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Abstract

This paper discusses rights-based management of international tuna fisheries that directly addresses the incomplete or absent property rights that create the incentives for overfishing, overcapacity, and failure to capture the full social and economic benefits that are possible. The United Nations Convention on the Law of the Sea, the United Nations Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fisheries, and other agreements require that States cooperate in the management of shared fisheries, but these agreements cannot ensure that cooperation succeeds or that the fisheries are optimally managed. Only by extending and strengthening the rights to access the fishery and harvest tunas is it possible to address effectively the problems of overfishing, overcapacity, damage to the ecosystem, and low social and economic benefits. Rights-based management must be self-enforcing because without a supranational sovereign body, cooperation, compliance, and enforcement are through voluntary agreement among the members of tuna regional fisheries management organizations.

Rights that are secure, exclusive and extend into the future can be specified for shares of the available catch by species or effort or to units of capacity, although the most effective right is over a share to catch. However, the allocation of rights should take account of any existing management framework and build upon it, where practical. Therefore, it may be necessary to evolve to a system based on catch rights, although effort rights may be applicable in some instances. This may involve maintaining complementary management measures, such as a limited-entry programme.

Rights can be allocated to States and then to individuals or groups or directly to individuals. Secure, exclusive and long-term rights provide fishers with a collective interest in the conservation of the fisheries and the efficient use of the resources. Transferability of rights allows fishing opportunities to be used by those fishers who produce the greatest economic benefits and can provide a means of reaching an agreement among different sectors of the industry via a transfer of fishing rights. Processors gain, whether they are rights holders or not, because rights-based management avoids the need for seasonal closures to maintain catches at optimum levels and underpins the consistent flow of raw material throughout the year, and a sustainable flow of raw material over longer periods. States with important processing industries can gain from stable and sustainable employment and incomes. Consumers gain through sustainable sources of seafood at more stable and lower prices over the long run. Where fishers own some of the resulting greater economic benefits into the future, they have greater incentives to comply, to police one another, and potentially, to invest in the stock and practice resource stewardship.

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Transferable rights provide a means of accommodating new members and increasing fishing by small island and coastal developing States (perhaps facilitated by a landings tax or levy on vessels or quota set-asides). In a fully exploited fishery, the rights of coastal States to expand their participation in a tuna fishery must be accommodated by mechanisms for reducing the participation of others. Rights of limited duration, which can revert to these States upon expiration, and set asides of initial allocations can also accommodate the aspirations of these States. Buybacks of vessels and/or rights through levies on existing industry members can also help accommodate these aspirations.

Rights-based management is not a panacea and does not address all issues, but it is the critical underpinning for sustainable fisheries, matching capacity with total allowable catches and sustainable fishing opportunities, realization of full social and economic benefits, and wealth creation. Rights will necessarily be supplemented with complementary biological and gear measures, certification, cooperation among regional management bodies, trade and port measures to foster compliance and enforcement, and other actions.

History shows that adoption of rights-based institutions tends to come late in resource use when the costs of both open access and central regulation are high but uncertainty has been cleared away, and that the most complete rights will be assigned to resources that are more valuable, less mobile, and more observable. Whether the transformation to rights-based management for international tunas backed by strong international treaties will be completed prior to this point remains an open question. Now is the time to begin before deteriorating fisheries makes the process even more difficult.

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The authors also greatly appreciate the assistance given by Jacek Majkowski (FAO Fisheries and Aquaculture Department) in providing valuable advice and assistance.

Abbreviations and acronyms

ACE	annual catching entitlement
AIDCP	Agreement on the International Dolphin Conservation Program
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CDQ	Community Development Quota
CMB	Community Management Board
DEA	data envelopment analysis
DML	Dolphin Mortality Limit
DWFN	distant-water fishing nation
EEZ	exclusive economic zone
EPO	Eastern Pacific Ocean
FAD	fish aggregating device
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IHQ	individual habitat quota
ITQ	individual transferable quota
IUU	illegal, unreported and unregulated
MCS	monitoring, control and surveillance
NGO	non-governmental organization
PAE	party allowable effort
PNA	Parties to the Nauru Agreement
RFMO	regional fisheries management organization
RVR	Regional Vessel Register
TAC	total allowable catch
TAE	total allowable effort
UNFSA	United Nations Fish Stocks Agreement
VDS	Vessel Day Scheme
VMS	vessel monitoring system
WCPO	Western and Central Pacific Ocean

Executive summary

This paper discusses rights-based management of international tuna fisheries that directly addresses the incomplete or absent property rights underlying the incentives for overfishing, overcapacity, and failure to capture the full social and economic benefits that are possible. The United Nations Convention on the Law of the Sea, the United Nations Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fisheries, and other agreements require that States cooperate in the management of shared fisheries, but these agreements cannot ensure that cooperation succeeds or that the fisheries are optimally managed. Only by extending and strengthening the rights to access the fishery and harvest tunas is it possible to address effectively the problems of overfishing, overcapacity, damage to the ecosystem, and low social and economic benefits. Rights-based management must be self-enforcing because without a supranational sovereign body, cooperation, compliance, and enforcement is through voluntary agreement among the members of regional fisheries management organizations (RFMOs).

Rights that are secure, exclusive and extend into the future can be for shares of the available catch by species or effort or to units of capacity, although the most effective right is over a share to catch. However, the allocation of rights should take account of any existing management framework and build upon it, where practical. Therefore, it may be necessary to evolve to a system based on catch rights. This may involve maintaining complementary management measures, such as limited-entry systems.

Rights can be allocated to States and then to individuals or groups or directly to individuals. Secure, exclusive and long-term rights provide fishers with a collective interest in the conservation of the fisheries and the efficient use of the resources. Transferability of rights allows fishing opportunities to be used by those fishers who produce the greatest economic benefits and can provide a means of reaching an agreement among different sectors of the industry via a transfer of fishing rights. Processors, whether or not they are rights holders, gain because rights-based management negates the requirement of seasonal closures and allows the consistent flow of raw material throughout the year, and a sustainable flow of raw material over longer periods. States with important processing industries can gain from stable and sustainable employment and incomes. Consumers gain through sustainable sources of seafood at more stable and lower prices over the long run. Where fishers own some of the resulting greater economic benefits into the future, they have greater incentives to comply, to police one another, and potentially, to invest in the stock and practice resource stewardship.

Large-scale tuna fishing vessels are highly mobile. Success in limiting fishing mortality and overcapacity in one area could easily redirect capacity to another area. This does not mean that capacity reduction should not be undertaken, but that global success requires coordination among RFMOs. Who should participate in a capacity reduction programme, and to what extent, is likely to be a controversial issue. There will be differences among participants' ambitions and abilities to partake in and to fund reduction programmes. Ideally, allocation of fishing rights should be made first, but reducing capacity among the participants is necessary in any event.

Rights-based management also helps break the deadlock facing RFMOs and improve their functioning. In the absence of allocated and well-structured property and use rights, each conservation and management measure represents an implicit allocation of opportunities and potential net benefits that differentially affects States and, even further, different constituent groups within each State. Even discussions and

decision-making of routine measures considered by RFMOs can slow to a halt because different decisions implicitly lead to different allocations of fishing opportunities, employment, assets, and net economic benefits. The absence of allocated and well-structured rights impedes RFMO cooperation and creates perverse incentives that foster non-cooperation. While RFMO governance reforms will improve performance, they do not address the root cause of perverse incentives and absence of conditions for multilateral cooperation. A once-and-for all allocation presents great difficulty but is preferable to the growing non-cooperation and ongoing implicit allocation decisions, increasing each year as capacity builds, and delay simply accentuates the difficulty of governance reform and addressing the root causes, particularly with resource declines and additional entry. After an allocation of well-structured rights, decentralized secondary markets for rights replace the ongoing and contentious deliberations that otherwise occur in the RFMOs.

The RFMOs attempt to control harvests at sustainable levels by implementing command-and-control regulations, such as total allowable catches, effort restrictions, and closed areas and seasons. These measures alone are often not adequate to conserve these valuable resources and their ecosystems, nor will they be adequate to stop the growth in fishing capacity or address any imbalances in capacity among gear types, fishing sectors, or nations. Moreover, these measures cannot create the incentives and conditions for economic efficiency, stable supplies of tunas, growing economic surpluses, and generation of wealth. Command-and-control measures by themselves do not tackle root causes, and instead create inefficiencies and perverse incentives as fishers invest in capacity, circumvent regulations, and race to catch fish before others do.

Transferable rights provide a means of accommodating new members and increasing fishing by small island and coastal developing States (perhaps facilitated by a landings tax or levy on vessels or quota set-asides). In a fully exploited fishery, the rights of coastal States to expand their participation in a tuna fishery must be accommodated by mechanisms for reducing the participation of others. Rights of limited duration, which can revert to these States upon expiration, can also accommodate the aspirations of these States. Set asides of initial allocations can also be made to accommodate the aspirations of coastal and small island developing States. Buybacks of vessels and/or rights through levies on existing industry members can also help accommodate these aspirations.

The ability of States to transfer their allocated property rights to other States may be limited by national policy or by the programme structure. An initial moratorium period before property rights transfers are allowed could help States understand the value of these rights, but this would delay the full realization of the benefits listed above. Transfers of use rights between gear types can be accommodated through use of a conversion factor to account for gear-specific impacts on the stock.

Transferable rights offer a new dimension for negotiations that could provide a means of reaching an agreement among different user groups, such as the fish aggregating device (FAD) and longline coalitions, via a transfer of fishing rights. For example, longline fishers could purchase bigeye quota from FAD fishers.

The first step towards controlling capacity and establishing strong and enforceable property rights is to establish limited entry, as might be set up via a closed vessel registry, after which reductions in the number of vessels can be negotiated. The United Nations Fish Stocks Agreement (UNFSA) establishes that participation in such programmes should be open to those with a "real interest." Although the criterion of "real interest" is not defined in the UNFSA, in practice, customary and legal frameworks appear to be evolving in support of programmes that are able to limit the number of participants in an effective way. Buybacks are a potential second step to reduce excessive capacity

voluntarily. An advantage of an initial buyback is that it could sidestep the very difficult negotiation of shares in a fishery among competing States.

There can be trade-offs between maximum economic efficiency and economic benefits achieved through the smallest number of vessels and crew required to catch the target catch or effort versus meeting social and political objectives through retaining larger numbers of vessels and crew. Experience in national programmes with strong rights-based management shows that there are fewer vessels remaining in the fishery but that economic benefits and wealth can be expected to rise considerably. The total number of crew- and vessel-days fished may not decline in a fully rationalized fishery, as the remaining crew and vessels fish longer, but there may be fewer vessels and crew numbers may be smaller. At the other pole, fewer vessels may exit the fishery to retain larger employment and protect smaller and vulnerable groups and communities, but at the expense of lower economic efficiency and economic benefits. Group rights rather than individual rights can also help protect groups and communities.

Rights-based management on target, commercial species by itself does not solve most of the concerns about bycatch and habitat preservation, and these concerns require their own set of specially designed incentives or other approaches to account for all catch (including bycatch) mortality or programme design. Rights can be delineated by area, although several RFMOs are contemplating allocating rights that can in principle be fished across all areas (both within exclusive economic zones [EEZs] and high seas) but which require a second right of access (i.e. a licence) to harvest within the EEZ of an individual State.

Under international law, nations hold the rights to fish and would receive the allocation. Individual nations would distribute use rights to vessels, gear types or sectors. Systems for the creation and transferability of the consequent rights to participate in the fishery can accommodate diversity in national legal systems. However, some domestic legislation may need additional interpretation and/or amendments to allow this management. All those with a real interest in a fishery should be involved in RFMO allocation decisions, irrespective of whether the membership practices of the RFMO are inclusive or exclusive. New entrants in fisheries may require adjustments in the allocations.

Total allocations should be science-based with the objective to maximize the benefits from the fishery as well as ensuring the health of the stocks and their ecosystem and, further, account for all removals from the fish stock. Denominating rights as a percentage share of the total allowable catch or effort will avoid the need for reallocations as fish stocks and optimum catch levels fluctuate. When accommodating new or increased participation by coastal States, the total of the allocations must remain equal to the target of the rights-based system. Effective allocations systems require a high level of confidence among the participants that their rights are secure and that the rules are applied equally to all. Any allocation system must be transparent in its establishment, implementation, compliance and enforcement. The duration or term of initially allocated rights can vary from perpetuity to shorter periods, with the former providing certainty and enhancing conservation, stewardship and investment, and the latter flexibility, providing a means of accommodating transfers and reallocations of rights, including developing coastal States and new members. Compliance and enforcement are necessary components of any allocation agreement and must be considered as part of the agreement and initial allocation. Along with the rights that an allocation specifies, an obligation to abide by the agreement and enforce its provisions is a responsibility of every participating nation. The allocation process should not be seen as an end in itself but as part of the movement to a rights-based management system in which future fishing opportunities may be available through subsequent transactions and not only from the initial allocation.

Key to successful capacity controls and rights-based management is an effective and transparent monitoring, compliance and enforcement system. For matters of compliance and sanctions, RFMO governance procedures that require consensus for most decisions are not appropriate. In principle, imposing appropriate sanctions for failure to abide by the allocated right should not present a legal problem. Available sanctions may include but, are not limited to: (i) port closures and bans on transshipment; (ii) reduction of allocated quota; (iii) trade or other commercial sanctions; (iv) removal of vessel officers' licences or eligibility to fish; (v) inclusion in illegal, unreported and unregulated vessel lists; and (vi) the possibility of an agreement of the RFMO members to permit enforcement in an international legal tribunal or other form of dispute resolution. Monitoring and enforcement are important factors to be considered in determining whether rights-based management is based on effort or catch. Many mechanisms for monitoring are available, both technical and human, and a suite of such measures should be implemented.

Rights-based management is not a panacea and does not address all issues, but it is the critical underpinning for sustainable fisheries, matching capacity with total allowable catches and sustainable fishing opportunities, realization of full social and economic benefits, and wealth creation. Rights will necessarily be supplemented with complementary biological and gear measures, certification, cooperation among regional management bodies, and other actions.

History shows that adoption of rights-based institutions tends to come late in resource use when the costs of both open access and central regulation are high but uncertainty has been cleared away, and that the most complete rights will be assigned to resources that are more valuable, less mobile, and more observable. Whether the transformation to rights-based management for international tunas backed by strong international treaties will be completed prior to this point remains an open question. Now is the time to begin before deteriorating fisheries makes the process even more difficult.

1. Introduction

International law allows every nation's citizens the right to pursue fisheries on the high seas under certain norms, but this law also establishes incentives contributing to overcapacity and overfishing of tuna resources that may already be fully utilized. Coastal States, which control access to resources within their exclusive economic zones (EEZs), face similar incentives to provide more licences to tuna vessels than are needed to take the available harvest.[1] Incomplete or even absent property rights under international and national laws have created these incentives that led to excess fishing capacity, overexploitation or full exploitation of tuna stocks, and losses in the social and economic benefits that could otherwise be enjoyed.

Unlimited entry into tuna fisheries must now change. Failing this, the inevitable outcome will be overexploitation of the world's tuna stocks. Command-and-control or prescriptive regulation through limiting total days or catch and time and area closures has been unable to address overcapacity and overfishing of several stocks and has led to insufficient economic benefits.

Instead, rights-based management, wherein catches, effort, or capacity are capped and allocated to participants as rights and fleets are limited in numbers, can usher in this change and establish incentives to fishers to maintain fleets at optimal levels.[2] Ownership of the right itself is typically vested in the State, or perhaps regional fishery management organizations (RFMOs) for the high seas, and rights of use for access, catch quotas, effort quotas, or units of capacity are then allocated by each State to their fishers, which can be groups (such as gear groups, communities, or indigenous peoples), companies, vessels, or individuals. The rights can also be directly allocated to individuals.

Successful management of these international fisheries with their shared fish stocks[3] requires a second element – effective self-enforcing multilateral cooperation through strong international agreements and institutions.[4, 5] Tunas, as highly migratory species,

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[1] Most tuna stocks are fully exploited, and some are overexploited. About 40 percent of the world's tuna are captured on the high seas beyond exclusive economic zones (EEZs).

[2] In principle, taxes provide an equivalent solution to the externality created by incomplete property rights (Weitzman, 2002, Kotchen and Salant, forthcoming). Taxes are also incentive compatible, i.e. they create economic incentives to address the commons problem. Taxes do not address the underlying, fundamental issue of absent or incomplete property rights and are administratively difficult.

[3] FAO classifies stocks as transboundary, highly migratory and straddling. Transboundary stocks are those that inhabit (or cross) the EEZs of two or more coastal States. Highly migratory stocks are those found both within the EEZs and the adjacent high seas and that are highly migratory in nature. Straddling stocks are those that also cover both EEZs and the high seas but are more stationary. This paper discusses highly migratory stocks but the term transboundary is also in its more general sense of crossing two or more boundaries that might be EEZs or one or more EEZs and the high seas, and hence transboundary is used as a general all-encompassing term.

[4] In the jargon and framework of economics, there are two key externalities, requiring two policy instruments. The first externality is the resource stock externality arising from incomplete property rights (thereby requiring strong and enforced rights), and the second is the transboundary externality arising from the incomplete and multiple jurisdictions found with transboundary resource stocks (in the general sense, and thereby requiring cooperation among States, i.e. multilateral cooperation). The literature on the first externality is voluminous and covered throughout this paper. For the transboundary externality, see Barrett (2003, 2005), who developed the concept of self-enforcing international agreements. FAO (2002), Munro, Van Houtte and Willman (2004), Bailey, Sumaila and Lindroos (2010), and Kronback and Lindroos (2010) discuss multilateral cooperation in international fisheries. See Schiffmann (2008) for a political science view.

[5] In a self-enforcing agreement, RFMO members must view it in their interest to abide by the agreement (as opposed to fishing outside the limits of the agreement), and non-members must either be provided with an incentive (an opportunity) to join and participate in the RFMO or be prevented from otherwise undermining the agreement.

straddle or move from one national jurisdiction to another, and back and forth between national jurisdictions and the high seas. Individual tuna vessels operate in different national jurisdictions and on the high seas, and it is not uncommon for individual vessels to operate in different ocean areas. Tuna catches supply global markets interconnected by prices and commodity flows (Jeon, Reid and Squires, 2008; Jiménez-Toribio, Guillotreau and Mongruel, 2010). Multiple nations control national waters and fishing fleets that fish in these waters and on the high seas. All of these elements mean that the cooperation required to conserve and manage international tunas must be multilateral. Because of the sovereignty of nations and the absence of a supranational authority that can insure cooperation among these sovereign States, multilateral cooperation requires self-enforcing agreements (Barrett, 2003, 2005).

The experience with rights-based management in fisheries has largely taken place in national EEZs, with a few exceptions discussed below, but the principles remain the same in international tuna fisheries, coupled with the necessity of multilateral cooperation through strong, self-enforcing international agreements and institutions. Property rights also help ensure that States that actively conserve, manage and cooperate with other States are the ones that benefit from their actions.

The two critical elements for successful conservation and management of transboundary tuna fisheries – rights-based management and effective self-enforcing multilateral cooperation – can increase the net economic benefits and strengthen sustainable fishing. The stronger and more well structured the property right is, the greater are the expected gains. The gains in net benefits and strengthened sustainable catches accompanying rights-based management and self-enforcing multilateral cooperation accrue to individual States, fishers, processors and consumers. The potential gains from multilateral cooperation and strong and well-enforced strong rights are clear increases compared with the uncooperative behaviour in the absence of rights, and ensure that all States can potentially benefit from participating in a rights-based management regime. Processors gain because rights-based management negates the requirement of seasonal closures and allows the consistent flow of raw material throughout the year, and a sustainable flow of raw material over longer periods. States with important processing industries can gain from stable and sustainable employment and incomes. Consumers gain through sustainable sources of seafood at more stable and lower prices over the long run.

Self-enforcing rights-based management is not a panacea for all issues associated with sustainable and profitable fishing industries, but coupled with sound complementary biological and other conservation and management controls (e.g. gear measures) – preferably by agreement among the rights holders themselves – rights-based management can establish stronger private, group and state incentives that are more closely aligned with broader social and biological objectives and contribute to greater economic efficiency and sustainability. Rights-based management can also enhance the effectiveness of self-enforcing multilateral cooperation and the governance of RFMOs, as discussed below. Rights-based management on target, commercial species by itself does not solve most of the concerns about bycatch and habitat preservation, and these concerns require their own set of specially designed incentives (Hilborn, 2007; Abbott and Wilen, 2009; Gjertsen, Hall and Squires, 2010), input controls (Emory *et al*., 2012), or other approaches to account for all catch (including bycatch) mortality (Turris, 2010) or programme design (Branch, 2008). Rights can be delineated by area, although several RFMOs are contemplating allocating rights that can in principle be fished across all areas (both within EEZs and high seas) but which require a second right of access (i.e. a licence) to harvest within the EEZ of an individual State. Rights implemented in one tuna RFMO area can also lead to vessels transferring to unregulated areas and increasing pressures on fish stocks there, an example of transboundary externalities (de Meza and Gould, 1992). In extreme cases, it may be economically rational to mine

a fishery (Clark, 1973) and rights-based incentives may not match society's goals. Fisheries that have implemented strong programmes of rights-based management are not without their remaining issues, but incentives and economic health have improved and costly command-and-control micro regulations curtailed or removed, and RFMO governance and functioning should improve markedly.

The balance of this paper discusses some of the key facets of self-enforcing rights-based management in the international fisheries for highly migratory species with a focus on tunas.[6] Chapter 2 considers use and property rights in transnational tuna fisheries within the context of self-enforcing multilateral cooperation, building off the contributions of Joseph and Greenough (1978), Libecap (1989), Ostrom (1990), Baland and Platteau (1996, 2005), Scott (2000, 2008), FAO (2002), Barrett (2003, 2005), Munro, Van Houtte and Willman (2004), Joseph (2005), Bayliff, de Leiva and Majkowski (2005), Bayliff and Majkowski (2007), Aqorau (2007), Allen (2010), Allen, Joseph and Squires (2008), Allen *et al*. (2010a) and drawing upon the chapters in Allen, Joseph and Squires (2010) and Inter-American Tropical Tuna Commission and World Bank (2008).[7] It gives special attention to the following key aspects: (i) characteristics of rights; (ii) type of rights adopted; (iii) allocations to States or directly to individuals or groups and the form of rights created; and (iv) constraints to the emergence of rights-based management. Chapter 3 discusses monitoring, control and surveillance. Chapter 4 briefly discusses the role of buybacks in the transformation to rights-based management, which is discussed more fully in Allen (2010), Curtis and Squires (2007), Allen *et al*. (2010a), Allen, Joseph and Squires (2010), Squires *et al.* (2010a) and Squires (2010b). Chapter 5 provides an overall assessment, summing-up and concluding remarks.

[6] This paper does not focus on the issues of international law and governance that are also important factors, and instead focuses on the economics of property rights and contracting for natural-resource industries, largely in the framework established by Gordon (1954), Chung (1970), Christy (1973), Libecap (1989), and Scott (2000, 2008), and on the principles of multilateral cooperation among parties in international environmental agreements, relying on the notion of self-enforcing agreements of Barrett (2003, 2005), and combinations of both (Ostrom, 1990) and Baland and Platteau (1996, 2005) for group rights, i.e. common property such as RFMO ownership of highs seas, sector allocations, and community or gear group rights. Serdy (2007, 2010) discusses legal issues.

[7] Additional papers addressing rights-based management are: Copes (1986), Libecap (1989, 2006, 2009), Neher, Arnason and Mollett (1989), Symes and Crean (1995), Squires, Kirkley and Tisdell (1995), Squires *et al.* (1998), Grafton (1996), NRC (1999), Shotton (2000), Arnason (2002, 2005), Macinko and Bromley (2002), Branch (2004, 2008), Hannesson (2004, 2010), Ram-Bidesi and Tsamenyi (2004), Leal (2004), Hilborn, Orensanz and Parma (2005), Huppert (2005), Fujita and Bonzon (2005), Branch *et al.* (2006), Parris and Grafton (2006), Grafton *et al.* (2006), Munro (2007), Crothers and Nelson (2007), Brandt (2007), Hilborn (2007), Scott (2000, 2008), Chu (2009), MRAG *et al.* (2009), Aranda and Christensen (2009), Ridgeway and Schmidt (2010), McCay (2010), Squires (2010a), Kroetz and Sanchirico (2010), and Turris (2010). An additional literature addresses fisheries management among nations within the framework of bioeconomics and game theory, examining the impact of strategic behaviour between States and the achievement of a stable cooperative equilibrium, and examines the impact of alternative distributions of net benefits, as recently discussed by FAO (2002), Barrett (2003, 2005), Munro, Van Houtte and Willman (2004), and Kronbak and Lindroos (2010). See Allison *et al.* (2011) for issues related to rights-based management in small-scale/artisanal fisheries.

