Complexity and Integration of Recreational Fisheries

Abigail J. Lynch, Len M. Hunt, A. Ben Beardmore, Brett T. van Poorten, Kevin L. Pope, and Robert Arlinghaus

Abstract Recreational fisheries are interconnected, complex, adaptive systems characterized by multiple direct and indirect interactions among ecological and human subsystems. This is important for many reasons, including that feedbacks between the social and ecological dimensions lead to difficult-to-predict, often entirely unexpected, outcomes and because many management and governance systems have multiple objectives that can involve social (e.g. fisher satisfaction), economic (e.g. license revenue), and ecological (e.g. fish conservation) dimensions. Embracing a social-ecological-system perspective can usher in an improved era of recreational fisheries science and management. Interdisciplinary approaches that unite experts across disciplines (e.g. social and ecological sciences) to create a unique theoretical, conceptual, and methodological identity are needed to gather crucial information from recreational fishers, quantify and predict fisher behaviours and outcomes from these behaviours, and integrate these findings into fisheries

A. J. Lynch (✉)
National Climate Adaptation Science Center, U.S. Geological Survey, Reston, VA, USA
e-mail: ajlynch@usgs.gov

L. M. Hunt
Ontario Ministry of Natural Resources, Thunder Bay, ON, Canada

A. B. Beardmore
Environmental Analysis and Sustainability Program, Wisconsin Department of Natural Resources, Madison, WI, USA

B. T. van Poorten
School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada

K. L. Pope
Cooperative Research Units Program, United States Geological Survey, Lincoln, NE, USA

R. Arlinghaus
Department of Fish Biology, Fisheries and Aquaculture, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

Division of Integrative Fisheries Management, Humboldt-Universität zu Berlin, Berlin, Germany

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management. In this chapter, we lay the conceptual foundation for recreational fisheries as coupled social-ecological systems that are also complex and adaptive, and discuss the interdisciplinary approach to operationalize this book's vision.

Keywords Adaptive systems · Complex systems · Coupled social-ecological systems · Fisher behaviours · Fisher outcomes · Fishery science

1 Recreational Fisheries

Recreational fishing is the act of attempting to catch fish or other aquatic animals with leisure as the primary motivation as opposed to meeting basic nutritional needs or sustaining livelihoods (FAO 2012). *Recreational fisheries* are the systems in which recreational fishing occurs. This fishing occurs with many gear types (e.g. gill nets, cast nets, spears, bows), but hook-and-line (i.e. angling) is most prevalent across the globe. It is also important to note that these definitions are somewhat opaque and that recreational fisheries can surely make substantial contributions to both food and livelihoods (e.g. Embke et al. 2022; Lynch et al. 2024; Nyboer et al. 2022).

Today, recreational fisheries are a major use of wild fish in freshwaters and many coastal areas, particularly in high-income countries (Arlinghaus et al. 2021). Recreational fisheries are socially and economically important (Weithman 1999; FAO 2012; Tufts et al. 2015; Arlinghaus et al. 2019), and bestow benefits (i.e. ecosystem services, Pope et al. 2016) to more than 220 million people globally (Arlinghaus et al. 2019). These benefits include nutrition and food, jobs dependent on expenditures by fishers, physiological and physical health benefits from nature contact (Griffiths et al. 2017), development of aquatic stewardship (Shephard et al. 2022), investments and motivation for conservation (Granek et al. 2008), and other social-psychological benefits enjoyed by participating in recreational fishing (Weithman 1999). Some of these benefits can be quantifiably measured using metrics such as utility and welfare (Perman et al. 2003), jobs generated (Tufts et al. 2015), and satisfaction of recreational fishers (Birdsong et al. 2021).

