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# A One Health perspective on recreational fisheries

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## Abstract

Recreational fisheries involve an intimate connection between people, individual fish, and the environment. Recreational fishers and their health crucially depend on healthy fish and ecosystems. Similarly, fish and ecosystems can be impacted by the activities of people including recreational fishers. Thus, amplified by the global interest in recreational fishing, we posit that recreational fishing is particularly suited as an empirical system to explore a One Health perspective, with a goal of creating pathways to better manage such socio-ecological systems for the benefit of people, fish, and the environment. Although zoonoses are uncommon in fishes, fish can carry pathogens, biotoxins, or contaminants that are harmful to people. When captured and released, fish can experience stress and injuries that may promote pathogen development. Similarly, when humans contribute to environmental degradation, not only are fish impacted but so are the humans that depend on them for nutrition, livelihoods, culture, and well-being. Failure to embrace the One Health perspective for recreational fisheries has the potential to negatively impact the health of fish, fisheries, people, society, and the aquatic environment—especially important since these complex social–ecological systems are undergoing rapid change.

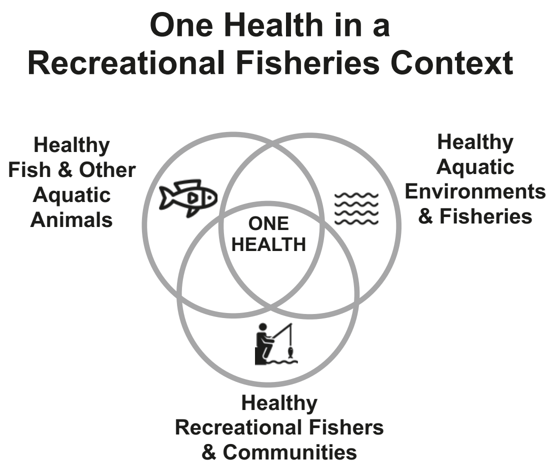
**Key words:** angling, fish health, recreational fishing, One Health, socio-ecological system, wellbeing

## Introduction

One Health has emerged as a framework of inquiry defined as "the collaborative efforts of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals and the environment" (AVMA 2008). The One Health concept has its roots in the study of zoonotic disease, with the recognition that anthropogenic alterations to ecosystems often have the unintended consequence of accelerating pathogen transmission from people to animals (Evans and Leighton 2014). One Health gained recent attention in this regard with the COVID-19 pandemic because of the zoonotic origin of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was likely catalysed by anthropogenically altered interactions among humans, animals, and the bats from which SARS-CoV-2 emerged (El Zowalty and Järhult 2020; Ruckert et al. 2020). The One Health concept has been widely embraced in a number of other realms, including livestock production (Sherman 2010), wildlife management and conservation (Buttke et al. 2015), human medicine (Zinsstag et al. 2011), and veterinary medicine (Destoumieux-Garzón et al. 2018). In 2022, the World Health Organization, the Food and Agriculture Organization, the World Organisation for Animal Health, and the United Nations Environment Programme developed a One Health Joint Plan of Action together. One Health has become a much broader framework for the laudable goal of improving animal, human, and ecosystem health simultaneously (and acknowledging them as being of equal importance; Evans and Leighton 2014), and for that reason, it can be applied to nearly any system in which these triadic interactions occur.

In this essay, we present a One Health perspective for recreational fisheries. We believe the recreational fishing sector and its associated activities can constitute a leading case for organizing interdisciplinary inquiry around the health of animals, humans, and ecosystems (Fig. 1). We posit that recreational fishing is particularly suited as an empirical system to explore One Health because of the global popularity of the activity. Recreational fishers and their health crucially depend on healthy natural ecosystems. Therefore, ecosystem health is an instrumental, yet threatened, component of healthy

**Fig. 1.** Recreational fisheries interfaces with the One Health concept.




recreational fisheries and for the psychological, mental, and nutritional health benefits that recreational fishing brings to people.