2. Rights-based management

ECONOMIC BENEFITS AND SOCIAL ISSUES[8]

Rights-based management restructures the relations among fishers, management authorities and States in two broad and important ways, by reorienting incentives from non-cooperative to cooperative among rights holders (in RFMOs, probably States), thereby strengthening the requisite multilateral cooperation that includes enhanced RFMO governance and self-enforcement, and second, by more closely aligning individual and state economic incentives with broad socio-economic and biological-ecological goals for the entire fishery.[9, 10] Only such a significant shift in institutional structure will realign the socio-economic and geopolitical incentives faced by those harvesting the resources from the race to fish to incentives that favour sustainable target catches and resource stocks, and generate a sustainable economic surplus and capital and employment in both the harvesting and processing sectors.[11] With incompletely defined and enforced property rights, private decision-makers do not consider or internalize external benefits and costs in their production or investment decisions. The benefits but not the full costs accrue to each harvester, and the benefits are less than what could otherwise be achieved. Rights-based management thus alters the incentives of both fishers and States, as competition for fish falls dramatically.[12] In contrast, these adverse incentives are not affected by command-and-control management strategies that retain the competition between fishers for a common resource. Under rights-based management, more flexible and rational choices about the timing and location to fish and even what to fish are now possible. When fishers own some of the resulting greater

[8] Asche *et al.* (2005, 2008) comprehensively discuss five empirical investigations of the benefits to individual transferable quotas (ITQs) in national programmes. As discussed below, some of these potential gains may require redistribution (transfer payments in cash or kind, also called side payments) to ensure that all States gain (Barrett, 2003, 2005).

[9] Holders of strong and well-enforced rights tend to align their separate interests in order to maximize the value of their rights. These incentives extend to collective measures that protect the fishery and hence the value of the rights asset they hold. In addition, property rights institutions, by assigning ownership to valuable assets and designating who bears the rewards and costs of resource-use decisions, structure incentives for economic behaviour within the society (Libecap 1989), and the same holds within RFMO areas. These institutions structure incentives for economic behaviour on an even broader scale for transnational resources. Moreover, by allocating decision-making authority, the property rights arrangement determines who the participants are in the economic system (Libecap, 1989).

[10] Scott (2000) observes that ITQs are rights to the catch or flow from the fish stock not to the fish stock itself, and hence not all of the resource stock externality is internalized or accounted for; other forms of catch rights, i.e. those held by groups or communities, would face the same issue. On the other hand, Danielsson (2000) proved that an ITQ system could generate a first-best solution even if production externalities existed. Anderson (2009), Higashida and Takarada (2009), and Van Putten and Gardner (2010) summarize the discussion on market power in the secondary market for ITQs (see also Hahn [1984], Adelaja, Menzo and McCay [1998] and Anderson [1991]). McEvoy *et al.* (2009) demonstrate that market power from imperfect competition by the processing sector can lower fisher welfare.

[11] There are other advantages including flexibility, cost savings, information generation, and migration to high-valued uses (Libecap, 2006). Johnson and Libecap (1982), Hannesson (2004), and Libecap (2006, 2009, 2010) provide a comprehensive answer to the advantages of rights-based management over command-and-control forms.

[12] Where multiple fishers compete to catch fish from a given population, each fisher maximizes his/her net income by continuing to fish as long as the value of his/her catch exceeds the cost of catching it (Gordon, 1954). Further, Huang and Smith (2010) show that ITQs do not fully eliminate growth overfishing owing to strategic interactions. Thus, the race to fish can still unfold within a season even if there is no recruitment overfishing.

economic benefits, they have greater incentives to comply, to police one another, and potentially, invest in the stock and practice resource stewardship (Scott, 2000, 2008; Libecap, 2009), although some countervailing incentives are possible (McCay, 2010). Establishing property and use rights clearly defines and allocates rights and responsibilities and costs and benefits.

The magnitude of the gains in economic benefits under rights-based management, including economic rents and capital through the capitalized value of the right, depends on the type of right adopted, the nature of the programme adopted for any given right (such as caps on the size of rights holding, and limits on transferability and duration), methods of monitoring, control, surveillance and enforcement, cost recovery and other factors. Nonetheless, some broad generalizations are possible, focusing on:

- lower overall industry costs through industry rationalization as vessels exit the fishery;
- improved product quality, changes in product form, and timing of landings and extended seasons (so that landings are spread throughout the year rather than flooding the market in a compressed period);
- lower operating costs per vessel as lower-cost vessels purchase quota from higher-cost vessels and the latter exit the fishery;
- cost savings through economies of scale and scope as unit costs decline when vessel fixed costs are spread out over a larger catch and the optimum size of vessels adjusts and as costs decline through a more efficient catch mix;
- increased capacity utilization (that lowers short-run costs for a given capital stock);
- the more skilled skippers remaining in the fishery (thereby increasing technical efficiency, which also lowers costs);
- equating marginal costs across vessels (the equi-marginal principle).

These effects lower costs and/or raise revenues, thereby increasing profits and creating capital where there was none before through the capitalized value of the expected rents over the life of the right. These are discussed in turn below.

Rights-based management facilitates the exit of excess harvest capacity and thus greater economic efficiency, most importantly through lower overall costs in the fishery.[13, 14] Through the secondary market for transferable rights that develops, in which rights can be bought, sold, leased, rented or otherwise exchanged, rights-based management provides a transparent and orderly means of entry into, and exit from, the fishery that maintains sustainable target catch levels, allows adjustments between gear groups and vessel size classes, and the flexibility to adapt to changing circumstances in the ecosystem, environment, fish stocks and product and input markets.[15] Transferability of the right is the key for the market for rights to develop and function and for vessels to exit the fishery. For transfers of rights to function efficiently, the market for harvesting rights must be competitive and prices must convey useful information about the profitability and status of fish stocks (Grafton *et al.*, 2006). A recent study of New Zealand's markets for individual harvesting

[13] To catch the same total allowable catch (TAC) in the Alaska sablefish fishery after ITQs were implemented, total hooks fell from 80 million to 50 million and vessel-days fell from 7 800 to 4 800. Where there were 46 vessels in the Greenland shrimp fishery prior to ITQs, there are now 7 larger vessels (Vestergaard, Stoyanova and Wagner, 2011).

[14] However, industry exit may be delayed owing to sunk costs (Vestergaard, Jensen and Jørgensen, 2005), or more generally the market price of exiting vessels (Branch, 2004), to other regulations and participation in other fisheries (Grafton, Squires and Fox, 2000), retention as an insurance policy should the ITQ system be scrapped (Asche *et al.*, 2005), or owing to the combined sale of both quota and vessel (Weninger and Just, 1997). Buybacks have followed to accelerate industry exit, such as in the Australia southeast trawl fishery (Fox *et al.* 2007).

[15] Quota prices can also send signals to policy-makers about the economic and biological health of a fishery. Arnason (1990) showed that, in principle and under the assumption of perfectly competitive markets, monitoring the effect on quota prices of changing the TAC could be used to converge to the optimal TAC.

rights found that prices there do reflect ecological variability and changes in fishing profitability (Newell, Sanchirico and Kerr, 2005).

The most important economic efficiency gains apparently come from reduced fleet sizes, which in turn lower overall industry costs of capital and other fixed costs and operations, and dampen pressures to overfish and overcapitalize that otherwise occur through the race to fish under weak or absent property rights and inadequate enforcement.[16] Fewer vessels in the fleet mean more fish, higher catch rates, and greater revenue and profits for the remaining vessels.[17] The closer the resource stocks are to total allowable catches (TACs) when economic rationalization involving industry restructuring occurs, the lower the rates of vessel exit. Eventually, the economic focus of rights-based management may shift from addressing overcapitalization, created by weak or absent property rights, to its ability to enhance competition in global markets through lower costs, higher-valued products and flexible responses to shifts in world markets, resource conditions and technology. Vessel exit under rights-based management is discussed in greater detail below.

Economic benefits sometimes come from improved product quality through handling and timing of catch, product form (e.g. fresh versus frozen), timing of landings and extended seasons, as in the Australian southern bluefin tuna and British Columbia halibut fisheries (Geen and Nayar, 1988; Casey *et al.*, 1995; Hermann, 1996; Grafton, Squires and Fox, 2000; Campbell, Brown and Battaglene, 2000; Sylvia, Mann and Pugmire, 2008).[18] Quality of landed product may suffer during the race to fish, so that prices are depressed by seasonal gluts, and higher value markets often require a consistent supply that short seasons cannot meet (Townsend, McColl and Young, 2006). In the British Columbia fishery, rights-based management allowed extending the fishing season and a shift in product form from frozen fish that had been landed within a very short season to fresh fish landed throughout the year. Landing fish in such a compressed time period lowers ex-vessel prices, and fresh fish fetch considerably higher prices. In Australia, catch rights migrated from longliners on the east coast, harvesting for the canned market, to south Australian purse seine vessels and pen-raised bluefin for the Japanese sashimi market that has a substantially higher value. Following this line of thinking, Anderson (2002) suggests that stronger rights

[16] Vessel exit is substantial in some fisheries and comparatively small in others. Branch (2004, p. 24) states: "In the U.S. surf clam and ocean quahog fishery, the number of vessels declined by 74 percent and 40 percent respectively, while catches per trip increased 2-3-fold (McCay *et al.* 1995, Wertheimer and Swanson 2000). In the Icelandic summer-spawning herring fishery, the stock gradually rebuilt after a collapse in the late 1960s, and the fishery was reopened in 1975 under an IQ system, which converted to ITQs in 1990 (Jakobsson and Stefánsson, 1999). Despite substantial increases in stock size and catches, the number of vessels in the fishery declined from a peak of 144 in 1980 to less than 40 in 1994-96, while the catch per vessel increased by more than an order of magnitude, greatly improving the profitability of this fishery (Jakobsson and Stefánsson, 1999)." Vessel exit was rapid in the Australian bluefin tuna fishery, but was protracted and slow in the Australian southeast trawl fishery, the Icelandic demersal fishery, and the Dutch flatfish fishery (Asche *et al.*, 2005; Fox *et al.*, 2007).

[17] Newell, Sanchirico and Kerr (2005), Asche *et al.* (2008), Arnason (2008), Munro *et al.* (2009), and Van Putten and Gardner (2010) report rising quota prices in ITQ fisheries, thereby implying the success of rights-based management (the value of an asset, such as an ITQ, is the present value of the expected net returns, so that a rising asset price implies higher expected net returns). Asche *et al.* (2008) assessed the realized and potential economic efficiency gains for five ITQ-regulated fisheries in Northern Europe and found that more than half of the vessels were estimated to be potentially redundant in all case studies. Gómez-Lobo, Peña-Torres and Barría (forthcoming) estimated potential for significant fleet reduction in Chilean ITQ fisheries.

[18] Branch (2004) observes that, in the New Zealand snapper fishery, there was a shift from trawling to longlining or gill-netting to supply the ike jime (a method of rapid killing) market in Japan, and that subsequently fishers started to export snapper live to Japan to obtain even higher prices (Boyd and Dewees, 1992, Annala, 1996). Branch (2004) further observes that in the Australian south east fishery, according to some fishers, quality was improved by increasing mesh sizes (from 13.5–23 cm to 22.5–30 cm), decreasing trawl duration (from 6–8 hours to 3–4 hours), and training deckhands on how to sort, wash and prepare different species (Waitt and Hartig, 2000).

for harvesters can create opportunities to increase rents by application of aquaculture technologies. The elimination of the race that allows vessels the time to handle their catch in the Pacific Whiting Cooperative allowed product recovery rates to rise from 17 to 24 percent, which corresponds to approximately 4.5 million kilograms more of seafood from the same catch (Sylvia, Mann and Pugmire, 2008). Similarly, product recovery rates in the Bering Sea Pollock Cooperative rose from 19 to 30 percent. Ex-vessel prices can also rise as landings are timed to accommodate market needs, as the secure catch right provides vessels with flexibility over the timing of catches and landings (Branch, 2004).

Rights-based management, at least in the form of catch rights, appears to have less effect on potential efficiency gains realized through reductions of variable (operating) costs on a per vessel basis than through industry exit and restructuring and through changes in when and where to fish and product form (Grafton, Squires and Fox, 2000; Grafton *et al*., 2006; Brandt, 2007; Kirkley and Walden, 2010). Some vessels may even realize higher operating costs per vessel if there is a longer season length for the remaining vessels. Remaining boats in the fishery can be expected to realize economies of scale and scope so that the most cost-efficient size of vessel for the volume of landings made and species mix remain.[19] Remaining vessels may also be more technically efficient, in part reflecting more skilled skippers, which also lowers costs.[20] Less efficient vessels can be expected to exit the fishery, which includes vessels of less cost-efficient size. Nonetheless, it remains unclear whether costs of those remaining in the fishery are substantially lower, and this point remains open to further research. Some research based on simulation suggests that remaining vessels will, on average, be more cost-efficient and will benefit from economies of scale, especially as there are fewer vessels harvesting the TAC (Weninger and Waters, 2003; Weninger, 2008; Lian, Singh and Weninger, 2010).

Rights-based management has the potential to reduce fishing capacity and thereby increase capacity utilization for the remaining vessels.[21] Vessels should then enjoy lower variable costs through more efficient utilization of capacity. The key issue is transferability of the right (Grafton, Squires and Fox, 2000; Asche, Bjørndal and Gordon, 2009). A limited number of studies have tested for the changes in capacity using data from before, at the time of introduction, and some years after the implementation of individual transferable quotas (ITQs) (Weninger, 1998, 2008; Dupont *et al.*, 2002; Felthoven, 2002; Lian, Singh and Weninger, 2010; Squires *et al.*, 2010a).[22] These studies have found that fishing capacity declines and capacity utilization increases following the introduction of ITQs. However, if not all commercial fishers are included in the allocation of rights, capacity can increase in excluded gear groups or vessel size classes (Grafton *et al.*, 2006). In Iceland, for example, until they were abolished in 1990, exemptions from individual catch quotas for vessels under ten gross registered tonnes

[19] Economies of scale reflect lower costs of production per tonne caught as larger quantities of tunas are caught, in large part because fixed costs are spread over larger catches. Diseconomies of scale refer to higher costs of production as larger quantities are caught. As more catch is consolidated onto fewer vessels, average costs per landed tonne of tunas are expected to fall. Economies of scope refer to cost savings from jointly harvesting multiple species of fish or different types of outputs. Under rights-based management, especially ITQs, vessels may alter their species mix among yellowfin, bigeye and skipjack tunas to enjoy cost savings through economies of scope. Single-species tuna harvesting, such as trolling for albacore, only realizes scale economies. Arnason (1993), Geen and Nayar (1988), and Weninger (1998) examined economies of scale in Iceland, Australia, and mid-Atlantic surfclams following ITQs, and Higashida and Managi (2010) showed experimentally that following an ITQ vessels can reach scale efficiency if the quota price reaches equilibrium.

[20] Technical efficiency refers to catching the most fish from a given quantity of effort (bundle of inputs).

[21] The lower variable and fixed costs from reduced total capacity was the first point considered.

[22] See also Kirkley, Morrison Paul and Squires (2002), Weninger and Just (2002), and Vestergaard, Jensen and Jørgensen (2005).

distorted the composition of the fishing fleet and encouraged investment in smaller vessels (Arnason, 1995).

Rights-based management is more cost-effective than traditional command-and-control fisheries regulation that relies on quotas, time and area closures, etc. This cost-effectiveness comes because it allows vessel participation and activity of participating vessels to adjust so that their marginal costs of harvesting equalize. Thus, lower-cost vessels tend to acquire rights and higher-cost vessels tend to reduce their holdings of rights or even exit the fishery altogether, until in principle the marginal costs of harvesting equalize. A larger resource rent develops in the fishery.

Rights-based management can help provide sustainable and more stable sources of raw material to processors. After initial allocation, rights can provide the industry with stability and ability to adjust quota holdings, so allowing both fishers and processors to make better operational decisions and investments (Clark, 1994; Yandle and Dewees, 2008). Rights-based management can also ensure stable, year-round employment at sustainable levels as measures such as time and area closures are no longer necessary except for factors such as protection of spawning.

Rights-based management in international fisheries harvesting transboundary fish stocks enhances multilateral cooperation. In the absence of well-defined and enforced rights, nations continually struggle over management measures within RFMOs. Conservation and management measures of any importance are implicitly allocation decisions, with some parties gaining or losing more than others, with potentially important distributional impacts upon the harvesting and processing sectors of each State. Without strong and enforced property rights, each State's incentive is to seek the management measure whose distributional consequences most favourably affect itself, which in turn increases the transactions costs of multilateral cooperation and impedes agreement within the RFMO; if major sacrifices are called for, the difficulty in achieving multilateral cooperation grows. Without side payments or compensation in some manner for losses, so that no party loses from a measure, the greater is the difficulty in reaching a decision, which is why the side payment (transfer of money or in kind from one party to another) often comes at the expense of the future through an increase in the TAC or TAE. When all parties must lose from a management measure, the deliberations can intensify, with each party attempting to minimize its losses through a "beggar thy neighbour" approach. Rights-based management requires a major and potentially contentious allocation of rights, but after such a once-and-for-all allocation has been made, most of the subsequent adjustments, and hence implicit reallocations of resources and net benefits, transpire through the newly created decentralized institutions of property rights and secondary markets for these rights. Rights are fully valued and reallocations agreed upon and compensated through the transactions in these markets for rights. The introduction of well-defined and enforced property rights also lowers the rate by which future benefits and costs are discounted by the parties, through removing more of the perverse incentives leading to the race to fish and raising the value of future net benefits from the fish, and thereby increasing the incentives for conservation and cooperation. In short, otherwise difficult allocation decisions are removed from the political sphere within the RFMO to the new and decentralized institutions of rights and markets. This, in turn, dramatically reduces the transactions and information costs of the RFMO and allows the RFMO to shed its concern with detailed and distribution-impacting command-and-control regulations and instead focus on oversight and more scientific and broader issues of governance, including social control over the market for rights.

The desired shape of the restructured industry and the degree of reorientation from a social, employment-generating activity associated with overcapacity to a more purely economic and wealth-generating activity is an issue for RFMOs and member

States.[23] That is, there is a trade-off between the maximum possible economic efficiency with a smaller fleet and fewer crewmembers (but working longer hours per vessel and crewmember) and social-distributional considerations that retain larger fleet and crew sizes and lower profits. In the broadest sense, this represents social control over markets, i.e. the extent to which society controls markets or markets instead set the tone for society (Polyani, 1944). In contrast to domestic fisheries solely within EEZs, most international tuna fisheries are dominated by large-scale production from purse seine and longline vessels with strong commercial orientation that compete in highly competitive global markets linked by prices and commodity and vessel flows, so that strong rights-based management as a policy designed to improved economic efficiency and sustainability is the appropriate orientation. States concerned with the distribution of benefits and opportunities within their waters, whether from these large-scale and capital-intensive vessels or from smaller-scale and more labour-intensive pole-and-line and other gear, always retain the option to allocate their share of the overall catch, effort or capacity as they see fit to satisfy these distributional goals. That is, these States can choose to give up some profit to retain more vessels and crew. Moreover, States can always attenuate the use rights within their national waters to satisfy these social objectives.[24] Moreover, the establishment of property rights and secondary markets in which rights are traded and an orderly means of entry and exit established offer the best option available to address the key social issue of aspirations of developing coastal and small island developing States and to address systematically the issue of new members (Bellagio Framework 2010), as discussed below.

Reduced employment and other adjustment costs following the introduction of rights-based management can be an important concern (OECD, 2000). The impact on employment depends on the extent to which the fishery initially faces overcapacity and overexploitation (Grafton *et al.*, 2006). When rights reduce employment, as might be expected in fisheries characterized by poor returns and overcapacity, the adjustment costs should be weighed against the possibility of declining returns, ongoing problems with traditional input controls, and the probability that current employment levels under existing regulations are unsustainable (Grafton *et al.*, 2006; Yandle and Dewees, 2008). The evidence points to fewer vessels and crewmembers but with these remaining vessels and crew fishing longer than before.

INTERNATIONAL EXPERIENCE

The theory of international fisheries cooperation finds that in these fisheries a "prisoner's dilemma" outcome may result owing to both static and dynamic incentives to overharvest even when the countries involved otherwise have good management (McWhinnie, 2009). After examining more than 200 internationally shared fish stocks,

[23] Social objectives are often employment and income spread among many participants, production of food, and maintenance of traditional communities (Copes, 1986; Squires, Kirkley and Tisdell, 1995; Brandt, 2005; Hilborn, 2007; Asche *et al.*, 2008; Bromley, 2009; McCay, 2010). Hilborn (2007) observes that ITQs or full transferability of individual vessel quotas have been opposed primarily because of the impact on employment and distribution of wealth and/or social equity (Macinko and Bromley, 2002; Copes and Charles, 2004; Brandt, 2005; Degnbol *et al.*, 2006; Asche *et al.*, 2008; Yandle and Dewees, 2008; Bromley, 2009; McCay, 2010). Libecap (1989) makes a similar argument. See Squires, Kirkley and Tisdell (1995) for an early discussion of these issues within the framework of Polyani (1944), and NRC (1999).

[24] For example, national programmes have historically limited transfer of rights for some period to allow national participants time to learn the system and have limited transfer to prevent concentration of rights by firms or regions in order to maintain communities and employment as well as gear and vessel size groups. Other States have limited the duration of rights to allow periodic redistribution, including ease of new entrants. States within rights-based management systems in transnational and shared stock fisheries can similarly attenuate use rights after allocation through the RFMO. Kroetz and Sanchirico (2010) discuss the opportunity costs of restrictions on rights, review other studies, and provide a methodology for evaluating the trade-offs and opportunity costs of these restrictions.

McWhinnie (2009) found that the probability of a fish stock being overutilized (underutilized) rises (falls) with the number of countries sharing the stock (as predicted by theory, see FAO, 2002; Barrett, 2003, 2005; Munro, Van Houtte and Willman, 2004). This negative effect of sharing occurs when stocks are harvested from either large or small portions of EEZs, implying that access to a fishery is all that is required to have an effect on stock status. For highly migratory species and specifically tunas, McWhinnie (2009) finds that harvesting in the high seas proved detrimental to these species.[25] From this empirical evidence, it is clear that the time is past for unlimited entry into international tuna fisheries. Failing this, the inevitable outcome will be further investment and continued growth in capacity, overexploitation of the world's tuna stocks and erosion of sustainable economic benefits and employment.[26] Strengthening, and in many instances even creating, property rights is required in order to effectively address this emerging "tragedy of the international commons".

Transformation of the transboundary tuna fisheries from open access or free entry to a form of rights-based management is already under way, through both customary ("soft") and formal ("hard") international law, but it requires extension and further strengthening. In the eastern Pacific Ocean, the Inter-American Tropical Tuna Commission (IATTC) instituted the closed Regional Vessel Register (RVR) that established a form of limited entry and a hybrid of international common property and individual use rights.[27] The IATTC's Agreement on the International Dolphin Conservation Program (AIDCP) established, under a regional and binding international agreement and formal international law, a form of international common property and individual use rights through the Dolphin Mortality Limits (DMLs) for purse-seine vessels to set their nets on dolphins to catch the yellowfin tuna that were associated with them (Joseph, 1994). The overall DML is divided into individual-vessel DMLs allocated to vessels that request them. The International Commission for the Conservation of Atlantic Tunas (ICCAT) allocates TACs its among members and cooperating parties to manage as they see fit, creating a hybrid right of international common property and State use rights, of limited duration. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) also established an RVR or form of limited entry. Australia uses ITQs to manage its share of the bluefin tunas. Although outside of the RFMO framework, the Palau Arrangement in the Western and Central

[25] In addition to the unfavourable impact of international sharing, some economic and biological characteristics affect stock status, including higher-valued and slower-growing stocks that face further exploitation pressure.

[26] With the exception of skipjack tuna, at least in the Pacific Ocean, most stocks of tunas are fully exploited, and two stocks (western Atlantic bluefin and southern bluefin) are clearly "depleted" (Majkowski, 2007). Increased fishing effort for most of these stocks will not result in sustained increases in catch, but would probably lead to reduced catches in the long term. Reid *et al.* (2005) demonstrated overcapacity in all of the major purse-seine fisheries for tunas in the regions under the jurisdictions of RFMO. High-seas longline fisheries are similarly believed to face such overcapacity (Miyake, 2005). About 40 percent of the world's tuna are captured on the high seas beyond the EEZs.

[27] In 2000, the IATTC created a register of vessels authorized to fish for tunas in the eastern Pacific Ocean (EPO) with an allowance for minimal expansion to fulfil the needs of several coastal States (Joseph *et al.* 2009.) In 2002, with its Resolution on the Capacity of the Tuna Fleet Operating in the Eastern Pacific Ocean (Revised) it restricted purse-seine vessels to those already on the registry. Existing vessels can transfer registration to another party, which provides opportunities to States desiring to acquire fleets, but the capacity quotas remain vessel-specific. (New quotas are allocated only when vessels are retired.) Such a register essentially places a moratorium on fleet growth. According to the resolution, "Any purse-seine vessel fishing for tunas in the EPO that is not on the Register would be considered to be undermining IATTC management measures." The resolution also prohibits "the entry of new vessels," a prohibition that applies to parties and non-parties alike. The resolution concludes with a plea, "To urge all non-Parties to … comply with its provisions." The IATTC target level of 158,000 m^3, was established in the resolution on fleet capacity of 19 August 2000, for the total capacity of the purse-seine fleet. Notwithstanding paragraphs (7) and (8) of the resolution, the following participants were allowed to add purse-seine vessels to the Register after 28 June 2002: Costa Rica, El Salvador, Nicaragua, and Peru.

