

Searching for responsible and sustainable recreational fisheries in the Anthropocene

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ABSTRACT

Recreational fisheries that use rod and reel (*i.e.*, angling) operate around the globe in diverse freshwater and marine habitats, targeting many different gamefish species and engaging at least 220 million participants. The motivations for fishing vary extensively; whether anglers engage in catch-and-release or are harvest-oriented, there is strong potential for recreational fisheries to be conducted in a manner that is both responsible and sustainable. There are many examples of recreational fisheries that are well-managed where anglers, the angling industry and managers engage in responsible behaviours that both contribute to long-term sustainability of fish populations and the sector. Yet, recreational fisheries do not operate in a vacuum; fish populations face threats and stressors including harvest from other sectors as well as

environmental change, a defining characteristic of the Anthropocene. We argue that the future of recreational fisheries and indeed many wild fish populations and aquatic ecosystems depends on having responsible and sustainable (R&S) recreational fisheries whilst, where possible, addressing, or at least lobbying for increased awareness about the threats to recreational fisheries emanating from outside the sector (*e.g.*, climate change). Here, we first consider how the concepts of R&S intersect in the recreational fishing sector in an increasingly complex socio-cultural context. Next, we explore the role of the angler, angling industry and decision-makers in achieving R&S fisheries. We extend this idea further by considering the consequences of a future without recreational fisheries (either because of failures related to R &S) and explore a pertinent case study situated in Uttarakhand, India. Unlike other fisheries sectors where the number of participants is relatively small, recreational angling participants are numerous and widespread, such that if their actions are responsible, they have the potential to be a key voice for conservation and serve as a major force for good in the Anthropocene. What remains to be seen is whether this will be achieved, or if failure will occur to the point that recreational fisheries face increasing pressure to cease, as a result of external environmental threats, the environmental effects of recreational fishing and emerging ethical concerns about the welfare of angled fish.

KEYWORDS

angling, ethics, fish welfare, recreational fishing, responsible and sustainable fisheries

1 | INTRODUCTION

Recreational fisheries operate in diverse aquatic ecosystems around the globe; from the ice-covered freshwater lakes of northern Finland to the coastal flats habitats of the Seychelles, from the depths of the Amazon Basin to the Great Barrier Reef. The motivations for participation in recreational fishing are diverse (Fedler & Ditton, 1994), but what unites all recreational fishers is that it is a leisure activity (*i.e.*, it is conducted largely “for fun”; Pitcher and Hollingworth, 2002) that also contributes to personal nutrition (Cooke *et al.*, 2017) in some instances (*i.e.*, when fish are not released). Recreational fishing is also big business, creating thousands of jobs across the world (World Bank, 2012). In developing countries recreational fishing can support rural livelihoods (Smith *et al.*, 2005), for example, by bringing angling tourism income into deprived coastal communities. The FAO (2012) definition of recreational fishing clearly differentiates recreational fishing from subsistence and commercial fishing as, “fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets”. Although recreational fisheries can use a variety of gear types (*e.g.*, spear, speargun, gillnet, trap, rod and reel; Arlinghaus & Cooke, 2009) depending on jurisdictional regulations, the dominant gear type is rod and reel with hook and line and is thus the focus of this paper (*i.e.*, recreational angling and the recreational angler).

Recreational fisheries are often considered comparatively less harmful in ecological terms compared with other more harvest-oriented fisheries sectors, but there are also many similarities between recreational and commercial fisheries (Cooke & Cowx, 2006; Lewin *et al.*, 2006). Fisheries collapse resulting from overharvest (Post *et al.*, 2002), fisheries-induced evolution (Jørgensen *et al.*, 2007), incidental fishing mortality (Coggins *et al.*, 2007) and environmental degradation (Cooke & Cowx, 2006) are largely considered to be consequences of

commercial fisheries, yet these have all been documented in recreational fisheries (Lewin *et al.*, 2006). However, most recreational fisheries are actively managed (*e.g.*, through harvest regulations) and are typically considered sustainable (at the population level) while generating important and numerous ecosystem services (Arlinghaus & Cooke, 2009). For example, the socio-economic benefits of recreational fisheries can include improvements to psychological well-being, forging connections between humans and nature, supporting livelihoods and communities and generating billions of dollars of economic benefit (Parkkila *et al.*, 2004, World Bank, 2012, Armstrong *et al.*, 2013; Hughes, 2014; Tufts *et al.*, 2015; Griffiths *et al.*, 2017; Hyder *et al.*, 2017, 2018). This human-nature connection promotes anglers to contribute to conservation in various ways such as funding of research, collecting and sharing data (citizen science such as angler diary programmes) and serving as advocates for environmental protection (Bate, 2001, Granek *et al.*, 2008; Florisson *et al.*, 2018).

The many ecosystem services that can be derived from fish populations (Lynch *et al.*, 2016) require that recreational fisheries be conducted in a manner that is sustainable. Yet, recreational fisheries do not operate in a vacuum and the fish and fish habitat upon which recreational fisheries are based, are in part very strongly and pervasively influenced by a range of non-fishing related anthropogenic disturbances, such as water abstraction, hydropower, climate change, invasive species and pollution (Dudgeon *et al.*, 2006; Costello *et al.*, 2010; Reid *et al.*, 2018), as well as other fisheries sectors. Thus, sustainable recreational fisheries depend on also addressing threats external to recreational fisheries and if these threats cannot be ameliorated easily (largely due to socio-political or economic constraints; Cowx *et al.*, 2010), recreational fisheries must be managed within a constraint productivity space to operate safely (Carpenter *et al.*, 2017). Indeed, as humans increasingly dominate the planet (Röckstrom *et al.*, 2014), it is

now widely accepted that we have entered a new geologic epoch, called the Anthropocene (Crutzen and Stoermer, 2000). The Anthropocene has inherently negative connotations (Corlett, 2015) but there are increasing calls to consider what can be done to achieve a “good” Anthropocene (Dalby, 2016). Moving forward, there will certainly be struggles to determine if and how activities such as recreational fishing interface with the concept of trying to achieve a good Anthropocene (Elmer *et al.*, 2017).

Beyond the obvious state of environmental change, there are other geo-political and social-cultural changes afoot that threaten the future of recreational fisheries. For example, as countries become more developed and economically-wealthy there tends to be an initial increase in recreational fishing fueled by more disposable income yet eventually such development leads to a nature-disconnected populace (Arlinghaus *et al.*, 2002; FAO, 2012; Arlinghaus *et al.*, 2015). This disconnection may contribute to a growing anti-fishing movement related to the belief that “fishing for fun is cruel to individual fish” (Arlinghaus *et al.*, 2012) and that recreational fishing is a threat to the few places still considered wilderness (Arlinghaus & Schwab, 2011; de Leeuw, 2014). Strong welfare or conservation-oriented beliefs have become a dominant viewpoint in some regions (Balon, 2000; Arlinghaus *et al.*, 2012) such that some forms of recreational angling (especially catch and release), are considered by some as socially unacceptable and in some cases have been banned (Berg & Rösch, 1998; Arlinghaus, 2006, 2007). Due to issues related to sustainability (as a result of the effects from the recreational fisheries sector itself and due to effects from other stressors or sectors), the perceived low value of the sector (compared with the commercial sector) and ethical concerns, the future of recreational fishing is being challenged in some jurisdictions.

In this paper we argue that responsible participation from all actors involved with recreational fishing is necessary to achieve sustainability. This is particularly acute in the Anthropocene, when there are many other environmental stressors and complex societal changes underway (Steffen *et al.*, 2007) that have the potential to undermine recreational fishing. For decades, the concept of sustainability has been at the forefront in discussions about the future of (commercial) fisheries (Pauly *et al.*, 2002). Here, we extend the idea of sustainability to include an emphasis on responsibility, the responsibility of anglers, industry and decision-makers, and first consider how the concepts of responsibility and sustainability (R&S) intersect in the recreational fishing realm in an increasingly complex socio-cultural context. We extend this idea further by considering the consequences of a hypothetical future without recreational fisheries (for example when the activity is banned in certain areas of conservation concern) and explore an ongoing case study situated in Uttarakhand, India. Our aims are by no means to advocate for constraints on recreational fisheries, but rather to outline what is at stake when recreational fisheries are not responsible. We conclude by discussing the role of various actors as agents of change and stewards not just for R&S recreational fisheries, but for aquatic ecosystems more broadly (*sensu* FAO, 2012). Unlike other fisheries sectors in which the number of participants is relatively small, recreational anglers are numerous and widespread, such that if their actions are responsible they have the potential to be a major force for good environmental governance and a key voice for conservation in the Anthropocene. What remains to be seen is if this will be achieved, or if failure will occur to the point where recreational fisheries face increasing pressure to cease, as a result of external environmental threats, the environmental effects of recreational fishing and emerging ethical concerns about the welfare of angled fish.