## On recreational fishing and fisheries

Recreational fishing is defined by the UN FAO (2012) as the "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". It is an activity practiced around the world, with estimates of total participation exceeding 220 million (Arlinghaus et al. 2021), averaging around 10% of the global population (Arlinghaus et al. 2015). In terms of numbers, there are about five times more recreational fishers than there are commercial fishers globally, and the activity is practiced in ponds, lakes, rivers, and coastal sites around the globe. Recreational fishing involves a variety of gear types (e.g., spearfishing and hand lining), but the most common form involves rod and reel fishing (known as angling). Estimates of global annual catch for the sector is ∼10 million metric tonnes, comprised of somewhere near 47 billion individual fish (Cooke and Cowx 2004). Because of its magnitude with millions of people involved, recreational fisheries generate substantial income for regional economies (over $120 billion per year according to the World Bank (2012).

Some fish captured by recreational fishers are harvested for food (Cooke et al. 2018), creating a link to personal nutrition and health that is often overlooked and underappreciated (Nyboer et al. 2022; Lynch et al. 2024). In some regions, the consumption rate of fish captured by recreational fishers is substantial (e.g., Canada, Poland, Finland, Argentina; Lynch et al. 2024). Indeed, there is a fuzzy boundary between recreational fisheries and subsistence fisheries in some locales with people dependent upon healthy and safe fish populations for nutrition (Nyboer et al. 2022). Nonetheless, approximately two-thirds of captured fish (equating to an estimate of ∼30 billion fish annually) are released (Cooke and Cowx 2004), a process termed "catch-and-release" (Arlinghaus et al. 2007). Fish are released for a variety of reasons including to comply with harvest regulations, because the size or species of fish is undesirable, because of the conservation ethic of the angler, or due to other individual social norms and motivations (Arlinghaus et al. 2007). Catch-and-release is relevant because the health status of the individual fish influences subsequent survival, which is a function of individual angler behaviour—how they capture and handle the fish (Cooke and Sneddon 2007). These fisheries also contribute to a range of other benefits to humans, including mental wellbeing, restoration, physiological health, nutrition and food security, culture, and social cohesion (reviewed in Parkkila et al. 2010; Tufts et al. 2015; Pita et al. 2022). In short, recreational fishing as a recreational activity constitutes a major component of the lifestyle of millions of people.

Recreational fisheries are considered a textbook example of a coupled social-ecological system (Arlinghaus et al. 2013, 2017). Such systems are characterized by many interactions, feedbacks, and processes within and among social and ecological components and occur over multiple spatiotemporal scales (Arlinghaus et al. 2017). A simplified description is as follows: humans exist and operate in a "human system" whereby they interact with the eco-evolutionary environment of "aquatic systems" where fish reside. When engaged in recreational fishing, humans interact with fish in the aquatic system at the level of the individual fish, fishery, and ecosystem, whereby their actions (e.g., harvest, catch-and-release) can generate services that benefit people, but also feedback on the ecological system through possible overfishing, spread of non-native species, habitat and wildlife disturbance, and pollution (e.g., lost angling gear such as lead sinkers; Lewin et al. 2006). Each ecosystem used by recreational fishers is linked to other ecosystems through the movement patterns of anglers and the dispersal of matter, with most inland systems serving as sinks in the landscape that integrate matter and pollutants from the catchments (Yuan et al. 2020). Fish bioaccumulate pollutants and become a source of pollution to recreational fishers when they eat the fish (Dórea 2008). Through these and other pathways (e.g., environmental destruction limiting the natural productivity of fishes to be caught by fishers), local ecosystems, including terrestrial ecosystems, are interlinked and thus shape one another's ecology (Cooke et al. 2019).

## Recreational fisheries through a One Health lens

Fisheries managers and policymakers often try to manage at the system level, which involves intensive feedback from people (e.g., through social pressure) and ecosystems (e.g., through monitoring). Typically, fisheries management is poorly integrated with other policy fields that affect local ecosystems, such as water management, energy production (e.g., hydropower), agriculture (e.g., water use), or navigation. It is these external pressures (externalities) that often undermine the health of ecosystems (Cooke et al. 2013) and lead to their pollution, which is highly relevant from the

**Fig. 2.** Reasons why One Health is important in a recreational fisheries context.


One Health perspective. Forward-looking efforts to ensure sustainable fisheries for future generations are often framed in terms of "preparing the social-ecological system to cope with change" (Arlinghaus et al. 2016). The point here is that humans, animals (e.g., fish), and the environment interact in many direct ways, thus supporting our position that there is merit and need for considering recreational fishing (and the recreational fisheries sector) through the One Health lens (Fig. 2), especially in light of rapid social and environmental changes occurring in the Anthropocene.

