Recommendations for the future of recreational fisheries to prepare the social-ecological system to cope with change

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Abstract
This paper presents conclusions and recommendations that emerged from the 7th World Recreational Fishing Conference (WRFC) held in Campinas, Brazil in September 2014. Based on the recognition of the immense social and economic importance of recreational fisheries coupled with weaknesses in robust information about these fisheries in many areas of the world, particularly in many economies in transition, it is recommended to increase effort to build effective governance arrangements and improve monitoring and assessment frameworks in data-poor situations. Moreover, there is a need to increase interdisciplinary studies that will foster a systematic understanding of recreational fisheries as complex adaptive social-ecological systems. To promote sustainable recreational fisheries on a global scale, it is recommended the detailed suggestions for governance and management outlined in the United Nations Food and Agricultural Organization Technical Guidelines for Responsible Fisheries: Recreational Fisheries are followed.

KEYWORDS: adaptation, angling, human dimensions, invasive species, resilience.

Introduction
Recreational fisheries have become the dominant or sole use of many freshwater and coastal fish stocks in industrialised countries and many economies in transition (FAO 2012). For countries with reliable statistics, on average about 11% of people participate in recreational fishing (Arlinghaus et al. 2015), which amounts to a global estimate of recreational fishers ranging between 220 million (World Bank 2012) and 700 million (Cooke & Cowx 2004). In view of these numbers, there is growing international recognition of the substantial economic, socio-cultural, ecological and evolutionary importance of recreational fishing (FAO 2012; World Bank 2012). This has motivated dedicated research and management activities intended to ensure that diverse recreational fisheries are sustainable and achieve multiple benefits at a global scale.

The tri-annual World Recreational Fishing Conference (WRFC) series provides an opportunity to advance knowledge relevant to the development of resilient and sustainable recreational fisheries. The conference constitutes one of the few opportunities for fisheries managers, policy-makers, scientists, recreational fishers and other stakeholders to meet and exchange cutting-edge information about the state and development of recreational fisheries on a global scale. The history of the WRFC was reviewed by Schratwieser et al. (2011), and the last conference was held at the State University of Campinas, Brazil, from September 1 to 4, 2014. Notably, this was the first time that the conference was held in an emerging economy country where recreational fishing is on the rise and where there is often limited governance capacity available to manage the sector (FAO 2012).

The theme of the 7th WRFC conference was Change, transformation and adaptation of recreational fisheries and its objectives were:

• to serve as a forum for professionals and institutions representing all components of the recreational fishing sector to exchange ideas and new knowledge related to the science and management of recreational fisheries;

• to foster and develop multi- and interdisciplinary actions directed toward the maintenance and enhancement of recreational fisheries and its practices, and to identify opportunities in the present and future;

• to stimulate scientific investigations and the development and application of science-based management practices in recreational fisheries around the globe, particularly in developing countries.

The 7th WRFC made progress in understanding the multifaceted problems related to recreational fisheries, noted the increased use of multi-disciplinary analyses of issues related to recreational fishing, and provided evidence that appropriate institutional capacity and effective communication among stakeholders and among scientists and managers are essential to promote the sustainability of recreational fisheries.

Rather than summarising the contributions of this special issue, the objective of this paper is to present key insights that emerged from the 7th WRFC conference in...
light of the recent peer-reviewed literature on recreational fisheries. Key conclusions and recommendations for the future are presented, based on a mini-review of key developments in the science and management of recreational fisheries at a global level. A particular focus in the selection of themes is placed on improving recreational fisheries in economies in transition and emerging economies, but some of the issues equally apply in the developed world.

