FISH and FISHERIES

Voluntary institutions and behaviours as alternatives to formal regulations in recreational fisheries management

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Abstract

Traditional regulatory options (formal institutions) imposed by government agencies such as harvest and gear restrictions represent the standard in recreational fisheries management, at least in developed countries. However, there exist a number of alternatives including the use of angler education programmes that attempt to evoke voluntary changes in angler behaviour, resulting in the emergence of voluntarily motivated resource-conserving informal institutions. These 'softer' approaches to aquatic stewardship and fisheries management can be developed in cooperation with stakeholders and in many cases are led by avid anglers and angling groups. Examples of such measures include voluntary sanctuaries, informally enforced seasonal closures, personal daily bag limits, self-imposed constraints on gear, development of entirely live-release fisheries, and adoption of fish and aquatic ecosystem conservation-oriented gears and release practices. Education efforts that provide anglers with knowledge on best practices and empower them to modify their behaviour hold great promise to meet formal management goals and objectives, but seem to be underutilized relative to formal regulations. This article highlights the benefits and challenges of relying on informal institutions as alternatives to traditional regulatory options. Informal institutions that protect resources and help overfished stocks recover hold great promise in both developed and developing countries, particularly when there is a single stakeholder group or when the capacity to enforce traditional regulations or to invest in stock assessments is limited. Informal institutions may help make formal institutions more effective or can even be alternatives to costly institutions that depend on enforcement to be effective.

Keywords angler education, harvest regulations, recreational fisheries, stakeholder engagement, voluntary regulations

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Introduction

Recreational fishing regulations are used throughout the world to manage social issues, prevent overfishing, or manipulate aquatic communities (e.g. managing against an exotic species, and manipulating predator–prey interactions) and populations (e.g. creation of a trophy fishery) (Radomski *et al.* 2001; Cowx *et al.* 2010). Such formal rules in use are known as formal *institutions* in the political science literature (Ostrom 1994). The traditional regulatory toolbox used to manage recreational fisheries is diverse and includes strategies to reduce the number of fish harvested (i.e. creel limits), to restrict the size of fish that can be harvested (e.g. minimum-size, maximum-size and closed or open slot limits), to influence choice of fishing gear (e.g. to both limit use of certain gears or promote use of resource-conserving gear), and to restrict when and where anglers can fish (e.g. use of seasonal closures or protected areas, ban on the use of boats and other tools that facilitate access) (reviewed in Noble and Jones 1993; Johnson and Martinez 1995; Cooke and Cowx 2006). Despite these and other traditional regulatory options that represent the standard in recreational fisheries management (Sigler and Sigler 1990; Krueger and Decker 1993; Sutinen and Johnston 2003), at least in developed countries, there exist a number of alternatives to formal institutions (e.g. formal regulations) imposed by natural resource agencies, such as the use of angler education programmes and voluntary changes in angler behaviour serving as informal institutions that guide voluntary behaviour locally. These 'softer' approaches to informal institution development could be strategically used to achieve management goals and objectives (Arlinghaus 2004), and they can be strategically developed in close cooperation with stakeholders, and, in many cases, have been initiated and led by stakeholders themselves. However, we think that fostering the development of resource-conserving informal institutions is less advanced relative to costly formal institutions that depend on appropriate enforcement and sanctioning to be effective (Walker *et al.* 2009). Simply because of the costs involved, it should be obvious that reliance on voluntary norms of proper behaviour among anglers that facilitates achieving management objectives (e.g. development of voluntary release of fish to reduce fishing mortality) is a preferred approach to formal constraints as it increases compliance and reduces monitoring, enforcement and other transaction costs. Clearly, it is also worth noting that in some instances, voluntary actions and behaviours by anglers can also undermine management activities (e.g. anglers do not harvest small fish even when encouraged; see Goeman *et al.* 1993), in which case informal institutions may also be a burden to management agencies. The question would then be how to modify undesirable behaviours to facilitate the uptake of more desired institutions.

The goal of this study is to highlight how angler education and voluntary changes in angler behaviour are often overlooked as alternatives to, or components of, traditional 'mandated' (i.e. formal) regulations. In this article, we discuss both the benefits and challenges of relying on the use of voluntary management strategies to achieve fisheries management goals. We also present a brief research agenda to identify the knowledge gaps that need to be addressed before there could be more strategic use of informal institutions that spiral among angler communities. To the extent possible, we attempt to be inclusive, covering both developed and developing countries, as well as marine and freshwater realms, but recognize that the majority of research on recreational fishing regulations has taken place in inland waters of North America. We adopt the definition of

Arlinghaus and Cooke (2009) for recreational fisheries, i.e. fishing of aquatic animals that do not constitute the individual's primary resource to meet nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets. A variety of gears can be used including rod and reel, traps, spears and nets, although for the purpose of this article we focus on rod and reel (i.e. recreational angling).

The need for exploring alternatives to formal institutions

The use of regulations to manage recreational fisheries is extremely common at least in the developed world (Noble and Jones 1993; Johnson and Martinez 1995), so why is there a need to explore alternative management strategies such as those that rely on education and voluntary actions? There are a variety of reasons to justify the exploration of alternatives to formal institutions, not least of which is the fact that for fisheries management to be successful, it is essential to engage stakeholders and involve them in the management process (Granek *et al.* 2008). To that end, using educational efforts to encourage actions that we call voluntary 'regulations' because they have effects similar to that of formal regulations (e.g. by reducing fishing mortality) represents an excellent opportunity for fostering stewardship by anglers and increase resource-conserving behaviour at low public costs. Formal institutions are usually costly as they need, at the very least, some level of enforcement to be effective (Walker *et al.* 2009). Often, anglers voluntarily develop norms of proper behaviour that then result in taboos, customs and habits that often are not under the control of managers, but help achieve public management objectives. Under many situations, such voluntary behaviours are useful for conserving fishery resources, and, therefore, changes to habits and voluntary behaviour often align with management objectives (e.g. the rise of voluntary release in largemouth bass [*Micropterus salmoides*; Centrarchidae] fisheries in the USA has strongly reduced mortality to levels that no longer demand any form of formal regulations; Myers *et al.* 2008). Where norms of voluntary behaviour that are desired are not yet in place, fostering of suitable behaviour might be approached using a range of outreach and communication efforts. Such investments might seem costly in the beginning, but may pay off in the long term by saving monitoring and enforcements costs that are often prohibitive for the vast landscapes fished by many contemporary recreational fisheries (Post *et al.* 2002).