Humans consume fish harvested by recreational fishers and in doing so support nutritional security and access to high-quality, culturally appropriate foods, including for individuals that are food insecure (Nyboer et al. 2022). Fishes, including those harvested by anglers, yield important micro and macro nutrients (Christensen et al. 2015) that are consumed by children and adults (Beehler et al. 2002). When fish populations are in decline, catch rates may also decline (and fisheries can collapse; Post et al. 2002) but more commonly management agencies will enact recreational fishing regulations to limit harvest or fishing effort (Isermann and Paukert 2010). Doing so can impact access to local, high quality nutritional resources that may be particularly important for those individuals that are low income and food insecure. Moreover, they may replace those "wild caught" foods with store-bought processed foods that are not as healthy (McClanahan et al. 2015).

Fish consumption from polluted areas where recreational fishers capture fish can pose health risks from chemical exposure (Cleary et al. 2021), and mobile fish can transport pollutants over large distances (Blais et al. 2007). The effects of anthropogenic disturbances such as chemical pollution on fish health are well known, and the acute results ("fish kills") are often dramatic (Austin 1998). Chemical pollution from textile and paper mills, coal mine dust, tanneries, and oil refineries has been recognized to affect fish since the 1870s (Heim and Schwarzbauer 2013; Zeitoun and Mehana 2014). For example, in the Laurentian Great Lakes there are many examples of legacy pollutants from historic industrial activities that to this day impact fish health and human health (e.g., heavy metals; Dellinger et al. 2014), in addition to emerging pollutants (e.g., pharmaceuticals; Jorgensen et al. 2018; microplastics; Bhuyan 2022). For this reason, fish consumption advisories exist for some pollutants (targeted towards recreational fishers and their communities) in an attempt to reduce risk for humans (Turyk et al. 2012).

The role of biotoxins in One Health has to do with their simultaneous effects on fish and the people who consume them, and this is especially true for toxins that bioaccumulate. Conditions that lead to high concentrations of biotoxins are mediated by human activities in coastal regions (Morabito et al. 2018). For example, ciguatera is a naturally occurring neurotoxin that accumulates in fish (Soliño and Costa 2020). There is some evidence that ciguatera bioaccumulation is exacerbated as a result of human activities ranging from coastal development to pollution to ecosystemic changes from overfishing (Loeffler et al. 2021). Similarly, harmful algal blooms and red tide events which are also naturally occurring but can be mediated by nutrient pollution leading to increased frequency and spatial extent (Alcock 2007). These event not only kill some fish (thus reducing catchable fish and system productivity; Landsberg et al. 2009) but can accumulate in fish. For example, brevetoxins bioaccumulate such that when consumed they can be hazardous to human health (Kirkpatrick et al. 2004) and microcystins have increasingly been documented in fish targeted and consumed by recreational fishes (Roegner et al. 2023). Of course, becoming ill from biotoxins has consequences for human health but so does not being able to consume fish (because of biotoxins) given the nutritional qualities of wild fishes.

The trade-offs between potential exposure to toxins or pathogens and not being able to access ecosystem services manifests on a routine basis. This may particularly be the case for low income individuals dependent upon fish captured via recreational fishing as food (Silver et al. 2007) or for individuals that lack sufficient education to be able to access, understand, or trust information about fish safety (McDermott 2003). Although people fish for diverse reasons, even those that embrace catch-and-release may keep and consume some fish. Fears of interacting with "toxic fish" or by extension, fishing in toxic waters, may alter fishing practices and the ability of recreational fishers to derive ecosystem services. It is also possible that fishing effort will be redistributed to other locations, with potential to increase exploitation. The complexity of behavioural responses among recreational fishers to direct and indirect effects of fish health remain unclear (Macdonald and Boyle 1997) although there is growing recognition that angler behaviour is highly variable and plastic relative to changing social-ecological contexts (Arlinghaus et al. 2013).