For the purpose of this paper we define a responsible fishery to be one where the fisheries actors are involved in supporting and promoting the sector (recreational in this case) to ensure that benefits are maximised (beyond the individual) in an ethically and socially appropriate manner while respecting ecological constraints and the intrinsic value of biodiversity. We further this by acknowledging that because the intrinsic value of biodiversity may not resonate with all actors that this idea could be extended to be about responsibility to future generations of anglers. In the German speaking world there is a specific term to represent this view, *Waidgerechtigkeit* (Arlinghaus, 2017). The Oxford Dictionary includes “obligation” in its definition of responsible, emphasising that there is a personal obligation to behave in a similar manner, an element missing from the definition of sustainable because it is directed at system outcomes (Arlinghaus *et al.*, 2017) and less so at the individual contribution of each angler, which responsibility as a concept tailors to. Our definition of responsibility aligns closely with the action-oriented normative framework of aquatic stewardship that is based on the moral obligation to care and take action for aquatic environments (Knuth and Siemer, 2007). Perhaps another way to view a responsible fishery is to ask, “what are the social and biophysical conditions desired or appropriate for a given fishery, accounting for local cultural and socio-economic interests” (McCool & Lime, 2001) and how can each individual contribute to that goal? Put differently, when each participant in recreational fisheries acts responsibly, the collective behavioural outcome assisted by proper management actions by decision makers will achieve sustainable outcomes. Our contribution is directed at the responsibility of each participant, be it an angler, company, or manager or any other actors in the system.

3 | RESPONSIBILITY IN THE CONTEXT OF RECREATIONAL FISHERIES

In the recreational sector, the notion of responsibility includes all actions that contribute to supporting and promoting the sector. The FAO (2012) states that users of living aquatic resources should conserve aquatic ecosystems and that the right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources. Albeit the notion of responsibility extends well beyond the actual act of fishing but includes the collective actions of individuals (anglers, industry, decision-makers). Acting responsibly may entail an immediate short-term sacrifice (*e.g.*, harvesting fewer fish, putting time into knowledge acquisition), to support continued benefits of the fishery in the future. For anglers this can mean increasing personal awareness and environmental conscience about when, where and how to fish and more broadly how to support healthy aquatic ecosystems and the continued provision of ecosystem services; Danylchuk *et al.*, 2017, 2018; Trushenski *et al.*, 2010; FAO, 2012; Arlinghaus *et al.*, 2017). Industry responsibility can relate to the behaviour of companies (*e.g.*, attempts to develop and market more environmentally-friendly tackle), guides and outfitters (*e.g.*, using their platform to help shape the behaviour of their clients) and fishing media (*e.g.*, showing fishing celebrities handling fish in a manner that maintains their welfare status). Responsibility for management agencies and policy-makers can mean making decisions that promote long-term use rather than short-term gain (*e.g.*, habitat restoration *v.* stocking that influences the sustainability of wild stocks) and designing regulations that promote environmentally conscious behaviours from anglers.

Although responsible behaviours may entail some form of immediate sacrifice either through lost time, profits, or popularity, they are critical to achieve sustainability in recreational fisheries.

We acknowledge the implicit assumption in how we have framed this concept, *i.e.*, that all anglers (young and old, in Brazil and in Alaska, male and female, rich and poor, urban and rural, harvest oriented and non-consumptive, *etc*) want the same thing whereas the reality is that there may be vastly different visions of the collective behavioural outcome. Indeed, it is well known that there is much heterogeneity (and conflict) within the recreational fishing community (Arlinghaus, 2005). The normative aspects of what it means to be responsible is beyond the scope of this paper but represents an important area of further debate and discussion within the recreational angling community.

4 | ON SUSTAINABLE FISHERIES

The term sustainable is generally used in the context of fisheries to describe fishing activities that can be carried out in the long-term at an acceptable level of productivity (biological, social and economic) without associated ecological changes that foreclose future fishing opportunities (NRC, 1998). Traditional fisheries management has generally focused on ensuring that commercial fishing operations remain sustainable by not exceeding the maximum sustainable yield (MSY; FAO, 2014), *i.e.*, the theoretically largest yield (or catch) that can be continuously taken from a given stock without significantly compromising future harvests (Ricker, 1975). However, this definition with its restricted focus on the biomass harvest of a small number of target species has come under scrutiny for ignoring fishery–ecosystem interactions (Hilborn *et*

al., 2003, 2015) and for bearing little pertinence for assessing the sustainability of recreational fisheries that center around much more than catch and harvest (McPhee *et al.*, 2002; FAO, 2012; Johnston *et al.*, 2010). According to the FAO (2009), sustainable fisheries are defined as “fishing activities that do not cause or lead to undesirable changes in the biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next” (or simply the ability to persist in the long run). While recreational fisheries sustainability is not often called into question by governments, management agencies, or communities, recreational fishing interactions with aquatic ecosystems have the potential to be both significant and numerous, extending beyond direct effects to the catch target (McPhee *et al.*, 2002, Lewin *et al.*, 2006). Thus, there is a current need to broaden the sustainable fisheries conversation beyond a narrative of commercial fishing (FAO, 2012) and to include multiple perspectives and competing management objectives for fisheries resources.

5 | SUSTAINABILITY IN THE CONTEXT OF RECREATIONAL FISHERIES

Sustainability in recreational fisheries pertains not only to the fisheries resource, but to the broader ecosystem (ecological dimension of sustainability), the quality of the fishing experience to anglers (social dimension of sustainability) and the economic benefits associated with recreational fisheries participation (FAO, 2012). Recreational fisheries should be widely accessible to people and should accommodate the complex motivations that people have to fish including time outdoors, interaction with wildlife, challenge, social motives or sport (Fedler & Ditton, 1994). The motivations of recreational fishers are often more complex than that of other

sectors (*e.g.*, commercial) that are economically driven and seek high revenue per unit effort to maximise the personal economic benefits derived from fishing (Sethi *et al.*, 2010). Anglers also seek to maximise benefit, but these benefits are measured in many more dimensions than harvest (Hunt, 2005; Johnston *et al.*, 2010). These social outcomes must be maintained concurrently with biological sustainability (not unlike the commercial sector where incentives exist; Greiner *et al.*, 2000) so that the activity can continue to persist in the future. The greatest threat to biological sustainability of recreational fisheries is the exploitation of aquatic resources both directly through harvest (Cooke *et al.*, 2018) and indirectly through discard or catch-and-release mortality (Coggins *et al.*, 2007). However, the issues surrounding recreational fisheries are more diverse than harvest and include factors such as fisheries-induced evolution, bait harvesting, species introductions, trophic perturbations, habitat destruction and pollution (McPhee *et al.*, 2002; Cooke & Cowx, 2004; Lewin *et al.*, 2006; Altieri *et al.*, 2012; Hyder *et al.*, 2017). To address the social, economic and biological aspects of sustainability, we must acknowledge that sustainability is a systems level outcome that is dependent on responsible actions of individual actors (anglers, industry, decision-makers).

6 | ON R&S RECREATIONAL FISHERIES IN THE ANTHROPOCENE

We argue that the sustainability of recreational fisheries and indeed many wild fish populations and aquatic ecosystems depends on having responsible recreational fisheries (Figure 1). The term sustainability is widely accepted as a vague term and the word responsible is equally ambiguous and subject to interpretation based on one's individual values, beliefs and ethical perspectives

(*i.e.*, social and cultural norms; Fehr & Fischbacher, 2004; Ostrom, 2000). Regardless of the interpretation, we believe that a unifying characteristic of responsible actions is that they contribute to sustainability and it is clear that the recreational fishing sector would be well served if we can collectively work towards recreational fisheries that are sustainable through responsibility of the individual actor.

There is an increasingly complex economic, socio-cultural and geo-political context in which recreational fisheries operate (Hunt *et al.*, 2013; Arlinghaus *et al.*, 2016, 2017) and this demands that we think well beyond simply meeting a biologically based management target. Moreover, recreational fishing is embedded in culture and for that to continue (in the face of mounting pressures that see humans disconnecting with nature; Soga & Gaston, 2016), the anglers of today have a responsibility to connect with the anglers of tomorrow. What is particularly salient with the notion of being responsible is that individual anglers should be able to identify directly with specific actions and know that they are inherently responsible (Danylchuk *et al.*, 2018). Relatedly, two different anglers could engage in different behaviours that both document responsibility, one handling a fish that is captured so it survives a catch-and-release event and another using the Japanese *ike jime* method to rapidly kill a fish that they intend to harvest by inserting a spike into the hindbrain to cease further reflex action (www.youtube.com/watch?v=HoPTTVkL6s0). The same can be said for the recreational fishing industry (*e.g.*, tackle manufacturers) where environmental responsibility can be viewed as benefitting their bottom line, but also recognised that a thriving recreational fishing sector depends on having an activity that is viewed as responsible by the broader public (Danylchuk *et al.*, 2017). These ethical behaviours completed by individual actors will contribute to the social components of sustainability, albeit those components may differ based on individual beliefs.

