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By

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Abstract

The failures of traditional target-species management have led many to propose an ecosystem approach to fisheries to promote sustainability. The ecosystem approach is necessary, especially to account for fishery-ecosystem interactions, but by itself is not sufficient to address two important factors contributing to unsustainable fisheries — inappropriate incentives bearing on fishers, and the ineffective governance that frequently exists in commercial, developed fisheries managed primarily by total harvest limits and input-controls. We contend that much greater emphasis must be placed on fisher motivation when managing fisheries. Using evidence from more than a dozen 'natural experiments' in commercial fisheries, we argue that incentive-based approaches that better specify community, individual harvest, or territorial rights and also price ecosystem services — coupled with public research, monitoring and effective oversight — promote sustainable fisheries.

Keywords: incentives, sustainability, rights, fisheries management

Introduction

Marine ecosystems are in global decline (Buckworth 2001; Pauly et al. 1998; Schiermeier 2002). The main cause is unsustainable fishing practices (Hannesson 2002) that arise from six principal factors: one, inappropriate incentives, two, high demand for limited resources, three, poverty, four, inadequate knowledge, five, ineffective governance, and six, interactions between fishery sectors and other aspects of the environment (FAO 2002a).

In response to fisheries failures and a fall in the total catch in marine capture fisheries (Hilborn et al. 2003), many have proposed an ecosystem approach to fisheries (EAF) that gives greater weight to integrated management and emphasizes the importance of maintaining ecosystem health for future generations (Ecosystem Principles Advisory Panel 1999; Busch et al. 2003; Browman et al. 2004). While EAF highlights the importance of fishery-ecosystem interactions and knowledge gaps, with a few exceptions (ICES 2005a) it overlooks the importance of fisher behavior and incentives for fisheries management.

In this paper, we examine what can be done to mitigate the factors that contribute to unsustainability in commercial and industrial fisheries. Our focus is upon inappropriate fisher incentives and ineffective governance, and we argue that a much greater emphasis should be placed on fisher motivation when managing marine resources (Larkin 1978). We propose incentive-based approaches to sustainable fisheries (IAF) to complement EAF and existing management approaches that promote sustainability. We contend that fishers need economic rights, and accompanying responsibilities, and also price signals to provide incentives for individual and collective action that promote more sustainable fishing practices.

The ecosystem approach: necessary, but not sufficient

The goals of ecosystem-based management are to promote healthy and resilient marine ecosystems and sustainable fisheries (FAO 2002a; Garcia et al. 2003). A key component of this approach is to conserve and protect key habitats critical for ecosystem and population processes (Pikitch et al. 2004), primarily through the enforcement of marine reserves and 'no take' areas (Garcia et al. 2003). Reserves can lead to increased abundance, size and biodiversity (Halpern 2003) and a more fecund population (Palumbi 2004) within 'no take' areas, and can potentially increase harvests in exploited areas via fish migration (Roberts et al. 2001; Gell and Roberts 2003). No take areas are particularly helpful in the face of uncertainties (Lauck et al. 1998), and can also promote resilience to shocks and raise profitability even when harvesting is optimal (Grafton et al. 2005). Despite these benefits, reserves only address some of the problems in fisheries (Allison et al. 1998; Leal et al. 2005) and do nothing to overcome key contributors to unsustainability, such as overcapacity. Nor do reserves provide incentives for fishers to take into account the full impact of their harvesting practices on fisheries.

Other aspects of EAF include the use of the precautionary approach and managing target and non-target species within the broader context of overall marine ecosystems, paying particular attention to bycatch, discarding and habitat destruction (Pikitch et al. 2004). We endorse these approaches and the goals of ecosystem-based management, but contend that a shift in priorities from target species to ecosystems (Pikitch et al. 2004), by itself, does not recognize the importance of fisher behavior and its motivations (Hilborn 2004). Unless fisher incentives and associated governance arrangements are compatible with long-term goals of sustainability (Hilborn et al. 2005), EAF, or any other alternative to traditional, commercial fisheries management, will fail to prevent over-harvesting of stocks or change fishing practices that damage habitat.

Failures of traditional, commercial fisheries management

The traditional approach to commercial fisheries management restricts fishing inputs and imposes total catch limits in an attempt to control fishing mortality. Input controls increase the costs of fishing and frequently fail in their objective to limit fishing effort because harvesters are often able substitute to unregulated inputs for controlled ones, causing gradual expansion of effort — called 'effort creep' (Wilen 1979; Scott and Neher 1981). Competitive Total Allowable Catches (TACs) in input controlled fisheries also provide incentives for fishers to race against each other for a share of the catch before the total harvest limit is reached. Such racing behavior frequently results in fishers investing in unregulated inputs to increase their effective fishing capacity at the expense of others. In turn, these investments and a 'race to fish' increase overall harvesting costs, lower the total net returns from fishing and jeopardize the sustainability of fisheries.