Traditional, formal management options require strong governance structures, institutional capacity and funding to enable the development and implementation of regulations (through legislative means), the enforcement of regulations (policy compliance strategies) and the application of regulations in a judicial context (through the judiciary) (Krueger and Decker 1993). In the developed world, such governance structures and capacity exist for some more valuable fisheries, but are not widespread (e.g. monitoring efforts are often not covering vast freshwater landscapes), although enforcement activities are expensive and in most jurisdictions seem to be supported at an insufficient level to cover the entire array of anglers and the abundance of waterbodies (Post *et al.* 2002). In developing countries, and some developed ones, formal enforcement is often even more limited, and in these conditions, peer-to-peer oversight might well function similar to official sanctioning. Sometimes existing governance structures do not have the capacity to enact timely regulations with a scientific basis, and this is also present in some developed countries (Daedlow *et al.* 2011). And when stock assessments and regulations exist in developed countries, compliance can be low (e.g. Sullivan 2002; Page and Radomski 2006; Wilberg 2009). Under these conditions, information institutions may be extremely helpful for maintaining fisheries' quality and critical habitats.

It is widely accepted within the management community that regulations need to be biologically effective and socially acceptable if they are to achieve their objectives (Brousseau and Armstrong 1987). In reality, regulations are rarely perfect in terms of achieving their objectives and keeping all stakeholders 'happy' (Renyard and Hilborn 1986). As such, bottom-up approaches to address fisheries management issues may be more effective in eliciting stakeholder support than top-down regulatory approaches (Granek *et al.* 2008; Danylchuk and Cooke 2011), although this increases the need for communication, participation and transparent decision making. However, even such approaches will not appeal to all anglers as there is a segment in most human populations that dislikes authority and feels that when, where and how someone can fish should not be dictated by anyone other than oneself. An extreme example emanates from the USA where over the past decade, there have been

efforts to enact the 'Freedom to Fish Act', which would make it essentially a constitutional right to fish all waters without the ability of governments to restrict access (Danylchuk and Cooke 2011). Under these situations, even the most well-planned formal regulation might not achieve its intended objectives, and alternative 'management' approaches, called *indirect* by Arlinghaus (2004), might be needed. These approaches would try to engage with anglers to harness voluntary behaviours that align with management objectives without any form of formal authority involved. Such institutions would decrease transaction costs and may stimulate viable fisheries with co-management properties, where governmental control is no longer a perquisite to successful management.

A caveat of formal institutions is that they tend to become complex if authorities move from 'one-size-fits-all' regulations that govern entire regions, to lake or river section-specific regulations. The complexity of current regulations in many freshwater recreational fisheries poses substantial challenges to anglers (Schill and Kline 1995; Schill and Scarpella 1997). A study in Minnesota revealed that anglers were less likely to be aware of complex regulations (e.g. open or closed slot limits) relative to simpler regulations, and thus failed to comply with some of these regulations (Page and Radomski 2006). Regulatory guidebooks in some jurisdictions are lengthy and complicated, which can detract from the fishing experience, and result in anglers questioning the legitimacy and need of some regulations (Radomski *et al.* 2001). To that end, there is a growing interest within fisheries management agencies in simplifying regulations in some jurisdictions (e.g. in Ontario, the Ministry of Natural Resources conducted within the 'Ecological Framework for Fisheries Management'), and alternatives to formal institutions might involve the fostering of resource-conserving or conflict-reducing softer approaches subsumed under the term informal institutions.

Given the arguments presented above, it is somewhat surprising that formal regulations are used to the extent that they are or, alternatively, that there is so little strategic use of informal institutions in contemporary recreational fisheries. There are certainly many success stories associated with the use of regulations, and we are not suggesting that they are not a key component for recreational fisheries management. Nevertheless, there are alternatives to traditional fisheries management tools that we submit warrant further investigation and application. Of particular interest is how educational activities and subsequent voluntary adoption of conservation measures by anglers and angler organizations could be used in situations where the capacity to use traditional regulations effectively is low (e.g. in developing countries, remote fishing areas, areas lacking enforcement personnel or funding) or where there may not be support for government-imposed regulations.

Overview of informal institutional options

Here, we summarize how the encouragement of voluntary 'regulations' that do not depend on enforcement and government control has been used, or could be strategically used, to help manage fisheries. As a preface, it is worth noting that our initial attempts to search the peer-reviewed literature (using ISI's Web of Science) failed to identify many examples of voluntary 'regulations' (including informal institutions, norms, taboos, habits and customs), so we expanded our search to include grey literature (e.g. government technical reports, and consulting reports) and even online examples (using general Internet search engines – e.g. fishing blogs, government and NGO websites and fishing media).

Creel limits

Creel limits, also known as bag limits, are intended to limit the number of fish harvested by anglers, usually on a given day. When applied in a traditional regulatory context, they are often used in terms of a daily creel, limiting the number of a particular species that can be harvested in a given day, or a possession limit, which restricts the total number that an individual angler can possess at any given time (e.g. in freezer at home). There are certainly individual anglers that practice voluntary catch-and-release even in the presence of creel limits (e.g. Clark 1983; Quinn 1996; Myers *et al.* 2008), although such activities are not the focus of this discussion. Instead, we were interested in the application of 'voluntary creel limits' that are not the result of a specific action by government, NGOs, clubs or some other entity and was directed at a specific fishery or suite of fisheries. Examples of voluntary creel limits were scarce. Indeed, we

were unable to find any peer-reviewed articles that discussed voluntary creel limits. Moreover, when they had been used (usually found in grey literature, media reports and online web forums), we were unable to find any examples of where the effectiveness of voluntary creel limits were evaluated (biologically and socially). However, we are aware that anglers develop personal norms of constrained harvesting, thereby voluntarily limiting the number of fish taken per day. Reasons are likely to vary among anglers, but resource conservation is likely to play an important role if awareness of overfishing potential is achieved.