Sustainability differs from responsibility in being a systems-level outcome, based on the collective behaviours of all actors surrounding a fishery, from the angler to the policy-maker. Indeed, it is impossible to achieve a sustainable fishery (in the broadest sense of the term, extending well beyond stock status) without responsible behaviours and actions. Striving for R&S recreational fisheries seems to be both desirable and essential in the Anthropocene and by placing a greater emphasis on responsibility moving forward there is potential to directly engage actors such as anglers in a more meaningful and tangible way (Danylchuk & Cooke, 2011).

7 | ANGLERS AS AGENTS OF CHANGE

Anglers are a broad, heterogeneous group that can encompass wealthy and mobile fly fishers dedicated to catch and release as well as poor and food-insecure fishers that harvest catches (Cooke *et al.*, 2018). A diverse host of fish species is targeted by anglers visiting many different marine and freshwater habitats. Moving toward more R&S recreational fisheries, anglers play key roles as agents of change in environmental practice, culture and management. Fisheries are often regulated through formal institutions, placing restrictions on fish harvest and fishing gear types, to which anglers must choose to comply. However, there are a growing number of examples of voluntary angler institutions, where anglers self-impose these restrictions to improve the quality and sustainability of the fishery (Cooke *et al.*, 2013). As catch-and-release fishing is growing as a conservation strategy (including voluntary fish release), employing angling practices that maximise survival and minimise fitness effects (*i.e.*, best angling practices; Brownscombe *et al.*, 2017) is increasingly important. In some cases, these practices are

implemented through regulation, but owing to the diversity and complexity of fishing practices, best angling practices are more commonly implemented voluntarily (Cooke *et al.*, 2013; Sims & Danylchuk, 2017; Danylchuk *et al.*, 2018). With a vested interest in the sustainability of natural resources, anglers also frequently serve as a social force for environmental protection and restoration (Tufts *et al.*, 2015; Copeland *et al.*, 2017). This can include pro-environmental behaviours such as waste clean-ups, as well as advocacy for large scale ecosystem changes such as dam removals to improve fish passage. However, there may be instances where anglers are only agents of positive change when the behaviour in question aligns with their resource capture desires and in other instances, they may support the conservation of one species at the expense of another (*e.g.* the proposed cormorant cull in Ontario; www.ofah.org/2008/04/federal-court-backs-cormorant-cul). The influence of anglers on management, legislation and policy surrounding recreational fisheries and more broadly on natural resources becomes particularly powerful when they form a shared voice with angling organisations and clubs and associations (Dean, 1996). Anglers can also provide essential information for effective fisheries management, including identifying potential conservation issues (J. W. Brownscombe, J. Hunt, A. Acosta, D. Morley, P. Holder, L. P. Griffin, N. Young, A. J. Danylchuk, S. J. Cooke, R. Boucek, J. Aaron A. J. Adams, unpubl. data) and providing valuable fisheries-dependent data on fish population dynamics through angler diaries, creel surveys, or smartphone applications (Venturelli *et al.*, 2017).

Because angler attitudes and behaviours cannot always be regulated, our ability to achieve sustainable fisheries with a positive effect on environmental conservation is highly dependent on forming and promoting a conservation-minded angling culture. For example, a considerable proportion of anglers acquire knowledge of conservation-minded angling practices

from their peers through in-person interactions, the internet and through the angling industry (Nguyen *et al.*, 2012; Danylchuk & Sims, 2017; Danylchuk *et al.*, 2017). This can extend to sanctioning behaviours where individual anglers attempt to guide others into engaging in responsible behaviours (Guckian *et al.*, 2018). In general, perceived social norms often have a major influence on angler behaviours (Bova *et al.*, 2017). There may be a possibility to use nudges (*e.g.*, behavioural-based management that uses subtle changes and indirect suggestion to make individual-level decisions more salient) to increase compliance with regulations but this has yet to be fully explored in an angling context (MacKay *et al.*, 2018). For example, are nudges best delivered *via* other anglers, the industry, or management authorities?

Anglers can help engage other members of the community through angling clubs and increasing youth opportunities (Burger *et al.*, 2018) which contributes to the social aspects of sustainability. Additionally, growing digital communities on social media are increasing the level and scale of angler connectivity throughout the world, providing opportunities to promote conservation movements more broadly (Danylchuk *et al.*, 2018). Relationships between anglers and conservation practitioners also enable collaborative opportunities for developing and applying conservation initiatives (Schroeder *et al.*, 2018). Although historically anglers have often distrusted practitioners, new approaches that respect these traditional barriers to collaboration are helping to better foster these relationships (Mannheim *et al.*, 2018). Relationships between anglers and the non-angling public are also important, especially considering the recent growth of anti-fishing movements (Arlinghaus *et al.*, 2012). Anglers also act as knowledge keepers for fisheries resources and can share ecological information related to a species beyond the angling community and increase broader ecological awareness surrounding the species (Granek *et al.*, 2008).

8 | THE ANGLING INDUSTRY AS AN AGENT OF CHANGE

A frequently overlooked agent for creating R&S recreational fisheries is the angling industry itself; essentially being those companies and entities that anglers rely on for their fishing equipment (*e.g.*, manufacturers, physical and virtual retail stores, consumer shows), access to certain fishing opportunities (*e.g.*, fishing lodges), professional guidance and training (*e.g.*, fishing guides, fishing schools) and inspiration (*e.g.*, popular media, brand ambassadors). Through marketing and promotion strategies, these entities drive clients (*i.e.* anglers) towards their goods and services to boost revenues in a capitalist economy. For instance, in the United States, for 2015, the economic benefit of recreational fisheries based solely on direct sales was estimated at US \$63.4 billion (NOAA, 2017), with additional economic gains resulting from fishing trips, employee income and value-added opportunities (*i.e.*, residual revenue related to fishing). As these entities reach out to customers to increase sales, they have an opportunity to also raise awareness about threats to recreationally-targeted fish species and their essential habitats, as propose actions that can lead to R&S recreational fisheries.

Broadly, if fishing opportunities and the rewards of catching a fish decline, angler participation could be affected, as could how anglers spend their money. This is reinforced by evidence suggesting a downturn in participation of nature-based recreation, including fishing (Pregams & Zaradic, 2008). As such, if the angling industry does not embrace R&S recreational fisheries and accelerate their efforts to positively affect change, they have the potential to affect their business. Conversely, because of the scale and scope of recreational fisheries and the

diversity of industry agents needed by anglers to outfit the sport, the industry has the opportunity to shape the recreational angling culture. Such efforts could work in conjunction with angler-based non-governmental grassroots organisations to shift social norms towards those that minimise the potential effect of angling on fish and their essential habitats, as well as foster a broader ethos of R&S actions towards the environment as a whole.

Evidence is emerging that the angling industry is indeed beginning to play a more active role in promoting R&S recreational fisheries. For example, trade organisations including the American Sportfishing Association (www.asafishing.org), American Fly Fishing Trade Association (www.affta.com) and European Fishing Tackle Trade Association (www.effta.co.uk) have conservation as part of their mandates and they partner with grassroots angling organisations to promote healthy recreational fisheries and habitats. There is also an increasing number of agents in the fishing industry that are directly incorporating sustainability initiatives in their business plans, product development and related marketing and promotional strategies. At a corporate level, the number of B-corporations that have mandated initiatives aimed at driving sustainability is increasing. The 1% for the Planet framework (www.onepercentfortheplanet.org/what-we-do/our-approach) also allows individuals and businesses to contribute 1% of sales to environmental non-profits, many of which focus on catchments, aquatic ecosystems and fisheries. Some companies within the angling trade are also going beyond 1% towards conservation by making greater monetary contributions directly to conservation organisation, as well as developing in-house initiatives that focus on R&S actions of anglers. Relevant examples include Patagonia Inc.; part of their mission statement includes doing no unnecessary harm and to use business to inspire and implement solutions to the environmental crisis (www.patagonia.com/company-info.html). This company has also played a

major role in supporting the removal of redundant dams as a way to restore waterways and ecosystems, including for the support of sustainable recreational fisheries. Other examples are the Kick Plastic (www.kickplastic.org) and Untangle Our Oceans spearheaded by Costa Sunglasses (www.costadelmarcampaigns.com), which includes developing sunglasses frames from discarded fishing nets that would otherwise be polluting the oceans and adversely affecting aquatic life. There are also a growing number of agents in the angling industry that are making a commitment to change their marketing and promotion of fishing to reflect actions that reduce the effects of angling on fish (*i.e.*, fish held in the water or dripping wet; #keepemwet; Danylchuk *et al.*, 2018). This movement of greater industry support and direct participation in actions leading to R&S recreational fisheries can only improve as they work in conjunction and cooperation with other agents that comprise the greater recreational angling community (Sims & Danylchuk, 2017; Danylchuk *et al.*, 2017).

