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# The ecological implications of individual fishing quotas and harvest cooperatives

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**Globally, 75% of fish stocks are fully exploited or overexploited, and fishing pressure continues to threaten marine ecosystems and the cultures and economies that depend on them. Decades of government regulation have largely failed to stem the ecological damage associated with fishing. Designated access privilege (DAP) systems such as individual fishing quotas (IFQs) and harvest cooperatives are one attempt to realign incentives so that fishers no longer race to maximize catches. IFQs are not appropriate for many fisheries. Fortunately, the IFQ debate has drawn attention to the link between incentives that fishers face and the ecological consequences of fishing. Despite important social concerns, preliminary evidence suggests that IFQs encourage cooperation, fisher stewardship, and a slower pace of fishing. This review points to the need to improve the metrics of marine ecosystem health and pursue quantitative methods for assessing the ecological impacts of different management approaches.**

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The National Marine Fisheries Service reports that over a third of assessed US commercial fish stocks are overfished or are being fished unsustainably (POC 2003; NMFS 2004), and substantial debate surrounds the management of fish populations. For many coastal nations, fishing remains an important economic activity, yet it can also deplete stocks (FAO 2002), disturb ocean habitats (NRC 2002), kill non-target species (bycatch; Chuenpagdee *et al.* 2003; POC 2003; USCOP 2004), and alter marine trophic relationships (Pauly *et al.* 1998, 2002; Myers and Worm 2003).

Such concerns are drawing widespread attention from governments, the fishing and seafood industries, scientists, economists, and environmentalists. In the United States, the US Commission on Ocean Policy and the Pew Oceans Commission highlighted the need to address these concerns to ensure healthy oceans and sustainable fisheries. The Commissions' reports conclude that traditional regulations used in most US fisheries have largely failed to solve the problems facing fisheries today (POC 2003; USCOP 2004).

## In a nutshell:

- Any attempt to resolve overfishing must address excess fishing effort and the "race to fish"
- IFQs give fishers an economic interest in the long-term health of fish stocks and marine ecosystems
- Incentives created by fisheries management systems have ecological implications
- IFQ fishers face incentives to develop innovative bycatch solutions and cooperate with other fishers, scientists, and managers
- Improved metrics of marine ecosystem health are needed

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Ocean fisheries suffer the classic "tragedy of the commons" (Gordon 1954; Hardin 1968), because no one owns a fish until it is captured. The result is that a fisher's strongest incentive is to pre-empt his or her rivals by capturing as many fish as they can, as fast as possible. The fisher has little incentive to conserve fish for tomorrow or to expend resources to enhance future stocks.

Although governments have introduced regulations to address the tragedy of the commons, conditions have worsened. When managers impose an annual overall catch limit or "total allowable catch" (TAC) without allocating it to individuals, a destructive race for fish results. Fishers race against each other to obtain their share of the catch, before the limit is reached and the season closed. Such practices are wasteful and dangerous, characterized by overcapitalized fleets, long hours, gear conflicts, and concentrated fishing effort (Figure 1). Regulations such as per-trip catch limits, days-at-sea limits, and shortened seasons are used to slow the pace of fishing, but they in fact often exacerbate the race and subsequent ecological damage (Leal *et al.* 2005).

Individual fishing quotas (IFQs) are one tool used to stop the race for fish. IFQs are a type of "dedicated access privilege" (DAP) system (Fujita and Bonzon 2005) that assigns fishers (or harvest cooperatives) a specific proportion of the TAC, reducing the incentive to race for fish. Fishers can work for their share of the catch when business and weather conditions are favorable, making fishing safer and more profitable. Many studies attest to such improvements (eg Buck 1995; Grafton 1996; OECD 1998; NRC 1999; Grafton *et al.* 2000; Fox *et al.* 2003; Leal 2005). Fewer studies have focused on the ecological implications of IFQs and harvest cooperatives.

Courtesy of H Gilroy and the International Pacific Halibut Commission

***Figure 1.*** *Halibut vessels waiting to offload catch in Homer, Alaska, after a 24-hour season opening in 1992. Before IFQs were implemented in 1995, the Pacific halibut* (Hippoglossus stenolepsis) *fishery was characterized by dangerous conditions, economic waste, gear conflicts, ghost fishing, and overharvested TACs. On this particular day, fishers landed 2.7 million pounds of halibut into the port of Homer.*

how governments should capture the windfall gains that result (Clark 2006). Fortunately, the characteristics that often accompany IFQ implementation (increased monitoring, effort reduction, and improved TAC compliance) are key components for addressing the various paths to overfishing.