There is much range in the type of organizations advocating for the use of voluntary creel limits. Most of the government-driven examples that we found emerged from North America, although likely representing a language bias of the authors. For example in 1989, summer flounder (*Paralichthys dentatus*; Paralichthyidae) anglers in Virginia were asked by the Virginia Marine Resources Commission to adopt a six fish creel limit voluntarily, although the state agency already maintained a mandatory 10 fish limit, which, at the time, was purported to be the first instance of a state agency advocating a specific voluntary creel limit (Waggoner 1989). Similarly, the Atlantic Coast Conservation Association – a stakeholder group – urged anglers to adopt the voluntary creel. More recently, the North Carolina Wildlife Resources Commission suggested a voluntary creel limit of five sunfish (*Lepomis* spp.; Centrarchidae) and two black bass (*Micropterus* spp.; Centrarchidae) at the Broughton Ponds public fishing site with a justification that the ponds were rather small. Similar arguments are known to some of the authors from small stillwater fisheries in Germany. In Wisconsin, the state government has suggested that a lake association (Solberg Lake Association) could assist by actively promoting a voluntary bag limit for large bluegill (*Lepomis macrochirus*; Centrarchidae) and crappie (*Pomoxis* spp.; Centrarchidae) as an interim 'precautionary' strategy until formal regulatory options could be identified and implemented (Scheirer and Neuswanger 2010). In a review of the status of American eel (*Anguila rostrata*; Anguilidae) in the Gulf region of Canada, Locke *et al.* (1995) report that voluntary bag limits have been instituted in Nova Scotia (10 eels) and Prince Edward Island (12 eels) when fishing recreationally with pot traps. A voluntary limit for recreational spearing of eels also exists in Nova Scotia (10 eels), which is encouraged but not enforced. Interestingly, at the time of their review, the commercial fishery did not have bag limits, although they did have to abide by a range of other regulations (e.g. seasonal closures).

There are also examples of voluntary creel limits that have been driven by formalized recreational fishing groups. In New Zealand, the North Island South East Regional Recreational Fishing Forum (a multi-stakeholder advisory group) advertised a voluntary bag limit reduction from 6 to 4 rock lobsters (*Jasus edwardsii*; Palinuridae) taken by recreational fishers from a local fishery in 2008, a voluntary move that was stimulated by a regulatory creel limit reduction made in the commercial fishery. The Forum distributed a press release to share the development with recreational fishers and the broader public (Moroney 2008). In the UK, The River Exe and Tributaries Association operate a voluntary bag limit for Atlantic salmon (*Salmo salar*; Salmonidae), with 60% of all salmon caught to be returned despite no regulatory authority demanding this occur. There are also examples of fishing guides and charter boats adopting fleet-wide or association-wide voluntary bag limits for some sensitive species. In one instance, the US Marine Fisheries Service issued a 'rule' that required captains and operators of federal-permitted charter vessels in Texas to 'voluntarily' limit anglers to two red snapper (*Lutjanus campechanus*; Lutjanidae) per trip, apparently a move that led to opposition from charter captains (Hawkes 2012). Similar findings are known from fishing guides in Germany who advise customers to limit the take of northern pike (*Esox lucius*; Esocidae) from the Baltic coast. Although we were able to identify several examples of where voluntary creel limits were used, there is no information on effectiveness, compliance or success of this approach in positively influencing fish populations and how these norms spread among anglers. However, if effort is not too high, any form of voluntary bag limit offers hope to reduce fishing mortality, unless the released fish are not compensated for by increased effort on alternative days (Beardmore *et al.* 2011).

Size-based harvest limits

Size-based harvest limits represent one of the most common tools used to regulate recreational fisheries; their use depends strongly on management objectives, along with the ecology and density

dependence of the target species. Minimum or maximum size limits are perhaps the most common regulations that enable management agencies to control the size of fish that are harvested to influence harvest size (e.g. some anglers prefer large fish in the harvest; Goeman *et al.* 1993) as well as the sizes of fish to be protected to safeguard future recruitment and replenishment of the stock (Pierce 2010). Slot-based limits come in two variants, open (i.e. harvest) or closed (i.e. protected) slots. They are generally not as common, and may be perceived by anglers as more complex; both tools can be used to either limit or encourage harvest of fish for given size range. Protected slots are thought to be useful in fish that are not recruitment limited, and can be used to thin small overabundant size classes to encourage rapid growth through the slot after which harvest is again permitted. Harvest slots, a combination of minimum and maximum size, may be useful in recruitment limited situations where large fish have a particularly valuable role to play as spawners and as trophies for anglers, and fish smaller than the lower harvest limit are important to maintain a suitable spawning stock size – harvest would then be constrained to intermediately sized 'kitchen' fish (Arlinghaus *et al.* 2010a). Despite the frequent use of mandated harvest regulations, such as those explained above, we were able to locate few examples of their use in a voluntary context in the peer-reviewed literature. Like creel limits, voluntary size-based harvest limits were, however, encouraged by a variety of entities including governments, tourist boards/resorts/marinas, charter boat associations and fishing clubs. Moreover, many anglers are known to develop their own standards of what sizes to keep or release ('I only keep fish over X mm no matter what the regulation says'), which interacts strongly with standard harvest regulations, and can even negate their well-indented objectives (Goeman *et al.* 1993). In some countries, such voluntary release behaviour conflicts with rules mandating harvest of any legal size fish, e.g. Germany (Arlinghaus 2007). Of course, in such situations, education for voluntary behaviour can be perceived as encouraging illegal behaviour, which is potentially costly as overfishing is induced by regulations that demand the kill of all legal fish captured (Arlinghaus *et al.* 2009).

The most well-studied voluntary size-based harvest limit that we found in our search was from work by the Missouri Department of Conservation on Lake Taneycomo, Missouri. A voluntary protected slot limit of 304–406 mm for rainbow trout (*Oncorhynchus mykiss*; Salmonidae) and brown trout (*Salmo trutta*; Salmonidae) resulted in the average size of trout in the population to increase from 269 to 325 mm, as well as the number of trout over 406 mm to increase by 6.5% in 1 year (Weithman cited in Brousseau and Armstrong 1987). Interestingly, only 13% of fish being caught in the desired protected slot were released voluntarily (Weithman 1980), suggesting relatively low compliance with this particular voluntary regulation. In retrospect, this study represents an association between a management action and a biological response, but, as outlined in Weiland (1994), the trout fishery in Lake Taneycomo was likely responding to a variety of factors that may have influenced population responses. This is a common feature of regulation research in that it is often case specific, unreplicated and unreported, and therefore, few systematic regulation assessments have been completed in recreational fisheries (Wilde 1997). Another unknown is the level of voluntary release within the slot size that would have occurred independent of the encouragement of a voluntary protected slot limit.