9 | DECISION MAKERS AS AGENTS OF CHANGE

Management authorities (which assumes a top down approach but could also involve various co-management structures such that resource users are also engaged in decision-making; Sutinen & Johnston, 2003) are tasked with the goal of maintaining ‘quality, diversity and availability of fishery resources in sufficient quantities for present and future generations’ (*i.e.*, sustainable use and development) as outlined by the FAO (2012). Sustainable fisheries regulations must therefore balance the management objectives set out for the population and ecosystem without being overly restrictive of fishing opportunities for social reasons (Koehn & Todd, 2012).

Management focussed on MSY has been the dominant approach for commercial fisheries that strive primarily to increase individual biomass harvest (Mace, 2001). Importantly, a focus on MSY does not mean that optimal social yield will be achieved, as shown by Johnston *et al.*, (2010) and Johnston *et al.*, (2013) and will not necessarily account for the varied and complex interactions among the recreational fishing sector and other aquatic system users (commercial and subsistence fisheries, agriculture, *etc.*) that characterise global recreational fisheries (Bower *et al.*, 2014). Recreational fisheries management (which often includes activities such as habitat enhancement, stock enhancement and harvest regulations) must avoid narrowly focussed management objectives such as MSY and incorporate multiple objectives that account for social, economic and biological considerations. Managers can achieve this by facilitating structured decision making that increases consultation and engagement from various stakeholder groups. That is, fisheries management objectives should be determined in an inclusive and participatory manner (Pita *et al.*, 2010). From a biological perspective, recreational fisheries managers should go beyond the single-species approach and consider the broader threats of fishing on the ecosystem including implications for biodiversity at all scales of measure. As suggested by FAO (2012), this will require a precautionary, adaptive and ecosystem-based approach to management that promotes resiliency to external threats to recreational fisheries (*e.g.* agriculture, damming, deforestation, navigation, wetland reclamation, urbanisation, water abstraction and transfer and waste disposal; Arlinghaus *et al.*, 2002). Management geared at long-term solutions will be critical to impart positive change to recreational fisheries (*e.g.*, habitat restoration *v.* stocking). On a regional or national scale, the actions of fisheries managers are restricted by the policies within which they must operate, highlighting the importance of policy-makers as agents of

change (*e.g.*, a landscape-scale approach to recreational fisheries management; Lester *et al.*, 2003).

To achieve sustainability in recreational fisheries, policy makers must commit to investment-oriented policies that address long-term social benefits (Jacobs, 2011). Longer-term investments can be uncertain, lack institutional capacity and typically require a politician to inflict short-term consequences to citizens that poses an electoral risk (Jacobs, 2011). Mardle and Pascoe, 2002 highlight that optimal fleet sizes are substantially reduced in the short-term when long-term policy objectives are considered, but that this will increase stock sizes and sustainable yields over the longer term. Given the relatively short length of political terms, a long-term vision is only likely when there is bottom-up pressure from voters to accommodate for the future. Nonetheless, policy makers and governments have a responsibility to communicate the importance of quality recreational fisheries and healthy aquatic ecosystems and support investment-oriented policies when support mounts (Jacobs, 2008).

10 | WHAT DOES FAILURE LOOK LIKE?

Failure of recreational fisheries will exist when people are no longer able to engage in the activity because fisheries have been damaged either directly from the sector or from external threats that face aquatic ecosystems. This may be the result of irresponsible actions from all sectors engaged in recreational fisheries from anglers, industry, or decision-makers that contribute to an unsustainable fishery. On the same note, recreational fisheries will also fail if recreational anglers do not acknowledge overexploitation of a fish stock when it occurs and

refuse to change their behaviours accordingly. Strong connections to a resource can foster feelings of entitlement that lead to these negative outcomes. McClenechan (2012) described perverse effects of united anglers on fish populations as advocacy for the right to fish triumphed over evidence that fish populations were being damaged. In this case, anglers' objectives did not align with conservation.

Recreational fisheries are inherently extractive, as even catch-and-release fisheries include some level of release mortality (Bartholomew & Bohnsack, 2005). One should therefore consider what aquatic ecosystems would look like in the absence of anglers and whether losing their corresponding environmental interaction is worth losing their benefits to aquatic ecosystems. Waterbodies without anglers would lose one of the primary users and advocates for conservation (Bate, 2001). Fish are umbrella species' because research on and management of, fish and fish habitat confer protection to aquatic mammals, birds and invertebrates as well (*e.g.* protected areas; Hilborn *et al.*, 2004). Anglers often support conservation of the shared resource and mobilise against threats that could affect their ability to target fish (Granek *et al.*, 2008; McClenechan, 2013). Anglers make substantial contributions to local economies that deter or dissuade others from poaching, polluting, or otherwise damaging a resource (Organ *et al.*, 2012) that represents a renewable economic sector that contributes to job security. Without anglers, we would lose leading international organisations such as Trout Unlimited (www.tu.org), Bonefish & Tarpon Trust (www.bonefishandtarpontrust.org) and the Billfish Foundation (www.billfish.org) that participate in fundraising, mobilise like-minded stakeholders, support scientific research on fish, fish habitat and fisheries, monitor aquatic habitats, advocate for favourable management and disseminate R&S through membership lists and publications. Conservation and stewardship principles may be damaged given that nature-based experiences

such as angling may assist youth with responsible decision making and environmental literacy (Siemer & Knuth, 1998, 2001).

Recreational fisheries must acknowledge the potential for adverse effects and operate under principles of R&S. If anglers fail to take accountability for their own fishing practices and that of the broader community (Guckian *et al.*, 2018), they will not be operating responsibly and will fail to achieve sustainability. Similarly, if bottom-up approaches from anglers are not undertaken to mount pressure on decision-makers to strengthen management and policy, the necessary framework to sustain aquatic resources and recreational fishing will never be achieved.

11 | FAILURE IN PRACTICE: THE CASE OF UTTARAKHAND, INDIA

Recreational fishing activity is not synonymous with conservation action *per se*. Yet, recreational fisheries can provide conservation support in areas where improved connections with nature (*e.g.*, through experiential learning; Jose *et al.* 2017) can foster interest and support for conservation. This case study is interesting for the fact that animal rights arguments were used to justify a ban under the banner of conservation, although philosophically speaking animal rights argument target the welfare of individual fish, while conservation targets the species or habitat levels and has less to do with the well-being of individual fishes (Arlinghaus & Schwab, 2011).

Recreational fishing in India was documented as early as the 12th century (Gupta *et al.*, 2015) and has experienced two surges in popularity: the first during British occupation and a second after a famous visit from the Transworld Fishing Team in 1978 that led to renewed appreciation for mahseer *Tor* spp. fishing (Pinder & Raghavan, 2013; A. C. Pinder *et al.*, unpubl.

data). Since then, recreational fishing has been identified as a potentially valuable strategy for aquatic conservation and catch-and-release has been promoted for *Tor* spp. conservation specifically (Gupta *et al.* 2016). Recreational fishing is believed to support conservation in India as outfitters support alternative livelihoods for poachers by employing them to act as guides and protectors of river reaches. Also, organisations managing recreational fishing activity promote catch and release of native species and collect catch data that they share with researchers (Pinder *et al.*, 2015). Until recently, most recreational fishing activity in India took place on the Cauvery River and its tributaries in the state of Karnataka, though angling has been growing rapidly around the country in recent years, including in Uttarakhand where the endangered golden mahseer *Tor putitora* (Hamilton 1822) is found (Everard & Kataria, 2011). It was hoped that the recreational-fishing-as-conservation model initiated on Karnataka could be duplicated in Uttarakhand also.

On 15 July 2018, the Chief Conservator of Forests, Forestry Department of Uttarakhand, India, announced a ban on angling (both harvest and catch-and-release activities) across the state on the basis that angling constituted cruelty to animals and citing Section 11 of the Prevention of Cruelty to Animals Act (Gov. India, 1960; as reported by Sharma, 2018). While initially thought to be the first global example of a state-wide angling ban arising from animal cruelty arguments, the ban was later clarified to apply to buffer zones between protected forest areas. Angling in waters encompassed in protected areas was previously banned under a national, 2009 Supreme Court decision to include catch-and-release activities as baited hunting under the Indian Wildlife Protection Act (Gov. India, 1972). It is likely that the argument for angling as animal cruelty was in part attributable to the social and political climate, as well as a 4 July 2018 decision by the High Court of Uttarakhand to grant the Animal Kingdom the same rights as humans (Upadhyay,

2018). The status of the ban and its application and enforcement may change over time.

However, regardless of intent or convenience, the precedent for a ban on angling based on animal cruelty has now been set.