Recent developments in recreational fisheries science and management

Economic and social importance

As elaborated in the governance and management framework for inland fisheries by Welcomme (2001), the initial step towards sustainable management of any recreational fishery is assessing and acknowledging its social and economic importance within a given region or country. Hence, the 1st WRFC conference held in 1996 in Dublin (Ireland) was heavily focused on establishing country profiles about key characteristics, and the economic value and social impact of recreational fisheries (Hickley & Tompkins 1998). This mirrored a long tradition in basic descriptive research on the socio-economics of recreational fisheries conducted in North America (e.g. Weithman 1999; Cooke & Murchie 2015). Recently, Parkkila et al. (2010) summarised methods and approaches for evaluating the economic importance and social benefits of recreational fisheries. These methods are now routinely being applied in several countries that can be classified as "economies in transition" (e.g. Argentina: Baigón et al. 2006; Brazil: Freire et al. 2012, 2016; Barrella et al. 2016), providing a first step to characterising the size and structure of the recreational fishing sector, the number of people engaged in recreational fishing, and its social and economic value in a given country or region. As more and more basic descriptive knowledge about the economic and social importance of recreational fishing accumulates it will likely lead to a greater appreciation of the sector by policy makers and fisheries managers in relation to science and management of capture fisheries in general (e.g. Arlinghaus et al. 2002; Cowx 2015; Cooke et al. 2016). The socio-economic importance of recreational fisheries often remains unnoticed in many emerging economy countries, and consequently governance structures have not sufficiently developed to cater for the unique social-ecological characteristics of recreational fisheries. In the more developed countries with longer traditions of assessing the benefits of recreational fisheries, the focus of science is increasingly moving away from simply characterising participation, expenditure or basic motivations of anglers to the assessment of the psychological, social and ecological importance of recreational fishing, including assessment of health benefits (Pretty et al. 2006), the social benefits of angling for integration of minority groups (Freudenberg & Arlinghaus 2010), fishing as a contributor to life satisfaction (Griffiths et al. in press), the role and importance of anglers and other recreational fishers for conservation (Bate 2001; Cowx et al. 2010), assessment of angler mental models about ecological processes (Li et al. 2016) and development of novel monitoring methods using social media and citizen science applications (Papenfuss et al. 2015). Moreover, there is an increasing realisation that national-level changes in demographics, economics and social values strongly affect both participation at a national level (Arlinghaus et al. 2015) and the moral acceptability of recreational fishing in some so-called "post-modernized" societies (Arlinghaus et al. 2012; Riepe & Arlinghaus 2014). Recreational fisheries may thus become increasingly vulnerable to changing social values on the acceptability of how anglers interact with aquatic environments and their living resources.

Governance

With a long history of participation, many developed nations have, over time, constituted comprehensive governance structures for recreational fisheries that include policies that outline broad goals and principles, include national or regional-level fisheries laws and regulations, and identify the organisations or structures that fulfil the governance and management roles. By contrast, developing countries generally have a limited history of recreational fishing and therefore seldom have well developed recreational fisheries governance structures and associated competencies and training of fisheries managers (FAO 2012). This is particularly problematic as growing recreational fisheries often conflict directly with the objectives of other (subsistence, small-scale, commercial) fisheries sectors. Ultimately, failure to develop comprehensive governance strategies for recreational fisheries will negatively impact the sustainable development of the sectors in economies in transition and emerging economies.

Tourism-based recreational fisheries

Angling has emerged as important form of domestic and international tourism in several areas of the world (e.g. Solstrand 2013). The largely unregulated and rapid growth of tourism-based recreational fisheries in developing countries has caused social and ecological issues
(Bower et al. 2014; Sheaves et al. 2016), and similar patterns have been seen in some industrialised countries that attract considerable numbers of tourists (Moksness et al. 2011; Solstrand 2013). Tourism imports new technology and fishing cultures, which can have both positive and negative impacts locally. In some countries, such as Argentina, tourism has influenced local angling behaviour as previously catch-and-kill tournaments targeting sharks have been converted to tag-and-release events (Dellacasa & Braccini 2016). As recreational fishing tourist destinations emerge, mechanisms that channel some of the economic benefits that are normally accrued primarily by foreign investors into the local communities must be developed (Freire et al. 2012).