Management of recreational fisheries is focused on habitat, biota, and human users (Hubert and Quist 2010) and the interactions of the three elements (FAO 2012; Arlinghaus et al. 2016, 2017). Unfortunately, management of recreational fisheries often occurs in isolation from other important uses of aquatic systems (e.g. other water-based recreation, commercial fisheries, coastal development, hydroelectricity generation, drinking water, navigation, agriculture, flood control, and other ecosystem services, MEA 2005). Sometimes, the management objectives and associated activities (see Barber and Taylor 1990; Krogman et al.2026) tailored to recreational fisheries can even be in opposition with other uses and users (Lynch et al. 2017). To manage recreational fisheries sustainably, managers can acknowledge existing externalities and operate within their sphere of influence (Carpenter et al. 2017) through iterative improvement in their understanding of habitat, biota, and recreational

fishers' behaviours and outcomes across disciplinary and sectorial divides (Arlinghaus et al. 2017).

The application of social-ecological-system thinking in recreational fisheries (Hunt et al. 2013; Arlinghaus et al. 2017) is now widely embraced and continues to grow (see review in Solomon et al. 2020). Yet, even still, independent theories and approaches of the natural and the social sciences applied to fisheries have hindered adoption of a social-ecological-system approach within fisheries science and management (Fenichel et al. 2013a; Arlinghaus et al. 2017). Historically, fisheries science has focused on understanding biota and habitat (principally via fisheries ecology, see Post et al. (2026)) with much less attention paid to understanding people and their behaviours (via social psychology, resource economics, political ecology, and other human-dimension studies, Arlinghaus et al. (2008b), Hunt et al. (2013)). It is important to note that these social sciences are all distinct disciplines where siloed thinking can also constrain cross-referencing and integration of knowledge of recreational fisheries (Fenichel et al. 2013a).

To advance this social-ecological-system approach, biologically and ecologically trained professionals—the group of professionals who dominate the science and management cadres of recreational fisheries (Barber and Taylor 1990)—need to understand and value the strength, diversity, and limits of various social science approaches to understand people's attitudes (i.e. mindset, outlook, and feelings toward someone or something that are typically reflected in behaviours; degrees to which people have favourable or unfavourable evaluations of specific behaviours), norms (i.e. shared standards of acceptable behaviours; perceived social pressures to perform—or to not perform—specific behaviours), and behaviours (i.e. range of actions and mannerisms made by individuals or organizations; ways in which people act or respond to a given situation) as well as the social and economic outcomes of recreational fishing. Likewise, those trained in social science disciplines need to recognize that siloed thinking constrains cross-referencing and integration of knowledge within the social sciences of recreational fisheries (Fenichel et al. 2013a). This book explicitly focuses on the social side of recreational fisheries and the utility of interdisciplinary approaches: common blind spots in fisheries professional training. It explains the backbone, methodological approach, and future of the social sciences of recreational fisheries, with the intention of providing a common understanding of social-scientific approaches to improve the integration of natural and social sciences within that framework. Ultimately, the aim is to support the continued integration of the ecological and social sciences for more sustainable management of recreational fisheries.

2 Social-Ecological-Systems Framework

We define a social-ecological system as one or more ecological subsystems interacting with one or more mutually dependent social, socio-economic, or socio-technical subsystems (Berkes et al. 2003; Folke et al. 2005; Ostrom 2007;