Given that the science underpinning the issue of whether fish feel pain trends away from an anthropomorphic experience of pain (Browman *et al.*, 2018), it would be simple to dismiss the Uttarakhand ban as lacking in evidence and thus be irresponsible based on scientific arguments. Yet, as the recreational fisheries research field moves towards approaching recreational fisheries science from interdisciplinary (*e.g.*, social-ecological systems, in which recreational fisheries are viewed as tightly coupled components of both social and biological systems; Arlinghaus *et al.*, 2017) and transdisciplinary (consisting of multiple disciplines and stakeholders working together in a participatory approach; Arlinghaus *et al.*, 2014; Fujitani *et al.*, 2017, Blythe *et al.*, 2017) perspectives, it becomes essential not to dismiss concerns regarding animal welfare on the basis of animal physiology alone. We need to develop a more coherent understanding of the various cultural, philosophical and ethical outlooks that shape anti-angling viewpoints (Arlinghaus *et al.*, 2012) and work collectively to address these concerns if recreational fishing is to act as a genuinely positive force for conservation. Clearly, not allowing the continuation of angling is unsustainable from an angler perspective and may be perceived as irresponsible. This specific example emphasises how issues related to ethics can in some cases constrain fishing activity much more so than issues related to sustainability.

12 | CONCLUSION

The world is changing and there are increasing threats facing aquatic ecosystems as we now acknowledge that we are in the Anthropocene. Similarly, there are also threats facing sectors that use natural resources in an extractive and non-extractive manner, including recreational fisheries. Some of these threats are directly related to the environment but others have to do with changing socio-cultural norms as more and more people disconnect with nature and reside in urban centres and are more likely to have ethical concerns about recreational angling. Elmer *et al.* (2017) argued that recreational fishing has a place in the Anthropocene but for it to contribute to a good Anthropocene it will be necessary to identify and rectify dark spots while leveraging bright spots. We believe that by adopting the responsible behaviours demonstrated in these bright spots, we can achieve sustainability across recreational fisheries (Figure 1). For that reason, we advocate for more emphasis on the idea that recreational fisheries depend on behaviours that are responsible from all actors and have emphasised here how responsibility of individual actors is a precursor to sustainability. In some ways this echoes Hilborn's (2007) thinking where he posits that fisheries management is really about "managing people". It has also become apparent that human behaviour is a key source of uncertainty in fisheries management (Fulton *et al.*, 2011).

In many ways it is a privilege to fish (Lam & Pauly, 2010) such that individual responsibility is inherently part of a social contract to engage in recreational angling. Yet, there are also instances of the angling community attempting to legally make it their right to fish (McClenachan, 2013). Responsibility puts some onus directly onto the individual angler, industry player (*e.g.*, guide, outfitter, bait dealer, tackle manufacturer, fishing media), management authority and policy-maker to engage in meaningful actions (small and large) that demonstrate to the broader community that recreational fisheries and their participants are committed to achieving sustainability. However, this is more than just demonstrating for others

in an effort to build support for the ethical aspects (and the privilege) of recreational fishing but also a requirement of all relevant participants to work collectively to ensure that their actions benefit fish, fish populations and truly enhances all aspects of the sustainability of the sector. Given that many of the threats facing the sector are external to it, greater effort will be needed by recreational fishing actors to mitigate those threats and ensure that recreational fish and the healthy aquatic ecosystems that they depend on are not forgotten. By sharing success stories (Granek *et al.*, 2008) and failures and engaging all parties within the sector and relevant allies, we suggest that it is possible to have a vibrant recreational fishing sector in the Anthropocene where responsibility leads to sustainability.

Failure to engage the recreational angling community in pursuing responsible action will lead to a variety of negative ecological and socio-economic consequences and, with that, mounting pressure for recreational fishing activities to cease. Unfortunately, there are already instances of this occurring (*e.g.*, in India) where angling has been halted as a result of ethical concerns and there are also increasing examples of where fishing closures triggered by exceedance of temperature thresholds are being used as means of mitigating threats to recreational fish in the face of climate change (see Gale *et al.*, 2015). This is a good example of decision-makers responding to external threats to the sector, as recreational fishing did not lead to the warmer-water conditions, but decision-makers responded effectively by curtailing fisheries interactions that are more stressful in warmer water temperatures. Responsible (and creative) actions by all recreational angling actors have the potential to address these and other challenges such that sustainability can be achieved; something that fits well within the socio-ecological framework proposed by Arlinghaus *et al.* (2016, 2017). Recreational fisheries are as much about

people as fish and thus the future of recreational fisheries is very much in the hands of the angling community.

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Conflict of interest statement

All of the authors on this manuscript are avid anglers. S.C.D. is an ambassador for Patagonia & Cooke; S.C.D., A.J.D., S.D.B., J.W.B. and R.A. are ambassadors for the Keepemwet fishing movement.

REFERENCES

- Altieri, A. H., M. D. Bertness, T. C. Coverdale, N. C. Herrmann and C. Holdredge., (2012). A trophic cascade triggers collapse of a salt marsh ecosystem with intensive recreational fishing. *Ecology* 93:1402–1410.
- Arlinghaus, R. & Cooke, S. J. (2009) Recreational Fisheries: Socioeconomic Importance, Conservation Issues and Management Challenges. In *Recreational Hunting, Conservation and Rural Livelihoods: Science and Practice* pp. 39–58.

- Arlinghaus, R. (2007) Voluntary Catch-and-Release Can Generate Conflict within the Recreational Angling Community: A Qualitative Case Study of Specialised Carp, *Cyprinus Carpio*, Angling in Germany. *Fisheries Management and Ecology.*, 2007, 161–171, doi:10.1111/j.1365-2400.2007.00537.x.
- Arlinghaus, R. (2005). A conceptual framework to identify and understand conflicts in recreational fisheries systems, with implications for sustainable management. *Aquatic Resources, Culture and Development*, 1(2), 145-174.
- Arlinghaus, R., (2006). Overcoming human obstacles to conservation of recreational fishery resources, with emphasis on central Europe. *Environmental Conservation* 33, 46e59
- Arlinghaus, R., Alós, J., Beardmore, B., Daedlow, K., Dorow, M., Fujitani, M., Hühn, D., Haider, W., Hunt, L. M., Johnson, B. M., *et al.*, (2017) Understanding and Managing Freshwater Recreational Fisheries as Complex Adaptive Social-Ecological Systems. *Reviews in Fisheries Science and Aquaculture.*, 2017, 1–41, doi:10.1080/23308249.2016.1209160.
- Arlinghaus, R., Cooke, S. J., Lyman, J., Policansky, D., Schwab, A., Suski, C., ... & Thorstad, E. B. (2007). Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social and biological perspectives. *Reviews in Fisheries Science*, 15(1-2), 75-167.
- Arlinghaus, R., Cooke, S.J., Sutton, S.G., *et al.*, (2016) Recommendations for the future of recreational fisheries to prepare the social-ecological system to cope with change. *Fisheries Management and Ecology* 23, 177–186.

- Arlinghaus, R., Mehner, T. & Cowx, I. G. (2002) Reconciling Traditional Inland Fisheries Management and Sustainability in Industrialized Countries, with Emphasis on Europe. *Fish and Fisheries* 3, 261–316.
- Arlinghaus, R., Schwab, A., (2011). Five ethical challenges to recreational fishing: what they are and what they mean. In T.D. Beard Jr, R. Arlinghaus and S.G. Sutton (Eds) *The angler in the environment: social, economic, biological and ethical dimensions. Proceedings from the fifth world recreational fishing conference.*
- Arlinghaus, R., Schwab, A., Riepe, C., & Teel, T. (2012). A primer on anti-angling philosophy and its relevance for recreational fisheries in urbanized societies. *Fisheries*, 37(4), 153-164.
- Arlinghaus, R., Tillner, R., Bork, M., (2015). Explaining participation rates in recreational fishing across industrialised countries. *Fish. Manag. Ecol.* 22, 45–55.
- Armstrong, M., Brown, A., Hargreaves, J., Hyder, K., Munday, M., Proctor, S., Roberts, A., Roche, N., Williamson, K., (2013). *Sea Angling, 2012 – a survey of recreational sea angling activity and economic value in England.* Defra, London, UK. 16pp.
- Balon, E. K. (2000). Defending fishes against recreational fishing: an old problem to be solved in the new millennium. *Environmental Biology of Fishes*, 57(1), 1-8.
- Bartholomew, A. & Bohnsack, J. A. (2005) A Review of Catch-and-Release Angling Mortality with Implications for No-Take Reserves. *Reviews in Fish Biology and Fisheries.*, 2005, 129–154, doi:10.1007/s11160-005-2175-1.