Here, I begin with an examination of how fisheries that emphasize slower fishing, effort reduction, TAC compliance, and improved monitoring have addressed the ecological concerns of overfishing, bycatch mortality, and habitat disturbance. Next, I address several indirect ecological impacts of IFQs, including the practice of high-grading (discarding less valuable size classes and species of fish), as well as incentives for cooperation, stewardship, and fisher-motivated research. Finally, I will explore how IFQs fit into the current movement toward ecosystem-based fishery management, a holistic approach that views fisheries in the context of whole ecosystem health and encourages precautionary approaches when ecological relationships are poorly understood (Pikitch *et al.* 2004).

## Overfishing

Overfishing persists in many fisheries, despite preventive regulations. Overfishing can occur if incomplete stock assessments and/or misunderstood population dynamics lead fisheries scientists to overestimate sustainable catch levels. It can also stem from political, economic, or social pressures that steer managers away from scientists' suggested TACs and toward higher levels of harvest (De Alessi 1998; USCOP 2004). Alternatively, fishers may simply land too many fish because of the strong incentive to maximize present catches.

Improving compliance with science-based catch limits is therefore an important first step toward achieving sustainable fisheries (NRC 1999, 2002; Jones and Bixby 2003). Certainly, IFQs are not a panacea for reducing the ecological impacts of fishing, and serious questions remain concerning the equity of the initial allocation and how governments should capture the windfall gains that result (Clark 2006). Fortunately, the characteristics that often accompany IFQ implementation (increased monitoring, effort reduction, and improved TAC compliance) are key components for addressing the various paths to overfishing.

### *New Zealand*

In the early and mid-1980s, scientists concluded that overfishing was a serious problem for New Zealand's inshore fisheries (NRC 1999; Connor 2001; New Zealand Ministry of Fisheries 2002). In response, New Zealand introduced individual transferable quotas (called ITQs or IFQs) for 97 species over 18 years, to improve the economic performance of the seafood industry and encourage sustainable fishery management. The New Zealand Ministry of Fisheries (2002) reports that 80% of the stocks initially placed under IFQ management for which information is available are above sustainable levels. In fact, between 1994 and 2002, the percentage of stocks above target levels grew by 67% (New Zealand Ministry of Fisheries 2002).

Improvements to New Zealand fisheries are due to a combination of factors, including increasingly reliable catch data that have improved biomass estimates, as well as decreased fishing effort and improved TAC compliance. Between 1986 and 1988, when the first 27 fish stocks came under IFQ management, the number of fishing vessels dropped by 36% (New Zealand Ministry of Fisheries 2002) and TAC overharvests became less frequent (NRC 1999).

### *US and Canada*

IFQ fisheries in the US and Canada have also exhibited improved compliance with scientists' recommended catch limits. In 2004, the National Marine Fisheries Service reported that all species under IFQ or harvest cooperative management in the US were being fished sustainably (ie no overfishing, not overfished; NMFS 2004). These species include several highly valued stocks, such as Atlantic surfclam (*Spisula solidissima*), Pacific halibut (*Hippoglossus stenolepsis*), sablefish (*Anoplopoma fimbria*), and walleye pollock (*Theragra chalcogramma*), as well as smaller stocks like Pacific whiting (*Merluccius productus*), and wreckfish (*Polyprion americanus*; Table 1). One exception is the highly migratory and internationally regulated Atlantic bluefin tuna (*Thunnus thynnus*), which at present continues to be fished unsustainably (Table 1).

 