The traditional approach to commercial fisheries management fails to address the technical change that makes fishing more effective over time (Squires 1992), and does not instil a long-term perspective in fishers. For example, in the North Sea cod fishery some harvesters oppose reductions in the total allowable catch despite the fact that the spawning stock is below a level that demands a harvesting moratorium (European

Environment Agency 2004). In Canada's Northern cod fishery concerns by the regulator that reduced harvests would generate bankruptcies and unemployment, coupled with uncertainties over the status of stocks (Department of Fisheries and Oceans 2004a) and overestimation of stocks and recruitment (Walters and Maguire 1996), resulted in the TACs being set too high and was a major contributor to stock collapse in the 1990s (Hutchings and Myers 1994).

The negative consequences of input controls, whether they are applied in traditional target-species management or with ecosystem approaches, are illustrated by the recent experience in Australia's federally managed fisheries. In the past ten years the Australian federal government has committed US$60 million per year to fisheries research and ecologically sustainable development, has undertaken substantial buybacks of fishing effort, implemented detailed scientific fishery management plans that incorporate strong stakeholder involvement, and expanded its National Representative System of Marine Protected Areas (McLoughlin and Findlay 2005). Despite such strategies, fishers have successfully lobbied against recommended reductions in the TACs (McLoughlin and Findlay 2005). This lobbying, combined with effort creep in some input-controlled fisheries (Kompas et al. 2004), have contributed to a three-fold increase in the number of Australian Federal fisheries classified as overfished in the past ten years (Caton and McLoughlin 2004).

A similar story can be told in many other developed fisheries even when the primary stated objective of management is to conserve fish stocks. Maguire (2003) observes that inappropriate incentives, inadequate and overly complex governance, and lack of knowledge are the main causes of the unsustainable harvesting of demersal fisheries in the North Atlantic. In these fisheries, despite the focus on the bio-ecological component of sustainability, management systems have frequently failed to achieve the desired outcomes. On-going ‘effort creep’ has also led, in some jurisdictions, to escalating complexity of rules as regulators try to close off the loopholes, leading to confusion and making enforcement difficult (Healey and Hennessey 1998). Resolving these challenges requires major changes that include a precautionary approach to management (FAO 1996), more transparent and participatory management, and a greater emphasis on incentives and rights for fishers (Maguire 2003).

Incentives-based approaches

The failures of traditional management suggest that total harvests must be set appropriately, but also that the greatest marine predator, fishers, be provided with the incentives to fish sustainably. A key to creating incentives for more sustainable behavior is to provide fishers with more secure harvesting or territorial rights to fish. Such rights enable fishers to enjoy a sustainable flow of benefits from fishing with an enforceable right to exclude others from these benefits, but generally do not give ownership over the resource stock. Fishing rights may take several different forms (The World Bank 2004, p. 46) and include individual harvesting rights (Scott 1999a), community or group-based rights (Baland and Platteau 1996), and territorial user rights (Christy 1999; Sharp 1999).

Economic fishing rights are commonly viewed as a recent innovation, at least in terms of individual harvesting rights, but they have existed for centuries. For example, in Oceania, ‘no take’ areas, territorial user rights and cooperative management ensured sustainable fisheries for centuries by allowing clans or families to control, for their benefit, reef and lagoon areas (Johannes 1978). The success of traditional marine tenure suggests that a key to generating appropriate incentives is for fishers to have the ability to exclude others from fishing, and thereby to reap both the pain of overexploitation and the gains from conservation. Exclusive property rights, however, do not guarantee sustainability. In extreme cases, it may be economically rational to 'mine' a fishery (Clark 1973), and if the holders of rights are large in number and with diffuse interests, incentives may still remain to cheat and 'free-ride' on the conservation of others. All fisheries are also subject to irreducible uncertainties (Ludwig et al. 1993) that make it difficult to set sustainable harvests and to understand the long-term impacts of fishing practices.