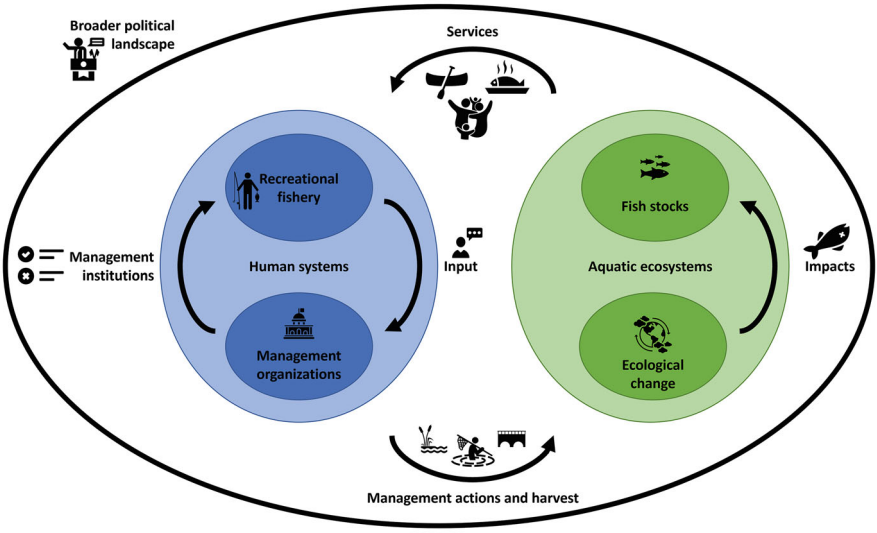

Fig. 1 A basic depiction of a recreational fishery as a coupled social-ecological-system

Arlinghaus et al. 2017; Colding and Barthel 2019). Note that "social" is used here exclusively with reference to humans as opposed to the social dynamics in ecological systems (e.g. collective behaviour of fish). The multiple direct and indirect feedbacks among the social and ecological systems are key to understanding difficult-to-predict system outcomes in recreational fisheries (e.g. sustainability, resilience), and they shape system trajectories and responses to interventions (Ward et al. 2016). Very often, the bidirectional interactions of social and ecological systems in recreational fisheries are directly impacted by the institutions (i.e. rules, norms, and strategies and tactics; Ostrom 1990) that regulate, and respond to, the social and ecological systems or by higher-order related ecosystems or political systems (Fig. 1).

A unifying framework for the study of social-ecological systems (also referred to as human-environmental systems or coupled human and natural systems in the literature) was first proposed by Berkes and Folke (1998) to improve resilience and sustainability of natural systems that are interdependent and co-evolving with human systems. The social-ecological-system framework that explicitly refers to human behavioural feedbacks builds on the foundation of earlier work in bioeconomics (e.g. Gordon 1954; McConnell and Sutinen 1979) and human dimensions of fish and wildlife (e.g. Hendee 1974; Lee and Driver 1998) recognizes interdependencies between social and ecological dimensions of exploited natural resource systems. Ostrom (2007, 2009) helped interpret recurrent patterns within these systems (see Arlinghaus et al. (2017) for an application of the Ostrom social-ecological-systems framework to recreational fisheries). Many studies and frameworks have followed from different research traditions to enhance or sharpen the

integrated framework for particular contexts (Anderson 1993; Ditton 2004; Liu et al. 2007; Schlüter et al. 2012; Colding and Barthel 2019; Abbott et al. 2022).

3 Recreational Fisheries as Complex, Adaptive Social-Ecological Systems

Recreational fisheries constitute a prime example of a coupled social-ecological system (Carpenter and Brock 2004; Hinkel et al. 2014, 2015; Schlüter et al. 2014) where fish are directly (e.g. harvest, stocking) or indirectly (e.g. catch-and-release, habitat management) impacted by one or more highly mobile user types (Johnston et al. 2010; Post 2013) and associated management agency (Fig. 1). The economic welfare (i.e. the economists' approach to wellbeing) of heterogenous recreational fishers are impacted by fish through their utility contributions for catch rates, species, sizes, and other catch-related attributes of the fishery (Hunt et al. 2019). Managers aim to achieve objectives for the fishery and are impacted by changes in the habitats, the fish, and the fishers as well as the broader socio-political climate and broad ecological changes (Carpenter et al. 2017). Beyond how recreational fishers and managers perceive and behave, an important aspect of a social-ecological-system framework is also how organizations of actors devise rule-based institutions that affect both fish (through stocking and habitat changes, van Poorten et al. (2011), Ziegler et al. (2017), Radinger et al. (2023)) and fishers (through harvest regulations and restrictions, Aas et al. (2000), Cox et al. (2003)).