Ecological impacts

The ecological impacts of recreational fisheries have been underestimated compared with those of commercial fisheries (Cooke & Cowx 2006). However, there is now abundant evidence to suggest that recreational fishers can substantially affect abundance, size structure and evolutionary trajectories of fish stocks as well as the water quality and terrestrial ecotones of both marine and freshwater ecosystems (reviewed in Post et al. 2002; Cooke & Cowx 2006; Lewin et al. 2006). Some recreationally targeted species are being overexploited (e.g. Post et al. 2002; Sheaves et al. 2016) and this, in some cases, resulted in shifts in effort towards new target species for which there may be no active monitoring or management, or which may include endangered species (e.g. Bower et al. 2014). To deal with overfishing, traditional management strategies of harvesting size and quota limits are common in many countries but occasionally are failing to prevent declines in stock status (e.g. Maggs et al. 2016), demanding more active management of effort (Johnston et al. 2015). In this context, the realisation that angling can be a major source of mortality on some coastal stocks is increasing (e.g. Strehlow et al. 2012), which is also happening in several African countries (Belhabib et al. 2016) that traditionally focused on commercial or subsistence fisheries.

Catch-and-release is regularly considered by managers and some angler groups as a solution to trade-off fishing effort and fishing impacts on stocks. Accordingly, the utility of catch-and-release angling and its effects on individual fish and populations has received considerable attention in recent years (e.g. Hühn & Arlinghaus 2011; Bower et al. 2016; Olausson 2016). Although with a primary objective to reduce mortality, catch-and-release can also lead to fitness impacts (Richard et al. 2013) and affect entire populations (Coggins et al. 2007; Johnston et al. 2015), in turn demanding continued attention by scientists and managers to develop science-based best-practice guidelines (Arlinghaus et al. 2007).

Recent research has moved beyond describing and documenting ecological impacts of recreational fishing towards a mechanistic understanding of what drives the interactions between anglers/fishers and fish stocks in a spatially explicit fashion (Post et al. 2008; Hunt et al. 2011). This has been done using mechanistic models of angler behavior (Fenichel et al. 2013) to study how dynamic angler behavior systematically affects fish stocks across a range of fish life histories (Johnston et al. 2013, 2015). Extending single fishery cases to a landscape perspective (Lester et al. 2003; Hunt et al. 2011) is also revealing how anglers may be important vectors of the spread of novel (and possibly invasive) organisms released from bait buckets (Johnson et al. 2009) or attached to fishing gear and boats (Drake & Mandrak 2014).

There is an increasing realisation of the potential for fisheries-induced evolution of life-history and behavioural traits, which can affect population dynamics and catchability/catch rates (Philipp et al. 2009; Sutter et al. 2012; Alós et al. 2015; Arlinghaus et al. in press a). The largest impact of anglers on the genetic composition of fish stocks is, however, likely to originate from stock-based stock enhancement (van Poorten et al. 2011), for which there is a growing conservation concern (Cowx et al. 2010; Arlinghaus et al. 2016). Also, there is growing recognition of the importance of maintaining diversity in age classes and demographic structure of fish populations to maintain resilient fisheries (FAO 2012). This includes conserving large individuals in exploited stocks, which can have the advantage of improving the angling experience for trophy-oriented angler types (Gwinn et al. 2015).

Monitoring and assessment

Managing recreational fisheries in the absence of at least some form of monitoring information is problematic (Hansen et al. 2015; Arlinghaus et al. in press b). However, monitoring poses particular challenges when assessing the usually diffuse recreational anglers disbursed across hundreds if not thousands of lakes, along the banks of a long river channel or across the coastal landscape (Lester et al. 2003). Novel data-poor assessment methods are thus urgently needed (Beard et al. 2011), and some important progress has been made (Lorenzen et al. 2016). In some areas of the world, there are large initiatives designed to improve the monitoring of recreational fisheries (Camp et al. 2016; Dedual & Rohan 2016; Motta et al. 2016; Ryan et al. 2016). For
example, large-scale survey efforts are underway in European marine fisheries to characterize catch and harvest of anglers and include the information in stock assessments (Strehlow et al. 2012). One case from an emerging economy country is the marine recreational fishery in Kwa-Zulu Natal, South Africa, which offers a 40-year catch and effort monitoring dataset (Maggs et al. 2015). While this monitoring project was built on conventional techniques and strong institutional support, this is seldom the case and novel assessment methods for data poor regions are needed for most recreational fisheries (Beard et al. 2011). Initiatives featuring under “citizen science” show great promise but are still under development and require data calibration and well-developed incentives for anglers to support the collaboration with scientists and/or managers (Papenfuss et al. 2015).