Incentive-based approaches make management more robust by ensuring, in most cases, that those who have the greatest impact on fisheries have an increased interest in their long-run conservation and directly bear the cost of overexploitation. We review the contributions of incentive-based approaches to sustainable fisheries using the following sub-headings: Rights and responsibilities; Individual rights and collective action; Group rights and collective action; Participatory management and the allocation problem; Incomplete harvesting rights; Multiple target species; Discards and bycatches; Overcapacity and buybacks; Transferability, returns and subsidies; and Adjustment costs, economic viability and flexible decision making.

Rights and responsibilities

The key to IAF is to provide harvesters with long-term and secure rights (Hannesson 2004) that are legally enforceable, and with corresponding duties by non-owners to not interfere with the exercise of these rights (Cole and Grossman 2002). In practice, individual harvesting rights are often specified as a 'revokable privilege', although New Zealand is a notable exception (National Research Council 1999). However, these privileges are *de facto* economic property rights, provided there exists adequate monitoring and surveillance. Control and enforcement should also ensure that the holders of the harvesting rights meet their responsibilities under the FAO's Code of Conduct (FAO 1995; Symes 2000) while fishers without such rights, or other privileges, are excluded from harvesting.

Secure and durable harvesting or territorial rights, in most cases, provide fishers with the incentive to one, protect the value of their assets and, two, obtain the greatest possible sustainable flow of benefits from fishing. These two incentives are complementary and occur concurrently, but the former is likely to be manifested in forms of collective action while the latter in individual actions. Individual efforts by fishers to maximize their net returns indirectly contribute to sustainable fisheries by improving economic performance and reducing the problems of overcapacity, while collective actions involve direct attempts to ensure sustainability by improving management decision-making, the quality of scientific advice and the monitoring of fisher behavior.

At the individual level, quantified fishing rights encourage fishers to harvest their fixed catch at lowest cost, to increase the value of landings through better handling and care of fish (Campbell et al. 2000; Rice 2003, Dupont et al. 2005), or to change product form (from frozen to fresh), as occurred in the British Columbia (BC) halibut fishery (Casey et al. 1995; Herrmann 1996). Such efforts, and the transferability that allows more profitable fishers to harvest a larger share of the total catch, improve efficiency (Grafton et al. 2000) and increase productivity (Fox et al. 2003a). Transfers of individual harvesting rights also, in many cases, help reduce overcapacity (Dupont et al. 2005) that is a major contributor to overexploitation of fisheries and poor economic returns for fishers.

Individual rights and collective action

A long-term interest in the fishery in the form of harvesting rights can encourage collective action to ensure management practices are consistent with maintaining the long-term value of these rights. Greater participation in management decision making by fishers, by itself, is not sufficient to promote sustainable fisheries, but we argue sustainability is promoted by fisher participation in combination with more secure harvesting rights. Individual harvesting rights also provide a way to allocate joint management costs and, thus, help overcome the under provision of services that benefit all fishers (Scott 1993).

Evidence exists that individual harvesting rights can promote collective action in shellfish, demersal and pelagic fisheries (Shotton 2001). In the New Zealand east-coast rock lobster fishery, for example, the introduction of individual harvesting rights prompted commercial stakeholders to initiate a locally focused fishing strategy. The industry successfully requested the regulator to lower the commercial catch and to restrict harvesting to a shorter winter period to make widespread illegal fishing easier to detect (Breen and Kendrick 1997). These and other fisher-initiated management measures have resulted in a dramatic stock recovery and substantially higher quota values (Leal et al. 2005). Similarly, in 2001 the scientist contracted by the Canadian Sablefish Association (CSA), an organization of commercial fishers with individual harvesting rights, advised of rapid declines in sablefish abundance. Shortly thereafter, the CSA recommended to the regulator that the total catch be immediately reduced as a precautionary measure. Subsequent stock recovery that followed a decline in the TAC by almost 50% has allowed CSA members to benefit from their conservation efforts. In the Tasmanian abalone fishery, individual quota-holders with direct involvement in advising the regulator successfully lobbied for large reductions in the total catch in the late 1980s. This allowed the stock to rebuild and the quota-holders were the principal beneficiaries of subsequent increases in the total harvest (Tasmanian Abalone Council 2003). The successful rebuilding of the Icelandic herring stocks, through cuts in the TAC, were also strongly supported by industry because fishers wanted to protect the asset value of their harvesting rights (Hannesson 1996).

