NRC Research Press

PERSPECTIVE

Where the waters meet: sharing ideas and experiences between inland and marine realms to promote sustainable fisheries management[1]

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Abstract: Although inland and marine environments, their fisheries, fishery managers, and the realm-specific management approaches are often different, there are a surprising number of similarities that frequently go unrecognized. We contend that there is much to be gained by greater cross-fertilization and exchange of ideas and strategies between realms and the people who manage them. The purpose of this paper is to provide examples of the potential or demonstrated benefits of working across aquatic boundaries for enhanced sustainable management of the world's fisheries resources. Examples include the need to (1) engage in habitat management and protection as the foundation for fisheries, (2) rethink institutional arrangements and management for open-access fisheries systems, (3) establish "reference points" and harvest control rules, (4) engage in integrated management approaches, (5) reap conservation benefits from the link to fish as food, and (6) reframe conservation and management of fish to better engage the public and industry. Cross-fertilization and knowledge transfer between realms could be realized using environment-independent curricula and symposia, joint scientific advisory councils for management, integrated development projects, and cross-realm policy dialogue. Given the interdependence of marine and inland fisheries, promoting discussion between the realms has the potential to promote meaningful advances in managing global fisheries.

Résumé : Si les milieux intérieur et marin, ainsi que leurs pêches et leurs gestionnaires des pêches et les approches de gestion propres à chacun sont dans bien des cas différents, ils partagent néanmoins de nombreuses similitudes qui, bien souvent, ne sont pas reconnues. Nous arguons qu'il y a beaucoup à gagner de la fertilisation croisée et du partage d'idées et de stratégies entre ces deux grands domaines et les personnes qui les gèrent. L'article a pour but de présenter des exemples d'avantages potentiels ou démontrés découlant des efforts intersectoriels en matière de pêche pour une meilleure gestion durable des ressources halieutiques mondiales. Parmi ces exemples figurent la nécessité (1) de considérer la gestion et la protection de l'habitat comme constituant les fondements de la pêche, (2) de repenser les dispositions et la gestion institutionnelles pour les systèmes de pêches à accès libre, (3) d'établir des « points de référence » et des règles visant le contrôle de l'exploitation, (4) d'adopter des approches de gestion intégrée, (5) de tirer parti des avantages en matière de conservation qui découlent du lien avec les poissons comme source de nourriture et (6) de recadrer la conservation et la gestion des poissons pour mieux mobiliser le public et l'industrie. La fertilisation croisée et le transfert de connaissances entre les domaines pourraient se faire en utilisant des cursus et des symposiums sans égard au milieu, des conseils scientifiques consultatifs conjoints pour la gestion, des projets de mise en valeur intégrés et un dialogue sur les politiques auquel participeraient des acteurs des deux grands domaines. Étant donné l'interdépendance des pêches marines et intérieures, la promotion des échanges entre ces deux domaines pourrait favoriser des avancées significatives dans la gestion des pêches mondiales. [Traduit par la Rédaction]

Received 9 April 2014. Accepted 22 May 2014.

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[1]This paper is derived from the J.C. Stevenson Memorial Lecture delivered by S.J. Cooke at the Canadian Conference for Fisheries Research at the University of Windsor, Ontario, January 2013.

