members by regulators and with existing infrastructure to monitor and enforce the collective's rules. For example, the US West coast and Alaska trawl fisheries and the British Columbia groundfish fishery all had 100% human observer coverage that facilitated collection and sharing of reliable bycatch information, as well as the location, time, and even depth at which vessels were fishing. However, it is notable that these collectives have not completely relied on individual allocations or monetary incentives to manage bycatch or habitat impacts. They are at least equally focused on incentivizing cooperative behavior and often rely on good-faith individual efforts to reduce impacts that may be difficult to monitor and enforce. In most of these cases, the set of rules and practices dictated by the contracts these groups have developed do not fully eliminate moral hazard. In addition, the groups rely to some degree on peer pressure, and perhaps the threat of future exclusion from the collective, to motivate individuals to make their best efforts to avoid bycatch.

Organizing formal collectives and deploying monitoring and enforcement can be very costly. Costs could exceed the benefits of doing so in some cases and may well be a reason why collectives have not emerged in cases where there appear to be benefits from collectivization. When comprehensive monitoring systems are already in place, as in the US Pacific coast and Alaska examples, implementing a collective that requires vessels to follow particular practices at sea and to share information is much easier and requires a relatively small incremental cost. In fisheries without intensive monitoring programs, collectives often must rely on voluntary compliance, and the effectiveness of rules like real-time closures is less clear (Little et al. 2015). In general, the effectiveness of these efforts based on voluntary compliance is uncertain, though a yellowtail flounder bycatch avoidance scheme in the Atlantic scallop fishery has enabled the fleet to harvest its full allocation of scallops without exceeding its yellowtail allocation and triggering a closure (Little et al. 2015).

Many of the examples discussed above are designed explicitly or implicitly to reduce financial risk associated with achieving environmental performance targets. Bycatch, including that of sessile organisms such as corals and sponges, can be highly variable and uncertain. Complete avoidance may be very costly or impossible. The collectives have generally responded by reducing risk of complying with limits at the individual level (e.g., by pooling bycatch quota). Like any insurance product, pooling may reduce individual incentives to avoid bycatch (moral hazard) and attract members with higher expected bycatch (adverse selection) (Holland & Jannot 2012). Zhou & Segerson (2016) show that, when bycatch is uncertain and quota is pooled, fishers may choose harvest strategies with higher expected bycatch, which may increase the risk of exceeding aggregate quotas, though that can also increase overall profit. However, risk pools have successfully addressed these moral hazard and adverse selection issues through contractual arrangements that mandate specific fishing practices and information sharing.

Even at the level of the collective, the ability and cost of complying with a bycatch cap may be highly uncertain and variable year to year. CRBFM institutions have sometimes negotiated higher explicit caps on collective impacts in return for demonstrable efforts to keep impacts as low as possible even when caps may not be binding. In some cases, this is an explicit aspect of the regulatory approach. For example, IPAs in the Alaska pollock fishery allowed higher salmon bycatch cap in 2 out of 7 years, providing that the sector had an IPA that demonstrated (to the satisfaction of the North Pacific Fishery Management Council) that vessels are incentivized to avoid bycatch when caps are not binding. Similarly, the British Columbia groundfish habitat quota was set well above the explicitly stated target level as a risk buffer, with an understanding that the industry would strive to meet the lower target. In other cases, the agreement is less explicit (e.g., less constraining halibut caps for BSAI groundfish), but there is an implicit understanding that failure to keep bycatch well below targets could lead to stricter regulation (M. Fina, personal communication).

As Deacon (2012) notes, the case studies of collective institutions and self-governance in fisheries are almost certainly a biased set, with successful cases over-represented, and there are very few rigorous analyses of CRBFM performance. There are likely many failures to organize, as well as failed collectives. Seeking more examples of failures, and failures to organize, may provide insights as valuable as those of studying successes. In any case, more research on how CRBFM can contribute toward addressing external impacts of fisheries is needed.

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