One of the first non-government-initiated voluntary size-based harvest limits we found was for striped marlin (*Tetrapturus audax*; Istiophoridae) in New Zealand where anglers promoted a minimum-size limit of 90 kg enacted in 1987/88 by the New Zealand Big Game Fishing Council (Kopf *et al.* 2005). Similarly, recreational charter boat operators off the British Columbia coast implemented a voluntary minimum-size limit of 65 cm for Pacific halibut (*Hippoglossus stenolepis*; Pleuronectidae), the same mandatory size limit that applied to the commercial halibut fleet (Murphy 2002). In the Thy Region of Denmark, a voluntary minimum-size limit of 40 cm is applied to rainbow trout and is advertised by the tourist board. Individual resort and marina owners have also instituted voluntary size limits. For example Kirk Kove Cottages in Ontario suggests a voluntary minimum-size limit for both walleye (*Sander vitreus*; Percidae) and black bass. The West Carling Association in Georgian Bay area of Ontario recommended a voluntary maximum-size limit on black bass for its members. Similarly, guides for northern pike in Germany argue for keeping intermediately sized pike and releasing all trophies; in essence, this equates to a maximum-size limit vol-

untarily enforced in addition to a voluntary bag limit of 1 northern pike per angler and day harvested. The examples represent a nearly exhaustive list of those that we could find emphasizing the relative rarity at which voluntary size limits have been applied. However, it is very likely that a systematic survey would reveal more voluntary behaviours by anglers and angling NGOs to complement, or even invent, new size-based harvest limits where they are currently not present. No scientific study is available on this topic, however, so far.

Gear restrictions

Gear restrictions are frequently used by recreational fisheries management agencies to influence the size/species of fish being captured, minimize catch-and-release mortality and ultimately prevent over-exploitation. Adopting conservation-minded fishing gears (i.e. gear types that the angler believes to reduce stress or injury for fish, or gears that have been actually validated to do so), even in the absence of regulations, represents one of the most widespread voluntary actions by angler communities and specialized angler groups. Barbless hooks represent an example of a gear modification that is required by law in many jurisdictions, but broadly encouraged as a voluntary practice for many fisheries. A review of fishing regulation guides in North America revealed that general catch-and-release guidelines for angled fish almost always included the encouragement to use barbless hooks (Pelletier *et al.* 2007). In the lower Columbia River, the Washington Department of Fish and Wildlife intended to enact a regulation for mandatory use of barbless hooks by anglers who fish for Pacific salmon (*Oncorhynchus* spp.; Salmonidae) and steelhead (*Oncorhynchus mykiss*; Salmonidae), but prior to instituting the regulation, they initially asked anglers to do it voluntarily. Many fishing lodges and guides also require, or strongly encourage, their clients to fish with barbless hooks, even in the absence of regulations. Circle hooks represent another gear type that has been voluntarily adopted by a number of anglers, guides and tournaments. Indeed, early adoption of this gear by the Billfish Foundation and their tournaments served as the basis for eventual regulatory actions by a variety of governments (reviewed in Cooke and Suski 2004 and Cooke *et al.* In Press).

The use or disuse of specific bait or lure types is also common in both regulatory and voluntary contexts. For example many fisheries restrict the use of live or organic baits and many anglers (or fishing clubs or associations) avoid using bait in favour of lures or flies. This is also the case with a number of competitive angling tournaments that restrict the use of live bait (e.g. bass fishing tournaments). The Haliburton Forest and Wildlife Reserve (HFWR) in central Ontario voluntarily restricts the use of live bait to worms despite the fact that provincial rules do not (HFWR 2012) in an attempt to minimize the potential for introduction of non-native species. Relatedly, government agencies and NGOs have attempted to raise awareness related to problems with transporting and releasing bait bucket contents. Although in some cases formal regulations are used, education appears to be a more common approach (e.g. Striped Bass Conservation Coalition, Ontario Federation of Anglers and Hunters).

Voluntary use or disuse of fish handling gear is also encouraged within certain segments of the recreational angling community. For example lip-gripping devices have been shown to result in the physical damage of bonefish (*Albula vulpes*; Albulidae; Danylchuk *et al.* 2008), and subsequently a bonefish-focused NGO (Bonefish & Tarpon Trust; BTT) is suggesting that these fish-handling tools not be used (BTT 2012). Similarly, landing net mesh type has been shown to influence the injury and mortality of fish (e.g. Barthel *et al.* 2003), and numerous formal and informal recreational angling groups call for the disuse of landing nets or only the use of landing nets with a knotless mesh (e.g. the Kamchatka region; Shatilo 2008) or even live release cradles (e.g. for large esocids – Muskies Canada Inc., Ottawa, ON, Canada). In some fisheries, such as common carp (*Cyprinus carpio*; Cyprinidae) fisheries in central Europe, anglers are encouraging the voluntary use of so-called unhooking mats to limit mucus abrasion to carp when handled and photographed (Arlinghaus 2007). Similarly, the use of antiseptics is encouraged by specialized carp anglers to limit the injury, and common carp anglers have also invented so-called bolt rights (fixed lead on the leader) to facilitate 100% shallow hooking (Rapp *et al.* 2008). Other tackle innovations for gearing artificial baits are currently being developed in Denmark, resulting in a very high incidence of shallow hooking and facilitating the use of small hook sizes in lures

such as crankbaits to limit injury (J. Bursell, Editor in Chief of Danish Fishing Magazine, Fisk & Fri, Denmark, personal communication).

In a more general context, the Minnesota Department of Natural Resources (MN DNR) has suggested that the continual improvements in fishing gear have made anglers more effective at finding and catching fish (e.g. depth/fish finders, GPS and underwater cameras) such that they are asking tough questions such as should they impose limits on technology to protect fish from overharvest (MN DNR 2012). In particular, they have considered whether such limits be voluntary, and, if so, would enough anglers comply to make a difference. Clearly, reducing the effectiveness of gear is something that is often used in a more regulatory framework. For example in many small German angling clubs, there are club-specific rules to limit the use of boats, groundbait or other techniques that are designed not only to constrain environmental impacts, but also to limit effectiveness of fishing. This reflects the norm of 'Weidgerechtigkeit' – a term describing ethical behaviour of fair chase with the fish. It actually appears that for some angler types, the old adage 'the harder the challenge, the greater the achievement' applies such that self-imposed constraints are accepted even if these make fishing harder (e.g. fly fishing only sections where organic bait could be more powerful in terms of catching fish).

Area and seasonal restrictions

Regulations that restrict access to a fishery are common and are thought to provide a means to limit access to fish and thus reduce fishing mortality, particularly during vulnerable or critical times of the year when angling could have disproportionately large impacts on individuals or populations (e.g. during spawning time; Noble and Jones 1993). Legislated protection of habitat or areas has been a cornerstone of terrestrial conservation for quite some time, while the concept of using legislated protected areas to conserve marine resources has been present for several decades (Agardy 1994). Because the legislative machinery required to implement mandated protected areas can move slowly (along with other obstacles including ownership and a lack of scientific data), conservation groups in the UK implemented Voluntary Marine Conservation Areas to provide protection for valuable marine resources (Gubbay 1993). Establishment of these voluntary reserves is dependent on public support for their effectiveness, and consequently involves a strong educational component to engage user groups and promote interpretation and awareness (Jones 1999). Studies have shown that this voluntary approach to spatial closures can be successful in both achieving conservation objectives and promoting stakeholder cooperation, indicating the potential for voluntary closures to be an effective management tool (Gubbay 1993; Jones 1999; Granek *et al.* 2008).