- Bate, R. (2001) Saving Our Streams: the Role of the Anglers' Conservation Association in Protecting English and Welsh Rivers. The Institute of Economic Affairs and Profile Books, London
- Berg, R. & Rosch, R. (1998) Animal welfare and angling in Baden-Wurtemberg, Germany. In: Recreational Fisheries: Social, Economic and Management Aspects (Proceedings from the, 19th session of the European Inland Fisheries Advisory Commission) (eds Hickley, P. & Tompkins, H.), pp. 88-92. Food and Agriculture Organization of the United Nations. Rome, Italy
- Blythe, J., Cohen, P., Eriksson, H., Cinner, J., Boso, D., Schwarz, A. M. & Andrew, N. (2017) Strengthening Post-Hoc Analysis of Community-Based Fisheries Management through the Social-Ecological Systems Framework. *Marine Policy* 82, 50–58.
- Bova, C. S., Halse, S. J., Aswani, S., & Potts, W. M. (2017). Assessing a social norms approach for improving recreational fisheries compliance. *Fisheries Management and Ecology*, 24(2), 117-125.
- Bower, S. D., Danylchuk, A. J., Raghavan, R., Danylchuk, S. C., Pinder, A. C., Alter, A. M. & Cooke, S. J. (2017) Involving Recreational Fisheries Stakeholders in Development of Research and Conservation Priorities for Mahseer (*Tor Spp.*) of India through Collaborative Workshops. *Fisheries Research* 186, 665–671.
- Bower, S. D., Nguyen, V. M., Danylchuk, A. J., Beard Jr, T. D., & Cooke, S. J. (2014). Inter-sectoral conflict and recreational fisheries of the developing world: Opportunities and challenges for co-operation. *Enhancing Stewardship in Small-Scale Fisheries: Practices and Perspectives*, ed. P. McConney, R. Medeiros and M. Pena. Too Big To Ignore

(TBTI) and Centre for Resource Management and Environmental Studies, Technical Report, (73).

Browman, H. I. & Skiftesvik, A. B. (2011) Welfare of Aquatic Organisms: Is There Some Faith-Based HARKing Going on Here? *Diseases of Aquatic Organisms* 94, 255–257.

Brownscombe, J. W. Hunt, J., Acosta, A., Morley, D., Holder, P., Griffin, L. P., Young, N, Danylchuk, A. J., Cooke, S. J., Boucek, R., Aaron J. Adams, A. J. (In Review). Bridging the knowledge-action gap: A case of research rapidly impacting recreational fisheries policy. *Marine Policy*.

Brownscombe, J. W., Danylchuk, A. J., Chapman, J. M., Gutowsky, L. F., & Cooke, S. J. (2017). Best practices for catch-and-release recreational fisheries—Angling tools and tactics. *Fisheries research*, 186, 693-705.

Burger, L. M., Neal, J. W., & Lusk, R. D. (2018). The Role of Private Ponds in Recruiting the Next Generation of Anglers. *Journal of the Southeastern Association of Fish and Wildlife Agencies*, 5, 59-63.

Carpenter, S. R., Brock, W. A., Hansen, G. J. A., Hansen, J. F., Hennessy, J. M., Isermann, D. A., Pedersen, E. J., Perales, K. M., Rypel, A. L., Sass, G. G., *et al.*, (2017) Defining a Safe Operating Space for Inland Recreational Fisheries. *Fish and Fisheries* 18, 1150–1160.

Coggins, L. G., Catalano, M. J., Allen, M. S., Pine, W. E. & Walters, C. J. (2007) Effects of Cryptic Mortality and the Hidden Costs of Using Length Limits in Fishery Management. *Fish and Fisheries* 8, 19, 196–210.

- Cooke, S. J. & Cowx, I. G. (2006) Contrasting Recreational and Commercial Fishing: Searching for Common Issues to Promote Unified Conservation of Fisheries Resources and Aquatic Environments. *Biological Conservation* 128, 93–108.
- Cooke, S. J., & Cowx, I. G. (2004). The role of recreational fishing in global fish crises. *AIBS Bulletin*, 54(9), 857-859.
- Cooke, S. J., Suski, C. D., Arlinghaus, R., & Danylchuk, A. J. (2013). Voluntary institutions and behaviours as alternatives to formal regulations in recreational fisheries management. *Fish and Fisheries*, 14(4), 439-457.
- Cooke, S. J., Twardek, W. M., Lennox, R. J., Zolderdo, A. J., Bower, S. D., Gutowsky, L. F. G., Danylchuk, A. J., Arlinghaus, R. & Beard, D. (2018) The Nexus of Fun and Nutrition: Recreational Fishing Is Also about Food. *Fish and Fisheries*, 19, 201–224.
- Copeland, C., Baker, E., Koehn, J. D., Morris, S. G., & Cowx, I. G. (2017). Motivations of recreational fishers involved in fish habitat management. *Fisheries Management and Ecology*, 24(1), 82-92.
- Corlett, R.T., 2015. The Anthropocene concept in ecology and conservation. *Trends in Ecology & Evolution.*, 30, 36-41.
- Costello, M.J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H. and Miloslavich, P., 2010. A census of marine biodiversity knowledge, resources and future challenges. *PloS one*. 5: e12110.

- Cowx, I. G., Arlinghaus, R. & Cooke, S. J. (2010) Harmonizing Recreational Fisheries and Conservation Objectives for Aquatic Biodiversity in Inland Waters. *Journal of Fish Biology.*, 2010, 2194–2215, doi:10.1111/j.1095-8649.2010.02686.x.
- Crutzen, P. J. & Stoermer, E. F. (2000) Have We Entered the ‘ Anthropocene ’? *Global Change Newsletter* 41, 17–18.
- Daedlow, K., Beckmann, V. & Arlinghaus, R. (2011) Assessing an Adaptive Cycle in a Social System under External Pressure to Change: The Importance of Intergroup Relations in Recreational Fisheries Governance. *Ecology and Society* 16.
- Dalby, S., 2016. Framing the Anthropocene: The good, the bad and the ugly. *The Anthropocene Review*, 3, 33-51.
- Danylchuk, A. J., Danylchuk, S. C., Kosiarski, A., Cooke, S. J., & Huskey, B. (2018). Keepemwet Fishing – An emerging social brand for disseminating best practices for catch-and-release in recreational fisheries. *Fisheries Research*, 205, 52-56.
- Danylchuk, A. J., Tiedemann, J. & Cooke, S. J. (2017) Perceptions of Recreational Fisheries Conservation within the Fishing Industry: Knowledge Gaps and Learning Opportunities Identified at East Coast Trade Shows in the United States. *Fisheries Research* 186, 681–687.
- Danylchuk, A.J. and S.J. Cooke. , 2011. Engaging the recreational angling community in the implementation and management of aquatic protected areas. *Conservation Biology* 25:458-464.

- Danylchuk, A.J., S.C. Danylchuk, A. Kosiarski, S.J. Cooke and B. Huskey., 2018. Keepemwet Fishing – An emerging social brand for disseminating best practices for catch-and-release in recreational fisheries. *Fisheries Research*, 205:52-56.
- De Leeuw, A. D. (1996) Contemplating the Interest of Fish: The Angler's Challenge. *Environmental Ethics* 18, 373–390.
- Dean, J. (1996). The role of angler organizations in fisheries management. In *Multidimensional approaches to reservoir fisheries management*. American Fisheries Society, Symposium (Vol. 16, pp. 172-175).
- DesJardins, J. (1998). Corporate environmental responsibility. *Journal of Business Ethics*, 17(8), 825-838.
- Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C., Naiman, R. J., Prieur-Richard, A. H., Soto, D., Stiassny, M. L. J., *et al.*, (2006) *Freshwater Biodiversity: Importance, Threats, Status and Conservation Challenges*. *Biological Reviews of the Cambridge Philosophical Society.*, 2006, 163–182, doi:10.1017/S1464793105006950.
- Dummet, K. (2006). Drivers for corporate environmental responsibility (CER). *Environment, Development and Sustainability*, 8(3), 375-389.
- Ebner, D., & Baumgartner, R. J. (2006, September). The relationship between sustainable development and corporate social responsibility. In *Corporate responsibility research conference* (Vol. 4, No. 5.9, p., 2006). Queens University, Belfast Dublin.