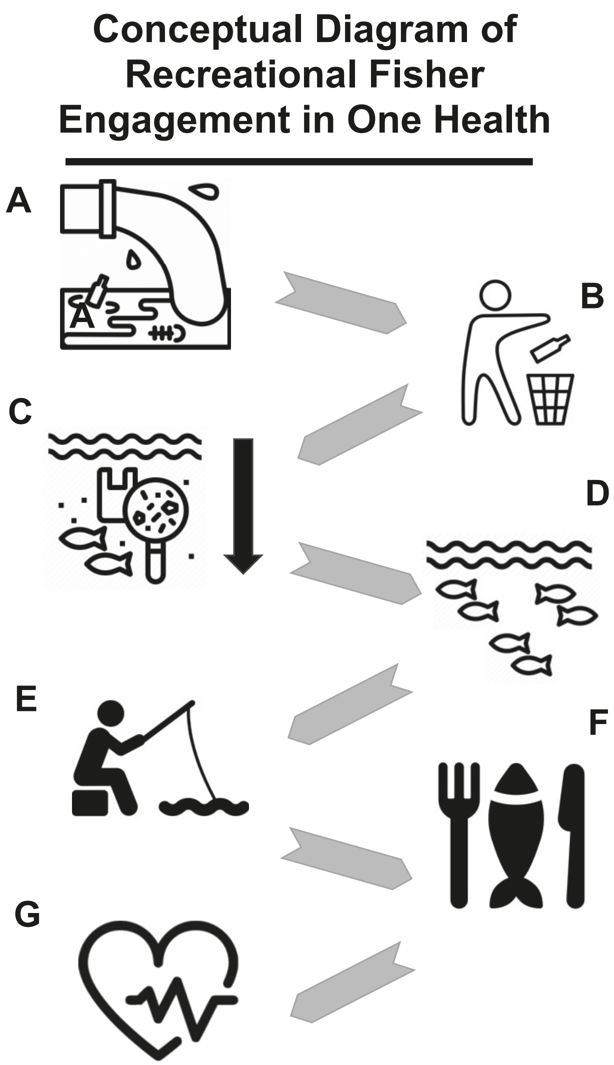
Wild fish are known carriers of pathogens and parasites of all types (viruses, bacteria, and eukaryotic parasites). Although few are zoonotic, fish pathogens can on occasion infect humans, usually through ingestion of undercooked fish (Chai et al. 2005; Boylan 2011). Proper preparation (e.g., cooking fish to a minimum temperature) can reduce those risks. In rare cases, handling of fish (even when they are to be released or during cleaning) can also lead to infections in hands (Lehane and Rawlln 2000). When fish are angled and released, those animals experience injuries (e.g., dermal disturbance; Colotelo and Cooke 2011) and also may experience physiological stress (and thus potentially be immunocompromised; Arlinghaus et al. 2007) that can collectively promote opportunistic pathogenic infections, some of which are zoonoses (notwithstanding the fact that zoonoses are rather uncommon in fishes; Chai et al. 2005; Boylan 2011). Moreover, pathogens can have long-standing effects on fish population numbers albeit often when mediated by other stressor like climate change (see Miller et al. 2014), and this could have an indirect effect on the nutritional well-being of recreational fishers who rely on fish as a protein source.

Recreational fishing is a leisure activity, and therefore it can deliver many psychological and other health benefits. It is well established that nature-based contact, including aquatic spaces (Gascon et al. 2017), can result in physiological and psychological well-being (Russell et al. 2013) through a healthy nature, healthy people mechanism (see Maller et al. 2006; Hartig et al. 2014, and Shanahan et al. 2016). That is, humans derive direct health and wellness benefit from being in or interacting with healthy natural environments. Recreational fishing is of fundamental importance for many people (Bryan 1977). Recreational fishers expect the activity to satisfy multiple psychological benefits including feelings of empowerment, achievement, social cohesion, restoration, sense of place, and other outcomes (Manfredo et al. 1996). Research in recreational fishing has shown that participants self-report reduced feelings of depression, angst, and other physiological relief and restoration after fishing (Pita et al. 2022). Participating in recreational fishing thus contributes to the well-being of participants, stemming directly from the satisfaction of expected psychological outcomes (Birdsong et al. 2022), from exercise, and generally from contact with nature and aquatic spaces (Griffiths et al. 2017). These mental health benefits are often stronger in fishing relative to other leisure activities (Pretty et al. 2007). Recreational fishing can also provide a restorative measure for the social integration of people with physical and mental disorders or disabilities (Freudenberg and Arlinghaus 2009; Bennett et al. 2014). Thus, recreational fishers not only personally benefit from contact with aquatic spaces through their fishing activity, but the activity can act as a catalyst for social reform, inclusion, and integration. In some places, recreational fishing creates social and informal economies where gathering together and sharing fish catches are a critical part of the culture and social belonging (Waitt et al. 2021).