Pacific Ocean (WCPO) was a limited-entry programme, which has recently been superseded by the Vessel Day Scheme (VDS) for purse seine vessels, a transferable effort programme (Aqorau, 2007; Shanks, 2010).[28] On 1 January 2011, the Parties to the Nauru Agreement (PNA) began a trial longline VDS. In short, rights-based management is beginning to take shape, creating hybrid rights of international common property and State and individual use rights, often with multistage allocations. The challenge is to further extend and strengthen these forms of rights-based management.

Similar transformations are under way for atmospheric public goods, namely greenhouse gases and ozone-depleting chemicals (Barrett, 2003, 2005). Management of these global public goods has been addressed through formal international law in the form of the Kyoto and Montreal Protocols, establishing forms of property in emissions through allocations first to States and then to individual entities. Although the Kyoto caps are national-level commitments, in practice, most countries devolve their emissions targets to individual industrial entities, such as a power plant or a paper mill, creating hybrid rights of international common property and State and individual use rights. National governments, some which may not have devolved responsibility for meeting the Kyoto obligations to industry, and that have a net deficit of allowances, can buy credits for their own accounts.

Models for such a transformation in the property rights of tunas and the ocean commons in general already exist in the form of the 1911 Convention for the Preservation and Protection of Fur Seals and the AIDCP as formal treaties, and, on the basis of regional agreements, the IATTC closed RVR and capacity management programme (IATTC, 2005) and the allocations to States of TACs by ICCAT. Rights-based management and economic incentives were critical in the analogous transboundary resource conservation issue, the northern fur seal industry, in which the international agreement effectively transformed property rights from open access to international common property established through a self-enforcing international treaty and restructured multilateral relations from non-cooperative to cooperative (Barrett, 2003). Strong and secure property rights established by the treaty created a sustainable economic surplus, dramatically lowered tensions among the parties involved, and established the foundation for a noteworthy rebound in the population from critically low levels. (The critical step was the allocation of benefits and harvest rights in such a manner that all parties to the agreement gained. This step required side payments.)

The formation of rights in natural-resource industries historically often occurs only after these industries have depleted common resources to seriously low levels (Libecap, 1989, 2010). The question for transnational tuna fisheries is whether this transformation to rights-based management occurs on a timely basis or instead lags until conditions more closely resemble those for Atlantic and southern bluefin tunas, Atlantic cod, and Atlantic and Indian Ocean swordfish, all of which have been severely depleted by overfishing.

RIGHTS-BASED MANAGEMENT AND BIOLOGICAL SUSTAINABILITY

On the whole, as discussed in this section, strong and well-enforced property rights can contribute to biological sustainability of a fishery. However, rights-based management entails more than simply assigning a property right. Rights are only parts of complex fisheries institutions (Hilborn, Orensanz and Parma, 2005; McCay, 2010), and are usually accompanied by more restrictive and/or better enforced management measures, more effective TAC or TAE or capacity levels, and better monitoring, control and surveillance (MCS) and enforcement (Branch, 2008; Bromley, 2009; Chu,

[28] Vessel licences are allocated and transferred through bilateral and multilateral agreements between the Forum Fisheries Agency parties and the distant-water fishing nations (Petersen, 2006).

2009). Complementary biological and gear measures further strengthen the impact of rights-based management. In short, the full suite of changes that accompany rights-based management contribute to biological and ecological sustainability.

Costello, Gaines and Lynham (2008) conducted a thorough statistical analysis of the impact of introducing ITQs on the status of a fishery, using a database covering 11 135 fisheries from between 1950 and 2003, of which 121 had instituted ITQs by 2003. Using the definition of collapse of Worm *et al.* (2006), they showed that introduction of an ITQ system reduces the probability of collapse by about 14 percent and that the fraction of ITQ fisheries that collapsed was about half that of the non-ITQ fisheries that collapsed. (This result may also be because of a well-enforced TAC.) Heal and Schlenker (2008) observe that, because both Costello, Gaines and Lynham (2008) and Worm *et al.* (2006) define a fishery as collapsed when the catch drops to less than 10 percent of the historic maximum to date, a policy that stabilizes catch by definition reduces the probability of collapse. Using the same data, Heal and Schlenker (2008) showed that sustained higher catches imply that a fishery is less likely to collapse and that the fishers reap the benefits through higher catches.

Overall, ITQs have largely positive effects on target species, but mixed or unknown effects can occur on non-target fisheries and the overall ecosystem that can often be mitigated through programme design (Branch, 2008). The ITQ system in the British Columbia groundfish trawl fishery provides incentives for the fleet to adjust its total catches (including discards) when the TACs for individual species are altered (Branch and Hilborn, 2008). Fishers made choices about fishing opportunities based on the multispecies mixtures in those locations, avoiding areas containing species with decreased TACs while targeting fishing opportunities containing species with increased TACs. While the allocation of catch rights leads to some good outcomes in terms of biological sustainability (Costello, Gaines and Lynham, 2008), a cap on target species alone will not by itself necessarily lead to any gains to biodiversity management, a key outcome of ecosystems-based fisheries management (Gibbs, 2010). Allocating rights only to specific target species can actually create a perverse incentive not to be good stewards of the greater ecosystems as these are explicitly excluded.

Improvements in some of the fisheries with ITQs may also be attributed to more appropriate TACs and improved or additional management measures (Chu, 2009). Declines in some of the fisheries indicate that the TAC may be too high or harvest compliance too low, or simply the complexity of managing dynamic resources in a changing environment. Chu (2009) examined the biomass responses after ITQs were introduced and found positive responses in 12 of 20 stocks examined, and a reduction in the rate of decline by 62 percent after ITQs were implemented, suggesting that ITQs can decelerate the decline of stocks.

Most fisheries under rights-based management have lower exploitation rates, and higher biomass and incentives are more likely to lead to lower exploitation rates than regulatory systems without it (Hilborn, 2007). Clark, Munro and Sumaila (2010) discuss the theoretical potential for fish stocks to decline to very low levels or even face extinction, even under ITQs.

Rights-based management can potentially strengthen the conservation incentives of harvesters and create joint stewardship between fishers and managers (Scott, 2000). The collective interest of rights holders is to manage the resource efficiently in order to increase future yields, present value of expected future benefits and hence the value of the asset now held. The stronger the right (e.g. greater exclusivity and enforcement, longer duration, stronger security of title) is, the greater is the individual and collective incentive to manage the resource efficiently and sustainably; this includes setting an efficient and sustainable TAC, TAE, or other capacity limit. Similarly, the smaller the number of rights holders is, the more those rights holders are the ones to exploit the resource, and related factors all serve to increase the collective incentive to manage

the resource sustainably (Ostrom, 1990; Baland and Platteau, 1996). Managers set the appropriate catch or effort limits and accompanying conservation measures. When these measures are set appropriately and enforced, conservation benefits follow. Rights-based management and the incentives it creates can lead to fishers innovating to stay within catch limits and reduce waste. In ITQ fisheries, fishers will reap the benefits of any rebuilding, and the value of their ITQ holdings will increase.[29]

Essington (2010) examined whether catch shares provide stronger incentives for ecological stewardship than conventional fisheries management, testing for 15 catch share programmes in North America the hypothesis that catch share systems lead to improved ecological stewardship and status of exploited populations. The average levels of most indicators were unaffected by catch share implementation, with the only significant response being the discard rate, which declined significantly in catch share fisheries. However, catch share fisheries were distinguished by markedly reduced interannual variability in all indicators, being statistically significant for exploitation rate, landings, discard rate, and the ratio of catch-to-catch quotas. Essington finds the primary effect of catch shares to be greater consistency over time.

The simple creation of rights-based incentives for target species does not automatically deal with ecosystem problems, because fishers have little incentive to minimize bycatch or habitat damage that does not affect their target species (Beddington, Agnew and Clark, 2007). However, when managers control the fishery through effort regulations such as trip limits, significant discards are often an unintended consequence. In moving to catch shares, many of these regulations are reduced, resulting in lower discards. Instead, fishers have flexibility in deciding how to best meet their specified share of the catch limit, and operators enjoy incentives to use more selective fishing gear, to target or avoid particular fishing locations, share information about which areas to avoid, increase self-enforcement and lease or buy quota to reduce mismatches between quota and catch compositions (Squires, Kirkley and Tisdell, 1995; Squires *et al.*, 1998; Dupont and Grafton, 2001; Sanchirico *et al.*, 2006; Branch, Rutherford and Hilborn, 2006). Property rights on bycatch or incidental catches can create incentives that reduce these catches (Boyce, 1996; Bisack and Sutinen, 2006; Gjertsen, Hall and Squires, 2010; Segerson, 2011). Individual transferable quotas for bycatch that are not rare events (such as sea turtles, as discussed by Holland [2010]) can help minimize losses, and are especially relevant when there are skill differences among vessel captains and crews in avoiding bycatch (Hall, 1996). The AIDCP that created DMLs is a prominent example, and a programme of substantial success (Gilman and Lundin, 2010; Hannesson, 2010b). Rights-based management is also possible in the form of individual habitat quota (IHQ) system for habitat conservation that would utilize economic incentives to achieve habitat conservation goals cost-effectively (Holland and Schnier, 2006). Individual quotas of habitat impact units would be distributed to fishers with an aggregate quota set to maintain a target habitat "stock". The use of habitat impact units would be based on a proxy for marginal habitat damage.

Rights can also be spatially defined to allow for different biological productivities and vulnerabilities of a species across areas. The secondary market for transferable

[29] Branch (2004) discusses two examples, the New Zealand Gisborne red rock lobster fishery (Breen and Kendrick, 1997) and the Atlantic sea scallop in Canada and the United States of America. In the former, ITQ holders helped shift the harvest season to winter (when illegal harvesting is difficult and prices are higher), landing only male rock lobsters, reducing the minimum tail width from 54 mm to 52 mm (to reduce pot mortality of sublegal lobsters by octopus) and lowering the TAC by about half. Catch per unit of effort increased fivefold, the size and numbers of lobsters increased substantially, and quota value per tonne increased from NZ$30 000–50 000 to NZ$200 000–300 000. After Canadian Sea Scallop Enterprise Allocations (rights given to firms), the biomass of larger scallops doubled, fishing mortality declined, the number of vessels halved, and revenue per sea day increased by a factor of 3–5. The United States sea scallop fishery achieved similar conservation goals through command-and-control approaches but at the cost of forgone profits and retention of overcapacity.

rights can be divided into trading zones with interzone trading either being prohibited or being based on exchange rates. Such delineation comes at the cost of losses in economic efficiency (in terms of gains from trade, least costs). Such spatial delineations in international tuna fisheries could include coastal areas and the high seas.

CHARACTERISTICS OF RIGHTS WITH TRANSBOUNDARY RESOURCES

Stocks of tunas generally occupy areas that encompass more than one zone of national jurisdiction, are also the high seas, are exploited by vessels of many nations, and are usually harvested by several types of gear. The highly migratory nature of tunas means that the spatially delineated territorial use rights (as conventionally applied with relatively limited areas) cannot control tuna catches, and make limited-entry, quota, and effort management systems the most likely rights-based systems. This paper considers only these as candidates for rights-based management of tunas. Scott (2000, 2008) discusses the basic background to the various types of fishing rights. Individuals (firms, persons), groups (communities, groups of firms, indigenous peoples, etc.), individual States, and even RFMOs can all hold property rights. Under effective group management, common property or group rights (including sector allocations) can potentially match individual private rights for economic efficiency, depending upon a number of conditions (Ostrom, 1990; Baland and Platteau 1996, 2005).[30] As a consequence, this paper does not generally distinguish between private or common property and use rights, simply noting that both are effective forms of ownership that depend upon the circumstances involved.

From a legal perspective, property is a bundle of rights over resources that the owner is free to exercise and that is protected from interference by others (Cooter and Ulen, 2004). Property rights are also political institutions that define or delimit the range of privileges granted to individuals or groups to specific assets (Libecap, 1989). The major source of externalities, and thereby economically inefficient resource use, can be traced to various impediments that prevent the establishment of property rights (Baumol and Oates, 1988). Property rights facilitate the socially efficient exploitation of resources, enabling the owner to exclude others from the resource and thereby internalize the externalities that would occur if access were free (De Meza and Gould, 1992). The ability to exclude also provides incentives to invest in improving the quality of the resource and exploit it at a socially optimum rate.

Use rights are distinguishable from property rights. Property rights entail "ownership" of the resource stock itself, but use rights do not. Use rights instead pertain to exclusive utilization or rights of access. States tend to retain ownership of the property, and grant the right of use to individuals or groups.[31] Rights in fisheries vary in their strength and characteristics by nation, and some nations specify use rights closer to property rights than others.

Property rights can be characterized along six dimensions: exclusivity, duration, flexibility, quality of title, transferability and divisibility (Scott, 2000, 2008). When the characteristics are limited in some way, the rights are said to be attenuated (Kroetz and Sanchirico, 2010).

Exclusive use of the resource by an individual, group or State also means excluding others from using or benefiting from the resource.[32] Exclusivity may include the right

[30] Sector allocations or sector-managed quota is a group of fishers voluntarily joining together to manage the group's combined quota allocation. See Pinto da Silva and Kitts (2006) and Townsend, Shotton and Uchida (2008) for sector allocations.

[31] Technically, States do not own the fisheries resources within their EEZ beyond 12 nautical miles but only control their use. Nonetheless, this paper continues to apply the concept of property right to the resources that States control.

[32] Kaul and Mendoza (2003) distinguish between technical and socially constructed excludability. Technical excludability refers to the intrinsic properties of a good and socially assigned properties. Socially constructed excludability is determined by establishing and enforcing property rights.

of access and enjoyment, the right of withdrawal, and the right to prevent interference. In practice, rights can often be specified as a revocable privilege, although New Zealand is a notable exception (NRC, 1999), and as such in the United States of America are called limited access privileges. Exclusivity requires that the right be enforceable and that there be penalties for those who infringe on other holders of the rights.

Duration refers to the length of time a right's powers may be held. Rights can, in principle, extend for any duration. Rights of sufficiently long duration reduce uncertainty, allow planning and support investments that allow fishers not only to recoup their investment costs but also to make an expected rate of return, and create rights of sufficient value to allow purchases of rights from sellers. Rights of shorter or intermediate duration allow flexibility and facilitate entry into the fishery by new entrants or for alternative uses that may arise in the future. The shorter the duration of a right, the greater the uncertainty over the benefits, the lower the right's value (in principle, the value of an asset is the present value of the expected net returns), and the weaker the incentives to conserve the resource. Limited duration rights can also be eligible for renewal. The duration of rights can be staggered to allow flexibility of new entrants. For example, in Chile, ITQs were initially allocated according to historical fishing performance, but each year 10 percent of quota is recovered from firms and is sold at auction. Namibia's allocation system included elements designed to achieve sociopolitical goals, such as increased domestic ownership, as well economic efficiency. In Sweden, the duration of rights extends up to five years (OECD, 2006). In the United States of America, all new transferable quota fisheries are subject to a 7–10 year duration, milkfish fry in the Philippines are subject to 1–5 years, abalone spiny lobster, and others are subject to 20 years, and giant catfish in Cambodia are subject to 2 years' duration (Costello and Kaffine, 2008). Ledyard (2009) finds that duration does not affect profitability of a fishery, but that it does affect the price discovery process and whether equilibrium is attained.

Under insecure property rights, i.e. rights of limited duration, but coupled with the possibility of renewed rights (after satisfying specified conditions), the regulator can design the right's contract to induce fully efficient exploitation, even with finite tenure and insecure property rights (Costello and Kaffine, 2008). Economically efficient outcomes require longer tenure periods when species grow slowly, appropriators believe the probability of renewal is small, and discount rates are high. If the probability of renewable is sufficiently high (low), any tenure length is sufficient to induce an economically optimal outcome (no tenure length can induce stewardship). In some instances, slackening the requirements for rights renewal can substitute for longer concession periods. The minimum tenure required to induce economic optimum is a decreasing function of the renewal probability and growth rate.

Divisibility indicates the ability of the holder of the right to divide up the environmental asset or the flow of benefits from the asset. That is, divisibility is division of the property right into smaller pieces, which is important as it facilitates exchange, quota balancing, and can improve the liquidity in the market. These results can greatly reduce the noise in quota prices.

Quality of title (security) represents how well the property right is specified, and includes the notion of possession and ownership (de facto and de jure). Quality of title refers to the extent that the right is recognized in law, such as a title or certificate of ownership. Quality of title depends on whether the right is established through custom or treaties under formal international law, the workings of the RFMO holding the property to the resource stock and governance of the fishery, and the effectiveness of compliance and enforcement. The quality of title is affected by the other characteristics of the right. For example, New Zealand's rights assign a greater degree of "ownership" to rights holders than say in the United States of America, where they are considered more of a use right. Consequently, ITQs in New Zealand can readily be used as

collateral for bank loans but much less, if at all, in the United States of America. Moreover, immediately after the introduction of ITQs in New Zealand, the issue of quality and the ITQs' use as security for bank loans arose owing to limitations on overseas ownership (most financiers were overseas owned); further refinement of the right was required before quota became fully bankable.

Transferability refers to the ease of transferring ownership or use of the right from one party to another. Transferability facilitates increases in economic efficiency and capital creation through gains in trade, flexibility to adjust to changing circumstances, and achieving market equilibrium.[33] There are three types of transfers: transfers of property rights among States; transfers of use rights within States; and transfers of use rights between individuals in different States.

Although the race to fish can be eliminated through the introduction of an individual vessel quota system (in which quotas are not transferable), the principle benefits in terms of rent generation can only be realized through fleet restructuring, i.e. moving to fewer, more efficient vessels (Grafton, Squires and Fox, 2000; Asche *et al.*, 2008). Without transferability of the quota, this restructuring could not occur. Transferability also allows decentralized, market-based restructuring of the industry in response to changes in product and input market conditions, resource stocks (including recruitment and migration and shifts of populations), environment, and technology. Transferability allows for staying within TACs, accounting for all catch mortality (not just target species), addressing operational realities such as weather and breakdown, allowing for new entrants, and balancing intersectoral allocation underages or overages (Turris, 2010). Transferability allows accommodating the aspirations of coastal developing States and small island developing States by providing the decentralized institutions of transferable property rights and secondary markets in which these rights can be exchanged, as discussed in greater detail elsewhere. The New Zealand example of Government purchasing quota for Maoris to settle grievances under the Treaty of Waitangi provides a clear example in this regard. There may be less transferability when fishers are risk averse than when they are risk neutral (Bergland and Pederson, 2006).

Transferability may have to be structured to take account of differential impacts on species, demographic structure of the populations, the ecosystem, and even biodiversity for different methods of fishing, gear types, or areas, and for asymmetric negative environmental externalities. For example, the capture of juvenile bigeye by purse-seine vessels fishing for skipjack aggregated around fish aggregating devices (FADs) reduces the availability of bigeye for longline vessels, which catch larger bigeye. Similarly, the capture of juvenile yellowfin by purse-seine vessels fishing for skipjack around FADs in the equatorial region of the Eastern Pacific Ocean (EPO) and by vessels in sets on unassociated yellowfin schools reduces the future availability of larger yellowfin in sets on tunas associated with dolphins. Bycatch of non-tuna species also varies by gear type, methods of purse-seine fishing, and area.

Transferability of rights among different flag States may also be attenuated, largely to maintain flag State control over the right to fish, ensure continued sources of fish for consumption, processing, employment, and incomes, and for geostrategic reasons. Transfers of use rights between parties of different flag States may also be limited for similar reasons, although concerns may be fewer because the right is over use and may be of limited duration. Transfers between parties of a given State may be limited to

[33] Ledyard (2009) observes that there are gains from trade (also called arbitrage efficiency) if at least two people can gain from reallocating quota between them. That is, if A can make more profit with the quota than B, then the quota can be transferred to A and A can compensate B in a way that makes them both better off. Such a trade is voluntary and improves the welfare of both. Moreover, all the possible gains from trade must be found and captured for market equilibrium and maximum economic benefits; in equilibrium, there are no more gains from trade. However, achieving equilibrium requires a well-functioning, transparent and liquid market place.

preserve distributions of rights among various stakeholders, such as preservation of communities or regions.

Serdy (2007) examined the legal issues surrounding transferability of quotas among members of RFMOs. He found that rudimentary systems for quota trading among States are allowed in some RFMOs, and that any such systems depend on decisions of the RFMO concerned, rather than on the development of new international law. Early instances of quota trading (and allocations) include the Convention for the Preservation and Protection of Fur Seals and early pelagic whaling on the high seas (Barrett, 2003; Serdy, 2007).

The following paragraphs briefly examine three examples of rights-based management in international tuna fisheries in terms of these characteristics, two established in the EPO by the IATTC and one in the WCPO by the PNA.

The limited-entry system of the IATTC, i.e. the closed RVR, faces an attenuated rights-based system, because, while the system provides exclusivity (the place of a vessel on the RVR[34] is not affected by other vessels moving off and on the RVR) and the duration of the right is permanent, the security and transferability is subject to government decisions, as any changes to the RVR involving changes of flag are made at the discretion of the governments under whose jurisdictions the vessels operate.

The DML of the AIDCP is a relatively weak right because it does not provide full exclusivity (there are national mortality limits, which, if reached, would curtail individual rights), its duration is for only one year (or a shorter period), and its security is subject to the ability of the various governments to renounce their DMLs or to reallocate them among vessels of their fleets. The agreement provides that a vessel changing flags retains its DML and its record of dolphin mortality during the year to date, and that its obligations under the AIDCP be enforced by its new flag. The AIDCP also provides some limited transferability[35] of the limits among vessels, in that limits from vessels that renounce or forfeit their assigned limits are redistributed among other vessels. In practice, however, the parties to the AIDCP have also allowed ad hoc transfers[36] among vessels.

The PNA VDS for tuna purse-seine vessels in the WCPO, which is a transferable effort programme, establishes a TAE that is allocated to individual States on the basis of catch histories and biomass within their EEZs. In turn, the individual PNA States sell use rights through bilateral arrangements with fishing States, largely distant-water fishing nations, whose vessels wish to harvest tunas within the EEZs. The VDS is discussed in greater detail below when transferable effort programmes are considered.

ENFORCEMENT OF RIGHTS

Enforcement is critical for well-functioning rights-based management, as exclusive use is otherwise hampered or even, in the extreme, rendered infeasible. Enforcement is also critical in international fisheries whose management depends upon multilateral cooperation. Property rights are costly to define and enforce owing to the resources used in allocating and demarcating entitlements, policing compliance and arbitrating disputes (Libecap 2009, 2010). In international tuna fisheries, MCS and enforcing property rights faces extra issues of large distances, languages, multiple nations, national sovereignty, lack of precisely defined EEZ boundaries, and related issues that differ from the national context. If property owners have to incur costs to enforce their rights, then the level of enforcement could be more or less than is socially optimal (de Meza and Gould 1992). Enforcement is strengthened if means of MCS that enhance

[34] The IATTC's RVR is the definitive list of purse-seine vessels authorized by the IATTC to fish in the EPO (available at www.iattc.org/VesselRegister/VesselList.aspx?List=AcPS&Lang=ENG).

[35] See Agenda item 11, Minutes of the 15th meeting of the Parties to the AIDCP, June 2006 (available at www.iattc.org/PDFFiles2/MOP-15-MinutesREV.pdf).

[36] *Ibid.*

enforcement and compliance, along with methods of enforcement and compliance, are considered when rights-based management systems are designed and allocated.

Enforcement of rights in transnational fisheries has few effective alternatives, the most useful being trade measures applied in a manner acceptable to the World Trade Organization and withholding access to national waters and ports (IATTC and World Bank, 2008). DeSombre (2010) discusses trade measures in greater detail.

Trade restrictions achieve two objectives. They can be used to punish countries that do not cooperate and to correct for losses in competitiveness of the countries that do cooperate (Barrett, 2003). To be effective, a trade restriction must be sufficiently severe (so that, when imposed, behaviour will be changed) and credible (meaning that if a country chooses not to participate or not to comply, the cooperating countries are better off for imposing the restrictions).

Trade measures can limit landings, imports and transshipments of fish to those that are caught within the regulatory framework. The specific ingredients of trade measures include: (i) lists of vessels allowed (or not allowed) to fish in the areas of concern; (ii) vessel monitoring; (iii) catch or trade documentation; and (iv) prohibition of importation of fish caught outside the regulatory framework or of transshipment of fish caught outside that framework. The burden of proof that the fish were caught within the regulatory framework would be on the owners of the fish, rather than on those that must enforce the regulations. Some RFMOs have tried versions of this approach, most fully ICCAT and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and through the documentation requirements have decreased fishing outside of the regulatory process and encouraged States to join or cooperate with the organization.