Individual harvesting rights can provide greater incentives for more 'bottom-up' decision-making and opportunities for more participative processes (Lane and Stephenson 2000). Indeed, if the creation of rights promotes economic sustainability, for which there is abundant evidence in the form of case-studies (Davidse et al. 1997; Kaufmann et al. 1999; Shotton 2001), it is not surprising that holders of such rights will be prepared to invest their time and effort to protect their flow of benefits from fishing. This may take the form of funding for more on-board and dockside surveillance, increased research to improve the quality of scientific advice, and greater participation in management decision-making. For example, in the BC sablefish fishery — managed by individual harvesting rights since 1990 — fishers initiated and funded research on trap escape rings that dramatically reduced juvenile capture and mortality. After individual harvesting rights were introduced in BC's halibut fishery, harvesters (through their industry association) have set up and pay for dockside monitoring that tags every fish

(Grafton et al. 2000). Similarly in the BC groundfish trawl fishery, also managed by individual harvesting rights, fishers are strong supporters of science and have contributed millions of dollars to research (Rice 2003). Elsewhere, such as in New Zealand's fisheries — managed by individual harvesting rights since 1986 — fishers, through their associations, are important financial contributors to management and are also active participants in some fisheries research (Lydon and Langley 2003).

Group rights and collective action

Collective action can be encouraged in a number of different ways, including allowing fishers to organise and express their concerns to managers (Pomeroy and Berkes 1997) and to participate in fisheries research and management (Rice 2001). It can also be promoted through the allocation and support of harvesting rights for groups and communities (Baland and Platteau 1996; Willmann 1999). For example, the Canadian government has created seven geographically based community management boards for the fixed-gear groundfish fishery in Nova Scotia. Each of these boards is charged with developing community harvesting plans and controlling the fishing activities of members (Peacock and Hansen 1999). This has helped utilize local knowledge to inform allocation decisions and to avoid a 'one-size-fits-all' approach to fisheries management.

The potential benefits of collective action with group rights is shown by purse seine fishers who recently established a cooperative in Alaska's Chignik salmon fishery following a change in regulations passed by the Alaska Board of Fisheries. In a 2002 survey of all cooperative members, 67% claim it has made them financially better off, 100% state it has improved fish quality, and 88% consider it has been either a very or somewhat positive change in management of the fishery (Knapp et al. 2002).

Numerous examples show that both community and group rights can improve management outcomes with collective action (Baland and Platteau 1996; Ostrom et al. 1994; Dietz et al. 2003). These actions are facilitated by social capital within communities, and trust between management authorities and fishers (Pretty 2003; Grafton in press), but social capital does not necessarily require the existence of individual or group harvesting rights (Dietz et al. 2003). Trust, for instance, between scientists and fishers in the BC rockfish fishery in the 1990s led to new hypotheses and novel ways for testing them (Stanley and Rice 2003). It also contributed to a constructive advisory process that included an official working group with members from the industry and the regulator (science and fisheries management) that was established before the introduction of individual harvesting rights in the fishery (Rice 2003).

Participatory management and the allocation problem

Examples of effective participatory management in fisheries where fishers bear the consequences of failures, as well as successes, should not be taken as proof that greater participation by fishers in management always generates better fisheries outcomes. We contend that participatory management coupled with a failure to resolve the allocation problem (who gets what?) may actually generate poorer sustainability outcomes and allow for capture of management authorities by special interests as fishers compete for influence over the allocation mechanisms. For example, under the U.S. 1977 *Fishery Conservation and Management Act*, power sharing between the federal government, fishers and other stakeholders has occurred through Fishery Management Councils (FMCs). Turner and Weninger (2005) find that this particular system of voluntary participation in the regulatory process leads to over-representation by industry members with ‘extreme’ preferences. Not surprisingly, this ‘deconcentration’ of management authority has not been viewed as success (Pomeroy and Berkes 1997). It has also been plagued by conflicts of interest (Allison 2002) and some FMCs appear to have sacrificed long-term conservation for short-run economic considerations (Parsons 1993, p. 659).

At least in the case of the United States, a consultative system and delegation of management authority to fishers and other resource stakeholders, but in the absence of appropriate fisher incentives and resolution of the harvest allocation problem, has contributed to rent-seeking behavior and conflicts between different interest groups. This has made decision making less, rather than more, effective (Mikalsen and Jentoft 2001).

Incomplete harvesting rights

An important issue when establishing harvesting rights is to ensure that they do not create perverse incentives that distort behavior and produce undesirable outcomes. This demands that rights for commercial fishers be complete as possible to avoid transfer of effort to non-quota species, and that all commercial fishers are included. In Iceland, for example, exemptions from individual catch quotas for vessels under 10 gross registered tonnes, until they were abolished in 1990, distorted the composition of the fishing fleet and encouraged investment in smaller vessels (Arnason 1995, p. 136). A similar increase in investment and catch also occurred with the Icelandic longline fleet because half of the demersal catch has been exempt from quota restrictions during the months November to February.