Social-ecological systems are one example of complex adaptive systems that are characterized by multiple nonlinear feedbacks acting across heterogeneous actors functioning over multiple spatial- and temporal scales (Levin et al. 2013; Arlinghaus et al. 2017). Complex, adaptive systems constantly evolve and are very difficult to understand, partly because micro-level interactions (e.g. among recreational fishers and local lakes) can create emergent macro-level outcomes (e.g. overfishing at the landscape) that are impossible to be understood at the local level alone. This is because local-level interactions create (emergent) outcomes at broader levels that then change the selection environment for local-level interactions. Complex, adaptive systems may be hierarchically organized at multiple spatial, temporal, or organizational scales (e.g. individual fish within populations or stocks, nested in lakes nested within a landscape of lakes). Interactions and feedback among hierarchies within a recreational fishery can be adaptive to actions by actors at all scales (e.g. agencies or recreational fishing organizations) as well as to changes in fish populations or the landscape (Gunderson and Holling 2001; Allen et al. 2014).

A fundamental question that demands thorough scientific understanding is how to steer complex, adaptive social-ecological systems towards a politically desired state given the multitude of complex feedbacks and outcomes (Arlinghaus et al. 2017). A central tenet proposed here and elsewhere (Biggs et al. 2012; Arlinghaus et al. 2019) is to explicitly manage relevant feedbacks to keep a recreational fishery in a desired

state (i.e. increase resilience) and prevent it from flipping to an undesired one (i.e. new stable state where target fish(es) are no longer available). This is a fundamentally new perspective and challenge because managers are accustomed to managing site or fishery-specific outputs generated by localized interactions (e.g. yield, catch rate, fisher satisfaction) or simply fish population states (e.g. spawning stock biomass) in selected ecosystems (Post et al. 2026) rather than focusing on managing feedbacks generating outcomes and states. A focus on managing feedback, however, demands a mechanistic understanding of how recreational fishers (i.e. people) respond to changes—a core tenet of this book.

4 Understanding Recreational Fishers' and Managers' Behaviours Through Various Social Science Disciplines

To understand a social-ecological system as complex and adaptive, variability in behaviours (for both fish and human subsystems), heterogeneity (e.g. among actors and ecological systems), relationships and considerations of power and privilege among fishers and non-fishers, and the broader implications of micro-level localized interactions should be included. Properly representing human behaviour (e.g. of recreational fishers and managers) or other behaviour-related outputs (e.g. support of management policies by recreational fishers) is the focus of this book. Different disciplines approach this need from different foundations with different focal points (Hunt et al. 2026). They vary in how recreational fisher behaviour and outcomes are conceptualized and measured (Fig. 2), what research questions are asked, which

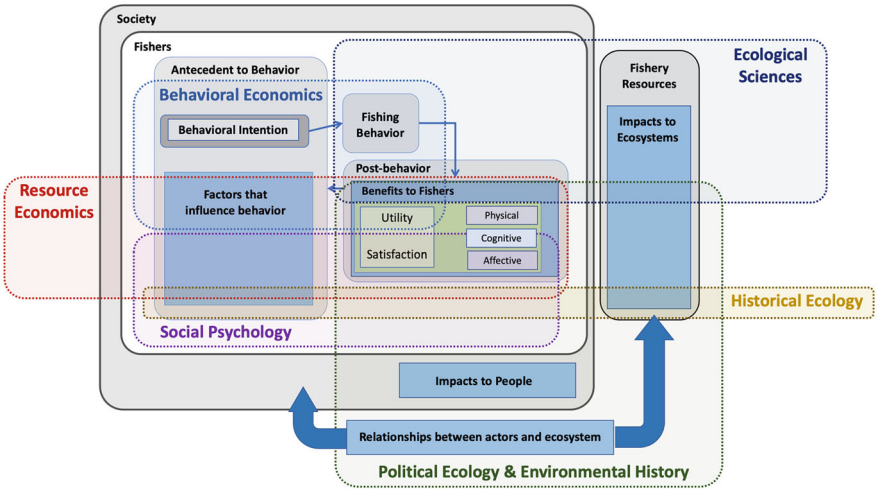

Fig. 2 The relationship of different disciplinary approaches covered in this book. (Modified from Beardmore (2013))