The use of voluntary time/space closures in fisheries has received comparatively less attention, but examples of protected areas to protect fisheries exist and their design and implementation continues to be encouraged (Suski and Cooke 2007). For example a no-fishing reserve in a Zimbabwe lake proved successful at increasing both the number and size distribution of several freshwater fish families (Sanyanga *et al.* 1995), whereas Murray and Ferguson (1998) reported that Voluntary No-take Bottom Fish Recovery Areas in the USA have been used as part of a network of marine protected areas to prevent overharvest of fish. In Germany, almost every small local angling group will implement so-called 'silence areas', parts of a lake where access and fishing are prohibited, and anglers would usually voluntarily enlarge legislated protected seasons. Some of these closures are at the interface of formal to informal as they are binding for all club members, but not part of official legislation for a given state. Their effectiveness in relation to fishing pressure has not been quantified to date.

Whereas the German example is self-organized by local anglers, in Ontario, Canada, researchers worked with local residents to design and implement voluntary no-fishing zones during critical spawning periods to protect black bass (*Micropterus* spp.; Centrarchidae), a popular group of freshwater sport fish. Black bass have a protracted parental care period, and research has demonstrated that removal of a black bass from his brood by anglers can result in complete brood loss from predation (Philipp *et al.* 1997). Existing laws in parts of Ontario prohibit anglers from targeting black bass prior to the last Saturday in June in an attempt to reduce the likelihood of angler capture and increase the probability of successful reproduction for brood-guarding males. However, for species such as bluegill and black crappie, it is

difficult for enforcement officials to distinguish genuine bluegill anglers from those illegally performing catch-and-release angling for nesting black bass. Local residents were frustrated by considerable illegal fishing targeting black bass and a lack of enforcement activity (Kubacki 1992; Ferguson 1995), and decided to try a different, grass-roots approach to protect vulnerable black bass. In an attempt to suppress illegal angling, voluntary no-fishing zones were subsequently established in three eastern Ontario lakes (Ferguson 1995; Suski *et al.* 2002). These conservation zones were not mandated by legal authority, but rather were established by conservation-oriented residents who wanted to provide extra protection to spawning individuals. Portions of lakes (i.e. embayments and stretches of shoreline) that had high densities of spawning individuals were voluntarily designated as off-limits to all fishing for any species during the black bass spawning period (approximately the months of May and June). The conservation areas were marked with floating buoys and signs along shore, and signs placed at public boat launches and tackle stores informed anglers of the closures. Anglers were allowed to fish legally for species such as bluegill and black crappie in portions of the lake outside of the conservation zone, but, by having voluntary conservation zones designated as zero angling, it was easy to identify anglers that either were unaware of regulations, or were attempting to fish illegally. If an angler was observed with lines in the water inside the voluntary conservation zones, even if they were targeting a legally allowed species, he/she was approached by local residents, informed of the voluntary sanctuary and asked to fish elsewhere on the lake. The residents had no legal authority to charge anglers or prohibit them from angling, but the hope was that anglers would voluntarily leave the conservation area, thereby ensuring maximum protection for black bass. Peer pressure has been shown to be a powerful source of pro-conservation behaviours in various instances across many common-pool resource contexts (Ostrom 1994). There were challenges, however, in that by identifying specific areas where fishing was to be 'restricted', they were also highlighting sensitive areas (i.e. spawning sites) for unscrupulous anglers (Ferguson 1995).

One key message of the above is that for voluntary regulations to work, some level of enforcement is still needed to deter law breakers. However, experience shows that in smaller closed clubs, peer pressure might be sufficient because law breakers are at risk of tarnishing their reputation, which may repel them from pursuing 'illegal' behaviour (e.g. see Milinski *et al.* 2002). Therefore, voluntary regulations depend on some level of peer-driven enforcement of voluntary regulations (or norms of proper behaviours). At sites where local residents had an active enforcement body and had voluntary conservation zones located in proximity to populated areas, voluntary conservation zones reduced the amount of illegal angling activity, and also increased the reproductive output of black bass (Suski *et al.* 2002). At sites with low levels of enforcement, either because of lack of interest from local residents or conservation zones being located far from populated areas, the signs identifying the conservation zones appeared to attract anglers as the level of illegal angling activity was higher inside the conservation zone compared to that in control areas outside the conservation zone (Suski *et al.* 2002). Together, results from the black bass study from Ontario demonstrate the potential for angler-driven voluntary conservation activities to have positive, population-level benefits for fish, but only if enforcement activities by peers are sufficiently high and effective, similar to results from more formal enforcement studies (e.g. Walker *et al.* 2009).

Voluntary licencing

In commercial fisheries, licencing is used as a means of effort control. In recreational fisheries, at least those in developed countries (especially North America and Australia), fisheries are open-access, and fishing licences are used primarily as a means of generating funds to support management, research and access related to recreational fishing, rather than to control effort or limit access (Cox *et al.* 2002). For adults, fishing licences are typically mandatory; however, youths and seniors are not required to obtain a licence. In recent years, some natural resource agencies have encouraged youths (e.g. Michigan DNR) and seniors (e.g. Indiana DNR) to purchase a voluntary fishing licence (typically for $1–$3 USD). Voluntary purchases of licences by seniors, youths and others who are legally exempt help generate additional funds that assist with management, habitat restoration, fish stocking, fishing and boating access, law enforcement and outreach programmes. In California,

recreational fishers can purchase a voluntary 'warden stamp' to support law enforcement activities specifically and in Minnesota, anglers may purchase a voluntary stamp specifically to aid in walleye management (R. Pierce, Minnesota DNR, personal Communication). Clearly, voluntary licences have largely been used as a means of increasing funding and do not in themselves represent a management tool to control effort. However, if angler education were linked to the licencing process, then voluntary licencing could have the potential to foster conservation-oriented behaviours and a conservation ethic among recreational fishers.