**Table 1. Overview of US federally managed IFQ and cooperative fisheries[1]**

| *Fishery* | *Type* | *Since* | *Overfished?[2]* | *Overfishing?[3]* | *Key characteristics* |
|---|---|---|---|---|---|
| Atlantic bluefin tuna (purse seine) | IVQ[4] | 1982 | Y | Y | Highly migratory international stock; biomass continues to decline; US purse seine sector represents less than 2% of all Atlantic bluefin tuna landings; quota is held by five participant vessels with limited transferability |
| Surfclam and ocean quahog | IFQ | 1990 | N | N | Substantial consolidation and effort reduction; current swept area is 0.3% of surfclam habitat; fisher-funded research; cooperative stock assessment |
| Pacific halibut | IFQ | 1995 | N | N | "Race for fish" eliminated; ghost fishing mortality reduction of 80% during first year under IFQs; quota currently valued at 3–5 times ex-vessel price[6]; improved fisher safety; improved monitoring and enforcement |
| Pacific sablefish | IFQ | 1995 | N | N | Catching efficiency increased by 1.8 times; 25 million fewer hooks used per year; spawning potential increased 9%; fisher-initiated logbook program; improved monitoring and enforcement |
| Wreckfish | IFQ | 1991 | N | N | While market demand for wreckfish has declined, the fishery is well suited to IFQs because it is single-species, the fleet is small, and there is no recreational component |
| Walleye pollock | Co-op[5] | 1998 | N | N | 1–2% bycatch rate; 100% observer coverage (larger vessels); "real-time" bycatch-hotspot monitoring; spreading of catch temporally and spatially has facilitated Steller sea lion protection measures; fisher-funded research |
| Pacific whiting | Co-op[5] | 1997 | N | N | 1–2% bycatch rate; "real-time" bycatch-hotspot monitoring; recent assessment indicates that overfishing was eliminated in 2002 |

[1]Sources: Sigler and Lunsford (2001); Gilroy (2004); Kelleher (2004); NMFS (2004); Wallace and Hoff (2005); NMFS (2006); [2]Overfishing = exceeding an established fishing mortality (harvest) rate; [3]Overfished = stock is below its prescribed biological threshold; [4]IVQ (Individual Vessel Quota) = similar to an IFQ, except that quota is allocated to specific vessels rather than fishers; [5]Co-op (Cooperative) = a private agreement, similar to an IFQ, that allocates fishers a specific share of the total catch; [6]Ex-vessel price = the price fishers receive for their catch at the dock.

The US Atlantic surfclam fishery exemplifies the potential for effort reduction and TAC compliance under IFQs. On the brink of biological and economic collapse, managers imposed an annual catch limit in 1977, and then adopted IFQs in 1990. Within 4 years (1990–1994), the surfclam fleet declined from 128 to 50 vessels (NOAA 1997; NRC 1999). In 1981 and 1984, surfclam TACs were exceeded by 22% and 21%, respectively, with a pre-IFQ average overharvest of 1.9%. Since the implementation of IFQs, the TAC has been exceeded only once (by a mere 0.2% in 2001), with a post-IFQ average underharvest of 2% (NOAA 2003).

The Atlantic surfclam experience also highlights the potential for substantial consolidation, concentrating quota into the hands of a few individuals or companies (GAO 2002). Consolidation represents a real social cost that some fishing communities may be unwilling to absorb, which, at a minimum, must be factored into implementation decisions and mitigated through program designs that place limits on quota ownership (McCay 1995). Consolidation may also impact ecosystems indirectly, via the activities of displaced fishers and the characteristics of fisheries and communities post-consolidation.

The US Pacific halibut and sablefish fisheries adopted IFQs in 1995. These fisheries experienced less consolidation than the Atlantic surfclam fishery due to quota ownership limits (GAO 2002), but exhibited similar, positive trends in effort reduction and TAC compliance. In the first year, the number of longline vessels targeting sablefish dropped from 1078 to 613, and the season grew from 9 days to 8 months (Sigler *et al.* 2004). The National Research Council (1999) reports that the average halibut overharvest dropped from 6% to –8%. Similarly, Sigler and Lunsford (2001) concluded that the sablefish IFQ fishery reduced overharvests and improved the spawning potential of sablefish by 9%.

Several IFQ fisheries on Canada's Pacific coast have shown that incentives to protect the fish stock (and thus the value of quotas) can lead to remarkable investments in monitoring (Turris 1994; Jones and Bixby 2003). For example, British Columbia groundfish IFQ fishers contribute CDN$3 million annually to fund the fishery's at-sea and dockside monitoring programs, which include nearly 100% observer coverage (Casey *et al.* 1995; Grafton unpublished; Turris unpublished). Obstacles to cheating (by overharvesting quotas or disregarding bycatch and area restrictions) are formidable, because penalties are severe (possible loss of valuable quota) and detection is probable, given the emphasis on improved monitoring and greater communication among all industry participants (Turris 1994). Of course, improved monitoring and enforcement is not unique to IFQs and could be instituted in any fishery at any time. The difference is that British Columbia groundfish fishers themselves are demanding it and paying for it, a reflection of the incentive to protect the value of quotas by ensuring that peers do not cheat.