concepts are used to address questions, and how questions and concepts are related. Disciplines also vary if they focus on the individual fisher or on patterns and processes leading to social outcomes (e.g. power structures). When examined in detail, the various social science disciplines that have dominated recreational fisheries science to date complement each other well (Fig. 2) and will in turn be presented in greater detail in other chapters in this book. A brief summary of the similarities and differences of various key social science disciplines follows to motivate the structure and organization of the various chapters in this book. Of course, our coverage of disciplines here is incomplete, and some important disciplines such as sociology or institutional economics, are not mentioned below. These and other disciplines have contributed and continue to contribute towards understanding recreational fishers and managing recreational fisheries.

Historically, the dominant research paradigm for recreational fisheries has been a rational actor model that assumes people who engage in fishing make optimal choices to maximize personal benefits (Hendee 1974; Driver 1985; Anderson 1993). In social psychology (Landon et al. 2026), personal benefits are expected psychological outcomes from fishing (Driver 1985; Manfredo et al. 1996) and may be measured as satisfaction, which has physical, cognitive, and affective components (Fig. 2; Birdsong et al. 2021). Social psychologists focus on how antecedents (e.g. values, beliefs, attitudes, personal norms) additively or synergistically influence intentions and behaviours (e.g. the theory of reasoned action, Ajzen and Fishbein (1980); the cognitive hierarchy model, Fulton et al. (1996)). This compositional approach to understand behaviours (termed this because the individual cognitions are composed to affect behaviour, Parkkila et al. (2010)) contrasts with the decompositional approach preferred by resource economists (sensu Lancaster 1966). Economists also favour a rational actor model, which assumes people make decisions that maximize personal utility (Fig. 2). However, they typically associate observed or stated behavioural choices (e.g. selecting a fishing site) with the attributes describing those choice options (e.g. different lakes with different catch rates or harvest regulations). Using statistical techniques, they in turn decompose the behavioural choices to learn about the preferences of people for attributes of fishing and to quantify the economic benefits from changes to an activity such as recreational fishing (Melstrom et al. 2026). Economics thus typically directly studies the behavioural choices of fishers, whereas social psychologists study the antecedents that form behavioural intentions and ultimately shape behaviours. Despite over 40 years of research on recreational fisheries and following the same rational actor idea, social psychologists and resource economists have used different units for measuring similar constructs (e.g. satisfaction or utility to measure wellbeing), have published in different journals, have shown little cross-referencing, and have had different research motivations (Fenichel et al. 2013a, see also Hunt et al. 2026). Furthermore, although behavioural economics, with its efforts to link economic and psychological theories, offers much promise to understand the behaviours of recreational fishers, few applications exist (Mackay et al. 2026), leading to little awareness or overlap with research conducted by resource economists or social psychologists (Fenichel et al. 2013a).

Other social science disciplines in fisheries science, including political ecology (Boucquey et al. 2026) and environmental history (Thurstan et al. 2026), have focused less on understanding individual behaviours, but rather study social units (e.g. communities of recreational fishers) and how these units are shaped by incentives, opportunities, constraints, and power structures (Fig. 2). Perhaps differences in scales of analysis (i.e. individual vs. social group) and time frames (i.e. past vs. present), in addition to ontological and epistemological differences among disciplines, further inhibits integration with other social science disciplines. Yet, social-psychologists and behavioural economists may also focus on outputs other than behaviour (e.g. norms, conflicts, procedural justice) because they affect the acceptability of rules, perceptions of the procedural fairness of management decisions, and support for management policies. As norms, conflicts, and perceptions of justice affect agency and power dynamics, we see ample opportunities for more crosstalk among the various social science disciplines involved in recreational fisheries.