Conflicts between commercial and recreational fishers can also be aggravated if the commercial fleet is subject to individual output controls, but the recreational sector is not. For example, if individual rights only exist in the commercial fishery and if fish stocks are under pressure due to expansion of the recreational catch, the regulator may be tempted to reduce fishing pressure by simply reducing the commercial TAC. This undermines the commercial right, creates uncertainty for investment, and generates protest from the commercial sector. Such commercial-recreation conflicts, however, are not unique to fisheries using individual rights. Nor do they necessarily imply that recreational fishers should be included within an individual quota management system, where the widely dispersed interests would generally make the transactions costs associated with trading and enforcing such rights prohibitive. Limits might be better specified for the recreational sector in other ways: for example, a mix of recreational fishing licences and individual daily bag limits. Such controls, however, may need to be supplemented with other methods, such as spatial allocations that keep bulk fishing methods away from favored recreational sites.

Multiple target species

The incentive-based approach is applicable to fisheries where there are a few target species, and also where there exist many target species. A major concern, however, is that harvesters may have little ability to separately target each species. Consequently, the catch mix of fishers may not match individual quota allocations that, in turn, may contribute to discarding and misreporting (Squires et al. 1998). A limited ability to target specific species may also result in undesirable individual quota underages and overages, and also severely constrain fishers' profitability if total harvests of target species are restricted to prevent the overexploitation of vulnerable bycatch species (Squires and Kirkley 1996). Another issue with multiple target species is that if harvesting rights are only assigned to a subset of target species, this can encourage the transfer of fishing effort to target species without individual harvest controls (Dupont and Grafton 2001)

Although multiple target species make fisheries much more difficult to manage, especially with the setting of TACs, the ability of fishers to target individual species is not as constrained by technology as is commonly believed. Given appropriate incentives, fishers are able to adapt their fishing practices to reduce bycatch and adjust their species mix even if the technology remains essentially unchanged. For example, purse seine vessels in the eastern Pacific were able to reduce dolphin mortality from over 130,000 in 1986 to less than 4,000 1993 by changing fishing practices, but using the same fundamental technology (Hedley 2001). In the BC groundfish trawl fishery, on-board observers record fishery mortality rates by species that count against quota owned or leased by fishers. This has created an incentive for fishers to avoid catching less desirable species, and led to greater communication between skippers to avoid harvesting in areas where there is a high incidence of unwanted species. Fishers have also changed their behavior by using shorter tows, by checking their nets at greater frequency and employing test tows before fishing (Grafton et al. 2004).

Discards and by-catches

IAF allow fisher incentives to be compatible with long-term conservation, but do not guarantee that all fishing practices promote sustainability. Examples exist where fishers with individual harvesting rights have dumped lower valued fish so as to maximize the value of their trip landings (Arnason 1994; Parsons 1993 p. 207; Squires et al. 1998), although such problems also exist in open access and input-regulated fisheries (Leal et al. 2005) — especially those regulated by trip and/or vessel-size restrictions. Discarding problems, however, with individual harvesting rights can be mitigated and adaptively managed with appropriate incentives and instruments.

In the BC groundfish trawl fishery — managed with individual harvesting rights since 1997 — dumping of fish is recorded by observers on all vessels and is counted against individual quotas. This quota reconciliation provides harvesters with the incentive to be much more selective in their fishing practices. As a result, the ratio of at-sea releases to the landed fish weight has greatly declined (Grafton et al. 2004). Recently, fishers have, on their own initiative, undertaken research that halved the fishing mortality of bocaccio rockfish — a by-catch species designated 'at risk' in 2002 by the Committee on the Status of Endangered Wildlife in Canada, and for which harvesters do not have specific species quota (Fisheries and Oceans Canada 2004b; Fisheries and Oceans Canada 2005). This protects their livelihood because, should the boccacio be listed as requiring protection by the federal cabinet under Canada's 2003 *Species at Risk Act* (SARA), groundfish trawl fishing could be prohibited if current practices compromise the rapid recovery of the species and if Incidental Harm Permits were not issued to allow boccacio bycatch (Rice 2003).