Potential difficulties with trade measures include: comprehensive documentation and/or monitoring obligations, although these may also be part of the documentation of property and use rights; domestic enforcement of trade measures; the legality of some port State measures, such as the degree of control the port State can exercise over a vessel; falsification of records; difficulties of tracing fish from catch to market, although this should not be a problem if the record-keeping system is properly designed; consistency across RFMOs; the legality of certain applications of trade measures; and the fact that the use of trade measures requires participation by major market and landing States. Rights-based management establishes incentives for self-compliance and self-enforcement because actions that reduce the resource stock reduce the value of all rights held, including those held by offenders. Riddle (2006), Le Gallic (2008), IATTC and World Bank (2008), DeSombre (2010), and Hallman *et al.* (2010) discuss enforcement in greater detail.

TYPES OF RIGHTS ADOPTED

The type of property right that is adopted depends on several factors (Libecap, 1989; Ostrom, 1990; Baland and Platteau, 1996, 2005), and for international tuna fisheries this aspect is discussed in greater detail by Allen *et al.* (2010a), Allen, Joseph and Squires (2010), and Squires *et al.* (2010a). Which rights emerge depend in part on the historical, resource, and economic conditions, political constraints, existing laws, type of resource involved, distribution of costs and benefits, costs of exclusion and monitoring, and even extant property rights. The type of right to emerge in a tuna RFMO also depends on the bargaining positions taken by the different member and cooperating non-member States. These positions, in turn, depend on their expected gains from this institutional change. In principle, each party will attempt to shape the nature of the right to give it the greatest share of the aggregate gain (Libecap, 1989). Players compare the expected gains with their current returns under the status quo. Delays are possible if new information is anticipated or political conditions are expected to change, but

these delays must be balanced with expected losses related to deteriorating conditions on the common tuna stocks or potential new entrants.

Limited entry

Limited entry is usually the first management step taken in establishing a rights-based management system, based on the principle of exclusive access to a fishery for a group of vessels, as discussed in Sinclair (1961), Wilen (1989), Townsend (1990), Sutinen (1999), and OECD (2006) and for international tuna fisheries by Joseph (2005), Allen *et al.* (2010a), Allen, Joseph and Squires (2010), IATTC and World Bank (2008), Joseph *et al.* (2010), and Hallman *et al.* (2010). Limited entry for transnational fisheries entails a mixture of limited access to national jurisdictions and the high seas for vessels of both coastal and distant-water fishing nations.

Limited entry is seldom, if ever, the long-term answer to the ill-structured property rights that establish the undesirable individual incentives for producers and even States that do not fully align with the biological–economic–social objectives of an optimally managed fishery. The primary reason is that limited entry is a weak form of property right because exclusive right is granted only to access to the resource, rather than to a share of the TAC or an amount of fish. Vessels, once granted access to the resource through a licence or permit, are not invested with a right to a share of the catch or the resource stock, although they may be further restricted by rules on seasons, areas fished, gear, and other practices. Permit holders compete for the TAC. The limited number of licences can maintain profits above the zero profits of unrestricted open access, but it also generates incentives to invest in socially excessive capital and usage of other inputs that raise costs and in some instances can lead to declines in product quality or ex-vessel prices as fishers do not have full ability to choose the time and places to fish in their competition to take the TAC. The incomplete right of limited access can thus generate short-term economic benefits, but in the long term these economic benefits erode through expansions in input usage not specified by the licence on already active vessels (sometimes called "capital stuffing"), increased fishing by relatively inactive vessels ("latent effort"), investment in the vessel and gear, and technical progress (growth in fishing power). Limited entry is also typically introduced as a moratorium, after the fleet has expanded well beyond the level necessary to match fishing capacity with the TAC.

The traditional response in limited-entry fisheries has been so-called "capital stuffing." This entails changes in vessel design and increases in other dimensions of the multidimensional capital stock (e.g. expanding gross registered tonnage and engine power when length is limited) and more efficient use of vessel time, i.e. spending less time in port and accelerated adoption of technical advances. Nonetheless, if limited access is the best that can be expected in the foreseeable future owing to the limitations of international law and custom, limits on growth of the physical measures of fishing capacity may be the preferred, albeit imperfect, management option. Replacement of existing vessels with new vessels might be restricted to vessels of the same well volume but other dimensions can change (as in the IATTC RVR). Replacement with a larger vessel may also require purchase of the licence for a second vessel to provide the necessary magnitude of capacity units (sometimes called "stacking"). To counter the inevitable creep in vessel productivity or fishing power due to innovations, replacement of a vessel with one of the same size could even require purchase of additional capacity units through purchase of another licence.

A limited-entry programme for a transnational fishery on shared transboundary stocks creates a form of RFMO international common property instead of high seas open access, such as established by the Convention for the Preservation and Protection of Fur Seals (Barrett, 2003). The common property and limited-entry programme can be created by customary international law through the auspices of an RFMO, such

as the closed RVR of the IATTC, or by formal and binding international law such as through the fur seal treaty. Limited entry can also be formed through the auspices of regional States for their EEZs, such as the now defunct Palau Arrangement of the parties to the Forum Fishery Agency. Their access agreements, as discussed by Havice (2007, 2010), can also be viewed in this light. Neither the United Nations Convention on the Law of the Sea or the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (generally called the UN Fish Stocks Agreement [UNFSA]) prohibits creation of a limited-entry programme and regional common property through a formal and binding (regional) international agreement.

Article 8(3) of the UNFSA provides that States having a "real interest" in the fisheries regulated by an RFMO may become members of that organization. The UNFSA does not further define the term "real interest" (Ple, 2000). New membership in most RFMOs does not necessarily guarantee immediate fishing opportunities, especially when the relevant target fish stocks are overexploited. The UNFSA lists criteria to determine the nature and participatory rights for new members, including: the status of the stocks and the existing level of fishing effort in the fishery; the respective interests, fishing patterns, and fishing practices of new and existing members; the contributions of new and existing members to conservation and management, data collection, and scientific research; the needs of fisheries-dependent coastal fishing communities; and the needs of coastal States whose economies are dependent on the exploitation of marine resources. Given that the fishing opportunities for even existing RFMO members are often limited, and there is typically little, if any, additional fish to allocate to new members, if prospective new members are not given the opportunity to fish, they may not have an incentive to join. Applicants for new membership may also not be accepted by RFMO members.

Limited entry in international tuna fisheries faces special issues because of the rights for free entry into fisheries under international law, as discussed further by Joseph and Greenough (1978), FAO (2002), Munro, Van Houtte and Willman (2004), IATTC and World Bank (2008), Joseph *et al*. (2010), Serdy (2010), Hallman *et al*. (2010), Allen (2010), Allen, Joseph and Squires (2010), and Allen *et al.* (2010a). Entry by new parties dilutes the gains from cooperation by existing parties, which, in turn, lowers the incentives for existing parties to cooperate and reduces the aggregate gains that could be achieved if entry into the fishery were closed.

New entrants into a fishery after rights have been assigned, and who were initially excluded, may have to pay an entry cost (Ostrom *et al.*, 1999). Markets for the exchange of fishing licences and capacity units between new entrants and existing fishers provide a decentralized mechanism to facilitate new entry or expansion by current participants. Such markets for entry and exit are standard in national limited-entry programmes, and are most effective in international tuna fisheries when licences and capacity units are not tied to flags.

The entry cost is normally thought of in terms of the future value of the fishing right. In addition, RFMOs could contemplate contributions towards the cost of the established management systems including data collections and research that existing members have paid for.

Access to the fishery by non-parties can be denied only if the existing parties are willing and able to enforce provisions related to exclusive use of the resource. International law does recognize that, along with the right to fish on the high seas, comes the obligation not to undermine fishery conservation efforts by RFMOs. However, to have any material effect, this latter obligation must be enforced. To deter entry requires negative incentives (Hallman *et al.*, 2010). Negative incentives help enforce provisions for member parties and deter entry by non-parties. At least five

such negative incentives are available: (i) domestic laws forbidding reflagging vessels and enforcing the agreement for member parties, that is, domestic compliance; (ii) deterring entry by non-parties through trade and port measures and changes in custom; (iii) preventing illegal, unreported and unregulated (IUU) vessels from fishing in the EEZs of member parties; (iv) diplomatic pressure and public censure; and (v) unilateral actions by member parties, including seizure of non-complying vessels or products of non-parties. Effectiveness requires willingness by States to enforce.

Parties to the regional agreements can pass domestic laws forbidding their own vessels from reflagging with States that are non-parties to fishery agreements (Hallman *et al.*, 2010). The principle that flag States control the conduct of their own fishing vessels can present problems because flag States may have little or no incentive to vigorously enforce catch limits, control fishing capacity, or enforce other conservation and management measures against their own nationals (Bederman, 2000).

Trade and port measures, acting as a credible threat, are one of the few negative incentives available to deter entry by non-parties into a transnational fishery. As discussed above, the two trade measures are to prohibit imports from non-member fishing vessels observed fishing in an RFMO regulatory area and to prohibit landing, other port use, and transshipments from non-parties (Ple, 2000; Barrett, 2003; DeSombre, 2005, 2010; Riddle, 2006; Le Gallic, 2008). Most tuna RFMOs allow for trade measures, which can be applied to both members and non-members. The first such multilateral trade restrictions by an RFMO applied to non-members to ensure cooperation with agreed conservation and management measures by these non-members was by ICCAT.

Trade and port restrictions may not always sufficiently deter entry by non-parties into transnational fisheries for highly migratory species, in which case custom, i.e. customary law, may change. Evolving customary law is reshaping conditions to deter free entry by non-parties through the formation of RVRs in the tuna RFMOs, particularly closed RVRs. The IATTC closed RVR restricts fleet growth through sizes of vessels, although expansion by some coastal States is allowed in the IATTC programme. The IATTC closed register, a form of limited entry, represents both evolving global customary international law and formal international law on a more regional basis through formal resolution within the treaty body, not by a separate treaty. The CCSBT also has a closed RVR. The treaties establishing the RFMOs provide the mechanism by which limited-entry programmes can be developed. In short, the treaties provide the necessary powers for limited entry, and a transformation is occurring, through custom, from free entry to the resource to exclusive use of the resource by a well-defined group of participants.

A third negative incentive might also help deter entry by non-parties into RFMO tuna fisheries. Precluding vessels that have engaged in high seas fishing in contravention of the relevant regional fishing agreement from fishing in the EEZs of member States might sufficiently reduce profitability of fishing to deter entry (Hannesson, 2005).

A fourth negative incentive to deter entry by non-member parties is unilateral action by member parties (Hallman *et al.*, 2010). The North Pacific Fur Seal Treaty allowed signatory countries to seize a violating ship from another signatory country and deliver it to the violating ship's authorities, which were bound by their own domestic laws to address the violation. Several other existing treaties, most notably the UNFSA and the agreement for the Western and Central Pacific Fishery Management Commission allow the vessels of one member party to board and inspect vessels of another party to the treaty. It is possible to go even further and to seize vessels of non-signatory nations. Direct enforcement of non-parties to fishery conventions on the high seas is not unprecedented in international law (Bederman, 2000). Other States must perceive actions, such as seizure of vessels, as legal, which in turn requires that the agreement must be seen to be legitimate.

Limited entry establishes a well-defined group of vessels that can then enter into stronger forms of rights-based management, such as rights over the catch or effort by individuals or groups. Limited entry is also a prerequisite for buyback programmes, as it defines the list of eligible fishers and/or vessels, as otherwise vessels will enter the fishery as conditions improve after a buyback (Squires *et al*., 2010b).

Limited-entry programmes can be differentiated by sector or methods of fishing. Limiting the total numbers of participants through a traditional licence limitation programme is a first step that eliminates the threat of further entry (Wilen, 1989). Once in place, the fishery may be further subdivided into individual fisheries, each containing a fraction of the individual fleet and total quota. A complicating factor is the differing participation in different sectors by vessels of different nations. Along similar lines, access rights can be attenuated to a specific and naturally definable geographic area, creating a well-defined group right with exclusive access, thereby creating an area-licensing scheme (Wilen, 1989). When the area of access is sufficiently restricted, the number of fishers in each area is reduced, and a well-defined group of fishers is created, so that cooperative behaviour by the individual players should be boosted. This has been found to improve the conservation and management for other types of common resources (Ostrom, 1990; Baland and Platteau, 1996). Capacity is reduced in each area. Multiple-area licences can be held by a single vessel owner/operator. However, as discussed above, the mobility of tunas makes areal allocation less attractive.

Fractional licensing, although never yet implemented, represents a form of limited entry that reduces fishing capacity (Townsend, 1992; Townsend and Pooley, 1995; Joseph, 2005). In contrast to limited-entry programmes, which tend to "grandfather in" the entire fleet in a moratorium, fractional licensing allocates a fraction of a whole licence to each individual vessel. Because a whole licence is required to fish, freely transferable licences allow consolidation of the fractional licences into a whole licence required to fish.

Experience in national fisheries shows that stronger forms of rights-based management establish stronger conservation incentives that make limited entry superfluous. However, limited entry remains imperative in international fisheries, at least until there is greater experience with stronger forms of rights-based management. The existence of subsidies, state incentives to maintain fleets that provide fish to labour-intensive onshore processing facilities, and geostrategic, non-economic incentives of States reinforce the need for maintaining limited entry, at least initially. Without limited entry, vessels may obtain rights but an insufficient amount for profitability and press for unsustainable expansions in the TAC or TAE. In short, limited entry is a necessary, but not sufficient, condition for stronger rights-based management, and, in a multilateral, transnational context, remains a valuable bulwark against economic, social, political and geostrategic pressures that erode sustainable targets of catches or fishing effort.

Imposing strong limits on resource use raises the question of which community of users is initially defined as having use rights and which is excluded from access (Ostrom *et al.*, 1999). Joseph (2005) observed that to qualify for entry on a number of RFMOs' RVRs a vessel would have to be considered to be actively fishing, and this term requires definition. In addition, to remain on a register, a vessel would have to continue to be active, according to the same or a similar definition. The allocation of licences, units of fishing capacity, or shares of the catch in a way that satisfies all parties is another part of the question. Devising methods of exclusion itself has substantial distributional consequences (Libecap, 1989).

Coastal States control entry into their EEZs, as provided by international law. Potentially viable limited-entry programmes must provide for the expansion of fishing capacity by these States, a measure allowed by the IATTC, for example, in its RVR and capacity limitation programme. Other ways to provide for expansion by these

States include decommissioning greater capacity from the fleets of distant-water fishing nations (DWFNs), assessing DWFN fleets at a different rate than coastal fleets in industry-financed buyback programmes, and fractional licensing in which coastal States receive a fraction of a licence greater than DWFNs. Multilateral funds to finance fleet expansions by developing coastal States and small island developing States is another possibility. Limited allocation of unused capacity to coastal States creates a reserve held by these States, and can be seen as an option that can be exercised at a later date. Yet another possibility is to require a limited percentage of licence or capacity units, with limited duration of the right, to expire on a periodic basis, that then are reallocated to developing coastal States or small island developing States, which can in turn sell to the previous rights holder.

Fishing capacity limits

Limited entry can be taken a step further by providing rights to fishing capacity as is done with the IATTC capacity control via a regional register of purse-seine vessels. The aggregate of the rights should equal a total allowable capacity in systems to provide rights to capacity.

Fishing capacity is defined by FAO (1998) as: "the ability of a vessel or a fleet of vessels to catch fish", and can be measured by techniques such as data envelopment analysis (DEA) (Reid *et al*., 2005; Reid and Squires, 2007). A DEA requires detailed data for individual vessels. Specifically, according to Reid and Squires (2007): "Within the context of measuring fishing capacity to allow for DEA to be undertaken, it is necessary, at the very least, to obtain a data set detailing fixed inputs (fixed physical characteristics of individual vessels) to the fishery and the associated outputs (catches) of those vessels."

It is not easy to measure the ability of a vessel or a group of vessels to catch fish. Shimada and Schaefer (1956) recognized six "size classes" of tuna baitboats, based on their fish-carrying capacities in short tons. They calculated the average catch per day of fishing by these vessels, and then assigned them "efficiency factors" relative to standard size classes of vessels (Class 4 for yellowfin and Class 3 for skipjack). The average efficiency factors for 1947–1954 were as shown in Table 1.

TABLE 1
Average efficiency factor for six classes of tuna baitboats, 1947–1954

Species	Class 1 (up to 50 short tons)	Class 2 (51–100 short tons)	Class 3 (101–200 short tons)	Class 4 (201–300 short tons)	Class 5 (301–400 short tons)	Class 6 (> 400 short tons)
Yellowfin	0.42	0.56	0.90	1.00	1.20	0.97
Skipjack	0.47	0.63	1.00	1.12	–	–

Note: 1 short ton = 907.18474 kg.
Source: Shimada and Schaefer (1956, Table 17).

Thus, the total annual standardized baitboat effort for yellowfin would be the sum of the number of days fished by Class 1 vessels × 0.42, number of days fished by Class 2 vessels × 056, …, and number of days fished by Class 6 vessels × 0.97, and rights could be assigned to different classes of vessels using the efficiency factors for calibration.

More recently, the IATTC has used the fish storage space or well volume of purse seiners, measured in cubic metres, as the unit of capacity for its RVR.

In general, limitations on fishing capacity are good because they prevent, or at least reduce, excessive capital investment. However, for two reasons, limitation of fishing capacity alone is unlikely to prevent overfishing. First, most fisheries are directed at more than one species. A limit on fishing capacity might be estimated from data for a period during which approximately equal amounts of effort were directed towards yellowfin, bigeye and skipjack tuna. Later, however, more effort might be directed

towards yellowfin and/or bigeye, which could result in overfishing of one or both of those species. (Conversely, if more effort were directed toward skipjack and less toward yellowfin and/or bigeye, one or both of those species might be fished at less than optimal levels.) Second, the abundance of fish fluctuates in response to the effects of natural factors, so fishing effort should be adjusted in response to fluctuations in abundance of the fish, but if the fishing capacity is limited it may be impossible to take advantage of greater-than-average abundance of fish unless vessels that ordinarily were not permitted to fish in the area in question were given permission to fish in that area for a limited period.

Management systems involving allocation of capacity rights will need to be recalibrated from time to time to ensure the aggregate of the rights is an appropriate target. Thus, DEAs, or equivalent analyses, must be conducted at frequent intervals, preferably every year, because, with the passage of time, vessels tend to become more efficient through the adoption of improved technology. Unless the increase in efficiency of the vessels participating in the fishery is counterbalanced by withdrawals of vessels from the fishery, the fishing season must be shortened or catch quotas must be established for species that were fully exploited prior to the adoption of improved fishing technology.

Because only one dimension of the multidimensional capital stock is controlled, fishers face incentives under incomplete property rights to expand the use of the uncontrolled dimensions, as described above. Moreover, fish-carrying capacity regulation may be supplemented by regulating the intensity of use through maximum allowable fishing days, according to the condition of the fish stocks at any time. In technical terms, the flow of capital services and capital utilization, in addition to the capital, is regulated when fishing days are restricted. In sum, fish-carrying capacity limits the capital stock rather than fishing capacity, and supplementary time limits restrict capital utilization rather than capacity utilization.

Individual catch quotas and shares

Transferable catch quotas or catch shares directly address the most critical issues, which are: limiting the total catch from a stock to the sustainable target catch; and establishing incentives for individual fishers that more closely align with broader economic and biological objectives.[37] Catch quotas can be allocated to individuals, groups or States, as discussed in greater detail by Shotton (2000), Scott (2000, 2008), Baland and Platteau (1996), Allen *et al.* (2010a, 2010b), Squires (20010a), Libecap (2009), and many others.[38]

[37] Christy (1973) first suggested individual private rights to a quantity of catch, ITQs. Another form of rights-based management with limited or little applicability to highly migratory species, also proposed by Christy (1982), is Territorial Use Rights in Fisheries, or TURFS. Moloney and Pearse (1979) and Boyce (1992) formalized ITQs within a bioeconomic framework. Montgomery (1972) formalized transferable property rights from the perspective of the individual firm or vessel. This paper considers "pure" cap-and-trade systems. Discussion of this approach with the atmosphere includes hybrid systems in which cap and trade for greenhouse gases includes price floors and ceilings to constrain the right's price in the secondary market (Grüll and Taschini, 2010), but this approach has yet to be applied in fisheries and this paper does not consider it further.

[38] More than ten major fishing nations use ITQs as the main or a major component of their fisheries management system within their EEZs and between 10 and 15 percent of the global ocean catch is taken under ITQs (Arnason, 2005), although Costello, Gaines and Lynham (2008) place it at about 2 percent. These nations include Australia, Canada, Chile, Denmark, Estonia, Greenland, Iceland, Mexico, Morocco, Mozambique, Namibia, the Netherlands, New Zealand, Norway, Peru, the Russian Federation, South Africa and the United States of America (Anderson, Arnason and Libecap, forthcoming). Costello, Gaines and Lynham (2008) state that there are 148 fisheries worldwide under ITQs. Tradable use permits are used in 9 applications in air pollution control, 75 in fisheries, 3 in water and 5 in land use control (Tietenberg, 2007). Currently, 92 out of 130 species fished commercially in New Zealand are under quota management. These institutional innovations have taken place as the resources at issue have become more valuable, as they have faced growing common-pool wastes, and as dissatisfaction has increased with existing centralized regulation (Libecap, 2009). Gilbert (2011) states there are at least 38 fisheries managed by some form of group rights/sector allocations/cooperatives with harvest rights.

Catch quotas provide the allocated entity the right to harvest a defined proportion, either an absolute amount or, more usually, a percentage, of the TAC within a given period, such as a year or season (Squires, Kirkley and Tisdell, 1995; Shotton, 2000; Scott, 2000, 2008).

Separate catch quotas are set for each species and sometimes stock. Specific quotas for specific gear types may also be necessary, because the catches taken in one fishery may, after some time, affect the catch possibilities in another (downstream or asymmetric externalities). For example, and as mentioned above in the discussion on transferability, purse-seine vessels fishing on FADs catch juvenile bigeye and yellowfin, some of which may not otherwise become available, after some time, to the longline fishery and or to the purse-seine fishery for larger yellowfin associated with dolphins. It may be necessary to set total catch quotas for several fleets exploiting the same stock, such as purse seining on FADs, purse seining on unassociated schools, purse seining on yellowfin associated with dolphins, and longlining.

Catch quotas can either be specified to allow fishing throughout the RFMO area or can be delineated by specific areas. The latter can reduce economic efficiency to the degree that transfer of quota from high cost and/or low value uses to low cost and/or high value uses is limited. The latter can raise economic efficiency over the long term to the extent that the biological health of the fish stocks and local depletion are limited. The former can increase efficiency to the extent that parties receiving an allocation in excess of its harvesting capacity can temporarily or permanently transfer quota to parties with sufficient capacity to harvest.

Transferable catch quotas as use rights create economic incentives for fishers that more closely align with broader economic and biological objectives. Transferable catch quotas as use rights create incentives for fishers to end the race to fish, to harvest their catch shares at the lowest cost, to increase the value of their landings through better handling and care of the fish, and, in some cases, to change product form, as occurred in the change from frozen to fresh fish in the British Columbia halibut fishery (Boyce, 1992; Casey *et al.*, 1995; Squires, Kirkley and Tisdell, 1995; Grafton *et al.*, 2006). Investment decisions can also be altered. These effects, coupled with transferability that allows the most efficient fishers to harvest greater shares of the total catch and to adjust their scale of harvesting, can raise economic efficiency. Transfers of catch quotas can also help reduce overcapacity. The largest gains in economic efficiency through lower costs probably come not from productivity (technical progress, technical efficiency, mix of species) at the level of the individual vessel but from the lower industry costs that follow from exit of now superfluous vessels and improved utilization of reduced fishing capacity at the industry level,[39] although Vestergaard, Jensen and Jørgensen (2005) demonstrated that the existence of sunk costs delays the achievement of the optimal fleet structure. The costs of voluntary exit of vessels are borne by those fishers who purchase the available quotas and licences. In short, the limited empirical evidence to date indicates that the long-lasting cost efficiency gains are more likely to come at the overall industry level through changes in industry composition, including vessel exit, rather than the level of the individual vessel (although far more research is

[39] In addition to less efficient vessels exiting the fishery, immediately after implementation of tradable property rights there will be a reduction in the fleet owing to: (i) the exit of vessels that were used to expand effort and maximize the allocation of tradable property rights; and (ii) the exit of vessels that delayed exit in order to retain their firm's claim to property rights (Brandt, 2007). Thus, there can be strategic behaviour in the negotiation period, primarily re-entry of particularly inefficient vessels and delayed exit, a form of moral hazard and even adverse selection if the departing vessels retained to claim property rights are the least efficient. In the long-run equilibrium, those vessels that remain in the fishery are by design the most efficient.

required in this area to make stronger conclusions) and that additional gains on the output side are possible at the level of the individual vessel.[40]

Invariably, transferable catch rights are introduced only after overcapacity has built up in the fishery, so that transferability results in quota holdings in the hands of the more efficient vessels and the exit of the less efficient ones, particularly as there is insufficient quota for all vessels to fish at the most efficient scale of production. Nonetheless, catch quotas do not fully eliminate overcapitalization problems stemming from stock and congestion externalities (Boyce, 1992). In some instances, vessel buyback programmes must help this reduction along (Curtis and Squires, 2007; Squires *et al.*, 2010, Squires, 2010b). Catch quotas can also induce harvesters to shoulder a greater share of the management costs and, in fact, provide a means by which to allocate these joint costs (Scott, 1993).