Limited cross-fertilization and cross-referencing exist among social science disciplines in fisheries science. The lack of clarity about specific needs combined with the fact that research on recreational fishers emerged in isolation among communities of researchers situated in different departments and faculties has resulted in a body of largely disciplinary-specific research (Arlinghaus et al. 2014) that lacks integration, let alone awareness of other disciplines (e.g. Fenichel et al. 2013a). This lack of understanding and appreciation for different disciplinary-specific approaches represents a key barrier for conducting interdisciplinary research (Hunt et al. 2026) that is directed at fundamental understanding of recreational fisheries dynamics with a view toward supporting management decisions.

5 Interdisciplinary Integration

Despite the importance of interdisciplinary work to understand and solve recreational fisheries issues from a social-ecological-systems perspective, many constraints exist in the contemporary academic system (reviewed in Heberlein (1988), Campbell (2005), Arlinghaus et al. (2014), Hunt et al. (2026)). Academic "silos" have prevented the effective integration of social and ecological sciences in recreational fisheries (Heck et al. 2015), thereby constraining our understanding of the dynamics and effects of feedbacks within and among the social and ecological components of recreational fisheries (Arlinghaus et al. 2008a, 2014; Ward et al. 2016). Better appreciating the various feedbacks and associated thresholds among humans and nature in a structured way and learning how these feedbacks, along with all involved structures (e.g. organizations), give rise to specific outcomes—such as conflicts or biologically unsustainable exploitation—are essential for building sustainability in recreational fisheries and in other coupled social-ecological systems (Arlinghaus et al. 2017; Camp et al. 2026; Jensen et al. 2026; Wilberg et al. 2026).

In recent years, there has been an increasing emphasis on interdisciplinary studies linking social and ecological dynamics in recreational fisheries (Carpenter and Brock 2004; Biggs et al. 2009; Johnston et al. 2010, 2013, 2015; Horan et al. 2011; Hunt et al. 2011; Matsumura et al. 2019). Many of the key feedbacks, between fishers and managers, and between fishers and aquatic ecosystems, involve behavioural dynamics, which is why studying interactions in recreational fisheries from the perspective of the behavioural sciences has become prominent both in the social and in the ecological domains (Cooke et al. 2026; de Kerckhove et al. 2026; Arlinghaus et al. 2026; Golebie et al. 2026; Kochalski et al. 2026; Kyle et al. 2026; van Putten et al. 2026; Venturelli et al. 2026; Vaske et al. 2026a,b). Evaluating recreational fisheries as complex social-ecological systems will help us better understand local, regional, and global fisheries dynamics (Sievert et al. 2026), will inform a much broader scientific literature on general human-environment interactions, and, perhaps most importantly, will support better management of these complex social-ecological systems (Arlinghaus et al. 2017; Robinson et al. 2026; van Poorten et al. 2026).

We believe that it is less helpful to approach the science of recreational fisheries from a particular discipline than to tackle the problem with the disciplines that are necessary to understand the problem (e.g. eliminating overharvest requires ecological understanding of fish population dynamics and social psychological understanding of fisher behaviour). In many cases, the knowledge may already have been produced in disciplinary ways, in other cases, new disciplinary and often interdisciplinary inquiry may be needed to integrate across scales from the individual to the collective and from the local lake to the landscape of fisheries. One key factor in these dynamics is the behaviour of recreational fishers and managers (Fulton et al. 2011). This book describes: (1) the foundations of each discipline (i.e. ecological sciences, resource economics, social psychology, political ecology, history, and behavioural economics), (2) the methods to be used (i.e. surveys, experiments, digital data mining, content analysis, mixed methods, evidence synthesis), and, (3) ways to integrate concepts across the social and ecological domains (i.e. integrated models, participatory modelling, adaptive management, standardization).