Overcapacity and buybacks

The potential payoffs from IAF include better protection of fish stocks and the environment, increased returns to harvesters (Dupont and Grafton 2001; Fox et al. 2003a; Dupont et al. 2005), and reduced fishing capacity (Grafton et al. 1996; Dupont et al. 2002). These benefits arise because secure and durable rights to fish, individually or communally, reduce 'racing behavior'. By contrast, in input-controlled fisheries the 'race to fish' results in excess effort, substitution to unregulated inputs (Squires 1987) and lower overall net returns (Dupont 1990). For example, in the Northern prawn fishery of Australia the imposition of effort controls in the form of combined engine size and hull length restrictions encouraged fishers to increase the headrope length of their trawls so as to maintain their effective fishing capacity. Unfortunately, this substitution lowered technical efficiency and raised the cost of fishing while failing to prevent effort expansion (Kompas et al. 2004).

'Top-down' input controls also promote an 'us versus them' attitude with managers (Charles 1995) and frequently fail to limit fishing effort (Townsend 1990) because the underlying incentives to 'race to fish' are unchanged. As a result, over the period 1970-90 worldwide harvesting capacity in commercial fisheries grew eight times faster than landings (Gréboval and Munro 1999), and overcapacity has been a significant contributor to overexploitation of fisheries (FAO 1997). Continued effort expansion under input controls also obliges regulators to implement further operational constraints in attempts to ensure TACs are not exceeded. These constraints, such as a shorter fishing season, often aggravate the 'race to fish' and contribute to further overcapacity (Clark 1982), as occurred in the BC halibut fishery before the implementation of individual harvesting rights, and in numerous other fisheries. The resulting capacity 'overhang' makes fisheries less robust to management errors, especially in the setting of appropriate TACs, and also creates political pressures by fishers to increase the total harvest.

When overcapacity reaches a critical level, regulators frequently resort to buybacks of vessels or associated fishing licences. Often the direct costs of buybacks are borne by the public purse, and not fishers themselves. Buybacks are only a short-term palliative for the underlying incentive problem because, if they are successful in temporarily increasing the returns to harvesters who remain fishing, higher profits encourage further investments and effort creep (Weninger and McConnell 2000), and if anticipated by fishers may even detract from conservation efforts (Clark et al. 2005). As a result, the ability of buybacks to reduce long-term fishing effort and help stocks recover is limited (Holland et al. 1999) without a corresponding change in fisher incentives (Fox et al 2003b). For example, buybacks initiated in the Northeast groundfish fishery in the United States reduced the number of permits and the number of vessels employed, but do not appear to have resulted in observable conservation benefits (Walden et al. 2003). In the BC salmon fishery there have been five buybacks at a cumulative cost of several hundred million dollars over the period 1970-2000. While these buybacks may have temporarily reduced the severity of the overcapacity problem caused by both effort creep and a decline in the size of some salmon runs, they have not provided a lasting solution to the chronic problem of overcapacity (Grafton and Nelson 2005; Schwindt et al. 2003).

Transferability, costs, returns and subsidies

Transferable harvesting rights, and the prices that they can command, induce some fishers to exit and remove excess fishing capacity, increasing returns to fishers who remain. 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. A recent study of New Zealand's markets for individual harvesting rights — the most comprehensive of any fisheries jurisdiction — found that prices there do, indeed, reflect ecological variability and changes in fishing profitability (Newell et al. 2005).

High values for harvesting rights, concentration of these rights or simply the *gratis* allocation of harvesting rights over a public resource are viewed by some as inequitable (Walters and Martell 2004, p. 38), especially if the initial allocation of rights excludes crewmembers and traditional participants in the fishery. To address some of these concerns it is possible to limit the amount of harvesting rights owned by any one individual or company, or to even set aside a share of the rights as a Code of Conduct Quota to promote the interest of crew, as has occurred in the BC groundfish trawl fishery (Rice 2003). A share of the increased returns (and long-term value of rights) attributable to incentive-based approaches may also be captured to reduce the entry costs for prospective fishers, and to collect revenues for the public purse (Grafton 1995).

Individualized and exclusive rights not only limit the number and identify resource users, but also the specific magnitude of the interests of each individual fisher in terms of the TAC. This allows research and management costs attributable to the fishing activity to be charged on a proportional basis to the beneficiaries. Such cost recovery introduces a new and powerful dynamic into the relationship between fishers and regulators. This has potential to drive down management costs, improve voluntary compliance, and encourage collective action and greater fisher participation in management and research.