## Bycatch and collateral mortality

Slowing the pace of fishing can also reduce the number of fish killed through unobserved encounters with fishing gear (collateral mortality). Until IFQs were introduced into the Alaskan Pacific halibut fishery in 1995, the season was restricted to three 24-hour periods (Figure 1). Fishers had an incentive to cut gear loose and race into port to avoid low prices during the inevitable glut of halibut. Apart from the economic losses and more frequent fisher injuries and deaths, this system resulted in a substantial amount of "ghost fishing" – each baited hook cut loose by fishers had the potential to kill several fish, as ensnared and dying fish in turn attracted and hooked other fish. In the first year under IFQ management, the halibut season grew to 8 months, incentives to race were reduced, fewer fishers died, and estimates of ghost fishing mortality in the halibut fishery immediately dropped by 80% – from 1 289 000 pounds in 1994 to 257 000 pounds in 1995 (Gilroy 2004).

IFQ programs may also create perverse incentives to discard saleable fish (Anderson 1994; Turner 1997). Discarded fish often have high mortality rates; thus, if fishers discard the younger, less valuable portion of their catch in order to maximize the market value of their quota (high-grading), they may undermine the breeding potential of target stocks as well as the efficiency of the fishery. Yet examples of quota-induced discards under IFQs are hard to find, in part because price differentials are often not large enough to justify high-grading (Leal *et al.* 2005).

New Zealand IFQ fisheries reduce bycatch by requiring that fishers purchase quota for bycatch or pay a fine (called a "deemed value") based on the amount caught (Squires *et al.* 1998; Sharp 2005). The cost of bycatch is thus internalized and New Zealand fishers can avoid discards by adjusting their quota holdings to reflect the natural mix of fish.

## Habitat

Linking IFQs directly to habitat improvement is challenging. The closest connection may be to the incentive to fish more slowly and selectively. For example, damage to wreckfish habitat decreased when IFQs were introduced, because fewer weights impacted corals and a slower pace allowed fishers to comply with the ban on bottom longlining (Gauvin 1994).

Consolidation of the Atlantic surfclam fleet and a new, high-efficiency dredge have allowed fishers to target areas of high clam density, thereby minimizing the area of seafloor that is swept by dredges each year (E Powell pers comm). Wallace and Hoff (2005) estimate that surfclam vessels currently cover only 110 nautical mi$^2$ out of a total of 40 000 nautical mi$^2$ of habitat. Some IFQ fishers have also taken measures that minimize habitat disturbance, simply for the purpose of lowering costs associated with hauling benthic detritus and repairing damaged gear. If consolidation moves a fishery toward larger boats and gear, associated habitat damage may also increase, although this has not yet been documented. With or without IFQs, additional measures, such as reserves, area closures, and/or individual habitat quotas (based on estimates of marginal habitat damage) may be necessary to help protect critical habitats (Grafton *et al.* 2005; Holland and Schnier 2006).

## Indirect ecological impacts

More than other fishers, IFQ participants invest in the long-term viability of target stocks and marine ecosystems, because individual quota values increase when fish stocks are healthy (OECD 1998). The result is that fishers, scientists, and managers share common goals under IFQs, allowing cooperation to replace the perennial battles and distrust often seen in traditional fishery management. While the evolution of a cooperative atmosphere is not unique to IFQs, the results under IFQ systems have been striking.

Since IFQs were introduced in the Atlantic surfclam fishery in 1990, a cooperative atmosphere has slowly evolved. Initially, IFQ fishers raised money to challenge TAC reductions in court. More recently, surfclam fishers have chosen to collaborate with scientists at Rutgers University's Haskin Shellfish Research Laboratory, using their funds to improve NMFS survey technology. By 1997, and again in 1999 and 2000, surfclam fishing vessels were assisting with NMFS studies to determine the efficiency of the hydraulic dredges being used to assess stocks and set sustainable catch levels. In 2002, surfclam fishers spent $70 000 on sophisticated survey sensing equipment, which "allow for more accurate estimates of current surfclam biomass" (NOAA 2003). And most recently, in June 2004, the fishers actually initiated and funded an important survey of declining Delmarva surfclam stocks, which NMFS lacked the boats and the money to undertake. IFQs have realigned incentives so that surfclam fishers now have a financial stake in the long-term health of the resource and in understanding surfclam population dynamics.

In many IFQ fisheries, fishers advocate *for* catch reductions and area closures (Grafton *et al.* 2005). New Zealand orange roughy stocks have benefited from several voluntary catch reductions, an ongoing voluntary closure of the Puysegur region, and a drop in the percentage of the orange roughy catch taken during spawning on the Chatham Rise, from 90% in the late 1980s to 10% today (Clement 2000; Annala *et al.* 2004). A group of New Zealand rock lobster quota owners voluntarily lowered their catch for the coming season, in response to an unexpected stock decline (D Sykes pers comm). The quick action of rock lobster quota owners contrasts with traditional management, which relies on government agencies to collect and analyze data and adjust catch limits accordingly, a process that can span years.