6 Evaluating Outcomes

Though the goals of recreational fisheries often include statements such as “satisfying anglers,” “conserving the resource for future generations,” and “ecological integrity and sustainability,” quantitative objectives are rarely stated explicitly in management plans (Lackey 1974; FAO 2012). This lack of clarity on quantitative objectives has made it difficult to evaluate the effectiveness of recreational fisheries management because we cannot compare where we are with where we would like to be (McMullin and Pert 2010). The importance of explicitly stating objectives was demonstrated in Johnston et al. (2010), who showed that different quantitative objectives lead to different fishery outcomes. Within the context of fisheries as

social-ecological systems, objectives should normally include quantitative measures of social, ecological, and economic values, as proposed in the context of Optimal Social Yield (Malvestuto and Hudgins 1996; Johnston et al. 2010).

The concept of Optimal Social Yield is equivalent to the economic concept of welfare. One key assumption is that the economic welfare of recreational fishers integrates ecological objectives (e.g. when the ecosystem and its fish stocks diminish, so also does the quality of fishing). Johnston et al. (2010) showed in modelling that optimizing a fishery to Optimal Social Yield thus would also be ecologically sustainable. However, a few aspects are problematic here. First, there might be other objectives that a management tailored to optimize fishing quality might compromise (e.g. the recreational quality of other non-fishing lake users). Second, optimization might be easily achieved in models, but not in reality. Third, for Optimal Social Yield to be operationalized, full knowledge of what determines the value of fishing to people must be known. The key point is that most recreational fisheries are multi-objective fisheries from a management perspective and at least some objectives will have a social dimension. Therefore, evaluation outcomes of social-ecological interactions demand interdisciplinary inquiry and knowledge.

The difficulty in stating objectives is especially important when considering fisheries as social-ecological systems because fisheries managers are typically trained in biology or ecology (Brooks et al. 2015). Although it may be that ecologically minded managers can at least qualitatively determine whether a fishery is at a conservation risk (i.e. not meeting sustainability objectives), it is much more difficult and contentious to determine the social value of a fishery and whether improvements can be made. Moreover, it is relatively easy to determine if catch rates or fish size are satisfactory (a possible biological determinant of social utility and satisfaction), but if recreational fishers are heterogenous in their relative importance of these attributes, managers may inadvertently reduce the social value of their fisheries. There is also the question of who is privileged with deciding what is meant by desirable outcomes (Fenichel et al. 2013b). By carefully considering what constitutes the social objectives of the fishery and how to measure those objectives, it will be possible to understand social measures of fishery value and to apply those measures to improve fisheries for the sake of recreational fishers.

Finally, management and governance are, by design, full of trade-offs (Fenichel et al. 2013a). Power structure and normative questions of how to allocate usually scarce goods are key considerations that demand social and ethical sciences to have a seat at the table. This book will hopefully provide some methodological basis to address these concerns or be informed about them.

7 Book Outlook

Recreational fisheries are complex, adaptive social-ecological systems. Yet historically, management of recreational fisheries did not apply interdisciplinary practices or provide foundational training for fisheries professionals in interdisciplinary

approaches. Holistic thinking can enhance disciplinary strategies and training, and it is needed to understand the complexity of recreational fisheries, specifically how fishers behave and the outcomes that recreational fisheries provide to people, ecosystems, and society. With the chapters to follow, we believe this book can help instil new fundamentals in how we conceptualize and study complex, adaptive social-ecological systems and can help transition how we manage recreational fisheries by integrating appropriate elements from multiple social science disciplines to ensure sustainable use of recreationally exploited fish species. The chapters that follow showcase examples of disciplinary background and methods to study the social aspects of recreational fisheries and ways to integrate different knowledge domains with a view to improve fisheries management.

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