- Elmer, L. K., Kelly, L. A., Rivest, S., Steell, S. C., Twardek, W. M., Danylchuk, A. J., Arlinghaus, R., Bennett, J. R. & Cooke, S. J. (2017) Angling into the Future: Ten Commandments for Recreational Fisheries Science, Management and Stewardship in a Good Anthropocene. *Environmental Management* 60, 165–175.
- Everard, M. & Kataria, G. (2011) Recreational Angling Markets to Advance the Conservation of a Reach of the Western Ramganga River, India. *Aquatic Conservation: Marine and Freshwater Ecosystems* 21, 101–108.
- FAO (2009). Aquatic Sciences and Fisheries Information System: Aquatic Sciences and Fisheries Thesaurus. Descriptors Used in the Aquatic Sciences and Fisheries Information System. Eds E. Fagetti, D.W. Privett & J.R.L. Sears. ASFIS Reference Series, No. 6. Rome: FAO. www.fao.org/tempref/docrep/fao/011/k5032e/k5032e.pdf
- FAO. (2012) Recreational Fisheries. FAO Technical Guidelines for Responsible Fisheries. NO. 13. 176.
- Fedler, A. J. & Ditton, R. B. (1994) Understanding Angler Motivations in Fisheries Management. *Fisheries*, 19, 6–13.
- Fehr, E., Fischbacher, U., 2004. Social norms and human cooperation. *Trends in Cognitive Sciences*, 8(4), 187-190.
- Florisson, J.H., Tweedley, J.R., Walker, T.H., Chaplin, J.A., 2018. Reef vision: A citizen science program for monitoring the fish faunas of artificial reefs. *Fish. Res.*, 206, 296-308

- Fujitani, M., McFall, A., Randler, C. & Arlinghaus, R. (2017) Participatory Adaptive Management Leads to Environmental Learning Outcomes Extending beyond the Sphere of Science. *Science Advances* 3.
- Fulton, E. A., Smith, A. D., Smith, D. C., van Putten, I. E. (2011). Human behaviour: the key source of uncertainty in fisheries management. *Fish and Fisheries*, 12(1), 2-17.
- Gale, M. K., Hinch, S. G., Donaldson, M. R. (2013). The role of temperature in the capture and release of fish. *Fish and Fisheries*, 14(1), 1-33.
- Gallagher, A. J., Cooke, S. J. & Hammerschlag, N. (2016) Risk Perceptions and Conservation Ethics among Recreational Anglers Targeting Threatened Sharks in the Subtropical Atlantic. *Endangered Species Research* 29, 81–93.
- Gov. India (1960). *The Prevention Of Cruelty To Animals Act*. Dehli: Government of India. www.indiacode.nic.in/bitstream/123456789/1547/1/196059.pdf
- Gov. India (1972). *The Indian Wildlife (Protection) Act, 1972 (as amended upto 1993)*. Dehli, India. www.envfor.nic.in/legis/wildlife/wildlife1.html
- Granek, E. F., Madin, E. M. P., Brown, M. A., Figueira, W., Cameron, D. S., Hogan, Z., Kristianson, G., De Villiers, P., Williams, J. E., Post, J., *et al.*, (2008) Engaging Recreational Fishers in Management and Conservation: Global Case Studies Engaging Recreational Fishers in Management and Conservation: Global Case Studies. *Conservation Biology* 2217372875, 1125–113443.

- Granek, E. F., Madin, E. M., Brown, M. A., Figueira, W., Cameron, D. S., Hogan, Z., ... & Zahn, S. (2008). Engaging recreational fishers in management and conservation: global case studies. *Conservation Biology*, 22(5), 1125-1134.
- Greiner, R., Young, M.D., McDonald, A.D., Brooks, M. (2000). Incentive instruments for the sustainable use of marine resources. *Ocean & Coastal Management*, 43(1), 29-50.
- Griffiths, S. P., Bryant, J., Raymond, H. F. & Newcombe, P. A. (2017) Quantifying Subjective Human Dimensions of Recreational Fishing: Does Good Health Come to Those Who Bait? *Fish and Fisheries* 18, 171–184.
- Guckian M.L., Danylchuk A.J., Cooke S.J. & Markowitz E.M. (2018) Peer pressure on the riverbank: Assessing catch-and-release anglers' willingness to sanction others' (bad) behavior. *Journal of Environmental Management* 219, 252–259.
- Gupta, N., Nautiyal, P., Borgohain, A., Sivakumar, K., Mathur, V. B., & Chadwick, M. A. (2016). Catch-and-release angling as a management tool for freshwater fish conservation in India. *Oryx*, 50(2), 250-256.
- Gupta, N., Bower, S. D., Raghavan, R., Danylchuk, A. J. & Cooke, S. J. (2015) Status of recreational fisheries in India: Development, issues and opportunities. *Reviews in Fisheries Science and Aquaculture* 23, 291–301.
- Hilborn, R. (2007). Managing fisheries is managing people: what has been learned? *Fish and Fisheries*, 8(4), 285-296.
- Hilborn R., Walters C.J., Stokes K. & Maguire J. (2004) When can marine reserves improve fisheries management. *Ocean & Coastal Management*, 47, 197–205.

Hughes, B., 2014. The socioeconomic values of recreational fishing. *Fisheries* 39, 291.

Hunt, L. M. (2005) Recreational fishing site choice models: Insights and future opportunities. *Human Dimensions of Wildlife* 10, 153–172.

Hunt, L.M., Sutton, S.G. and Arlinghaus, R. (2013) Illustrating the critical role of human dimensions research for understanding and managing recreational fisheries within a social-ecological system framework. *Fisheries Management and Ecology*, 20, 111–124.

Hyder, K., Radford, Z., Pallezo, R., Weltersbach, M.S., Lewin, W.-C., Zarauz, L., Ferter, K., Ruiz, J., Townhill, B., Mugerza, E., Strehlow, H. V., 2017. Research for PECH Committee - Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels, 134pp.

Hyder, K., Weltersbach, M.S., Armstrong, M., Ferter, K., Townhill, B., Ahvonen, A., Arlinghaus, R., Baikov, A., Bellanger, M., Birzaks, J., Borch, T., Cambie, G., de Graaf, M., Diogo, H.M.C., Dziemian, Ł., Gordo, A., Grzebielec, R., Hartill, B., Kagervall, A., Kapiris, K., Karlsson, M., Kleiven, A.R., Lejk, A.M., Levrel, H., Lovell, S., Lyle, J., Moilanen, P., Monkman, G., Morales-Nin, B., Mugerza, E., Martinez, R., O'Reilly, P., Olesen, H.J., Papadopoulos, A., Pita, P., Radford, Z., Radtke, K., Roche, W., Rocklin, D., Ruiz, J., Scougal, C., Silvestri, R., Skov, C., Steinback, S., Sundelöf, A., Svagzdys, A., Turnbull, D., van der Hammen, T., van Voorhees, D., van Winsen, F., Verleye, T., Veiga, P., Vølstad, J.-H., Zarauz, L., Zolubas, T., Strehlow, H. V., 2018. Recreational sea fishing in Europe in a global context-Participation rates, fishing effort, expenditure and implications for monitoring and assessment. *Fish and Fisheries*, 19, 225–243.

Jacobs, A. M. (2008) The Politics of When: Redistribution, Investment and Policy Making for the Long Term. *British Journal of Political Science* 38, 19, 193–220.

Jacobs, A. M. (2011) *Governing for the Long Term: Democracy and the Politics of Investment*. Cambridge University Press Pp 306.

Johnston, F. D., Arlinghaus, R. & Dieckmann, U. (2013) Fish life history, angler behaviour and optimal management of recreational fisheries. *Fish and Fisheries* 14, 554–579.

Johnston, F.D., Arlinghaus, R. and Dieckmann, U. (2010) Diversity and complexity of angler behaviour drive socially optimal input and output regulations in a bioeconomic recreational-fisheries model. *Canadian Journal of Fisheries and Aquatic Sciences* 67, 1507– 1531.

Jørgensen, C., Enberg, K., Dunlop, E. S., Arlinghaus, R., Boukal, D. S., Brander, K., Ernande, B., Gårdmark, A., Johnston, F., Matsumura, S., *et al.*, (2007) Managing evolving fish stocks. *Science.*, 2007, 1247–1248, doi:10.1126/science.1148089.

Jose, S., Patrick, P. G., & Moseley, C. (2017). Experiential learning theory: the importance of outdoor classrooms in environmental education. *International Journal of Science Education, Part B*, 7(3), 269-284.

Koehn, J. D. & Todd, C. R. (2012) Balancing conservation and recreational fishery objectives for a Threatened fish species, the Murray Cod, *Maccullochella peelii*. *Fisheries Management and Ecology*, 19, 410–425.

Lam, M. E., Pauly, D. (2010). Who is right to fish? Evolving a social contract for ethical fisheries. *Ecology and Society*, 15(3). www.jstor.org/stable/26268187

- Lester, N. P., Marshall, T. R., Armstrong, K., Dunlop, W. I., Ritchie, B. (2003). A broad-scale approach to management of Ontario's recreational fisheries. *North American Journal of Fisheries Management*, 23(4), 1312-1328.
- Lewin, W. C., Arlinghaus, R. & Mehner, T. (2006) Documented and potential biological impacts of recreational fishing: Insights for management and conservation. *Reviews in Fisheries Science.*, 2006, 305–367, doi:10.1080/10641260600886455.
- Lynch, A. J., S. J. Cooke, A. Deines, S. Bower, D. B. Bunnell, I. G. Cowx, V. M. Nguyen, J. Nonher, K. Phouthavong, B. Riley, M. W. Rogers, W.W. Taylor, W.M. Woelmer, S. Youn and T. D. Beard, Jr., (2016). The social, economic and ecological importance of inland fishes and fisheries. *Environmental Reviews*, 24, 115-121.
- Mace, P. M. (2001) A New Role for MSY in Single-Species and Ecosystem Approaches to Fisheries Stock Assessment and Management. *Fish and Fisheries* 2, 2–32.
- Mackay, M., Jennings, S., van Putten, E. I., Sibly, H., Yamazaki, S. (2018). When push comes to shove in recreational fishing compliance, think ‘nudge’. *Marine Policy*, 95, 256-266.
- Mannheim, S. L., Childs, A. R., Butler, E. C., Winkler, A. C., Parkinson, M. C., Farthing, M. W., ... & Potts, W. M. (2018). Working with, not against recreational anglers: Evaluating a pro-environmental behavioural strategy for improving catch-and-release behaviour. *Fisheries Research*, 206, 44-56.
- Mardle, S. & Pascoe, S. (2002) Modelling the Effects of Trade-Offs between Long and Short-Term Objectives in Fisheries Management. *Journal of Environmental Management.*, 2002, 49–62, doi:10.1006/jema.2001.0518.