Higher fisher returns with IAF allow for the possibility of fisher-funded monitoring and additional data collection. Incentive-based approaches also reduce the motivation for price supports, or vessel and gear subsidies that contribute to overfishing (Milazzo 1998; Munro and Sumaila 2002). For example, Iceland and New Zealand both have long-term individual harvesting rights in many of their fisheries and had government financial transfers in the late 1990s equal to about 4% of the total value of their respective landings

(Cox and Schmidt 2002, Table A.2). By contrast, the total government financial transfers to fisheries regulated with input controls are often much higher. In 1999, for instance, total government transfers were, on average, some 20% of the total value of landings in OECD countries (Cox and Schmidt 2002, Table A.4).

To the extent that traditional input regulation contributes to overcapacity and low fishing incomes, this stimulates government financial transfers. By contrast, IAF may be viewed as generating a 'win-win': better sustainability outcomes at a lower overall cost of management (including transfers). Indeed, a recent comparison of Iceland, Norway and Newfoundland found that the costs of fisheries management, not including government financial transfers, were lowest in Iceland — the country that has gone the furthest to implement secure fishing rights in any of these three jurisdictions (Arnason et al. 2003).

Adjustment costs, economic viability and flexible decision-making

A key concern, especially to crew, is that IAF reduce employment and create other adjustment costs (OECD 2000, pp. 22-63). The impact on employment, however, depends to what extent the fishery is overexploited in an economic sense. For example, in New Zealand total employment and the number of vessels actually increased in the first five years after the introduction of individual harvesting rights (Connor 2001; Davidse et al. 1997) due to 'domestication' of the deep-water fisheries and increased harvests from some relatively unexploited stocks. When harvesting 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 difficulties with traditional input controls, and the probability that current employment levels under existing regulations are unsustainable.

Political decision-making in respect of fisheries management is influenced by economic circumstances. Where there are many fishers with poor incomes and few alternative employment opportunities, it is much more difficult to reduce current catches to sustainable levels than when fishing is economically viable. In other words, inappropriate incentives that generate low fisher incomes reduce management flexibility and, therefore, increase the likelihood of risk-prone decisions (Sissenwine and Rosenberg 1993). By contrast, incentive approaches promote economic performance. Thus, when an unexpected negative shock arises, the economic impact is less critical and the management response is likely to be quicker and more effective. The incentive approach, therefore, helps to avoid the social and biological amplification of natural fisheries variability — a highly desirable characteristic of fisheries management (Rice 2002).

Sustaining ecosystems

Harvesting, community, and territorial rights do not guarantee that all fishery practices will be sustainable, but they can create incentives for fishers to protect their rights by discouraging practices that are overtly damaging, and promote actions that conserve target species. We address how different incentives can contribute to sustaining ecosystems using three sub-headings: Multiple stakeholders and collective action; Coordination and effective oversight; and Quantity and price incentives for ecological services.

Multiple stakeholders and collective action

In New Zealand commercial fishers have recognized the vulnerability to harvesting of the Fiordland environment — listed as a UNESCO World Heritage Site. To address these concerns, an alliance of conservation groups, commercial and recreational fishers, and Maori interests — called the Fiordland Marine Guardians (FMG) — developed a strategy to protect environmental quality while providing for sustainable harvesting. It creates eight fully protected marine reserves and several no-anchoring zones, excludes commercial fishing from all inland waters, creates a tailored recreational fishing regime, and establishes the FMG as a formal advisory body to the government (New Zealand Government 2005). Without well-defined harvesting rights, and the incentives they engender, this successful balancing of interests and responsibilities across stakeholders would have been impossible.

Coordination and effective oversight

Despite the potential of IAF to contribute to sustainability, a public oversight and coordination role to integrate commercial resource use with environmental impacts and other resource interests is still required. This is because it is not possible to specify in advance property rights over every aspect of the environment and, thus, prevent all the negative spillovers that might arise from harvesting. Public oversight is also needed to manage straddling fish stocks and highly migratory species and for the setting of societal objectives and target and reference points in terms of fish stocks and marine ecosystems. Coordination and oversight may also be justified if the average cost of monitoring and enforcement is lower when there are a greater number of fisheries under surveillance, if the average cost to provide management services is lower the larger is the number of services (science advice, monitoring, research, etc.) or if there is a public good aspect (such as species diversity) to fisheries management (Grafton 2000).