Catch quotas as use rights can also promote collective action in conservation and management of fisheries (Scott, 1993, 2000, 2008). These rights provide incentives to fishers to protect their investments, including the asset value of their investments in quota and capital stock, through sustainable harvesting and, even further, by collectively working together in formal and informal means to enhance the fishery. Higher returns, vested interests in the fishery, and smaller numbers of more committed fishers can lead to fishers shouldering a greater share of the research costs, such as data collection and stock assessments, and MCS such as onboard observers. Cost recovery in this manner followed the introduction of ITQs in New Zealand (Scott, 1993, 2000).

When establishing catch rights, care must be taken to ensure that they do not create perverse incentives that distort behaviour and produce undesirable outcomes (Grafton *et al*., 2006). The absence of comprehensive catch rights covering the major gear types, vessels and species establishes incentives to transfer effort to non-quota species (Dupont and Grafton, 2001; Asche, Bjørndal and Gordon, 2009.) Moreover, the catch mix of fishers may not match individual quota allocations, which, in turn, may contribute to discarding and misreporting (Squires and Kirkley, 1995, 1996; Squires *et al*., 1998; Sanchirico *et al.*, 2006; Branch *et al.*, 2006). In practice, the evidence for increased discarding in ITQ fisheries is mixed (Branch *et al.*, 2006). Several methods address the potential mismatch between individual quota holdings and catches in multispecies fisheries, such as quota trade (either the full entitlement or simply renting or leasing or borrowing or swapping for limited duration without affecting the entitlement holding), banking quota (carry-over of unused quota), borrowing of quota overages from the next accounting period (perhaps with a penalty through a levy of quota in the future), onboard observers, full mortality accounting (whereby discard mortality of marketable fish is deducted from landing limits), payment of deemed value to land quota overages (paying the presumed marginal cost of harvest so that a vessel does not directly lose by landing quota overages), full retention requirements, stiff penalties, and other approaches (Squires, Kirkley and Tisdell, 1995; Squires *et al.*, 1998; Sanchirico *et al.*, 2006; Branch *et al.*, 2006). The greater flexibility under rights-based management afforded fishers on when, where and how to fish can also lower discards. Economic incentives under rights-based management serve to reduce discards by an individual vessel, because discards reduce the value of their rights over time, but the remaining resource stock externality covering the entire fishery means that the entire fishery bears the cost, so that this individual incentive to reduce discards may be weak. A limited ability to target specific species may also contribute to undesirable individual quota underages and overages and lower fishers' profitability if total harvests of target species are restricted to prevent the overexploitation of vulnerable bycatch species. Bigeye

[40] See Weninger (1998), Grafton, Squires and Fox (2000), Fox *et al*. (2003, 2006), Dupont *et al.* (2002, 2005), Weninger and Waters (2003), Brandt (2007), Asche *et al.* (2008), Squires *et al.* (2010a), Kirkley and Walden (2010), Lian, Singh and Weninger (2010), and Evans and Weninger (2010).

tuna catches in purse-seine fisheries are an example. The issue of fishing on dolphins, unassociated schools, and floating objects, especially FADs, further contributes to this issue. All of these unanticipated spillover effects lower the biological and economic efficacy of harvest rights.

In some instances, high transactions and political costs can impede the transition to stronger forms of rights-based management such as ITQs (Libecap, 2008; Deacon, Parker and Costello, 2011). Fishers who can effectively compete under weaker forms of property rights may have incentives to impede the transition. The initial allocation also forms an obstacle to ITQs, with some individuals or groups fearing reduced shares of fish or wanting to gain a larger share. Fish processors may also object to the transition over fears of increased bargaining power by fishers, processing capital becoming redundant and sunk (as under open access there may have been excessive investment in processing capital or the processing capital may be specialized towards the timing and location of landings and product forms under open access), and owners of this capital can sometimes face incentives to hinder the transition (Matulich, Mittelhammer and Reberte, 1996; Wilen, 2009, 2010; Matulich, 2010; Deacon, Parker and Costello, 2011). In other instances, processors may strongly favour a movement to stronger forms of rights-based management because it ensures a sustainable and year-round supply of fish, full-time rather than part-time employment and operation of the plant, less disruption of supply lines, and reduced or no need to import fish to keep processing lines and product markets supplied. Uncertainty over the size and distribution of the costs and benefits can also impede the transition to rights-based management (Libecap, 2008).

Group catch quotas and sector allocations

Rights to catch, effort, or vessel capacity can be allocated to groups as well as individuals. These groups can be communities, indigenous peoples, cooperatives and sectors. There may be at least 38 such programmes around the globe in various forms, including community development quotas, sector allocation, and cooperatives (Gilbert, 2011).
Rights can be assigned to groups of indigenous peoples, such as in the Western Alaska Community Development Quota (CDQ) (McCay, 2010). This CDQ is a share of the TAC for groundfish, halibut and crab allocated to six non-profit corporations that represent 65 eligible communities for all vessel types and sizes ranging from small catcher vessels to large catcher-processors and motherships. The CDQ provides common property to eligible western Alaska villages with the opportunity to participate and invest in fisheries in the Bering Sea and Aleutian Islands Management Area. These communities receive about 11 percent of the TAC and auction off harvest rights to the highest bidders. The six corporations may exchange the CDQs among one another, but they do not have the right to sell their CDQs or accumulate more by purchase from other groups, and they do not have a seat at the table for fisheries management, although they are present and active politically. Another community programme is the Community Management Board (CMB) programme created in the 1990s for small-scale fisheries in the Scotian Shelf region of Atlantic Canada (Kearney *et al*., 1998; Kearney, 2005). The CMBs receive portions of the overall quota for cod, haddock and other species based on historic landings of individuals in the areas, coordinate quota holders, assign quotas to individual members of the CMB, and help enforce quotas (e.g. reductions in quota and/or time that can be spent at sea [Peacock and Annand, 2008]). Fishers can voluntarily join or fish competitively (McCay, 2010). Transferability is limited for individual fishers, but CMBs can transfer quota among one another.

More broadly, rights can also be assigned to communities other than those of indigenous peoples (McCay, 2010). For example, the spiny lobster fishery of Baja California, Mexico, is harvested by nine cooperatives along the Pacific coast, and

communities are allocated exclusive rights to harvest lobster (among other species) in specific spatial areas for a 20year period (Costello *et al.*, 2010). Renewal is contingent on performance. This approach creates at least two incentives for conservation: (i) requiring stewardship as a necessary condition for renewal provides a strong incentive to comply; and (ii) a stewardship incentive, apart from renewal, is created if the tenure length of the concession is sufficiently long so that conservation enhances stocks and profitability (Costello and Kaffine, 2008).[41]

Groups can also assign a portion of the TAC to a voluntary cooperative of heterogeneous fishers (Kitts and Edwards, 2003; Matulich, Sever and Inaba, 2001; Pinto da Silva and Kitts, 2006; Kitts, Pinto da Silva and Rountree, 2007; Townsend, Shotton and Uchida, 2008; Holland, 2010; Gilbert, 2011; Deacon, Parker and Costello, 2011).[42] The cooperative can effectively operate in two broad ways: (i) de facto individual quota systems through legal agreements or informal contracts, such as the Pacific Whiting Conservation Cooperative that divided quota among four firms (Matulich, Sever and Inaba, 2001; Kitts, Pinto da Silva and Rountree, 2007); or as a profit-sharing agreement under which a limited number of vessels would catch the groups harvest allocation and the profits shared among the groups members, with some of the less efficient vessels perhaps not fishing, such as the Chignik salmon cooperative (Deacon, Parker and Costello, 2011).[43] The latter approach reached the point of a single vessel in the Challenger Bay Scallop Enhancement Company (Mincher, 2008). Internal enforcement can come through strict regulations, social pressures, penalties, legally binding contracts, and other measures (Uchida, 2007; Gilbert, 2011). Allocations of rights can be made directly to groups or to individuals who then consolidate their quota allocations. New England sectors receive allocations based on individual members' catch histories and share out the sector allocations according to what each member brings in and allow trades among the members, coming close to ITQ systems (Holland, 2010; McCay, 2010). Intersector trades within a given year, banking to the next year of up to 10 percent of unused quota are allowed, and annual reserves are required to allow for quota overages (Holland, 2010). Sectors will be required to contract with third-party vendors for dockside and at-sea monitoring. Sector members are jointly liable for quota overages, misreporting, illegally discarding fish. There are penalty schedules, requirements to indemnify each other for harm they may cause each other due to joint liability, and sector members can be prohibited from fishing or even be expelled; all provide considerable sector self-enforcement. The Producer Organisation quota management programmes in the United Kingdom of Great Britain and Northern Ireland and the Biesheuvel groups in the Netherlands (Christensen *et al*., 2009), involve

[41] In 2004, the North Pacific Fishery Management Council modified the Alaska ITQ programme for halibut, sablefish and other species to limit the movement of quota away from many small communities due to transfers among quota holders (McCay, 2010). Forty-two small, isolated and fishery-dependent communities in the Gulf of Alaska can organize as non-profit Community Quota Entities with the right to purchase quota on behalf of community members. Each year the Community Quota Entity then leases its quota to one or more permanent members of the community. Owners of the quota are also required to be on be onboard the vessel harvesting under the quota provisions.

[42] In conjunction with government, the five permit holders in the stout whiting fishery of Queensland, Australia, implemented a voluntary TAC (Townsend, Shotton and Uchida, 2008). In the Spanish fleet that harvests in the Celtic Sea, seven producer organizations are each allocated a portion of the national TAC (Garza-Gil and Varela-Lafuente, 2008). These producer organizations then allocate harvesting rights to individual vessels, which can reallocate the rights among themselves. The result is essentially a producer-organization-run individual quota programme.

[43] Much of the benefit for the Pacific whiting and Alaskan pollock cooperatives arose from higher-valued landings as fishing slowed under individual allocations (Townsend, Shotton and Uchida, 2008). Product recovery increased from 17 to 24 percent in the Pacific whiting catcher-processor fleet and from 19 to 30 percent in the Alaskan pollock catcher-processor fleet. Through cooperation, the Pacific whiting catcher-processor vessels could harvest later in the year in more northerly waters (as the fish migrated northwards), as the fish were larger.

the allocation of shares of overall quotas to organized groups of fishers (Dubbink and van Vliet, 1996).

Consolidation or coordination of members' activities, quotas, and even investment decisions, reductions in transactions costs, and transfer of catch quotas among sector members can thus lower harvesting and capital costs. In addition, as Deacon, Parker and Costello (2011, p. 7) state in discussion of the Chignik salmon cooperative: "Some of these gains arose through the oft-discussed channel of effort consolidation. Substantial additional gains came through channels that have received far less attention, including coordination on the location and timing of fishing, sharing of information on stock locations and provision of shared infrastructure." Sectors also provide opportunities for members to coordinate bycatch reduction activities and even to conduct fishery-specific research. Even a well-designed ITQ system may not be able to internalize all externalities and create incentives that facilitate coordination among competing users of the common resource (Scott, 2008; Costello and Deacon, 2007).

The voluntary nature of the cooperatives and sector allocations means that fishers voluntarily self-select in or out; hence, only those who will gain will join (Costello *et al.*, 2010). The voluntary organization facilitates securing political support prior to establishing rights-based management. The sectors organized by cooperatives and those that are not can be designed so that the existence of property rights does not impair the profitability of those remaining outside of the voluntary sectors and cooperatives (Deacon, Parker and Costello, 2011).

Effort quotas and shares

Rights-based management can establish transferable property and use rights over fishing effort.[44] Effort rights can be allocated to States, groups, or individuals and there have been at least 16 transferable effort programmes around the globe. When allocated to individuals, these are often called Individual Transferable Effort (ITE) programmes, and as discussed elsewhere, individual vessels, sectors, or groups may receive these rights through States. Transferable effort programmes represent a major step forward from open access and limited entry and are a more well-structured right because of the stronger exclusive use of the right by individual vessels. In national programmes, the property right is held by the State and use rights are allocated to individual firms or vessels. Ownership of the fish stocks and access is retained by the State or by an RFMO for the high seas established by a binding international treaty

Transferable effort programmes set a Total Allowable Effort or TAE, typically denominated in nominal units of effort, such as days at sea or number of sets of gear, although other units can be used such as units of gear such as hooks or traps. They can also be denominated in flows of capital services (the flow of services – or activity -- from a stock of capital, measured in units corresponding to the stock of capital of concern, such as vessel numbers or kilowatt for engine power), such as kilowatt-days (kW-days), GT-days, trap-days, hook-days, etc. Effort in European individual effort and individual transferable effort programmes is denominated in kW-days, where the time dimension is sometimes called activity. Denominating effort as capital services should provide a more accurate measure than simply a measure of time (activity) or a measure of capital stock, as it contains more information.

In principle, units of effort can be expressed as standardized or effective effort, attempting to account for differences in productivity (states of technology and technical efficiency, sometimes called fishing power) across different and unique

[44] For discussions and case studies of transferable effort programmes (effort shares), see Aqorau (2007), Barton (2002), Baudron *et al.* (2010), Borg and Metzner (2001), Cotter (2010), Demarest (2002), Garza-Gil and Varela-Lafuente (2008), Harte and Barton (2007), Jákupsstovu *et al.* (2007), Khalilian *et al.* (2010), Larkin and Milon (2000), Løkkegaard *et al.* (2007), Nielsen *et al.* (2006), Shanks (2010), Thomsen (2005), and Squires *et al.* (2010c).

production technologies (such as gear types, national fleets, and vessel size classes).[45] Europe, for example, has multispecies and multigear fisheries, so that setting up a large market in tradable rights is not simple, as a kilowatt day in gillnetting for cod is not the same as a kilowatt day in trawling, and standardization to units of effective effort is required. In principle, the resulting coefficients establish comparable fishing mortality across species and gear, so that when transfers are made across species and gears they yield the same impact on fishing mortality. A trade-off may exist between economic efficiency gains from trade of transferable effort and uneven impacts on fishing mortality. Transferable effort can be specified by area, by gear, and to accommodate varying productivity for different-sized vessels by vessel size class or by the product of vessel size and time (Shepherd, undated).

Compared with catch share programmes, transferable effort programmes may induce less industry exit and instead allow more vessels to remain in the industry, albeit at lower profitability, because effort is a less precisely defined right. Effort rights without accompanying catch limits on individual vessels may not constrain production as much as ITQs, and especially on the most profitable species. There are more ways to circumvent the effort right, including productivity growth and expansion of uncontrolled dimensions of effort. Overall effort may remain higher and profitability lower in fisheries regulated by transferable effort compared with catch shares.

Transferable effort programmes based on fishing time or activity (such as days at sea) unaccompanied by licence limitation programmes can generate incentives and pressures to increase the TAE. Should vessels purchase days to enter the fishery, but should the number of days be insufficient for profitability owing to an excessive number of vessels, pressures can be generated to increase the TAE or to multiply the actual fishing time of a unit of effort. As such, transferable effort programmes that retain limited-entry (licence limitation) programmes as a concomitant policy instrument can buttress expansions in the TAE and subsequent expansions in fishing capacity. (Limited-entry retention also helps other fishing externalities not addressed by a property or use right.) To some extent, and especially with small numbers of homogeneous participants (and even more so if participants live near the resource), stewardship and conservation social norms develop that can yield counterveiling pressures and greater self-enforcement (and enforcement through social processes) to reduce the TAE in a similar manner to the roles of quota holders in conservation and compliance in the New Zealand ITQ programme (Baland and Platteau, 1996, 2005; Ostrom, 1990; Scott, 2000, 2008).

Transferable effort programmes have been less extensively used than other forms of rights-based management such as limited access or ITQs. Transferable effort programmes have been applied in:

- the New England groundfish fishery (this programme was subsequently disbanded and is in the process of conversion to ITQs and sector allocations / group rights);
- a system of tradable fishing days by fleet for the demersal gadoid fishery of the Faroe Islands since 1996;
- the Hawaiian pelagic shallow set longline fishery for swordfish (this provision was recently disbanded);
- the Falkland Islands (Malvinas) squid fishery;
- transferable traps in the commercial lobster fisheries in Lobster Conservation Management Areas of Outer Cape Cod and Southern New England;
- a federal waters transferable trap programme in New England;
- two individual transferable trap programmes in Florida;

[45] For biologists, effort should be proportional to fishing mortality. For economists, effort should represent a consistent composite index of all inputs in the production process that also accounts for the state of technology (both embodied or investment-specific and disembodied) and levels of technical efficiency.

- fleet capacity in Sweden;
- salmon netting in the United Kingdom of Great Britain and Northern Ireland;
- the coastal fishery for plaice, perch, salmon and herring in Estonia;
- transferable fishing days in the Torres Strait prawn fishery;
- transferable vessel days in the Area H Johnson Strait chum salmon demonstration fishery in Canada;
- fleet capacity with limited transferability for tropical tuna purse seiners in the EPO;
- the Australian Southern zone rock lobster fishery;
- Greenland shrimp vessels of less than 75 GRT;
- transferable fishing days in for the Spanish 300 fleet operating in the Atlantic Community waters.

In the Florida commercial trap sector of the spiny lobster fishery, a management target of 400 000 traps was set in 2001. The transferable trap programme reduced the total number of traps from more than 825 000 to fewer than 500 000, while maintaining the trap sector's overall catch (EDF DCTF, 2010). The Western Australia rock lobster fishery, which is managed under a transferable effort system, is also divided into three zones that distribute effort across the fishery and enable managers and fishery representatives to address zone-specific issues effectively (EDF DCTF 2010). A transferable effort programme based on length of head rope in the Australian Northern Prawn Fishery was converted in 2010 to an individual quota fishery. Iceland was managed by a transferable days programme prior to conversion to ITQs (Asche *et al.*, 2005). Industry opposition to ITQs in the Faroe Islands prompted the transition to a system of individual transferable fishing days (Hannesson, 2010).

The PNA introduced the VDS for the tuna purse seine industry in the WCPO (Aqorau, 2007, 2009; Havice, 2010; Shanks. 2010). The VDS, implemented on 1 December 2007, restricts the total number of number of tuna purse-seine vessel days fished within the PNA EEZs. (Fishing day means any calendar day, or part of a calendar day, during which a purse seine vessel is in the waters of a Party outside of a port, but does not include a calendar day, or part of a calendar day.) A fishing day under the VDS has been apportioned based on vessel length. Specifically, fishing days for vessels with overall lengths of less than 50 m, 50–80 m, and more than 80 m are equated to deductions of 0.5, 1.0 and 1.5 fishing days, respectively. The PNA has committed to a longline VDS in PNA EEZs with trial implementation commencing in 2011. Little is known about the actual and potential effectiveness of the purse seine VDS.

The VDS replaced a purse seine limited-entry programme capped at 205 vessels with an overall days limit for PNA EEZs of 33 856 days per year, which is based on historical data of days fished in PNA waters in 2004. The PNA allocates shares or proportions of the TAE, called party allowable effort (PAE), among each of the eight parties.[46] The allocations are set for twelve-month time periods and can be set for up to three years in advance. These shares are in turn transformed into days by multiplying allotted PAEs by the TAE. The days form use rights, where the individual Parties retain the property right itself. Each of the eight Parties in turn allocates to contracting parties, which are largely governments. Once a PNA Party uses its three-year allocation, no more days are allocated to it until the following three-year period. Days have a duration of one year. Divisibility is specified in blocks of 50 days rather than individual days. There are no refunds, extensions or credits. As of 1 January 2010, observer coverage has been

[46] The eight member States that are parties to the Nauru Agreement, in whose waters about 80 percent of the WCPO tuna purse seine catch is found, are: the Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu (Havice, 2010) The allocation formula is approximately 50 percent determined by biomass of yellowfin and skipjack tunas within EEZs and 50 percent by catch histories. See Havice (2010) and Shanks (2010) for further details on the VDS scheme in general and the allocation in particular.

100 percent, which is coupled with an electronic vessel monitoring system (VMS).[47] The Western and Central Pacific Fisheries Commission has recognized the VDS by the following measures: CMM 2005-01/CMM 2006-01, and now in CMM 2008-01 which is the current bigeye, yellowfin and skipjack measure, and the requirement that compatible measures are adopted for non-PNA EEZs and high seas areas (20°N to 20°S).

The VDS allows for the unused days each of the PNA Parties to be transferred between Parties during a three-year period, but not between individual flag State vessels once days have been purchased from a Party. The VDS programme allows borrowing and banking of days; that is, days can be borrowed from future years, and unused or unusable days can be carried forward. The provision of borrowing and banking is a form of transferability across time, but it implicitly establishes incentives that limit transferability across Parties and vessels. To date, minimal trade has been observed; this for a variety of reasons, including: newness and unfamiliarity of the programme, nations intent on retaining sovereignty, a still emerging secondary market infrastructure, information and transactions costs and uncertainty, and attenuation on rights and their transfer owing to social and political purposes.

Transferable effort programmes may be useful where input-based management is preferred, such as in complex multispecies fisheries, where multiple species greatly complicate ITQ programmes, which are necessarily denominated in catches of species or species assemblages (Squires, Kirkley and Tisdell, 1995; Squires *et al.*, 1998; Sanchirico *et al.* 2006; Shepherd, undated, 2003). Transferable effort programmes might also be useful for fish stocks and catches that are highly variable, such as squid and some small pelagic species, where the non-linear and stochastic relationship between effort and catch is par for the course. Transferable effort programmes may also be useful when there is not the infrastructure for MCS, such as onboard observers, to enforce use rights over catches, which requires considerable infrastructure at ports and even afterwards when the fish are transported and traded. Compliance can be monitored through VMSs. Bycatch may pose less of an overt issue as there are not catch limits, but this does not make it go away.

Exclusive use is provided for the units of effort held. Transferability of individual transferable efforts can face few limitations, as in the Hawaiian programme, or can be highly attenuated as with the VDS of the PNA. Duration can range from limited periods to perpetuity, with a single year's duration for the Hawaiian programme, and in the WCPO rights are limited in duration to three years. Divisibility can be finely structured down to a single day or unit of gear. Quality of title and security are similar to ITQs.

Taking stock of the type of property right

This section takes stock of the different forms of property right by evaluating on the basis of four criteria (when possible): (i) the law and economics approach of the characteristics of property rights based on Scott (2000, 2008);[48] (ii) the production process and nature of the secondary markets that develop for transferable rights; (iii) the broader bioeconomic approach that considers the overall net benefits within the fishery and related processing sector (but does not explicitly consider property rights);

[47] In 2008, the PNA adopted additional terms and conditions for fishing access: 3rd Implementing Arrangement: 3 month FAD closure 1 July – 30 September; High Seas Pockets Closure; Compulsory Catch Retention; 100 percent Observer Coverage. In December 2008, the Western and Central Pacific Fisheries Commission successfully adopted CMM 2008-01, which *inter alia* recognizes 3IA in PNA waters, and requires adoption of compatible measures in non-PNA and high seas waters. Additional initiatives to generate increased benefits to PNA domestic economies tuna fisheries have included establishment of the PNA Office in Majuro in 2010.

[48] The Organisation for Economic Co-operation and Development (OECD) adopts this approach for national property rights and provides a comprehensive discussion.

and (iv) the population biology approach that considers the dynamics of the fish stocks and the resulting yields or catches (and also does not explicitly consider property rights).

Limited entry is a fundamental prerequisite for rights-based management in transnational fisheries. A universe of participants is created and a bulwark established protecting the TAC, TAE, or total fishing capacity limit in these stronger forms of rights-based management. Limited entry also allows licences differentiated by fishery or species, collection of licence fees, and other advantages. Only after stronger forms of rights-based management have been implemented and a track record established might limited entry then be eliminated. Limited entry by itself, even with transferable licences, is a relatively weak right as it is a right of access with limited divisibility and exclusivity and has only an indirect and relatively weak relationship with total catch and fishing mortality.

Vessel-carrying capacity shares are a stronger right than limited entry, but they are built upon limited entry with limits to divisibility and transferability. Catch shares have substantially stronger exclusivity. Fish-carrying capacity is easy to measure and monitor, but, as with input controls in general, the relationship between fish-carrying capacity and catch is indirect and unstable, and incentives are created to circumvent capacity limits through expansions in uncontrolled dimensions of effort, length of time fishing, or more extensive use of other inputs. Ongoing productivity (fishing power) growth also renders both limited entry and fish-carrying capacity shares increasingly weaker over time. Fish-carrying capacity regulation may be supplemented by regulating capacity utilization through limiting the length of time at sea or spent fishing and mandatory retiring of fish-carrying capacity when vessels are transferred or consolidated into a larger one.