Aquatic ecosystems, especially freshwater, are among the most threatened ecosystems on earth, with their biodiversity in steep decline (Reid et al. 2019). The impacts on most ecosystems are caused by factors external to recreational fishing, but these impacts strongly undermine the health benefits that fishing may bring to people (Lynch et al. 2023). In this context, recreational fishers, assisted by the relevant associations (e.g., angling clubs) and governmental wildlife and fisheries agencies, can be powerful actors for animal and environmental health and can act as stewards and forces of good for aquatic environments, individual fish, and fish populations (Shephard et al. 2023). For example, as advocates for environmental improvement and restoration of the many anthropogenically altered and polluted waterways, recreational anglers can contribute to building a community of environmental stewards who are actively involved in lobbying, and sometimes actually paying, for environmental improvement on which their beloved practice so intensively depends (Granek et al. 2008; Shephard et al. 2023). Consequently, engaging them with the One Health perspective offers a unique opportunity to extend their impact from a traditional focus on just ecological process, ecosystem restoration, and provision of healthy fish stocks and ecosystems, towards a health focus that emphasizes the link between healthy ecosystems and healthy fishers.

Climate change will have dramatic effects on recreational fisheries, fishing, and fishers in both marine (Townhill et al. 2019) and freshwater (Harrod et al. 2019) systems. One Health is a logical framework to link recreational fishing with climate change. Fish health, ecosystem health, and human behaviour and well-being will respond in myriad ways (some predictable and some not) to climate change (Hunt et al. 2016). Given that One Health effectively links relevant aspects of the recreational fishing sector, that framework could be used for monitoring to understand the interconnected ways in which changes in one aspect of the One Health triad will impact the others. There are already several holistic analyses that suggest climate change will negatively impact fish populations and in doing so will impact food security of people (Nyboer et al. 2021; Lynch et al. 2024). A One Health approach would also be useful for exploring whether climate change will increase the zoonotic potential of parasites and lead to more human infections or other adverse effects. Moreover, biotoxins may also become more problematic. Scombroid (histamine) biotoxin is bacterial and occurs during improper handling, storage, and preparation of some fish (Feng et al. 2016) with expectation that such cases may rise with warmer temperatures and challenges with keeping fish tissues chilled. From a climate change adaptation perspective (Zinsstag et al. 2018; Jeanson et al. 2021), One Health can be used to consider consequences of various management actions (or inaction) thus providing decisions makers with an integrated and holistic perspective rather than attempting to manage individual components (e.g., just the fish or just the people) in isolation. One Health frameworks can also be embedded within other conceptual frameworks such as planetary boundaries (Lerner and Berg 2017).

**Fig. 3.** Hypothetical example of outcomes that could result from viewing recreational fishing in a One Health context where humans are active participants in their own health determination. A river is polluted with extensive plastics (A) prompting action by a local fishing club to do a river cleanup event (B). That action reduces the presence of microplastics (C) thus leading to a healthier ecosystem with healthier and more abundant fish populations (D). Anglers are now able to fish in this area (with associated well-being benefits) and value it for its ecosystem health and the potential to catch a fish (E) that is safe to eat (F) supporting food security and providing health benefits (G).