Education, information and outreach

All regulations, whether formal or informal institutions, usually demand some form of education, information and outreach programmes to increase awareness within angler groups. In the case of formal regulations, it is the success of such programmes that increase awareness and regulatory compliance, and sometimes draconian sanctioning is needed to repel people from insidious rule breaking (e.g. illegal release of non-native fish, Johnson *et al.* 2009). Compliance-based regulatory enforcement relies upon education strategies that are persuasive and cooperative in nature (Randall 2004). Education programmes that are structured to increase cooperation between anglers and management authorities can help build trust in the role of mandated regulation and encourage acceptance of fishing rules (Policansky 2008). These education and outreach programmes can consist of a range of formats and approaches including informational flyers and Internet sites, news releases, postings and interpretive signs at common access points (e.g. public docks), informal conversations between management authorities and anglers, and formal presentations to angling clubs and other stakeholder groups, although whatever strategy is used should be based on communication theory (see Manfredo 1992), given that peripheral and central routes to persuasion (to accept regulations) work differently and by different means in humans. In many ways, the goal would be to change attitudes as they strongly influence human behaviour (see also recent developments in conservation psychology; Bott *et al.* 2003). The most persuasive types are those that change 'central' cognitions (e.g. beliefs) (Petty *et al.* 1992) by showing how the regulations help achieving personal goals and the goals of the collective well-being. To that end, people must understand not only the content of the regulation but also its background, rationale and effectiveness, and see personal value in it. Achieving this usually demands regular feedback modes where successes or failures of regulations are regularly communicated back to anglers and the saliency of the action for personal well-being is enhanced. Of course, this assumes that new or different regulations are properly and objectively monitored and evaluated, which is seldom the case. One exception is a recent review (i.e., Kerr *et al.* 2012) of new minimum-size limits for muskellunge, where the 'paper' was written to be accessible to both scientists and anglers and was based largely on angler diary data (i.e. data generated by the angling community). Regardless of their structure, education and outreach programmes thus require considerable financial and time investment by fisheries management agencies, and it is critical that there is adequate institutional capacity, legacy and 'memory' so that such programmes provide a consistent and persistent message related to the presence, structure and role of fisheries regulations. It is strongly encouraged to employ education and outreach specialists to become professional and as effective as possible.

Nevertheless, even with such programmes in place, angler compliance of fisheries regulations can be lower than expected (Pierce and Tomcko 1998), which can undermine regulation success and create social dilemmas (Sullivan 2003). For example Pierce and Tomcko (1998) showed a low level of angler compliance of protected slot limits for northern pike, even with a considerably detailed education and outreach programme in place. Potential causes for reduced compliance include a lack of comprehension of perhaps complex regulations (e.g. slot limits) associated with the poor conveyance of the regulations in the education and outreach programmes, or that some anglers were willing to cheat in spite of regulations geared at increasing the sustainability of the fishery. Moreover, the protected slot demanded the take of small pike, which may simply be undesirable for consumption, in turn motivating non-compliance. One should always expect the greatest opposition to regulations if they are not understood in terms of objectives or conflict deeply with personal norms and preferences. In these situations, it

is particularly difficult to obtain high compliance at low enforcement activities. Only heavy sanctioning can then perhaps achieve the intended levels of compliance, although the regulation will always remain suboptimal as the personal attitudes have not changed (peripheral route to persuasion, Petty *et al.* 1992). In either case, adequately structured education and outreach programmes founded on an *a priori* understanding of angler motivations and norms could increase the voluntary acceptance of mandated regulations, as has been shown for a variety of pro-environment behaviours (see Steg and Vlek 2009).

The same rationale is true for the development of informal institutions (i.e. voluntary 'regulations'); however, identifying who is responsible for education and outreach programmes is more ambiguous. Without an authoritative link, the onus of producing informational material and interfacing with anglers might be left up to individuals and organizations with little training in education, and with limited financial support for programme implementation. Quite often, voluntary regulations are promoted via angling-based grass-roots conservation organizations and stakeholder groups, and the conveyance of voluntary regulations is commonly in the form of small informational brochures, informative signs, text on an Internet site or in a newsletter, or via informal discussions and presentations. Although these efforts clearly have merit, we know of very few examples where the effectiveness of such education and outreach programmes has been quantified as per the adoption of volunteer regulations. One exception is the black bass area/season restrictions in Ontario mentioned earlier in the article (Suski *et al.* 2002); however, in this case, local conservation-orientated stakeholders received guidance from researchers to create the mechanisms for disseminating voluntary regulations. Ideally, education and outreach programmes aimed at increasing awareness and adoption of volunteer regulations (and even guidelines) should be backed by experience related to how to convey such information effectively. In most cases, informal institutions simply 'evolve' over time when the norm of proper behaviour moves from an innovator stage to become accepted by the wider community through face-to-face interactions, changing values and experience. In these situations, education and information programmes may simply speed up the process and thus be used strategically by management authorities to encourage 'the good' and avoid 'the ugly' behaviours by anglers. Spreading best practice release guidelines to which anglers should voluntarily adhere is one good example where this strategy can be used to increase survival of released fish over time.

Codes of practice and other voluntary instruments

Although not a regulation *per se*, there is a growing movement towards development of various codes of practice (COP) or best management/handling practices in the context of catch-and-release that are shared with anglers, and may be one tool to promote voluntary 'regulations' and other forms of informal institutions. COPs have been developed by a variety of government bodies (at the international, national and regional scale) as well as by angling clubs, associations and environmental NGOs. Their adoption is voluntary and individuals may decide to follow none, some or all of the proposed actions. One such example on an international scale that extends the topic of catch-and-release is the COP for recreational fisheries developed by the European Inland Fisheries Advisory Council with support of the United Nations FAO in 2007 (EIFAC 2008; Arlinghaus *et al.* 2010b). That COP serves as a document that describes the minimum standards of environment-friendly, ethically appropriate and – depending on local situations – socially acceptable recreational fishing and its management. Frequently included are statements about adhering to fishing regulations (voluntary or mandatory) or to 'best practice' behaviours at the waterside, including how to best release fish. Although not intended solely for anglers, it does provide guidance to anglers and may serve as one catalyst to develop more locally tailored codes of conducts of proper behaviour that circumvent or complement formal institutions.

Other regional entities and angling clubs have already previously developed their own COPs, many prior to the existence of the international EIFAC Code (EIFAC 2008). For example the Australian Department of Agriculture, Fisheries and Forestry (DAFF) developed a national COP in 2001 which is a voluntary agreement among Recfish Australia's 11 national and state/territory fishing member associations (DAFF 2001). In California, the Sportfishing Conservancy has not only developed their own code of ethics, but also encourages their constituents to follow the more

global guidelines developed by the FAO. COPs are particularly common among specialized angling groups. In the UK, the National Angling Alliance (NAA) and the Specialist Anglers Alliance developed a code specific to coarse (i.e. non-salmonid) fisheries which was endorsed by the UK Environment Agency (NAA 2002).