Transferable effort shares are also an important form of rights-based management, but they are a weaker form of right than catch shares as there is not a direct relationship between fishing effort and catch, and it is easier to expand effort along many margins, such as substituting unregulated inputs for regulated inputs. Issues with defining and measuring unobserved effort that is also subject to ongoing productivity growth raise problems with effort shares ("effort creep"). From the population dynamics perspective, an effort-based approach tends to be favoured over a catch-based approach, because fisheries under effort management are less likely to be overfished during poor years as overall limits are set on effort, the TAE, rather than catch, the TAC. Thus, poor years will result in lower catches for a given amount of effort. This conclusion is strengthened the weaker or the more variable is the stock-recruitment relationship relative to the harvest-effort relationship. Bioeconomic results are agnostic (Hannesson and Steinshamn, 1991; Quiggin, 1992; Danielsson, 2002; Kompas, Che and Grafton, 2008; Yamazaki, Kompas and Grafton, 2009). As fishing costs decrease and the price of fish rises, the advantages to total effort control grow relative to a total harvest control when evaluated by expected net profits and biomass. Whether a TAC or TAE is preferred depends on the relative costs in MCS and enforcement, the ability of fishers to substitute to non-ITQ species or unregulated fishing inputs, the uncertainty between fishing effort and harvest and their performance in multispecies fisheries, and the uncertainty between the fish stock and the level of recruitment or growth in the fishery.

Catch and effort shares are both delineated in shares of the TAC or TAE rather than in absolute quantities to account for changes in the TACs or TAEs, as required to achieve the optimum. Delineating catch and effort as shares rather than absolute amounts automatically balances the annual catch entitlements with the TAC or TAE, and shifts the risk of quota holding away from the management authority to the rights holder rather than those disbursing the quota and retaining ownership of the resource stock.

In sum, limited entry serves as a necessary first step with rights-based management that can be followed and supplemented by even stronger forms of rights-based management. Transferability in all cases is critical in achieving economic efficiency and for flexibility and industry restructuring, including accommodating new members and for the rights and aspirations of coastal developing States and small island developing States. Fishing capacity programmes are a step forward from limited entry as they are a stronger form of right and place more limitations on the input bundle, but they may not be as strong as transferable effort and catch share programmes. Valid arguments can be made for both transferable effort and catch share approaches to rights-based management. Transferable catch share programmes are largely preferred as a form of first-best policy from the perspective of the firm or vessel and its production process owing to the difficulties of defining and measuring unobserved (nominal and effective) effort, potential for increasing unregulated input components of effort, and the indirect, stochastic and time-varying relationship between effort and catch subject to ongoing productivity growth that continuously widens the gap between TAE and TAC. That is, catch share approaches (to either individuals or groups) are the strongest form of rights-based management because exclusive use is given to catches. This directly limits total catches from a stock to what the stock will sustainably support and establishes the strongest incentives to reduce the race to fish. Separate catch quotas must be set for each stock and, perhaps, by gear type. Monitoring, control, surveillance and enforcement requirements and costs are the greatest for catch shares of all the forms of rights-based management (and along with a more strongly enforced right, TAC probably makes a large contribution to their success). Transferable catch quotas are also preferred from the law and economics approach to property rights because transferable catch quotas are a stronger and more well-defined form of property right than limited entry, transferable effort, or capacity as exclusive use is given to catches. From the bioeconomic perspective, no clear advantage exists for either TAC or TAE approaches (abstracting from catch or effort quotas as rights-based management). Benefits from catch quota rights-based management must also be sufficiently large relative to the increased management costs in quota reconciliation, MCS and enforcement to favour catch-based over effort-based rights-based management (Grafton and McIlgorn, 2009; Shepherd, 2003). However, the allocation of rights should take account of any currently existing management framework and build upon it, where practical. It may therefore be necessary to evolve to a system based on catch rights. This may involve maintaining complementary management measures. Transferable effort systems can be more effective when existing size, sex and season regulations are effectively meeting biological goals for a fishery.

Transferable effort approaches are sometimes advocated in multispecies fisheries. Where there are no stocks requiring limits to fishing mortality and/or the TAE is sufficiently low so that species are not subject to excessive fishing mortality, then transferable effort can be suitable for multispecies fisheries. However, if supplementary catch limitations on species are required in order to limit fishing mortality for these species, then catch shares may be more suitable as they can induce species substitution in the catch mix and directly address the excessive fishing mortality. A similar case could be made, not for a multispecies fishery, but for a single species that is exploited by different gear types. This would allow, for example, transferrable effort in the purse seine fishery and catch quotas for the longline sector.

In practice, practical and cost matters of implementation, including monitoring, compliance, surveillance and enforcement, along with the political economy of achieving cooperation to actually implement a programme, may well be the deciding factors. Transferable fishing capacity and effort and catch share forms of rights-based management improve economic benefits, conservation, and sustainability of populations and catches compared with the alternative of no rights-based management,

although no approach is a panacea and always appropriate in all fisheries. A case can be made for effort shares in a multilateral and transboundary fishery because the MCS requirements and costs can be substantially less, including the absence of necessity for a vessel observer programme and the system of quota reconciliation, and the use of VMS. This case is weakened if bycatch and catch limits require directly limiting catches and a vessel observer programme. Effort share programmes are most effective when the TAE can be set low enough to allow for expansion of effort along many margins and to keep fishing mortality down in mixed stock species.

In all cases, transferability among individual vessels and across States of licences, vessels, fish-carrying capacity units, catch shares, or effort shares enhances economic efficiency and introduces flexibility, allowing the fishing industries to restructure in a decentralized manner in response to changes in technology, markets, resource conditions and locations, and the environment. Use rights tend to end up in the hands of the more economically efficient users. Transferability helps secondary markets for the rights to emerge, in which use rights are exchanged, which in turn help facilitate entry into the fishery by new members to an RFMO and exit from the fishery to reduce fishing capacity and overcapitalization and thereby lower costs and raise overall industry profitability. Transferability and duration of the selected right can be attenuated and shaped to achieve social objectives such as employment and aspirations of coastal developing and small island developing States. Duration of the right is essential for transferability. Duration can vary according to the objectives of the RFMOs and States, does not affect efficiency in equilibrium (Ledyard, 2009), and provides considerable flexibility in programme design and objectives.

Property rights versus access rights (licences)

Rights to catch, effort or capacity differ from rights of access to EEZs, i.e. to licences. Property rights can be spatially delineated to particular EEZs or the high seas, or can be specified throughout the entire RFMO area without distinguishing areas of fishing. When rights are spatially defined to an EEZ, the catch/effort/capacity right is bundled with an explicit and separate right of access (i.e. licence), and when delineated to the high seas it is implicitly bundled with an access right (licence) to the high seas. A separate right of access or licence is required to harvest within individual EEZs whenever rights are not spatially defined (other than the general RFMO area). The price or rental value for a bundled property and access right should, for the same vessel harvesting in the same area and time, have a higher economic value than any of the two separate rights individually considered. When rights of property and access are unbundled and rights holders are distinct, the relative bargaining strengths of coastal States and separate holders of catch rights delineated for EEZs determine the distribution of economic benefits and even potentially the size of the overall benefit as determined by the impact of relative economic efficiencies. When catch or effort rights within EEZs are allocated solely on the basis of historical use rather than location of fish catch, historical use rights of flag State vessels that differ from the EEZ flag State can be viewed as given greater precedence over States' rights over resources within States' EEZs.

ALLOCATION OF RIGHTS

Allocation of rights can be contentious and divisive, and it is probably the most difficult part of implementing rights-based management.[49] Allocation entails distribution of opportunities, income, profits, employment and wealth with impacts on political influence (Libecap, 1989). Different allocations lead to different distributions. Any effective rights institution requires exclusion, which creates winners and losers (Libecap, 2009). Rights create a stream of net revenues from production, investment

[49] The establishment of the 200-mile EEZ allocated sovereign access rights to individual coastal States.

and trade, and, if the fish stock rebounds from open-access depletion, the wealth and associated distributional impacts can be substantial, affecting established social patterns and political influence. Costs can include deteriorating social cohesion and the possible losses of other collective values. Cost can also include exiting vessels and fewer crewmembers and the shrinking of some communities as activities formerly taking place are displaced. Distributional pressures play an important role in the political economy of rights-based management, shape the kinds of property rights established, and affect their ability to address open access. As a general rule, the more potentially valuable the resource in question is and the less well socially established the assignment rule is, the more intensive is the struggle over who receives the rights and in which quantities. The adoption of property-rights-based institutions (and assignment of property rights) typically comes relatively late when the cost of open access and/or centralized regulation becomes too great and distributional issues can be settled (Libecap, 1989, 2007); only then are the benefits starkly clear.

Solving the allocation problem is not necessarily a matter of explicitly developing the allocation, but rather it is about creating and managing a sustainable fishery that can in turn implicitly define the allocation. The allocation has to serve a definite management purpose, and is thus a means to the end rather than the end itself.

Allocations (and establishment of rights) require keeping an eye on two issues: (i) legitimacy; and (ii) compliance and enforcement. Allocations that are not legitimate will not sustain a self-enforcing agreement and will generate pressures to reallocate in the future. Allocations made with an eye on compliance and enforcement facilitate compliance and enforcement; some allocations are inherently more enforceable than others, and some allocations instil greater incentives for compliance. For example, proposals under consideration by the Indian Ocean Tuna Commission create negative incentives for compliance by annually deducting shares of TAC to States that fail to comply.

Allocations of rights and privileges in international fisheries inherently differ from national allocations, because as an agreement among RFMO member and cooperating non-member nations, the outcome must be self-enforcing. Sovereign nations within an RFMO must voluntarily agree to the allocation without external compulsion and enforcement and, thus, the allocations must be perceived as fair. A self-enforcing allocation should also be immune to subsequent renegotiation, and at no point in the future should there be an incentive to deviate from the initial allocation except through voluntary exchanges or transfer of rights from one party to another.

Allocation in international fisheries is also linked with entry into the RFMO and fishery, with entry ultimately being the critical issue. If entry to the RFMO is not limited, then an allocation of rights and subsequent improvements in the fishery will attract new vessels and even new members. Allocations are strategic decisions that can reshape and reorient the incentives of RFMO members to facilitate participation, cooperation and self-enforcement.

All those with a real interest in a fishery should be involved in RFMO allocations, irrespective of whether the membership practices of the RFMO are inclusive or exclusive. In a fully exploited fishery, the rights of coastal and small island developing States to expand their participation in a tuna fishery will have to be accommodated by mechanisms for reducing the participation of others. Other new entrants in fisheries will require either adjustments in the allocations or the ability to obtain fishing rights from existing members.

The right to be allocated must be determined. Rights may be allocated according to specific areas, different species, age classes of fish that occur in different areas, different gear groups, vessel size classes, and other distinguishing criteria.

Allocation mechanisms

Anderson, Arnason and Libecap (forthcoming) classify four types of allocation mechanisms:[50]

- political allocation;
- uniform allocation;
- first possession or grandfathering;
- auctions.

Political allocation refers to the direct assignment of property rights by government officials, which has a clear potential for rent-seeking. Namibia and South Africa allocate fisheries rights politically, but otherwise it is rare in fisheries. Potential reasons include the widespread use of first possession (which shows up in catch histories), the specific information and human capital required for entry into a fishery, and because rights-based management typically has been implemented when fish stocks have been dangerously depleted, reducing available rents and their value as political rewards (Hannesson, 2004; Libecap, 1989, 2008).

Uniform allocation distributes equal shares to all fishers or States. This approach is ostensibly equitable and avoids the transaction costs associated with designing auctions or with verifying claims based on past production for grandfathering. In principle, subsequent exchange of rights and low costs of trade lead to an efficient solution via exchange (Coase, 1960; Montgomery, 1972; Ledyard, 2009). The resource still migrates to high-valued users and rents remain in the fishery. In practice, transactions and information costs will preclude full trade from higher-cost to lower-cost producers. Uniform allocation such as lottery distribution has not been used for fisheries rights-based management. The distribution of wealth and opportunities can markedly vary from the status quo, and as a consequence can lead to considerable resistance to this approach.

First possession or grandfathering assigns ownership to existing fishers based on historical catch, capital investment, or some combination of the two. This approach can be extended to the proportion of biomass in EEZs. It can also distinguish between catches taken on the high seas (and claimed by the flag State of concern) and catches taken within EEZs that can either be attributed to the flag State of harvest or to the State in whose EEZ the catch was made (should they differ). First possession is by far the most common approach in fisheries (Ostrom *et al.*, 2009). In the PNA VDS, the combination is historical catch and biomass in EEZ. First possession rules recognize current parties, who have experience in exploiting the fishery. Libecap (2006, p. 34) observes: "There is more than political expediency in the allocation of ITQs based on historical catch. As outlined above, it can be efficient as well. Assigning quotas to those with knowledge and past experience in the fishery is likely consistent with granting rights to the low-cost users. This practice reduces the need for subsequent re-allocation and therefore, economizes on transaction costs." Anderson, Arnason and Libecap (forthcoming) thus argue that first possession produces efficiency. Restrictions on such allocations (rights set-asides for particular groups such as developing coastal States or new members and exchange limitations) may then be costly in the long run for maximizing the value of the resource (Libecap, 2010). First possession also protects incumbents who otherwise lose in the reorganization that follows the beginning of rights-based management (Ledyard, 2009). First possession allocation is often deemed necessary to gain acceptance of rights-based management. As discussed below, limited duration or buybacks of the rights and levies allow subsequent restructuring of the fishery to achieve social and political goals after the initial first-possession allocation.

[50] Moloney and Pearce (1979) discuss a fifth approach – lotteries, but this approach has never been implemented.

Auctions[51] allocate rights to the highest bidder with the revenues going to the seller, generally the State or perhaps the RFMO for the high seas. Auctions are mostly used to grant use rights for previously unexploited resources with no incumbents for which the State may have clear ownership, such as timber concessions, oil and gas leases, and the division of the electromagnetic spectrum. Auctions have rarely been used in fisheries.[52, 53] Revenues from auctions can be used to offset distortionary taxes in a double-dividend approach (Goulder *et al.*, 1999). Revenues from auctions can also go to other opportunities where their use could either further increase the efficiency of the fishery, such as for MCS and enforcement, or the fairness of the initial benefits created by the rights-based management programme. Auction revenue could also be used to address participation of coastal developing States and small island developing States. Auctions help achieve allocative efficiency with minimal information required from the agency as the better-informed bidders reveal their privately held information. Well-designed auctions provide very efficient price discovery and are very transparent. Auctions of initial allocations or of any quota annually or periodically made available by expiring rights of limited duration help establish markets for rights and price discovery. Many types of auction formats exist.[54] All auction formats select the bidders with the highest valuation, so that all auction formats are efficient (Latacz-Lohmann and Schilizzi, 2005). Thus, there is no incentive after the auction to reallocate the traded asset among bidders. None of the losing bidders would be willing to offer a price that would top the winner's valuation.

Some individual tuna RFMOs have established criteria for allocation that are partly based on grandfathering (Table 2). Other specific allocation criteria that have been considered include: measures of compliance with other obligations and measures; assigning different weights to historical participation for members and cooperating non-members; contributions to conservation; and resource stock conditions. These "supplemental" criteria can modify political, historical, uniform or auctioned allocations. In order to ensure participation, agreement and compliance, grandfathering in international fisheries within the framework of a

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[51] For the theory behind auctions, see Klemperer (2004), Milgrom (2004), Athey, Levin and Seira (2004), Latacz-Lohmann and Schilizzi (2005) and Whitford (2007).

[52] Anderson, Arnason and Libecap (forthcoming) observe that there are four cases of auctions used as a primary tool to allocate ITQ rights in fisheries: in certain fisheries in the Russian Federation and Estonia in the late 1990s (Vetemaa, Zero and Hannesson, 2002; Hønneland 2005); in a few small fisheries for squat lobster, yellow prawn, black hack, and orange roughy in southern Chile (Pena-Torres, 1997), and in the Washington State Puget Sound geoduck fishery (Huppert, 2005). To this list can be added auctioning of transferable effort rights in the Falklands Islands (Malvinas) (Barton, 2002). They were discontinued in the Russian Federation and Estonia. See Anderson and Holland (2006), Anderson and Sutinen (2005, 2006), Anderson, Freeman and Sutinen (2008), and Higashida and Minagi (2010).

[53] The initial allocation of rights in Chile is by auction (Arnason 2002). This is followed by subsequent auctions where 10 percent of outstanding ITQs are auctioned off. This means that each company's holdings are reduced by 10 percent every year. However, the companies can replenish their holdings by successful bids in the annual auctions.

[54] Klemperer (2004) distinguishes ascending bids, descending bids and first-price sealed bids where each bidder independently submits a single bid without seeing others' bids, with the sale going to the bidder with the highest bid and the winner pays the highest or first-price. English auctions are ascending bids with open information, and Dutch auctions are descending bids with open information. A Vickrey auction or second-price sealed bid occurs when each bidder independently submits a single bid, without seeing the bids of others with the object sold to the bidder with the highest bid. The price paid is the second-highest bidder's bid or second price, an incentive-compatible revelation procedure. Most auctions in theory provide the same revenue to the bid-taker, known as the Revenue Equivalence Theorem, but they are not equivalent in practice (Whitford, 2007). Auctions are usually discriminatory, in which the authority pays each bidder his/her actual winning bid. In a uniform-price auction, all units earn the cut-off price, which is either the highest accepted or lowest rejected bid, and all winners except the one at the cut-off price receive payments higher than the opportunity costs implied in their bids. A bidder's (unique) bid only determines the chance of winning but not the payment received. A bidder's dominant strategy is to bid his/her true opportunity costs. The potential for adverse selection is higher.

TABLE 2
Summary of RFMO responses to allocation issues

ISSUES	ICCAT	CCBT	IOTC	IATTC	NAFO	NEAFC	CCAMLR
Data used in making allocation.	Stock assessment, historical catch, bycatch.	Stock assessment, historical catch, aspirations developing countries.	Gross registred tonnage. Catch data now being used to prepare allocation plans.	Vessel carrying capacity.	Stock assessment, historical catch.	Historical catches, and to certain extent (atlantoscandian herring, mackerel) stock distribution.	Allocation decisions are not actively made on any data other than applications to fish.
Balancing interests of coastal States and DWFNs	Negotiated allocation criteria. Negotiated balance of interests on a stock by stock basis.	Negotiated allocations based on historical catch. Development of mathematical management procedure for setting TAC.	Capacity restriction to protect bigeye. Preparation of a multi-year plan for allocations.	Longline: Negotiated allocations based on historical catch Purse seine: fish carrying capacities frozen at 2002 levels.	Negotiated settlements Use of Allocation Working Group to prepare criteria for stock not currently or ever allocated by NAFO.	Herring, mackerel, and blue whiting are allocated first by the coastal States which determine a high seas portion of the stock to be given to NEAFC. NEAFC then allocates this proportion to other non-coastal States.	TACs are determined by CCAMLR for areas under national control, but allocation is not specified for them. Coastal States have right of veto under the Chairman's Statesment
Accounting for the increasing interests of Members developing fisheries and new entrants	Set aside poportion of quota for developing fisheries. Small unassigned albacore quota pool. BFT quota offered to UK and France to join the Commission.	Small unassigned quota pool in 2003. korea and Taiwan offered allocation as Members.	Allowed smaller fleets to expand within a development plan submitted to Commission.	Exemption for developing fleets from capacity limits on major fleets.	Non-Members may accede to NAFO but quotas are fully allocated. Limted fishing opportunities for new Members within "others" categories.	In the only Fishery primarily controlled by NEAFC, redfish, a small quota (0.3%) is set aside for cooperating non-contracting parties.	Not adequately dealt with; apparent "catch 22" restricting harvesting to current Members. New entrants discouraged.
Cases of where compliance is used to determine allocations	Allocations for NCPs to join or gain cooperating status. Notification and Trade sanctions for violators. Penalties for violating Memberrs. (Chinese Taipei).	South African allocation reduced due to non-compliance. Japanese allocation reduced for 5 years following overcatch.	Compliance committee reviews applications for cooperating status.	Removal vessel from the register of fishing vessels affecting the fishing capacity of the nation.	Quota reductions in subsequent periods to deal with over-runs.	A party can only become a cooperating noncontracting party if its compliance record is good and it has not engaged in IUU.	IUU list vessels cannot partecipate in an exploratory fishery. Poor compliance by an existing vessel may lead to it being on the IUU list.

Source: MRAG (2006).

self-enforcing agreement may require allocating rights to RFMO members and even cooperating non-members that do not have a historical record of fishing.

Allocations based on historical participation may require a transfer of benefits ("side payments") from those RFMO parties with a record of historical participation to those without historical participation. These benefits are economic options with economic value that can be exercised in the future and can take many forms, including allotments of rights for capacity, effort or catch or even benefits that are not directly related to the fishery (e.g. access to national markets for tunas or other products). These transfers of benefits, required so that all parties gain from the allocation, can take place immediately or can be phased in over a period of years.

Auctions of rights provide a number of advantages in principle. Auctions help establish a secondary market for rights, including prices that embody the information

from all bidders not just those exchanging rights after the initial allocation. Not all rights have to be auctioned for auctions to establish price discovery. When coupled with some proportion of property rights expiring in each year, auctions can facilitate the price discovery process using those expiring rights. Auctions can also raise revenues, although in some instances the auction revenues can be passed back to the bidders after the initial allocation and the secondary market for rights has formed. Auctions may face considerable resistance if implemented when industry and tuna stock conditions are distressed and the economic benefits from the fishery do not allow financing auction bids. Auctions can also represent a transfer of economic benefits from the industry to governments possessing the right, providing further resistance.

Catch and effort rights are best allocated as shares or proportions of the (periodically updated) TAC or TAE rather than in absolute units. Allocating absolute units, such as tonnages or fishing days, precludes flexibility in response to changes in sustainable target levels.

Two different classes of allocations could also be created, one permanent and the other of limited duration. The limited duration allocation can be periodically allocated to accommodate new members, expansions of fishing opportunities by coastal and small island developing States, movements of tunas, and other changes that might occur.

When the grand total of allotted rights exceeds the sustainable target level, then the benefits allotted to RFMO parties represent borrowing from the future from all members proportionate to their existing holdings. A mechanism, such as buybacks or expiring rights, is subsequently required to remove the "overallocation". Differing priorities for future versus present trade-offs make it more difficult to achieve a common acceptance of sustainable allocations and can provide incentives to "overallocate".

In principle, when transactions costs are low, which parties receive the right in the initial allocation does not affect the final market equilibrium (Coase, 1960; Montgomery, 1972). In essentially a mechanism design approach of this, Ledyard (2009) found that, in equilibrium, neither the duration of the quotas nor the method of initial allocation affect the profitability of the fishery or the sustainability of the environment, but the distribution of wealth differs. All fisher choices, including effort, gear, entry or exit, are the same in all variations in equilibrium.

If the initial distribution of rights is not critical in affecting the final market equilibrium (but the distribution of wealth differs), the information required to implement a rights-based management programme efficiently is reduced and the absence of opportunity costs from forgone benefits to alternative distributions opens up the door to alternative allocations on social and political grounds. However, the theory literature has identified several conditions under which the independence of the initial distribution of transferable rights for undesirable outputs and facility emissions might fail to hold (Fowlie and Perloff, 2008), and these conditions can be expected to extend to fisheries rights. Stavins (1995) demonstrated that the permit market equilibrium can be sensitive to the initial allocation of permits in the presence of transaction costs, so that increasing (decreasing) marginal transaction costs imply a negative (positive) relationship between permit allocations and firm-level (vessel-level) emissions in equilibrium. These transactions costs are a function of information about the resource, the nature of the asset, the number and homogeneity of the claimants, equity concerns, and public trust or public interest notions (Libecap, 2010). Montero (1997) extended Stavins' work to incorporate uncertainty. When firms (vessels) face transaction costs in the secondary market for rights and they are uncertain about the likelihood that their rights trades will be approved, firm-level emissions are more likely to be increasing with initial permit allocations. Finally, Hahn (1984) showed that the initial distribution of permits can have efficiency implications if permit markets are imperfectly competitive.

The impacts on the distribution of benefits differ dramatically depending on the method of allocation. When a firm or State must purchase all of its allowances (as is the case when all allowances are auctioned), the potential policy-generated rents are transferred from the firm to the auctioning political entity, a government or RFMO. In contrast, when a firm receives rights free of charge, it retains these rents. In practice, in national programmes, fishery managers have routinely chosen to forgo auction revenues in favour of handing permits out free of charge to fishery participants. The ability to make concessions to adversely impacted and politically powerful stakeholders via grandfathering has been an important factor in the widespread adoption of rights-based management programmes. Nonetheless, a mix of both free and auctioned allocation is possible, in which free allocation of some of the rights helps preserve profits and allocation of some of the rights releases auction revenues to the government or tuna RFMO for conservation and management purposes (Goulder, Hafstead and Dworfsky, 2010), including buybacks and entry into the fishery by developing coastal and small island developing States. Duration of the allocated right can also vary.