The areas where recreational fishers can be change-makers and contribute to achieving One Health are manifold (see Fig. 3). For example, recreational fishers already engage in environmental monitoring, sharing data with management bodies, and reporting environmental violations (Granek et al. 2008). They also engage in habitat restoration (Copeland et al. 2017), raise fish (for better or for worse) to enhance wild stocks or conserve threatened species (Harrisson et al. 2018), and lobby governments and agencies for better environmental protections and regulations (Shephard et al. 2023; Twardek et al. 2023). Fish are also considered "canaries in the coal mine" and can serve as proxies for overall environmental health and status (Lynch et al. 2016). Recreational fishers increasingly collect data using angler diaries or various fishing "apps" and in doing so provide information to decision makers on the state of the resource (Venturelli et al. 2017). Fishers can also report harvest patterns providing insights into the extent of nutritional benefit but also risk associated with various contaminants (Venturelli et al. 2017). Many anglers also equip themselves with knowledge on how to best handle fish to ensure their welfare so that released fish survive (Brownscombe et al. 2017; Cooke et al. 2017). However, many of these activities are so far not motivated consciously by a health feedback among recreational fishers and ecosystems, and we think that the One Health perspective could generate a novel perspective that posits recreational fisheries as a model to achieve One Health outcomes.

## Moving forward

Recreational fisheries represent a fascinating example of where humans, animals (i.e., fish), and the environment intersect in intimate, reciprocal, and cross-cutting ways. For that reason, embracing the One Health approach when thinking about the sector and its links with other systems that strongly impact the health of ecosystems (e.g., agriculture, water management, and production of industrial products that pollute the environment) is prudent. Yet, we are unaware of any efforts to do so. Most agencies are ill-equipped to deal with interdisciplinary issues due to a tendency to work in separate "silos". In a world where the understanding of recreational fisheries is only becoming more complex, a breakdown of these "silos" is required (e.g., Hunt et al. 2013; Manlove et al. 2016). Most recreational fisheries are managed by natural resource management agencies in isolation from agriculture, water management, and public health policies. Although fisheries agencies tend to have a dual role of promoting recreational fishing and ensuring that fish populations are sustainably managed, the "health" aspects (whether it be the health of fish, people, or the overall environment) tend to be relegated to other agencies. In that way, the One Health perspective, which is both timely and sorely needed, falls through the cracks.

We suggest that natural resource management agencies, in collaboration with other relevant organizations and agencies with a stake in the pollution of natural waterways, begin to consider the truly interconnected nature of recreational fisheries and build teams of professionals from different agencies and areas of expertise to modernize the governance and management of these complex systems from a One Heath lens. Previous calls have already argued for the need to bring more social science and other forms of human dimension expertise to the table for recreational fisheries (Hunt et al. 2013; for an example, see Woldehanna and Zimicki 2015). We advocate that experts in fish health (at the level of the individual—think veterinarians, aquatic animal health specialists, and epidemiologists), human health (think nutritionists, toxicologists, zoonotic specialists, environmental psychologists, and restoration therapists), environmental health (extending beyond just exploitable resources to include aspects of water quality and ecosystem health), and key managers, stakeholders, rightsholders, and civil servants (recreational fisheries are a perfect area to involve the public) should be involved with ensuring that recreational fisheries are managed through the One Health approach. We also encourage efforts to consider how some of the issues raised here vary among different segments of the recreational fishing community (e.g., the extent to which fishers are consumption oriented as a result of socio-economic status) in an effort to ensure potential for all individuals to benefit from recreational fisheries in an equitable and just manner.

We acknowledge that the One Health concept we embrace and explore here is the westernized perspective of One Health which has its roots in the study of zoonotic diseases (AVMA 2008). However, Indigenous societies the world over have been living a One Health existence and form of learning and management for Millenia (Pollowitz 2023) as stewards of fish and aquatic ecosystem health whereby some fish are a form of medicine. There are opportunities to learn from Indigenous knowledge systems about what One Health means and how to enhance the application of the One Health concept to recreational fisheries while simultaneous elevating Indigenous science and knowledge systems (Pollowitz 2023).

Others have advocated for a One Health approach to wildlife conservation and management (Buttke et al. 2015) and we would like to emphasize that this is equally important in an aquatic context. This fits squarely with calls for ensuring that recreational fisheries are both responsible and sustainable to ensure benefits for all (Cooke et al. 2019). People often act when they know their health is impacted, so from a stewardship perspective, bringing the One Health lens to the fore may promote attention or action to a sector that is often underappreciated. Failure to embrace the One Health perspective for recreational fisheries has the potential to negatively impact the health of fish, fisheries, people, society, and the aquatic environment—particularly important given that these complex social-ecological systems are undergoing rapid change (Arlinghaus et al. 2016; Elmer et al. 2017).



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