Courtesy of R Mincher

***Figure 2.*** *The* FV Tasman Challenger *is a 26-m vessel specifically designed to carry out research, enhancement, and monitoring activities in the New Zealand southern scallop and oyster fisheries. From the design phase to the present, the* FV Tasman Challenger *has been funded exclusively by quota owners.*

There is preliminary evidence that IFQ fishers are also more likely to fund ecological research and contribute their practical knowledge of fisheries to scientists. IFQ fishers recognize that better ecological data can guide decisions to improve the future stability and value of the fishery, as well as their stake in it.

New Zealand southern scallop fishers fund research and stock enhancement activities, manage a rotational fishing regime, and encourage cooperation among fisheries (Arbuckle and Metzger 2000). The Challenger Scallop Enhancement Company Ltd (Challenger), which represents scallop quota owners, carries out all stock assessment and enhancement research with contributions from fishers constituting up to 20% of their earnings (Arbuckle and Metzger 2000). These levies have given quota owners the ability to act quickly on stock assessment data and new technology. In 1995, Challenger invested in a sophisticated research vessel, the *FV Tasman Challenger* (Figure 2), because quota owners felt that greater knowledge of the fishery was needed to develop a more responsive management regime (Arbuckle and Metzger 2000). The *FV Tasman Challenger* monitors closed areas and executes scallop-bed seeding operations to hedge against volatile stock abundances and changing environmental conditions. While scallop fishers are focused on the long-term stability of the fishery, the exact cause for this is unclear. It is likely that this level of stewardship is the result of fishing a sedentary stock with IFQs that are strictly defined as property rights.

In the US, IFQs are privileges rather than property rights, a distinction that could affect long-term investments in the fishery. Still, participants in the US North Pacific pollock cooperative (a private harvest agreement that works very much like an IFQ) have collaborated with NMFS to develop bycatch exclusion devices and have funded research to understand Bering Sea ecosystem dynamics, improve stock assessment models, and examine factors involved in the decline of Steller sea lion (*Eumetopias jubatus*) populations. Members of the pollock cooperative have also initiated innovative and effective bycatch reduction strategies (Panel 1; Figure 3).

## ■ Marine protected areas and sustainable management

IFQs alone will not address all of the ecological concerns associated with fishing. IFQs do not address problems such as the vulnerability of gag grouper spawning aggregations, in which male groupers congregate at specific locations (Coleman *et al.* 2004). Nor can IFQs provide 100% protection for particularly unique or sensitive marine habitats. For this reason, complementary measures such as marine protected areas (MPAs), gear restrictions, and others are required. Fortunately, IFQs can help provide incentives for fishers to accept and even create MPAs.

MPAs are a popular tool for conferring protection to unique marine habitats and hedge against overfishing and environmental variability. Indeed, Halpern and Warner (2002) suggest that the benefits to species within MPAs or marine reserves accrue quickly and are long-lasting. Yet protected and reserved areas by themselves only address a symptom of overfishing (Sanchirico 2000) and "work best in conjunction with constraints on fishing effort outside the reserves" (Garrison 2002). Losing prime fishing grounds to MPAs has the potential to bankrupt fisheries or concentrate fishers into other sensitive areas. To be effective, MPAs must therefore be created with broader ecological, economic, and social implications in mind (Coleman *et al.* 2004). It seems unlikely that the current movement toward ecosystem-based fishery management will live up to expectations, unless excess fishing

**Panel 1. Harvest cooperative management encourages innovative bycatch solutions**

The Pollock Conservation Cooperative (PCC) was formed in 1998 to promote the conservation and utilization of marine resources. The cooperative is an agreement among US Bering Sea pollock fishers that assigns individuals a specific share of the catch, thus acting as a privately administered IFQ. Since the PCC was formed, the pace of fishing has slowed, resulting in "better fishing practices, including lower bycatch and higher utilization rates" (NPFMC 2002).