In summary, the following points about initial allocations can be made:

- Multilateral allocations of rights opportunities need to be self-enforcing, requiring the voluntary cooperation of nations and may require transfers of benefits (side payments) so that all parties benefit from the allocation.
- Entry into the fishery and allocations are closely linked, and the fishery must first be closed in terms of number of participants.
- An allocation is not necessarily an end in itself, but instead is designed to facilitate a final conservation and management objective.
- Denominating rights as a percentage share of the TAC or TAE will avoid the need for reallocations as fish stocks and optimum catch levels fluctuate.
- It must be established who initially holds the rights and how they are allocated.
- Initial allocations will necessarily result from negotiations among the RFMO members as there is no one formula that is either "best" or that will be acceptable in every situation.
- A number of allocation mechanisms are possible, but in practice are often based on rights of first possession or grandfathering. The grandfathered measure may be based on quantities and locations of historical catch or effort, capital investment, and/or biomass within EEZs and the high seas, further modified by other specific criteria.
- Allocations must be perceived as equitable (though not necessarily equal) or fair, or at least allow for rational transition to such an outcome in order to confer legitimacy.
- An allocation that is not legitimate will not in the end foster self-enforcing agreements and may lead to requests for reallocations and/or non-compliance.
- Compliance and enforcement are necessary components of any allocation agreement and must be considered as part of the agreement. Allocations that are not enforceable or that do not lead to compliance may suffer from lack of biological sustainability and instability and may inhibit economic efficiency. Along with the rights that an allocation specifies, an obligation to abide by the agreement and enforce its provisions is a responsibility of every participating nation.
- A mechanism is required to transfer allocations (especially to coastal nations and small island developing States) and to accommodate new members.
- Transferability of rights after an allocation facilitates reaching an initial allocation, full benefits, and adjustments to changing conditions in markets, fish stocks, and the environment, but may be limited for sociopolitical objectives.
- The duration or term of initially allocated rights can vary from perpetuity to shorter periods, with the former providing certainty and enhancing conservation,

stewardship, and investment, and the latter flexibility providing a means of accommodating transfers and reallocations of rights, including developing coastal States and new members.

- Effective allocations systems require a high level of confidence among the participants that their rights are secure and that the rules are applied equally to all.
- Any allocation system must be transparent in its establishment, implementation, compliance and enforcement.

The balance of this section does not discuss the principles of allocation in relation to the distribution of net benefits, but instead discusses the allocation to States, individuals, or both. Joseph and Greenough (1978), Shotton (2001), Chand, Grafton and Petersen (2003), Hannesson (2004), Butterworth and Penny (2004), Ram-Bidesi and Tsamenyi (2004), Lodge and Nandan (2005), McDorman (2005), Munro (2006), MRAG (2006), Cox (2009), Alcock (2010), Libecap (2010), and Serdy (2010) further discuss allocation.

Once the choice of right has been settled and international common property established by the RFMO through a treaty or by custom, the key questions become: (i) whether to allocate rights to States or to bypass States and allocate rights directly to individuals (including companies) as private use rights or even to groups (such as fishing cooperatives or sectors); (ii) which States receive allocated rights; and (iii) the amount of rights to allocate to each State.[55] Rights allocated to States can, in turn, be allocated to individuals or groups in multistage allocations (multistage games).

Before examining these issues further, it is instructive to revisit the economic requirements of a self-enforcing international environmental agreement that underlies treaties and allocations (Barrett, 2003). Self-enforcing agreements will have to satisfy the following conditions:

1. Create an aggregate gain (here through rights-based management), so that each party involved has a reason to participate.
2. Distribute these gains equitably and transparently, so that all parties would prefer that the agreement succeeded.
3. Ensure that each party would lose by not participating, given that all the other parties agreed to participate.
4. Provide strong and clear incentives for all the parties to comply.
5. Establish robust deterrents to entry by third or unauthorized parties.

Critically, initial allocation must address conditions 2–4, so that the expected return for each party exceeds the payoff from not participating. Barrett (2003, 2005) argues that States participating in self-enforcing agreements will probably to comply for this and other reasons.

Initial allocations will probably include explicit or implicit side payments, whereby gainers transfer sufficient net benefits from satisfaction of condition 1 – here the property right as a claim to future benefits – to ensure that conditions 2–4 are

[55] Catch and effort shares are both calculated as explicit proportions of the total sustainable limit or quota, whereas limited entry is typically a number of vessels, and fish-carrying capacity is measured in cubic metres or tonnes of fish.

satisfied.[56] These side payments will probably include allocation of sufficient quantities of the rights, as, for example, occurred in the initial IATTC allocation of capacity units to coastal States,[57] even those without current active fisheries. In order to achieve agreement among parties in an allocation, rights in excess of the sustainable target may be allocated, such as the IATTC capacity rights of cubic metres of well capacity or the "hot air" of excess allocation beyond the target for the Kyoto Protocol. The overallocation represents a side payment from the future so that all parties gain in the present (typically without reductions in current production levels of current participants). In principle, transferring from the future facilitates an agreement in the present that in turn allows conservation and management of the resource stock to enhance the future. However, such side payments from the future may simply represent a high discount rate of the future. Side payments to recipients that currently do not fish or do not fish as actively as they desire represent economic options for the future and can be valued as economic options accounting for uncertainty on both the supply and demand sides. Side payments were instrumental in the allocations of the Convention for the Preservation and Protection of Fur Seals and the Kyoto Protocol (Barrett, 2003, 2005).

Allocation to States

Property and use rights on the oceans have been created and allocated to coastal States. In fact, large portions of the ocean commons were allocated to coastal States through the extension of the territorial sea to 12 nautical miles and the creation of EEZs extending up to 200 nautical miles from shore. These measures nationalized a large portion of the ocean's resources. However, nationalization of the EEZs proved ineffective for the management of tuna fisheries, as tunas move from one EEZ to another and back and forth between EEZs and the high seas. Creation of EEZs and territorial seas did not preclude the need for multilateral or bilateral agreements or treaties. Nationalization instead shaped the nature of the agreements that were negotiated and followed.

If rights are first allocated to States, any State, in turn, can, in a second stage, allocate use rights to individuals or groups within that State or leave its share under regulated open access (generally subject to TACs for the entire fishery or an allocated share for the State) for vessels registered in that State or licence holders from other States. Grafton *et al.* (2010) discuss in greater detail this two-stage allocation of rights. This two-stage allocation is used by ICCAT to allocate shares of TACs to States that, in turn, are generally reallocated in a second stage through the requirement of a licence (use right of access). Members of the Forum Fisheries Agency similarly established a two-stage allocation of fishing days, as discussed by Shanks (2010). Such a form of property and use rights created through a two-stage process establishes a hybrid form of property or use right, with common property over the fish stocks created and held by the RFMO, and state rights over the allocation and even use rights if there is further allocation by the States to individuals or groups. The Kyoto Protocol adopted a similar multistage allocation of rights.

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[56] Side payments, or transfers between and among parties, have both distributive and strategic functions (Barrett, 2003, 2005). Side payments redistribute the additional gain from cooperation and help guarantee that all parties are at least as well-off as before cooperation, thereby ensuring a gain in economic welfare (Pareto improvement) and perhaps an economic optimum (Pareto optimum) (and, hence, individual rationality, as noted by Barrett [2003, 2005]). Side payments are one way to ensure that a joint outcome is a stable solution to the management of a fishery from which no one has the incentive to deviate. An alternative approach is the introduction of threat strategies (Kronbak and Lindroos, 2010). The threat broadens the scope for cooperative agreements as they are now threatened by an alternative (non-cooperative) strategy. As an example, Iceland has increased its catch of mackerel after the fish increased their abundance in the Icelandic EEZ, and the United Kingdom of Great Britain and Northern Ireland has threatened Iceland's potential membership of the European Union.

[57] Resolution on Fleet Capacity adopted at the 37th Meeting of the IATTC in October 1998.

Both state property and use rights can, in principle, be transferable across States, divisible (allowing all or only portions of the state use rights to be transferred), and of varying duration from one-year allocations to perpetuity. Use rights are more likely to be traded across States than state property rights. The strength of security or quality of the title would depend on whether the right is established through custom or treaties under formal international law, the workings of the RFMO holding the property to the resource stock and governance of the fishery, and the effectiveness of compliance and enforcement.

State use rights can also be allocated and the rights attenuated across various dimensions to achieve social goals such as protection of communities or to maintain higher levels of employment than might otherwise be realized under strict economic efficiency. For example, rights could be allocated to communities or gear groups and transferability limited to retain the right within the communities or gear groups.

Allocations to individuals or groups

While RFMOs commonly make allocations of quota or fleet capacity among their member parties, there is little precedent for allocations made either directly or indirectly to individuals.

The allocation of quotas directly to individuals, for example by an RFMO, has not been analysed legally, although national quotas may be allocated to individuals. Some examples are the Australian quota for southern bluefin tuna, the bigeye tuna quotas of Taiwan Province of China, and Pacific halibut quotas allocated to fishers of Canada and the United States of America. The closest example of allocation of quotas to individuals by an international agreement is provided by the AIDCP DMLs for individual vessels since 1992.

Taking stock of allocation to States, individuals or groups

The RFMO allocation of use rights for access, capacity, catch or effort directly to individuals or groups represents an option. States, rather than individuals or groups, have the option to remain the central actors in the RFMOs owing to the inherent constraint of state sovereignty in the international arena.

Rights are initially more likely to be part of a system of overlapping or hybrid rights in the form of regional common property established through the RFMOs, state use rights following an allocation of shares of the TAC, overall fleet capacity, or TAE or access (licences) by the RFMO to individual States, and in a second stage, States allocate use rights from the RFMO to individuals or groups. Some States may simply decide to allocate access via a limited-entry programme or not even regulate their share of the TAC, TAE or overall capacity other than through an overall catch, capacity or effort limit.

States are likely to receive the initial allocation of rights from the RFMO, but a key practical question is whether States subsequently allow free transfer of these rights from one individual or group to another outside of the State's sovereignty. Direct allocations of use rights by RFMOs to individuals or groups and/or full transferability among rights holders across state sovereignty can be expected to lead to greater economic efficiency and economic rents than allocations to States without transferability beyond flag State vessels. A smaller number of rights holders within a State or a greater similarity of their cost structure reduces the options for gains from trade.

Which States receive allocations?

Several issues arise in the choice of States to receive initial allocations of rights by the RFMO. These recipients should be those with real interests, but this begs the question of who has real interests. Nonetheless, these issues include:

- shares for coastal, developing including small island developing, and distant-water States (which may also be coastal) with historical and/or current participation;
- RFMO criteria for member States;
- proportions of the biomass within coastal waters;
- lengths of time, locations, and amounts of historical fishing and variability of these;
- long-term, new and potential participation
- existing investment, which can even include onshore processing;
- aspirations to expand economic activities by coastal States, especially lower-income ones;
- reliance on the resource
- asymmetric (downstream) negative externalities between fishing nations owing to type and age of species harvested and gear type;
- equity norms and precedents;
- conservation;
- expansion of harvesting by existing participants.

All of these issues affect the allocation of wealth and power among and within States, and as such are likely to be highly contentious and ultimately the key issue in the transition to rights-based management. Libecap (1989, 2010), Shotton (2001), Clark (2002), Chand, Grafton and Petersen (2003), Ram-Bidesi and Tsamenyi (2004), Lodge and Nandan (2005), McDorman (2005), Alcock (2009), and Grafton *et al.* (2009) all discuss this matter.

New entrants and reallocation[58]

Major issues in introducing rights-based management with shared tuna stocks are accommodating new members, protecting the rights of current members against the impact of new members, non-members that still seek to exercise their right to fish on the high seas or within RFMO member EEZs through licences and access agreements, or expansions by developing coastal or small island developing States that are members of RFMOs. Fishing effort and capacity should not be allowed to increase beyond what is sustainable as new participants are added (FAO, 2002; Munro, Van Houtte and Willman, 2004; Lodge *et al.*, 2007; IATTC and World Bank, 2008; Allen, Joseph and Squires, 2010; Allen *et al.*, 2010a; Allen, 2010; Cartwright and Willock, undated).

A limited number of options are available to accommodate new members' entry and receipt of allocation:

- allow them to access only underdeveloped resources;
- allow them to participate only under charter, or through quota transfers;
- accommodate them within existing allocations, either through existing members voluntarily relinquishing quota or through exchange, such as rights markets, to new participants;
- set aside a portion of the quota for future use by new members or the interests of developing countries, allowing them to rent quota from the Commission;
- limit duration of rights so that some rights are always available every year for reallocation in some manner;

[58] The UNFSA establishes a non-exhaustive list of criteria to be considered when RFMOs allocate rights to new members (MRAG, 2006). Article 11 sets out a non-exhaustive list of criteria to be considered including: the status of stocks and level of current fishing effort; the respective interests, fishing patterns and fishing practices of new and existing members; the respective contribution of new and existing members to the collection and provision of data and conduct of scientific research on the stocks; the needs of coastal communities that are dependent mainly on fishing for the stocks; the needs of coastal States whose economies are overwhelmingly dependent on the exploitation of living marine resources; and the interests of developing States in the region in whose areas of national jurisdiction the stocks also occur.

- allow buybacks of existing rights that are either reallocated or permanently expired to make room for expansion by others.

These options also allow reallocation to existing or new members when environmental conditions change and fish change their locations, such as increased number of mackerel in Icelandic waters.

One of the most important factors in the design is creating the greatest incentive for compliance and participation by non-member States (IATTC and World Bank 2008). In particular, the Commission will have to decide:

- Under what conditions new entrants are allowed to become cooperating non-contracting parties and/or members.
- Under what conditions cooperating non-contracting parties or new members are allowed to participate in allocation schemes.
- How to allow the introduction of new participants without compromising conservation objectives.
- What transfers or trades of quota are allowed to enable the participation of cooperating non-contracting parties or new members in fisheries.

Under rights-based management, several forms of reallocation, i.e. of accommodating new entrants and changes in rights holdings by existing participants, are possible. New entrants and existing participants can increase their rights holding through purchase or other forms of transactions from existing rights holders, rather than allocation of new rights. In other words, after the initial allocation, subsequent changes in rights holdings occur through the secondary market that develops for fishing rights. In fact, the opportunity to enter a fishery through the new institution, the secondary market, rather than the politically charged approach of RFMO reallocation of existing rights or unsustainably expanding rights beyond the current TAC or TAE, is an important advantage of rights-based management. Several national ITQ programmes limit duration of the right on a staggered basis among different vessels, which then makes these rights available for allocation by the quota authority through markets (such as auctions) or in other manners. This approach of limited duration and periodic reallocation is another form of readily accommodating new entrants into the fishery (and accommodating changes in the distribution of fish).

Transferability and the presence of a secondary market for rights and/or limiting the duration of the right allow market-based approaches to accommodate the entry and/or expansion of vessels from developing coastal and small-island developing States. Existing vessels can also be taxed (Grafton, 1995) either through a landings tax or a lump sum annual assessment graduated by vessel size or landings that finances purchases of use rights transferred to developing coastal and small island developing States, thereby making use of market mechanisms to provide full compensation for exit from the fishery.

Moreover, managing large-scale purse-seine and longline tuna vessels can be a complex managerial process that can challenge the capacity of some States. One approach to address the difficulties in managing complex fishing vessels is a tuna corporation in which the participating countries would agree to provide explicit shares in the use rights to the tuna stocks.[59] These shares would be the rights in the fishery expressed as a percentage of the TAC. The corporation (TunaCorp) would be owned by the members of the participating countries with share-holdings in proportion to their ownership interest in the fisheries rights. Each year, the countries would vest the annual catching rights (annual catching entitlements [ACEs]) generated in TunaCorp to be managed to maximum economic benefit. Country ACE allocations could be

[59] Joseph and Greenough (1979), Trondsen, Matthiasson and Young (2006), Hilborn (2007), IATTC and World Bank (2008), and Crothers and Nelson (2007) all discussed larger, global institutions or suggested something similar but for all of the participants in the fishery.

allocated in a variety of means and may be encumbered according to the policies of the member whose rights they are associated with.

GOVERNANCE, INSTITUTIONS AND RIGHTS-BASED MANAGEMENT

In a number of recent reviews published by non-governmental organizations (NGOs), scholarly institutions, or prepared as background papers for UN Consultations, RFMO performance and governance have been decried and examined.[60] Specific governance issues of concern include: the inability to achieve cooperation on individual management measures (such as time and area closures), on overcapacity and control of capacity, and on overfishing and overfished tuna stocks for some species; decision-making in general – especially the need for consensus or super majorities; pressures to expand TACs or TAEs beyond recommended sustainable target levels; IUU fishing; unilateral actions such as such as authorizing nationals to fish in a manner that undermines an RFMO's conservation measures; non-compliance by RFMO member vessels; accommodating new members; processes of negotiating and bargaining among the participants in an RFMO. The participation issue of developing States including small island developing States also remains important.

An independent panel based at Chatham House, United Kingdom of Great Britain and Northern Ireland, compared practices of RFMOs with international standards and recommended best practices for RFMOs, including practices for conservation and management (Lodge, 2007; Lodge *et al.*, 2007). These practices include alternative dispute resolution procedures, such as panels of technical experts or negotiation facilitators, to promote more effective decision-making, a more systematic approach to the problem of non-members, deterrence of free riding through careful manipulation of costs and benefits, punishments and incentives for each participant, and creating incentives for States and other parties to participate and comply. These studies recognize that

- the allocation issue is paramount, but that this issue cannot be addressed until the problems of intra-RFMO compliance, unregulated fishing, and accommodating new members have been resolved;
- simply limiting entry to new members at the regional level is unlikely to prove globally effective;
- that access arrangements and quota trading and leasing can help bring cooperation and compliance.

Many of the reviews have been relatively optimistic, recommending comparatively minor changes as necessary to improve performance of RFMOs. In contrast, Hilborn (2007) sees total failure, with weakness in governance, particularly decision-making by consensus or super majorities and reliance on national governments to monitor and carry out enforcement for their own fleets. He calls for fundamental changes to the existing legal framework, for high seas governance to achieve conservation goals and for governments to pass their role in regulating high seas fisheries to a single organization that would set the rules to maximize their value for all people. This recommendation in essence followed from Joseph and Greenough (1979), who explored the idea of a global organization for all tuna fisheries in 1979. Crothers and Nelson (2007) argued that existing governance arrangements are inadequate and that high seas overfishing follows from a lack of incentives for States or RFMOs to act responsibly in dealing with the effects of an overcapitalised fishing sector. They offer an alternative of a sole owner (High Seas Fisheries Corporations), collectively owned by States and having explicit and exclusive authority to manage the relevant high seas fisheries. The IATTC-

[60] See Lodge *et al.* (2007), Hilborn (2007), Crothers and Nelson (2007), Cullis-Suzuki and Pauly (2010), and Pintassilgo *et al.* (2010). Moreover, from one perspective, the conservation and management relationship between RFMOs and the fishing industry is a principal–agent problem of asymmetric information. See Vestergaard (2010) for a general discussion of this topic in fisheries management.

World Bank workshop and Trondsen, Matthiasson and Young (2006) discussed similar arrangements as one possibility.

The root cause of many of these governance issues lies in: (i) the requirement for self-enforcing multilateral cooperation (especially in the absence of an overarching supranational body to develop, propose, implement and enforce conservation and management measures); and (ii) the absence of allocated and well-structured property and use rights. As a consequence, for example, each conservation and management measure represents an implicit allocation of opportunities and potential net benefits that differentially affects States and even further different constituent groups within each State. Even discussions and decision-making of routine measures considered by RFMOs can slow to a halt because different decisions implicitly lead to different allocations of fishing opportunities, employment, assets and net economic benefits. The absence of allocated and well-structured rights impedes RFMO cooperation and creates perverse incentives that foster non-cooperation. Reforms in RFMO governance will improve performance, but they do not address the root cause of perverse incentives and absence of conditions for multilateral cooperation. A once-and-for all allocation presents great difficulty, but it is preferable to the growing non-cooperation and ongoing implicit allocation decisions, increasing each year as capacity builds; and delay simply accentuates the difficulty of governance reform and addressing the root causes, particularly with resource declines and additional entry. After an allocation of well-structured rights, decentralized secondary markets for rights replace the ongoing and contentious deliberations that otherwise occur in the RFMOs. Entering and new vessels simply purchase rights on the secondary market.

Further development of the institutions associated with rights-based management will inherently strengthen the institution and governance of RFMOs by relieving RFMOs of much of the highly politicized (and economically inefficient) process of command-and-control regulations, because each regulation, to varying degrees, affects the distribution of benefits and costs and is often an underlying if unspoken current. The institutions of property and secondary markets will remain embedded in the international system of governance, treaties and law, because this expanded global tuna market economy is not self-regulating. Strengthened and reformed governance of RFMOs and at the supranational level is absolutely critical, but by itself it is insufficient.

Simplicity, direct responsibility, and accountability of all institutions, including those of rights-based management, are a critical component of success (Hilborn, Orensanz and Parma, 2005). When institutions are simple and there is direct responsibility, the managers have better incentives compared with complex organizations (management councils in the United States of America, large international commissions, the European Union, RFMOs). In more complex organizations, many competing interests cause a dilution of responsibility and incentives for good economic or biological stewardship and increase transactions costs in reaching agreements. The key is attaining the right institutional balance for effective conservation and management of international tuna fisheries. Markets and property rights are both institutions. Creating and allocating property rights, a fundamental prerequisite to any market, and the subsequent emergence of secondary markets for well-structured and transferable property or use rights in effect substitute for some of the functions of the RFMO institutions that are more effectively performed by markets.[61] In some instances, decentralized

[61] As an example, Townsend, McColl and Young (2006, p. 138) state: "The most comprehensive case is the New Zealand Challenger Scallop Enhancement Company ("Challenger"). Challenger undertakes virtually complete self management. Challenger seeds juvenile scallops, closes newly seeded areas to allow growth, sets overall quotas, and monitors biotoxins and seafood safety. Challenger has negotiated agreements with recreational harvesters and with oyster dredge vessels to manage conflicts over use. A significant self-imposed fee on landings, which has ranged from 17 percent to 20 percent, finances this management activity."

market activity can perform some functions more effectively and cheaply than centralized RFMOs where resource allocation (through management measures) occurs through formal and often protracted voting procedures with very high accompanying transactions, overhead and bureaucratic costs.[62] Some of the governance functions, including some decision-making, administration and enforcement, that rights holders can perform under RFMO oversight and costs can be devolved (with transparency throughout the process) to rights holders. In effect, the question is the boundary between the market and the RFMO, a parallel question posed by Coase (1937) for the boundary between markets (or bilateral contracts) and firms. These boundaries change over time, especially for rights-based management, as discussed by Allen *et al.* (2010b).

One of the key issues with rights-based management and, more broadly, markets in general, is the degree of social control over markets and the extent to which unfettered market forces are allowed full sway (Polyani, 1944). Put differently, once rights-based management takes root, the task of RFMOs beyond the scientific realm becomes: the ultimate arbiter of the degree of social and political control over rights and secondary markets that are not fully self-regulating; managing and insuring sustainable resource use; science, data collection, and monitoring; and enforcement of rights and regulations. In short, no other institution on the horizon but property and use rights over the common tuna stocks, secondary markets for exchange, and supporting laws has the capability to establish private economic incentives aligned with social goals, and to deliver sustainable resource use, and to streamline RFMO governance.

MARKETS FOR TRANSFERABLE RIGHTS

Market design can affect the price discovery process in the secondary market for the right (i.e. how the market equilibrium is attained) and the method by which the initial allocation of rights is made (Ledyard, 2009). Transactions costs along with asymmetric information (different parties hold different quantities and quality of information) impose significant frictions and prevent traders from finding and sharing the gains from trade, so that the market place lacks transparency and liquidity, reduces the number of trades, and creates a failure to achieve market equilibrium and realize the full economic benefits from trade (Ledyard, 2009).

Liquidity in the market mitigates the asymmetric information problem through competition (Ledyard, 2009). Relying on the natural emergence and development of brokers to facilitate trades is insufficient as there is typically insufficient trade to support many brokers. Brokers reduce search costs, but asymmetric information and broker's fees lead to continued significant market frictions and preventing traders from finding and sharing the gains from trade, and the market remains underdeveloped in terms of transparency and liquidity. Incomplete trading follows, and potential economic benefits do not fully develop. Creating transparency is possible through steps discussed by Ledyard (2009) and by Newell, Sanchirico and Kerr (2005), such as a central trading exchange. Transparency and liquidity are necessary to attain sufficient trade to exhaust all potential gains from trade and hence realize the full potential economic benefits.

Under a policy in which a grant of permanent quota is made and nothing further is done, there will be significant search and negotiation frictions (Ledyard, 2009). The naturally occurring market place will be neither naturally transparent nor liquid. Auctions can provide a clear and transparent signal as to the clearing price for quota. One means of facilitating price discovery in every period is expiration of some limited duration rights that can only be acquired by auction (that thereby establishes prices).

Initially, trade in permanent rights can be expected as vessels exit the fishery and the fleet structure reconfigures. Over time, lease or rental prices of rights can be expected

[62] Transactions costs include negotiation and bargaining costs, and search and information costs.

to increasingly dominate quota markets. Short-term quota trading and prices are more likely in multispecies fisheries as rights holders balance catch rates and quota holdings.