In some jurisdictions, COPs have extended beyond simply a list of recommendations to actual hands-on action by volunteers. In New South Wales, Australia, the Fishcare Volunteer Program (FVP) organized by the state government uses volunteers to talk to anglers about fishing rules and responsible fishing, as well as help in a range of activities, such as fishing clinics, catch surveys and community fishing events. The volunteers are part of a growing team of community members who are taking practical steps to increase awareness and the values of sustainable recreational fishing practices.

In some cases, competitive angling event organizers have imposed restrictions for participants (e.g. creel limit and gear restrictions), and although for participants the regulations are mandatory, their participation in the event as a whole is voluntary (see Diggles *et al.* 2011 for voluntary code of practice for tournaments). Some marinas have voluntarily instituted rules related to harvest of sharks (i.e. shark-free marinas), which, again, is mandatory for those who wish to use the marina, but not a requirement of any government body, *per se*. In some cases, fisheries management agencies have attempted to influence angler activities via advertising campaigns. In Australia, for example inland recreational fishers are encouraged to harvest introduced/invasive species such as common carp and release endemic species.

Beyond the examples noted above, there has been widespread advocacy for voluntary catch-and-release by a wide variety of agencies and organizations, even in the presence of regulations. Voluntary catch-and-release has been practiced for centuries (reviewed in Arlinghaus *et al.* 2007). Radonski (2002) summarized the influence of angler-authors (such as Zane Grey and Roderick Haig-Brown) and contemporary conservation organization such as Trout Unlimited on the modern-day voluntary catch-and-release ethic. Specialized muskellunge (*Esox masquinongy*; Esocidae) fishing organizations such as Muskies Canada and Muskies Inc. encourage their members and the broader public to release muskellunge, and have awareness campaigns on the merits of doing so as well as how to practice catch-and-release properly. Voluntary catch-and-release can exceed 98% for some specialized fisheries (e.g. bonefish; Policansky 2002; muskellunge; Fayram 2003), which tends to minimize the need for recreational fishing regulations designed to reduce fishing mortality for some species. The voluntary release of fish that are legal to harvest has increased for many recreational fisheries (Quinn 1996; Bartholomew and Bohnsack 2005), although little is known about whether observed shifts in angler behaviour (e.g. voluntary catch-and-release) has the potential to influence long-term trends in fish populations (but see Myers *et al.* 2008). Fayram (2003) suggested that the similarity in magnitude of effects of both formal regulatory actions and voluntary angler behaviour on release rate of walleye and muskellunge demonstrated that the effects of voluntary release can play as large a role as the application of formal harvest regulations which mandate release. It is also doubtful that reducing fishing mortality by voluntary release can maintain highly prized trophy fish (Arlinghaus 2007) and help protect spawning stocks unless hooking mortality rates and cumulative fishing effort remain low (Coggins *et al.* 2007). Similarly, in studying the response of a smallmouth bass (*Micropterus dolomieu*; Centrarchidae) fishery on the Tennessee River in Alabama to harvest regulations, Slipke *et al.* (1998) suggested that the voluntary catch-and-release philosophy practiced by anglers should not be overlooked as an important factor that has had positive impacts on the fishery independent of the regulatory actions. Indeed, Slipke *et al.* (1998), Fayram (2003) and Myers *et al.* (2008) all suggest that voluntary catch-and-release must be measured and considered when making management decisions, especially when attempting to quantify the effectiveness of mandatory harvest regulations for recreational fisheries management. This is necessary to understand the failure of standard regulations, as the study by Pierce and Tomcko (1998) showed, because the results of any formal regulation will depend on angler behaviour aligning with the objectives of the regulations. In an ideal world, formal and informal institutions complement each other, as is the case in the evolution of a voluntary catch-and-release ethic across most countries in the world, with exceptions being Germany and Switzerland where voluntary release is illegal (Arlinghaus 2007; Arlinghaus *et al.* 2009).

Thus, in these countries, mortality-reducing activities that maintain fishing effort (e.g. voluntary catch and release) are not encouraged, which may put populations at risk of overfishing (Arlinghaus *et al.* 2009).

Issues and research needs

Our review identified that although voluntary regulations and evolution of informal institutions that complement formal regulations appear prevalent and becoming increasingly common, we failed to find many examples in the peer-reviewed literature about the effects of voluntary 'regulations' on the target fishery alongside educational and information-based approaches or their evaluation. Indeed, most of the examples presented here were found via Internet searches and do not represent traditional scientific sources. Nonetheless, the examples that we did find represent real examples of how voluntary regulations and angler education programmes are being integrated into the angling community. It is time for the research community to pick up on these important components of our fisheries and study their effects and implications in social, economic and biological terms in a rigorous quantitative framework.

Several trends were evident from the examples we presented. For example, there appears to be a pattern where voluntary regulations in marine recreational fisheries are often done so to make their sector align with mandated regulations put in for commercial fisheries (e.g. Moroney 2008). Also clear is that many of the voluntary regulations used are not enacted or encouraged by government or other scientific experts, but emerge more from grass-roots support by conservation-minded stakeholder groups and NGOs. As such, there is the potential that voluntary 'regulations' may either perfectly align with locally determined needs that a fisheries management agency has been slow to pick up, or the behaviours may have little or no scientific basis or associated monitoring to evaluate their performance and necessity over time, which could lead to mismanagement and erosion of public support for mandatory or voluntary 'regulations' or negate the indented effects of formal institutions. For example in Germany, avid zander (*Sander lucioperca*; Percidae) anglers advocate to 'alarm' any fish showing signs of barotrauma by 'throwing' it back into the water, on the belief that this makes the fish swim quickly back into depth. Biologically, it is highly unlikely this norm of 'proper' behaviour will meet its objectives. Moreover, there is potential for the creation of competing and conflicting voluntary regulations if norms of proper behaviour advocated by one group conflict with those advocated by other groups. In such cases, it is necessary to determine who will intervene in the case of conflict and which behaviour or regulation best aligns with its objectives. Another apparent trend is that voluntary limits seem to develop first where fishing is primarily for recreation, and the 'table fare' or 'kitchen fish' value has been relegated to a much lesser role, although quantitative data to support that assertion are lacking. There are clearly a number of benefits and challenges associated with the use of voluntary regulations and the education programmes to promote specific behaviours (summarized in Table 1). However, there are also many research gaps that make it difficult to evaluate their potential effectiveness and advocate for the strategic inclusion of voluntary approaches in the recreational fisheries management toolbox.