- Mc Cool, S. F. & Lime, D. W. (2001) Tourism Carrying Capacity: Tempting Fantasy or Useful Reality? *Journal of Sustainable Tourism* 9, 372–388.
- McClenachan, L. (2013) Recreation and the ‘right to fish’ movement: Anglers and ecological degradation in the Florida Keys. *Environmental History*, 2013, 76–87, doi:10.1093/envhis/ems110.
- McPhee, D. P., Leadbitter, D., & Skilleter, G. A. (2002). Swallowing the bait: is recreational fishing in Australia ecologically sustainable? *Pacific Conservation Biology*, 8(1), 40-51.
- Nanjappa, R. Regan, R.A. Medellin, R. Cantu, R.E. McCabe, S. Craven, G.M. Vecellio and D.J. Decker., 2012. The North American Model of Wildlife Conservation. The Wildlife Society Technical Review 12-04. The Wildlife Society, Bethesda, Maryland, USA.
- National Marine Fisheries Service. (2015) Fisheries Economics of the United States, 2015. NOAA Technical Memorandum 265 pp.
- Nguyen, V. M., Rudd, M. A., Hinch, S. G., & Cooke, S. J. (2012). Differences in information use and preferences among recreational salmon anglers: implications for management initiatives to promote responsible fishing. *Human Dimensions of Wildlife*, 17(4), 248-256.
- Organ, J.F., V. Geist, S.P. Mahoney, S. Williams, P.R. Krausman, G.R. Batcheller, T.A. Decker, R. Carmichael, P., *et al.*, (2012) The North American model of wildlife conservation. *The Wildlife Society Technical Review*, 12(04).
- Ostrom, E. (2000) Collective Action and the Evolution of Social Norms. *The journal of economic perspectives* 14, 137–158.

- Parkkila K., Arlinghaus R., Artell J., Gentner B., Haider W., Aas Ø. *et al.*, (2010) European Inland Fisheries Advisory Commission Methodologies for Assessing Socio-Economic Benefits of European Inland Recreational Fisheries. Rome: FAO: European Inland Fisheries Advisory Commission Occasional Paper 46, 112 pp.
- Pauly, D., Christensen, V., Guénette, S., Pitcher, T. J., Sumaila, U. R., Walters, C. J., Watson, R. & Zeller, D. (2002) Towards Sustainability in World Fisheries. *Nature.*, 2002, 689–695, doi:10.1038/nature01017.
- Pergams, O.R.W. and P.A. Zaradic. , 2008. Evidence for a fundamental and pervasive shift away from nature-based tourism. *Proceedings of the National Academy of Science* 105:2295-2300.
- Pinder, A. C. & Raghavan, R. (2013) Conserving the Endangered Mahseers (*Tor* spp.) of India: The Positive Role of Recreational Fisheries. *Current Science.*, 2013, 1472–1475.
- Pita, C., Pierce, G. J., Theodossiou, I. (2010). Stakeholders' participation in the fisheries management decision-making process: Fishers' perceptions of participation. *Marine Policy*, 34(5), 1093-1102.
- Pitcher, T. J., E., H. C. & P., C. S. (2002) Fishing for Fun: Where's the Catch? In Pitcher, T. J., E., H. C. & P., C. S. (Eds) *Recreational Fisheries: Ecological, Economic and Social Evaluation*. Blackwell Science 1, 1-16.
- Policansky D. (2002) Catch-and-release recreational fishing: a historical perspective. In: T.J. Pitcher & C.E. Hollingworth (eds) *Recreational Fisheries: Ecological, Economic and Social Evaluation*. Oxford: Blackwell Science, pp. 74– 94

Post, J. R., Sullivan, M., Cox, S., Lester, N. P., Walters, C. J., Parkinson, E. A., *et al.*, (2002).

Canada's recreational fisheries: the invisible collapse? *Fisheries*, 27(1), 6-17.

Reid, A.J., Carlson, A.K., Creed, I.F., Eliason, E.J., Gell, P.A., Johnson, P.T.J., Kidd, K.A.,

MacCormack, T.J., Olden, J.D., Ormerod, S.J., Smol, J.P., Taylor, W.W., Tockner, K.,

Vermaire, J.C., Dudgeon, D., Cooke S.J., (2018). Emerging threats and persistent

conservation challenges for freshwater biodiversity. *Biological Reviews*, (online).

doi.org/10.1111/brv.12480.

Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish populations.

Bulletin of the Fisheries Research Board of Canada, Bulletin, 191, Ottawa.

<http://www.dfo-mpo.gc.ca/Library/1485.pdf>

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., Lenton, T. M.,

Scheffer, M., Folke, C., Schellnhuber, H. J., *et al.*, (2009) A Safe Operating Space for

Humanity. *Nature* 461, 472–475.

Schroeder, S. A., Fulton, D. C., Altena, E., Baird, H., Dieterman, D., & Jennings, M. (2018). The

Influence of Angler Values, Involvement, Catch Orientation, Satisfaction, Agency Trust

and Demographics on Support for Habitat Protection and Restoration Versus Stocking in

Publicly Managed Waters. *Environmental Management*, 1-13.

Sethi, S. A., Branch, T. A. & Watson, R. (2010) Global Fishery Development Patterns Are

Driven by Profit but Not Trophic Level. *Proceedings of the National Academy of*

Sciences 107, 12163–12167.

- Sharma, N. (2018). Uttarakhand first to ban angling, cites cruelty to fish. Hindustan Times 18 July 2018. www.hindustantimes.com/dehradun/uttarakhand-first-to-ban-angling-cites-cruelty-to-fish/story-iX3w1z63rSOBTv22NQdSiO.html
- Siemer, W. F. & Knuth, B. A. (1998). Youth Participant Outcomes Associated With Local Hooked on Fishing - Not on Drugs Programs. Human Dimensions Research Unit Publication 98-5. Department of Natural Resources. Cornell University, Ithaca, NY. 94 pp.
- Siemer, W. F. & Knuth, B. A. (2001) Effects of Fishing Education Programs on Antecedents of Responsible Environmental Behavior. *The Journal of Environmental Education* 32, 23–29.
- Sims, B., & Danylchuk, A. J. (2017). Characterizing information on best practice guidelines for catch-and-release in websites of angling-based non-government organizations in the United States. *Fisheries Research*, 186, 688-692.
- Smith, L. E., Khoa, S. N., & Lorenzen, K. (2005). Livelihood functions of inland fisheries: policy implications in developing countries. *Water Policy*, 7(4), 359-383.
- Soga M. & Gaston K.J. (2016) Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment* 14, 94–101.
- Steffen W., Crutzen P.J. & McNeill J.R. (2007) The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature. *AMBIO: A Journal of the Human Environment* 36, 614–621.

Sutinen, J. G., Johnston, R. J. (2003). Angling management organizations: integrating the recreational sector into fishery management. *Marine Policy*, 27(6), 471-487.

Trushenski, J., Flagg, T. and Kohler, C.C., 2010. Use of hatchery fish for conservation, restoration and enhancement of fisheries. In *Inland Fisheries Management in North America 3e*, Chapter: 9 (Hubert, WA., Quist, MC, Eds). American Fisheries Society P. 261-293.

Tufts, B. L., Holden, J., & DeMille, M. (2015). Benefits arising from sustainable use of North America's fishery resources: economic and conservation impacts of recreational angling. *International Journal of Environmental Studies*, 72(5), 850-868.

Upadhyay, V., 2018. Animals have equal rights as humans, says Uttarakhand high court. *Times of India*, July 5th, 2018. Retrieved from <https://timesofindia.indiatimes.com/city/dehradun/members-of-animal-kingdom-to-be-treated-as-legal-entities-ukhand-hc/articleshow/64860996.cms>

Venturelli, P. A., Hyder, K., & Skov, C. (2017). Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. *Fish and Fisheries*, 18(3), 578-595.

Figure Caption

FIGURE 1 Schematic depiction of the role of individual responsibility in supporting sustainable recreational fisheries.