The PCC highlights the benefits of reducing effort and the importance of monitoring and enforcement in "designated access privilege" systems. It also serves as an example of innovative, bottom-up conservation measures and self-policing. In addition to 100% observer coverage, the PCC collects levies from fishers and contracts with a private firm (Sea State Inc) to compile "real-time" NMFS catch data for individual vessels. This information is sent to all vessels, to discourage quota busting and bycatch. Normally, NMFS managers close large "salmon savings areas" in the Bering Sea to pollock fishing when bycatch thresholds are reached. The goal is to protect salmon populations, but Sea State data indicate that bycatch levels have actually increased during these large area closures (K Haflinger pers comm; Figure 3). Recognizing that salmon congregations are concentrated and highly mobile, PCC fishers have developed an alternative strategy, which voluntarily closes "hotspots" – specific areas where pollock trawlers have encountered salmon – for various lengths of time, based on each vessel's overall bycatch rate.

Preliminary evidence suggests that real-time "hotspot" monitoring is an effective means of reducing bycatch in the PCC pollock fishery. It is a solution designed to fit the specific characteristics of the pollock fishery. Moreover, it is a strategy developed and supported by pollock fishers, through their cooperative.

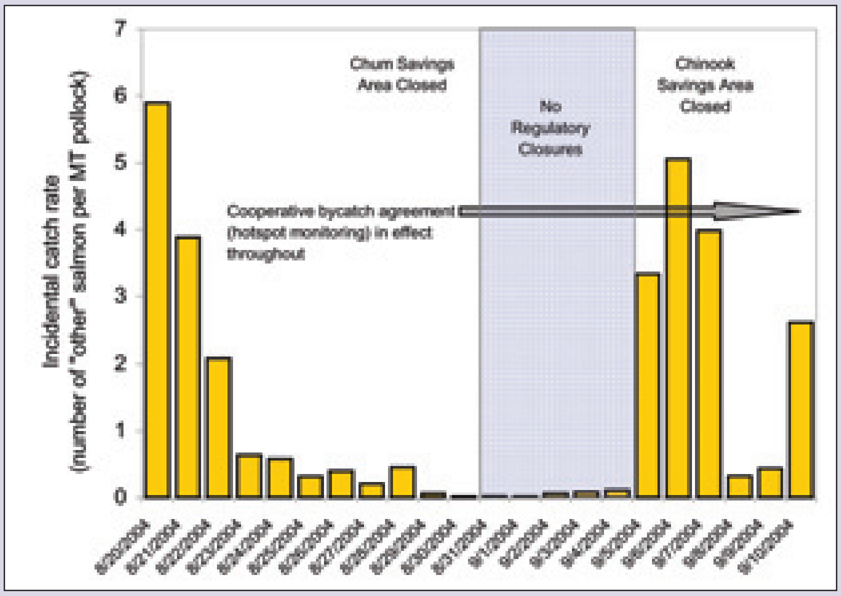


***Figure 3.*** *Incidental catch rate of "other" salmon in the "catcher vessel" walleye pollock* (Theragra chalcogramma) *cooperative. A voluntary bycatch monitoring agreement among cooperative members that disseminates real-time data on salmon congregations has helped fishers avoid "hotspots" where bycatch rates are high. Unfortunately, when NMFS also closes the expansive chum and chinook savings areas, incidental catch rates often increase because fishers are forced into areas that contain high concentrations of salmon. Data from Sea State Inc and NOAA fisheries observer data (2004).*

effort, misaligned incentives, and the social dimensions of sustainability can be addressed first (Grafton *et al.* 2005).

## Conclusions

IFQs are often criticized as a management tool that is inconsistent with the movement toward ecosystem-based management. This view ignores a major strength of IFQs, namely that their implementation can realign fundamental incentives and thereby help to address the immediate threat of overfishing. Effective ecosystem management will require a deeper understanding of marine ecosystems than currently exists. Even if scientific uncertainty persists, IFQs create incentives to help fishers accept precautionary approaches and conservative catch limits (Witherell *et al.* 2000). Most importantly, IFQs create a management environment in which all stakeholders, including fishers, managers, scientists, and the public, have long-term interests in mind.

There is pressing need for more rigorous and quantitative studies of the ecological impact of IFQs, especially the development of new metrics to clarify the contexts in which IFQs are most effective. Creating fishery management programs that realign incentives while balancing economic, social, and ecological values is a challenging and complex endeavor (see Fina 2005). The continuing debate surrounding IFQs highlights the importance of understanding the social dimensions and incentives of fishery management systems. Hopefully, lessons from our experiences with IFQs and harvest cooperatives can inform future management decisions that more explicitly address the ecological importance of incentives.

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**For suggested reading, please see WebPanel 1.**

 

**WebPanel 1. Suggestions for further reading**


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