If voluntary regulations and education programmes are to be used along with, or even instead of, traditional mandated harvest regulations, it is essential that managers understand the factors that influence the biological and sociological effectiveness of voluntary approaches and their spread in the angler community. To that end, there is an urgent need for research on the level of compliance that is required or can be expected with voluntary regulations or actions. Indeed, even in fisheries with mandated regulations, there are often problems with compliance (Sullivan 2002), thus it could be more problematic when voluntary regulations are promoted. There is opportunity to study the use of incentives and role models to ensure compliance as well as more broadly understand the social, context-dependent, economic and ecological factors that promote emergence of informal institutions and their compliance. Also relevant is understanding whether the type of entity (e.g. government, industry or NGO) that recommends a voluntary regulation influences the likelihood that it will be successful in both a biological and a sociological context. The extent to which and reasons why anglers value a given species/fishery may influence their response to informal regulations and thus deserves study. There is also substantial scope for a variety of other human

Table 1 Summary of the benefits and challenges associated with the application of voluntary regulations for recreational fisheries.

Benefits	Challenges
Potential reduction in implementation costs compared to traditional regulations because of reduced need for enforcement and legal activity	Potential for implementation of regulations that are not based on best available science and result in damage to nature or conflicts
Potential for greater acceptance of controls, especially if the message is not coming from the government	Diverse motivations among anglers within the same fishery (e.g. harvest-oriented anglers vs. trophy catch-and-release anglers), thus difficult to expect all recreational fishers will be willing to embrace voluntary regulations
Ability to engage stakeholders in management and thus foster a strong sense of stewardship	Potential conflict with other sectors if allocation issues exist such that it may be difficult to obtain angler buy-in of voluntary regulations
Potential to apply voluntary regulations in developing countries that lack appropriate governance structures for mandatory regulations	Potential to create tension/conflict and even vigilantism among stakeholders
Potential to reduce transaction costs	Recreational fishers travel and although voluntary regulations may be the norm in a particular region/waterbody, visitors may not embrace or be aware of the local norms
Help to develop and maintain co-management structures	Potential for low compliance and thus failure of regulations to achieve desired biological outcome
Help maintain viable fisheries with low enforcement and monitoring costs	Regulations (voluntary or institutional) that do not work, because they are not based on the best available science, cause a more general skepticism among anglers and lack of faith in the benefits of regulations
Could result in tackle/gear innovations	Hidden costs associated with the dissemination of what the voluntary regulations are, especially if the government agencies are not taking on that responsibility
Potential to apply voluntary regulations in remote areas of developed counties where enforcement of traditional regulations is difficult	Unclear who is responsible for 'implementation' of voluntary regulations and thus potential for multiple groups to implement different and even contradictory regulations for same fishery (relates to diverse motivations)
Potential for rapid implementation compared to traditional regulation with formalized government processes	Potential lack of regional consistency if regulations enacted by various entities lack coordination
Potential to simplify/reduce government mandated regulations and thus address declining participation trend in recreational fisheries	
Potential to evoke a broader environmental awareness among stakeholders where individuals embrace the concept of personal responsibility for sustainable use of natural resources	

dimension studies that explore attitudes of various stakeholder groups towards the use of voluntary regulations and education rather than mandated regulations. For example do such approaches actually increase resource stewardship? Do education and outreach result in changes in the social norms in angling subcultures, even for voluntary regulations? Underpinning some of these specific questions are the need for field-scale case studies on voluntary regulations and education programmes to better understand when, where and how they can be applied to best address objectives. Clearly, the theories underpinning such type of research come from the education sciences, communication sciences and pedagogical psychology along with sociology and more traditional human dimensions work. Agencies are encouraged to employ respective experts who can pursue field-based intervention

research, before-after-impact-control field experiments or even studies in laboratories using game theoretic approaches and behavioural experiments (see Kraak 2011) to test various communication means and their effects of voluntary behaviours and norm change in individual anglers alone or in groups of different composition to account for social learning effects. It is also important to note that scientific research should directly support and inform the communication and outreach that are so important for successfully changing values and compliance. For example studies of hooking mortality and the factors that increase survival are critical to informing the development of best practices advocated for by NGOs and governments (Pelletier *et al.* 2007).

Conclusion

Despite traditional regulatory options representing the standard in recreational fisheries management, at least in developed countries, there exist a number of alternatives to regulations imposed by natural resource agencies that include the use of angler education programmes and the encouragement of informal institutions based on voluntary changes in angler behaviour. These 'softer' or indirect regulatory approaches (Arlinghaus 2004) can be developed in close cooperation with stakeholders, be strategically used to complement formal institutions, and, in some cases, are actually initiated and led by the stakeholders themselves, presumably helping to foster stewardship and maintain viable fisheries. There are many benefits of engaging recreational fishers in fisheries management and conservation (Granek *et al.* 2008; Danylchuk *et al.* 2011); therefore, the use of voluntary regulations that are developed in coordination with recreational fishers could pay serious dividends and strongly reduce the transaction costs of more formal regulations.

Our essay revealed that there are a number of benefits and challenges associated with voluntary regulations relative to traditional mandated regulations that one must bear in mind, in particular because enforcement authority is largely lacking in voluntary behaviours and there is more room for unscientific claims for or against particular behaviours to fall on fertile ground. Although voluntary regulations are certainly not ideal for all situations, we submit that voluntary regulations may be particularly useful on an interim basis until mandated regulations can be enacted or during periods of transition when mandated regulations are rescinded or in cases where voluntary behaviours perfectly align with overarching management goals and objectives (e.g. if fishing mortality is to be reduced, development of voluntary catch-and-release will have a perfect match to the overarching objective). Voluntary approaches overall represent an important, yet usually overlooked, element of the fisheries management toolbox that should be considered, particularly when there is a single stakeholder group exploiting a closely bounded fishery where regular face-to-face interaction is happening and thus the potential for peer pressure to comply with regulations is particularly likely (e.g. small angling clubs in Germany; Daedlow *et al.* 2011). When multiple stakeholder groups are active, especially multiple fishing sectors with different objectives (e.g. commercial or aboriginal may be more focused on harvest rather than catch-and-release), it will not be possible to consider voluntary regulations for one group without thinking about overall allocation issues, which would likely drive acceptance of voluntary approaches. Moreover, voluntary approaches may also be effective in developing countries where governance and enforcement structures are lacking, although we were unable to find any examples (in English) of such an application to date. We also failed to locate many examples of the application of voluntary regulations and educational approaches or their evaluation in the peer-reviewed literature. As such, we hope that this article will stimulate controlled experimentation to better understand the biological and sociological benefits and challenges associated with the use of voluntary regulations and education for recreational fisheries management.

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