Newell, Sanchirico and Kerr (2005) find that there has been substantial price dispersion within individual ITQ markets in New Zealand, but that the magnitude of this dispersion has declined over time, particularly for quota sales, and is comparable with that found in other well-functioning markets. They observe both a sufficient number of market participants and market activity, which is rising steadily over the years, to support a competitive quota market. Nonetheless, some markets have relatively few transactions, although these tend to be economically and ecologically unimportant fisheries. Market thinness could be addressed through aggregating illiquid quota markets into other quota markets. They further find that the trends are consistent with a period of market development where participants learn how to operate in the newly created market, and traders and brokers begin to establish operations. Their estimates indicate that prices in these markets are related in an expected manner with underlying economic fundamentals, including measures of fishing value, relative quota demand, ecological variability, and market rates of return. They infer from the revealed behaviour in the New Zealand ITQ market that the overall flexibility of the system and the ability to transfer shares has high economic value. Furthermore, the flexibility provided to quota holders by having the option to lease appears to have significant value as revealed by the dramatic increase in leasing over time. In addition, the opportunity to arbitrage across the sale and lease market provides an additional dimension across which relevant market information can be exchanged and rationalized.

CONSTRAINTS TO RIGHTS-BASED MANAGEMENT

The transition to rights-based management, although conferring net benefits, faces numerous constraints. The resource is transboundary and highly migratory, shared across multiple national jurisdictions and the high seas; there are usually multiple target species; fishing fleets are comprised of multiple gear types and vessel sizes; nations are coastal, distant-water, or both; heterogeneous coastal nations have jurisdiction over the EEZs within which tunas occur; many investments are sunk (i.e. they are not recoverable at anything close to the original investment cost); economic, social and geopolitical national interests are intertwined; management authorities are multilateral and diverse; asymmetric (downstream) negative externalities exist, depending on the species and ages of the fish harvested and the gear types used; and there are still other factors. Uncertainty arising from multiple sources creates a national resistance and preference for the status quo. The distribution of costs and benefits and of winners and losers permeates all of these factors, as discussed elsewhere in this chapter.

National aspirations and objectives differ, and can hinder realization of increased benefits from the fishery and establishing rights-based management. For example, some coastal States rely heavily upon onshore processing for employment and incomes more than from fishing. Other States face few opportunities for processing, or even fishing, and may simply rely upon access fees as a source of revenue. Some distant-water fishing nations may wish to maintain fleets as extensions of their geo-strategic interests.

3. Mechanics of management, monitoring, control and surveillance for rights-based management systems

Rights-based management requires MCS to ensure compliance and as a fundamental requirement for the enforcement of property and use rights (Allen, Joseph and Squires, 2010; Allen *et al*., 2010a; IATTC and World Bank, 2008). Rights-based management also enhances MCS by establishing incentives for providing accurate and timely data and for compliance because actions that degrade the resource reduce the value of all rights, including those of the degrader (Scott, 2000, 2008).

Weak MCS sets the stage for undetected "cheating" – violations of the conditions of the right (Munro, 2006). Such violations lower the expected returns from cooperation, which, in turn, creates incentives for non-compliance, or, more broadly, non-cooperation.[63]

The method of payment for MCS can affect the size and composition of fleets (Lian, Singh and Weninger, 2010). Charging vessel operators directly for any observer costs on a days-at-sea basis favours larger vessels over smaller ones, as they can spread this cost out over more tonnes of catch. Collecting observer costs from active boats lowers profits, which leads to a smaller fleet and lower fleet harvests. If observer costs are collected through landings taxes, both the harvest quantity and fleet size can diminish, and fleet composition can favour larger vessels.

Management requirements and costs rise because effective property rights require strong MCS and enforcement (OECD, 2003; Beddington, Agnew and Clark, 2007). For example, Iceland and New Zealand, which arguably have the most fully developed ITQ systems in the world, also have some of the highest costs of management per fishing vessel. In a number of fisheries managed by strong rights, fishers increasingly assume these costs of management. Because fish stocks and the ecosystem in which they are embedded also generate public-good benefits that all citizens enjoy, the management costs can be shared between private fishers and the public sector.

This section discusses MCS mechanisms that are required for limited entry and for quota- and effort-based systems. In all cases, the required MCS mechanisms are much more complicated if the rights include transferability than if they do not include transferability.

LIMITED ENTRY AND CAPACITY ALLOCATIONS

Limited entry requires a list of all those entitled to fish, and, if there are controls on investments that increase fishing capacity, mechanisms to ensure their compliance. For example, the IATTC limited-entry programme entails the closed RVR[64] of purse-seine vessels that have the right to fish in the EPO. In addition to not allowing new vessels to be introduced except as replacements for vessels leaving the fishery, there is a rule that prohibits increases in well[65] volumes of vessels; the only exception is when

[63] This leads to a violation of the individual rationality requirement discussed by Barrett (2003, 2005) as one of the components of a self-enforcing international environmental agreement.

[64] www.iattc.org/VesselRegister/VesselList.aspx?List=AcPS&Lang=ENG

[65] Purse-seine vessels store their catches in spaces known as wells.

equal well volumes are removed by other vessels that leave the fishery or reduce their well volumes. (However, as noted above, fish-carrying capacity is not necessarily proportional to fishing capacity.) This provision envisages the transferability allowed by the resolution[66] establishing the limited-entry system. Because the fisheries authorities responsible for compliance with the rules of the RFMOs do not always have adequate communication with the maritime authorities responsible for registration and flagging of vessels, States do not always have the mechanisms in place to monitor compliance with vessel changes that may include increased capacity. Thus, systems maintained by the IATTC itself, including information collected by at-sea observers and inspections by staff members, have been used to monitor compliance with that aspect of the Resolution.

A formal register must be maintained in order to preserve the integrity of the system. The register must be easily accessible to participating governments and other interested parties. Without transferability across States, each State can establish and maintain its own register in isolation. However, once transferability across States is allowed, a central register becomes crucial to ensuring compliance with any controls on investment that increases capacity and to maintaining the integrity of the right in general.

The IATTC's limited-entry system accommodates transferability in several ways. First, a vessel that is included in the RVR may change flag from one participating State to that of another without affecting the status of the vessel on the RVR. Vessels may also be replaced on the RVR by other vessels, providing the well volume of the new vessel does not exceed that of the vessel or vessels subject to replacement. The well volume of a vessel may be increased only if an equivalent amount of well volume is removed from the RVR. In 2004, the IATTC agreed that, when a vessel was removed from the RVR and its well volume was not replaced completely, the State concerned would retain a right to the residual well volume. Thus, in addition to maintaining the list of vessels on the RVR, the staff of the IATTC maintains a record of the residual well volume for each participating State. Between 30 June 2002 and 31 December 2007, 317 such transactions were recorded.

The question of flag changes of vessels on the RVR has been one of the key difficulties in the administration of the RVR. The IATTC considers the flag of a vessel as being the sole determinant of the government with authority over the vessel. It has been troubled by the complex situations of bare-boat charters in which the registration in one country is temporarily suspended and the vessel is allowed to fly another flag during the duration of the charter. Moreover, the resolution does not explicitly require approval from any government to retain a vessel on the RVR when its flag is changed. However, a government does have the ability to remove a vessel from the RVR before it changes its flag. Some IATTC member governments would prefer that the rights to places on the RVR belonged to the governments, rather than to the vessels, and have sought to achieve this with an explanatory note in the minutes of the 73rd meeting of the IATTC[67] or via an instruction to the Director that any of its vessels be removed from the RVR if they change their flags.

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[66] Resolution C-02-03, available at www.iattc.org/ResolutionsActiveENG.htm

[67] Page 8 of the Minutes of the 73rd Meeting of the IATTC: "A change of flag by a vessel from one CPC [party, cooperating non-party, or fishing entity] to another, and the vessel's status on the RVR, shall not be considered effective until the Director has received official notification of the change from both governments involved." The Commission endorsed this statement, and noted the importance of each government establishing adequate internal procedures to ensure the necessary coordination between the various domestic agencies involved in the process of flag transfers. (available at www.iattc.org/PDFFiles2/IATTC-73Minutes-Jun05-REV.pdf).

CATCH AND BYCATCH LIMITS

Monitoring compliance with quotas requires more complex systems than those discussed above for limited entry. Registers of quotas, sometimes for multiple species and/or areas, and records of catches against those quotas are required. Owners of vessels maintain their own records of catches against quotas, but those records require verification by authorities, requiring a near real-time data recording system that now could rely on reports by at-sea observers or estimates reported electronically from sea, and verification at the time of unloading. Balancing of catches (Squires, Kirkley and Tisdell, 1995; Squires *et al*., 1998; Sanchirico *et al*., 2006) against quotas includes banking quotas from one year to another, use of deemed values for catches in excess of quotas, and, for multispecies fisheries, substitution of a quota for one species for a quota for another. The problems associated with quota balancing are far more serious in multispecies fisheries than in single-species fisheries, because it is common for such fisheries to include stocks whose productivities are different from their representation in normal catches. Such balancing systems add complexity to the system for recording quotas and catches against them, but no alternative exists.

As with licences, each State could maintain its own quota register and record catches against the quotas of its own vessels when there is not transferability across participating States. With transferability across States, a central register of quota holding and reporting of catch against quota would be required.

Transferability includes several possibilities. It might involve sale or leasing for determined periods of quota. It could also be used to address over- and under-catching (referred to above). The combination of provisions for over- and under-catching and of transferability requires a complex and carefully defined system for recording quotas and for counting catches against them.

The basic system for registering individual-vessel DMLs under the AIDCP works as follows. There is only one limit for each vessel, the total number of mortalities of dolphins in the EPO allocated to that vessel in a given calendar year. If a vessel kills more than its limit of dolphins in any year, the excess, plus an additional 50 percent of its limit, is deducted from its DML for the following year. However, in addition to this basic system, there are complex rules that relate the vessel's performance in achieving a low mortality rate and in compliance that affect the vessel's DML during the next year. In addition, the DML system operates under, and may be constrained by, a wider quota system that provides global limits for each stock of dolphins involved in the fishery, for both the total number of dolphins that may be killed and the number that may be killed by vessels of any participating State.

TRANSFERABLE EFFORT

The MCS measures for management using transferable effort limits are similar to those required for transferable catch quotas. This requires a register of all participants in the fishery with a description of the effort entitlement of each participant. The trading system must include a link to the register so that changes in effort entitlements can be recorded immediately, and there must be a monitoring system that provides a near real-time record of the effort employed that can be compared with the effort holdings. The monitoring system must be operated while vessels are at sea, and at-port inspections are not of the same utility as they are for catch quota systems. The system may be a little simpler than a quota system in a multispecies situation because effort does not have to be categorized by species, although there may be some other subdivisions (such as sets on FADs or sets on schools with other associations, or deep or shallow longlines). There is also not the same need for a system for quota balancing as fishing

in excess of effort limits should not happen in the same way that unexpectedly catching more than the quota may happen.

REGISTERS

For most limited-entry and all quota systems, it is essential that there be a register of rights that is maintained by an agency that is trusted by all States and participants in the fishery. This might be operated by the RFMO concerned, as is the case for the IATTC limited-entry system, or by an independent agency, such as FAO. Even in the relatively simple IATTC system, the operation of the Register is a sensitive issue that has led to controversies, which, in several cases, are still unresolved.[68] Some vessels are recorded on the Register under two flags or two names, indicating a difference of views of governments about the probity of particular flag transfers.

This highlights the importance of ensuring that rules concerning transfers are unambiguous, so that the administrator of the system is not subject to differing interpretations of participating governments. It is also desirable that those operating the register be as far removed as practical from the influence of governments or individuals whose interests are recorded in the register.

[68] See IATTC-75 Prop F1 VVen Capacity at www.iattc.org/PDFFiles2/IATTC-75-PROP-F1-VEN-Capacity.pdf

4. Buybacks in the transition to rights-based management

Buybacks can purchase vessels, gear, licences or other forms of rights. Buybacks of fishing vessels, licences, access, use or other rights, and gear, sometimes called decommissioning schemes, address overcapacity, overexploitation of fish stocks, and distributional issues in fisheries (Holland, Gudmundsson and Gates, 1999). Buybacks facilitate a transition to a longer-term objective of rights-based management, along with objectives for public goods, such as conservation of biodiversity or ecosystems management (Curtis and Squires, 2007; Allen, Joseph and Squires, 2010; Allen *et al*., 2010a; Squires *et al*., 2010a; Squires 2010b). Most buybacks focus on the vessel, gear and licence, although some buybacks allow the purchase of only gear, such as in the Italian clam (*Chamelea gallina*, Veneridae) fishery buyback (Spagnolo, 2007). A limited number of buybacks only focus on the licences of inactive permits, such as in the New England groundfish fishery (Thunberg, Kitts and Walden, 2007).

Buybacks may be an important factor in facilitating a change to rights-based management, as they will facilitate the economic transition by purchasing unnecessary sunk investment in human and technological capacity, help restore profitability for a period, and ease out disgruntled players. Buybacks can help smooth tensions among nations by helping to settle issues related to allocation of rights. Buybacks that are not followed by a rights-based framework do not change the underlying incentive to add capacity and are doomed to fail eventually. Multilateral buybacks are required in a transnational tuna fishery. Otherwise, unilateral buybacks by a single nation simply remove fishing capacity from the fleet of that nation, but open up opportunities for free-riding by other nations.

Buyback programmes can purchase the vessel and/or licence. If only the licence or right is purchased, the vessel is free to fish elsewhere. If the vessel, but not the permit, is purchased, the permit holder can purchase another vessel (unless prevented by the programme). If both the licence and vessel are purchased, the price includes the values of both assets. Many programmes must buy out many vessels or rights of access owing to latent capacity (low-activity vessels). Purchasing high-activity vessels can be expensive and quickly absorb the entire budget while purchasing only a limited number of vessels. Reverse-bid auctions in which the buyer puts up the price are the most common form of buybacks. Even with such attempts to control price, buybacks can be costly. Additional, but related, concerns include whether to scrap the vessel, convert it to a different use, such as a research vessel, or restrict its use in other fisheries to fisheries on stocks that are not overexploited. It can be argued that, if the buyer wishes to use the vessel in another fishery, it is the responsibility of the organization with jurisdiction over that fishery to decide whether it can enter that fishery.

Buybacks can help industry restructuring after the introduction of rights-based management. In principle, transferability of the right allows vessels to utilize available economies of scale efficiently and, over time, align fleet harvest capacity with target total catch levels.[69] Over time, low-profitability fishers learn enough about the productivity of the fleet, sell quota to more profitable operations, and exit the fishery. Uncertainty,

[69] On development of the secondary market for rights, vessel exits and industry restructuring, see Weninger and Just (1997, 2002), Dupont (2000), Newell, Sanchirico and Kerr (2005), Newell, Papps and Sanchirico (2007), Vestergaard, Jensen and Jørgensen (2005), Anderson and Sutinen (2005, 2006), Brandt (2007), Asche *et al.* (2008), Higashida, and Takarada (2009), and Evans and Weninger (2010).

noisy prices (high price dispersion) in the secondary market for rights, high transaction and information costs in these markets or for bilateral exchanges outside of the markets, high information costs on productivity and profitability of vessels and hence price of the right, and other factors can all retard the rate of exit by marginal vessels. There may also be exit from fishers that have built up vessel operations, including purchasing vessels and increasing activity of previously low-activity vessels, in order to increase their eligibility to receive larger initial allocations of rights (Brandt, 2007). An adverse selection issue can also arise in that vessels that would otherwise have exited the fleet prior to introduction of rights-based management remain long enough to receive the initial allocation of rights and only then exit the fishery. Vessel restructuring can also be mired in legal and procedural questions over the initial allocation, such as occurred in the Australian Southeast Trawl ITQ programme (Fox *et al.*, 2007).

As discussed elsewhere, and one of the most relevant situations for a buyback, rights may have been "overallocated" through transfer payments from the future and the creation of options in order to achieve an agreement in the initial allocation. In this instance, a vessel and/or rights buyback, financed by a tax, can purchase sufficient rights to match capacity with demand more closely. Similarly, buybacks can be used to transfer vessels and rights to coastal developing and small island developing States (as discussed elsewhere). Annual licence fees, perhaps graduated by vessel size, landings taxes, or other levies can be used to replace ownership of vessels, fishing-capacity, effort or catch rights by distant-water fishing nations with that by developing coastal and small island developing States.

Buybacks and their financing in a transnational fishery may have to be rooted in individual countries, each of which must perceive that the buyback is in its best interests. Buybacks that do not bring gains to each potential participating party may fail to achieve the full cooperation and participation required to preclude a buyback by only a coalition of nations that allows non-participatory nations to expand their fleets and fill a void. This is precisely what happened with the Italian buyback of transnational swordfish vessels (Spagnolo and Sabatella 2007). Buybacks may also be tailored to allow for the expansion of economic activities by coastal States. Compensatory mechanisms can address asymmetries among nations. Buybacks can be aimed at different gear types or for different areas or type of fishing (e.g. floating objects or unassociated sets) for a gear type.

5. Concluding remarks

Multilateral RFMOs created by legally binding agreements can serve as the basis for management of the global tuna fisheries, but incentives still remain to enter the fisheries, expand fishing capacity, and overfish tuna stocks. The United Nations Convention on the Law of the Sea, the UN Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fisheries, and other agreements require that States cooperate in the management of shared fisheries, but these agreements cannot ensure that cooperation succeeds or that the fisheries are optimally managed.

Only by extending and strengthening the rights to access the fishery and harvest tunas can the problems of overfishing, overcapacity, damage to the ecosystem, and low economic benefits be effectively addressed.

Establishing long-term and secure property rights that are legally enforceable and self-enforcing creates positive economic incentives that more closely align the private economic interests and incentives of fishers with the interests of society in sustainable harvests and high levels of economic welfare. Rights-based management also establishes incentives for member States to cooperate. Profits and capital values for the rights are created where little profit and no capital previously existed. Shifting economic incentives from the perverse and counterproductive to socially desirable complements any social norms contributing to conservation and management. Eliminating the need to compete for a share of the available catch allows individuals to optimize their investment in fishing effort and capital to match their share of the catch, providing them with the incentive to avoid overcapacity. Secure, exclusive and long-term rights provide fishers with a collective interest in the conservation of the fisheries and the efficient use of the resources. Transferability of rights allows fishing opportunities to be used by those fishers who produce the greatest economic benefits, establishes means of entry and exit, allows for flexible responses to changes in biological, environmental and market conditions, accommodates the aspirations of coastal developing and small island develop States, and can provide a means of reaching an agreement among different sectors of the industry via transfer of fishing rights. The positive economic incentives ("carrots") established by rights-based management, backed by strong international agreements, can be complemented by negative economic incentives ("sticks"), most notably trade and port measures and the market power of processors.

Transferable rights provide a means of accommodating new members and increasing fishing by small island and coastal developing States (perhaps facilitated by a landings tax or levy on vessels or quota set-asides). Rights of limited duration, which can revert to these States upon expiration, can also accommodate the aspirations of these States. Buybacks of vessels and/or rights through levies on existing industry members can also help accommodate these aspirations.

There can be trade-offs between maximum economic efficiency and economic benefits achieved through the fewest number of vessels and crew required to achieve the target catch or effort versus meeting social and political objectives through retaining larger numbers of vessels and crew. Experience in national programmes with strong rights-based management shows that there are fewer vessels remaining in the fishery but that economic benefits can be expected to rise considerably. The total number of crew- and vessel-days fished may not decline in a fully rationalized fishery, as the remaining crew and vessels fish longer, but there may be lower vessel and crew numbers. At the other pole, fewer vessels may exit the fishery to retain larger employment and protect smaller and vulnerable groups and communities, but

at the expense of lower economic efficiency and economic benefits. Group rather than individual rights can also help protect groups and communities. Each State and RFMO can evaluate the appropriate trade-off between economic efficiency and social-political objectives, including the distribution of costs and benefits and the type of right implemented. Emerging experience in national rights-based management programmes, especially ITQs, shows that the distributional issues may not fully emerge until after the programme has matured and the costs, benefits, and distributional issues become fully apparent. Nonetheless, this experience also shows that the distributional issues must be addressed at some point. The question is when and how, and it is best addressed initially before new investment patterns develop.

The first step on the road to strong and comprehensive fishing rights may be limited entry in the form of a closed RVR, with transferability for purse-seine, longline and pole-and-line vessels, thereby creating a form of common property in the jurisdictional regions of each RFMO. Limited entry is a necessary first step, even if stronger and more complete forms of property rights, such as national allocations of a TAC on a permanent basis or ITQs, are adopted. Even with stronger forms of rights, limited entry maintains a bulwark against vessel entry and pressures to expand the TAC or TAE. Although there is no fundamental international legal obstacle to any RFMO either making quota shares permanent or introducing a rule that there must be no fishing by its members unless it has made a positive decision to allow it, none is likely to do so for as long as there is no limitation on entry to the fishery.

These limited-entry programmes can be created through customary international law, but binding international agreements create even more durable, secure and exclusive rights. Measures will have to be undertaken to deter entry and enhance compliance and to ensure mechanisms whereby entry is secured for new entrants, such as secondary markets for rights. The issue of separating access rights from flag-state sovereignty and the desire of States to retain these rights will have to be addressed. Because of the remaining transnational externality owing to the mobility of vessels and, to a lesser extent, the highly migratory nature of the tunas, problems associated with bycatch, and also the incomplete jurisdictions of the RFMOs, global coordination across RFMOs is required.

International common property over the resource stocks has been formed through the United Nations Law of the Sea and the Straddling Stocks Agreement under the management of the RFMOs. However, stronger property and use rights are required, which can be held by States, groups or individuals.

Stronger state rights, in the form of access, share of a TAC or a TAE, and other use rights, are emerging because of the inherent nature of state sovereignty. The RFMOs can allocate use rights, such as shares of TACs with ICCAT, or shares of bycatch or capacity and access, such as with the IATTC, to coastal and distant-water States or directly to companies or vessels. The RFMOs might even retain rights on the high seas and allocate directly to States or individuals. State rights could be a perpetual property right, with full properties comparable with an EEZ, after allocation to the States by the RFMOs, or, more likely, they could be a use right, or even a combination of a perpetual use right for a share of the fish in EEZs and a use right for the share on the high seas. In principle, such state use rights can be of varying duration, divisibility and transferability. Ownership of the resource stock itself, at least on the high seas, is likely to be retained by the RFMO itself as international common property, with only the resource or effort flows, such as TACs or TAEs, allocated to States or individuals.

Allocated state use rights, such as the shares of TACs allocated by ICCAT can, in turn, be allocated to groups or individuals in a two-stage process. These rights can range from simply a right of access to harvest or effort rights. Ideally, individuals or groups then would be able to trade rights across flag State jurisdictions so that rights end up in the most socially and economically valuable uses.

Some forms of bycatch and the ecosystem and its services may be retained as international common property by the RFMO. Some forms of bycatch, such as sea turtles and seabirds, and the ecosystem and biodiversity in general, have insufficient commercial value or are sufficiently rare events (for some endangered populations) to make the benefits of creating state or individual property or use rights outweigh the costs. Their non-market values, such as indirect-use value and existence value, and history of minimal commercial exploitation suggest that they remain as global public goods with "ownership" retained by the RFMO members or even humanity as a whole. In contrast, because of their value as a private-good bycatch along with their public good of biodiversity (and relatively large numbers) led to the formation of DMLs, a use right. Such RFMO common property may at some point emerge for some definable contributions of the ecosystem for ecosystems-based management, whereas States may exert greater rights over those aspects of the ecosystem with a more distinct spatial delineation or actual or potential commercial value.

Overlapping combinations or hybrids of international common, state, and individual property and use rights imposed upon resources are likely for the species of sufficient commercial value. The formation of international common property in dolphin stocks by the AIDCP, followed by allocation of use rights to States and then to individuals within each State serves as a clear model. As conditions change, one form of right may predominate over another. For example, it might be a logical step to extend current allocation of capacity units in the EPO to ITQs based on the same percentage of a TAC as percentage of the overall fish-carrying capacity.

History shows that adoption of rights-based institutions tends to come late in resource use when the costs of both open access and central regulation are high but uncertainty has been cleared away, and that the most complete rights will be assigned to resources that are more valuable, less mobile, and more observable (Libecap, 2006, 2010). Whether the transformation to rights-based management for international tunas backed by strong international treaties will be completed prior to this point remains an open question. Nonetheless, a stronger start has been reached than initially meets the eye through ICCAT's allocation of TACs by State, the PNA's transferable effort programme, and IATTC's bycatch share programme for dolphins, the AIDCP, and IATTC's limited entry and capacity management programme, the closed RVR.

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This technical paper discusses rights-based management of international tuna fisheries that directly addresses the incomplete or absent property rights underlying the incentives for overfishing, overcapacity, and failure to capture the full social and economic benefits that are possible. Rights that are secure, exclusive and extend into the future can be defined over shares of total allowable catch or effort or by units of capacity, but catch shares provide the strongest and most effective right. Rights-based management creates positive incentives that end the race to fish and creates conditions for matching capacity with fishing opportunities and sustainable catches, economic efficiency, full benefits, and wealth. Transferable rights provide a means of accommodating new members and increasing fishing by small island and coastal developing States.