Recreational fisheries as coupled social-ecological systems

The 6th WRFC in 2011 in Berlin focused strongly on an integrative view of recreational fisheries as complex adaptive social-ecological systems (SES) (Arlinghaus et al. 2013) where behavioural dynamics of anglers, managers and policy makers are key drivers shaping system outcomes (Ward et al. in press). Coupled SESs differ from simple systems due to the presence of cross-scale interactions, non-linear feedbacks and the existence of large individual and spatial heterogeneity (reviewed in Arlinghaus et al. in press b). There is much to gain from developing a systematic understanding of how recreational fisheries function and how macro-scale emergent properties such as regional overfishing emerge from localised interactions among anglers and ecosystems (e.g. Carpenter & Brock 2004; Hunt et al. 2011; van Poorten et al. 2011; Arlinghaus et al. in press b). It is likely that analysing the sustainability of coupled SES based on a complex adaptive system view will become more important in the future, as well as being integrated interdisciplinary projects in general (Arlinghaus et al. in press b). Taking a complexity-science view on recreational fisheries is particularly important to understand how the system deals with change, whether it can adapt to new situations and how to move particular recreational fisheries from one state to another where there is a desire to transform (see Arlinghaus et al. in press b for a full account). In this context, collaboration between researchers, fisheries managers, recreational fishers and other stakeholders is of great importance to the sector and the management of recreational fisheries (Dedual et al. 2013). This can be best accomplished by fostering integrated, interdisciplinary recreational fisheries science and management, which is rarely done (Arlinghaus et al. 2014).

Conclusions and recommendations for the future

In light of the issues discussed above: the following key conclusions and recommendations were derived at the 7th WRFC.

- In many developed and most developing nations, a strong focus towards commercial fisheries has created a large data gap in relation to recreational fisheries. Well funded assessments of recreational fisheries (including long-term commitments to development of reliable national-scale survey instruments) and capacity building programmes are needed to address the issues and to foster greater acceptance of recreational fisheries as a significant component of global fisheries. Gaps in knowledge of recreational fisheries that need to be addressed include: the biology of target species, monitoring of the resource status, fishing pressure, sustainability and ecological impact, demographics and human dimensions of fishers, economic impact and value, efficacy of management interventions, and options to apply new technologies to obtain data and information from the sector (Beard et al. 2011; Cooke et al. 2016; Lorenzen et al. 2016). Partnerships among scientists from different countries will be important when there is lack of local knowledge on some of these issues.

- The capacity of recreational fisheries practitioners to deal with global and regional change depends on a solid interdisciplinary knowledge base (FAO 2012). There is an urgent need and scope for universities and research institutions to develop interdisciplinary recreational fisheries science programmes that cross and integrate social and ecological sciences to train and educate a new generation of scholars and managers that will be able to work collaboratively and across disciplines (Arlinghaus et al. 2014). Such programmes needs to adhere to the same rigor as disciplinary approaches to recreational fisheries. It is not a trivial task for a biologist, for example, to become proficient with angler survey methods and psychometric scaling techniques. Hence, we strongly advocate to build interdisciplinary teams of disciplinary experts rather than individuals or groups trying to accumulate all expertise in a range of methods and competencies as economics, econometrics, survey research, population biology and evolutionary biology (Arlinghaus et al. in press b). In both developed and developing nations interdisciplinary capacity need to be urgently developed, possibly assisted by training programmes offered by established programmes as suggested by FAO (2012).

- There is an urgent need to develop rapid data poor assessment methods and generally better monitoring systems of both fish and fishers.
• Increasing needs and demands from a growing recreational fisheries sector call for functional and efficient governance arrangements to ensure sustainable recreational fisheries and integrate management of commercial and recreational fisheries. Recreational fisheries governance improvements require research into the following.