One of the more important factors in justifying public oversight, in terms of sustainability, is the deleterious impact on the marine environment from fishing that is incidental to the catches of target species (Scott 1999b). For example, longlining can cause incidental catch of sea turtles and sea birds, trawling for shrimp can contribute to turtle mortality, and purse seining for tuna can, in some cases, result in incidental dolphin deaths (Dayton et al. 2002, pp. 16-23). If reduced numbers of sea birds, turtles and dolphins do not affect the value of fishers' harvesting rights over target species, and reducing these incidental catches is costly, there is no financial incentive for fishers to address these bycatch issues.

Quantity and price incentives for ecological services

Where threats to ecological services arise, and are deemed sufficiently costly by society to warrant intervention, fishers can be given incentives to employ bycatch reduction devices, to make conservation investments, or to undertake practices that may reduce the adverse impacts of fishing. The potential of a quantity-based incentive approach compared to traditional input controls can be illustrated by regulations that are part of the 1998 Agreement on the International Dolphin Conservation Program in the Eastern Tropical Pacific (Hedley 2001). As part of this agreement, vessels flagged by signatory countries that exceed their annual Dolphin Mortality Limits (DMLs) must stop fishing. DMLs are enforced by on-board observers on all vessels greater than 400 tons who record the numbers of dolphins killed from the harvesting of yellowfin tuna (*Thunnus albacares*). Although by no means a complete property right (Campbell et al. 2000), some reassignment of unused or forfeited rights is permitted, and in the first year of their introduction DMLs helped to reduce total dolphin mortality by more than 75% (Hedley 2001).

Habitat damage can arise from some forms of harvesting, such as bottom trawling (Dayton et al. 2002, pp. 26-29; ICES 2005b, pp. 22-23; Jennings and Kaiser 1998, pp. 209-222). This could potentially be mitigated through incentives, for example, through the use of transferable Habitat Impact Units (HIUs) that would proxy marginal habitat damage associated with different gear and habitats (Holland and Schnier 2004). The total number of HIUs would be set to ensure a desired level of habitat protection and enforced with a vessel monitoring system that would track each vessel's location and rate of movement. Fishers would have the incentive to take into account the impact of fishing on habitats because HIUs would be scarce and tradable. Those who exceed their initial allocation of HIUs would be required to purchase more units that would increase their fishing costs, while those who have HIUs left over after fishing could sell or lease them to others at a profit.

A price-based approach to sustaining ecosystems could involve the imposition of environmental charges on vessels that impose a particular risk or harm to the marine environment, and then use the funds from these charges to undertake conservation investments. For example, an industry association of gillnet fishers in California have proposed a 'turtle tax' — related to turtle mortality from swordfish harvesting — to pay to protect critical leatherback nesting sites in Agua Blanca, Baja California (Chuck et al., in press). Similar approaches could also be adopted in other fisheries, especially if public, private sector or non-governmental funds were used to provide financial incentives for fishers to undertake more sustainable fishing practices. These could, for example, include the eco-certification of sustainable fisheries (Peterman 2002) and harvesting practices so as to provide a price premium for 'eco-friendly' fishing, vessel or gear-specific harvesting charges to promote sustainable practices and market-based instruments to 'price' ecosystem services. A price-based approach that would help maximize the environmental payoff per dollar of conservation expenditures by regulators or non-governmental organizations would be to allow fishers to bid or tender for biodiversity conservation payments to undertake specific management actions, but within a framework of well-defined ecological quality objectives (ICES 2005b, pp. 32-60). Such an approach has proved successful in changing practices by landholders and has promoted conservation in a cost-effective way on farms in the State of Victoria, Australia (Stoneham et al. 2003).

Both price and quantity-based incentives complement ecosystem approaches as they reduce the negative effects of harvesting on endangered and protected species, and help to conserve non-marketed ecosystem services. The key insight from experience to date in commercial fisheries is that appropriate fisher incentives — coupled with public research, monitoring and effective oversight — promote more sustainable fishing practices.

Concluding remarks

The alarming trends in the world's fisheries demand a fundamental change in management and fishing practices. As managers grapple with these problems, many scientists are arguing for a new paradigm and, in particular, an ecosystem approach to fisheries to overcome the failures of single or target species management. While the ecosystem approach and existing strategies that promote sustainability are necessary, especially to account for fishery-ecosystem interactions, they are insufficient by themselves to address the key drivers of unsustainable outcomes — inappropriate incentives for fishers and the ineffective governance that exists in commercial fisheries regulated exclusively by input controls and total allowable catches. Evidence from more than a dozen 'natural experiments' of commercial, developed fisheries supports our conclusion — incentive-based approaches that better specify individual and group harvesting rights, and/or territorial rights and also price ecosystem services promote both economic and ecological sustainability.

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