  ◦ Institutional frameworks: strong organisations of recreational fishers appear to result in better functioning government institutions for recreational fisheries; stories of success and failures need to be better communicated and shared.

  ◦ Policy frameworks: comparative studies of successful and failed frameworks should be conducted and outcomes need to be communicated and shared.

  ◦ Licensing frameworks: mechanisms to establish license systems and angler registrations and their benefits and pitfalls should be documented and disseminated.

  ◦ Management frameworks: development of rigorous management frameworks based on agreed-upon objectives and harvest control rules are needed.

• To foster sustainable angling tourism, there is a need for case studies that demonstrate effective and responsible development of recreational fisheries in economies in transition that accrue benefits locally as well as those that are managed sustainably in line with local culture and customs.

• To address conflicts and improve co-management of commercial and recreational fisheries, there is a need to build good communication structures where stakeholders with different views and aspirations can work together in a productive atmosphere.

• In some developed countries the angler population is decreasing due to structural change and changing values from anthropocentrism to biocentrism, which strongly affects accepted management policies and angling practices (Arlinghaus et al. 2012). To address this issue, there is a need to understand how societal values influence perspectives on angling and how angling, and generally fishing participation, can be fostered through removal of structural barriers. This demands moving beyond the “piscicentric” focus that has characterised recreational fisheries for decades (Cowx 1998).

• Illegal, unreported and unregulated (IUU) recreational fisheries are prevalent in many countries (Baigün et al. 2006; Freire et al. 2012), causing conflicts, overexploitation and reduced effectiveness of management. The scope and size of this problem is not well-understood, demanding increased scientific and management attention. Traditional management strategies that require extensive enforcement are prohibitive and there is room for increasing use of non-traditional management approaches that foster compliance (Cooke et al. 2013).

• Catch-and-release is common in many recreational fisheries, which is a consequence of harvest regulations or voluntarily done by more specialised anglers (Arlinghaus et al. 2007). With evolving fishing techniques and technology and warming waters, there is need to develop and refine species-specific best practice guidelines to maintain the welfare status of fish and ensure sub-lethal effects and post-release mortality are minimised (Cooke & Suski 2005; Arlinghaus et al. 2007). This information should be shared with anglers and managers through effective communication channels (Nguyen et al. 2012). Conversely, in cases where fish will be consumed or have been overstressed (decreasing their chance of survival), proper killing techniques should be applied to minimise welfare impacts and maximise flesh quality (Diggles 2015).

• Levels of research and communication on recreational fisheries vary tremendously between countries and regions. This has caused gaps in global knowledge on issues such as exploitation levels/pressure, introductions of species and restocking, or spread of invasive species. New forms of communication technologies, using social media and apps, offer great promise to facilitate data collection and communication within and beyond the sector, but data quality needs to be rigorously assessed. In this context, recreational fisheries researchers, fishers, managers, policy and decision makers and other stakeholders should maintain and increase collaboration (Dedual et al. 2013), to maximise the value and utility of recreational fisheries research and management and ensure that work towards sustainability objectives will be coherent and effective, while acknowledging local and regional diversity in values and cultures.

To conclude, recreational fisheries management requires a rapid transition from single objective management to ecosystem management and aquatic stewardship using adaptive approaches that include monitoring and re-evaluation of practices through time (FAO 2012; Arlinghaus et al. 2016, in press b). Policy and management decision-makers, and all stakeholders involved in developing and executing policy and technical interventions relevant to recreational fisheries, are recommended to apply the FAO Technical Guidelines for Responsible Fisheries: Recreational Fisheries (FAO 2012), which were developed by an Expert Consultation held in conjunction with the 6th WRFC in Berlin, Germany, and were promoted at the global level by the FAO at the 7th WRFC in Campinas, Brazil. It is hoped that the presented documentation of key papers from the 7th WRFC and the conclusions and recommendations given above assist in achieving healthy, vibrant, resilient and
sustainable recreational fisheries on a global scale. Part of this future includes the need for resilience by dealing with unavoidable change and to adapt, and where necessary, transform to new social and ecological conditions, while maintaining high quality ecosystem services from recreational fisheries into the future.

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