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Introduction

Charles Caleb Colton's quote (1824), "imitation is the most sincere form of flattery", is still used today, but in the scientific realm some might call imitation a form of plagiarism or "academic thievery" or simply assume that imitators are unable to come up with their own good ideas. In reality, scientists spend much of their time reading the literature and attending seminars and conferences in an attempt to learn about the state of the art and grasp novel, different, and hopefully innovative perspectives in hopes that these activities will influence their own thinking. Researchers then justifiably imitate, co-opt, and extend these ideas or methods into their own research and management programs. Ideas in science (arising from hypothesis testing) become contagious when "successful", which superficially may seem like imitation (Quinn and Dunham 1983; Landy 1986). However, when ideas cross boundaries, they are often viewed in new contexts and challenged with new data and tests (Cummings and Kiesler 2005), making the synergies unique and important for advancement of our abilities to understand system dynamics and how to better manage for sustainable outcomes. The notion of multi- and interdisciplinary research has gained much traction over the past several decades in fisheries because of the many benefits of working across traditional boundaries (Klein 1990; Repko 2008), despite various cultural, institutional, and economic constraints (Boyer 1990; Campbell 2005). Indeed, having such training and professional networks and incorporating multidisciplinary approaches into one's research program is virtually expected for most contemporary scientific positions, and this is reflected in the personnel being hired in fisheries, aquatic science, and management (Arlinghaus et al. 2014). Cross-sectoral and multidisciplinary approaches are also being adopted by the international development community to frame strategic work plans (FAO 2013). When thinking or working across disciplinary lines, it is possible to overlook artificial divides or boundaries such as those related to taxa, geography, environment, method, and explanation.

In the fisheries world, the scientific community may be called "guilty" of promoting an artificial boundary between the marine and freshwater (herein called inland) realms. The divide of realms between marine and inland fisheries may simply stem from the way such resources are managed by different institutions and governance systems. Moreover, marine and inland fisheries sciences have emerged from different scientific traditions. The dominant paradigms have involved single species population dynamics in marine systems and more limnology, ecosystem-based approaches in inland fisheries, sometimes complemented by an agrarian view of culture-based management of lakes and rivers similar to insights gained in pond aquaculture (Arlinghaus et al. 2008). There are obvious differences in hydrologic, zoogeographical, and ecological conditions when comparing the vast oceans with the many smaller lakes and rivers, and there are similar differences in the scale of the operation of most fisheries in marine or inland waters. Nevertheless, there is much to learn from each other, and many ecological principles are reasonably similar. There is large potential to learn about different ways of approaching and solving fisheries management problems (or failed attempts) from the other realm, "imitating" when it makes sense to do so. Indeed, we argue that ideas should not have boundaries if they represent general truths about the structure and function of the world. Using the apparent and commonly exercised artificial divide between the inland and marine realms as an example, we demonstrate how sharing ideas and experiences across boundaries have the potential to advance scientific understanding and management for sustainable outcomes.

Despite the existence of a range of ecological particularities that mainly stem from the vastly different spatial scales characterizing marine and freshwater ecosystems, many ecological processes that govern aquatic systems transcend marine and freshwater boundaries (Arlinghaus et al. 2008; Lapointe et al. 2014). Hence, there should be many commonalities in the ecological laws that govern fish production in both environments (e.g., in terms of stock–recruitment relationships, trophic cascades, and metapopulation structure). While there will probably remain a largely historical separation among management and policy in marine and inland fisheries (perhaps best exemplified by the fact that most management agencies deal with either one realm or the other), it is time to merge the different research traditions and integrate the quantitative population modelling that has dominated marine fisheries science with the more ecosystem-based approach to fish production that has been prevalent in inland fisheries (Arlinghaus et al. 2008).

We strongly believe that sharing ideas and experiences between inland and marine realms is vital to sustainable fisheries, perhaps, never more so than now, when overfishing and habitat alteration in both environments has resulted in a global fisheries crisis (Allan et al. 2005; Worm et al. 2009). Very specific management strategies and policies have been developed to address overfishing and habitat issues in both realms; we contend there is much that could be gained by considering other ideas that could be shared between realms to promote sustainable fisheries. We recognize that there is certainly no panacea in fisheries approaches and policies, given that fisheries and associated habitat and social context within both realms — marine and inland — are often different in scope, context, and objective and thus may demand unique policy solutions and approaches for sustainable resource management. Yet, there are also many striking similarities, especially between small-scale coastal marine and small-scale inland fisheries, which are important to recognize. To foster dialogue, here we have generated a list of six examples of the potential or demonstrated benefits of sharing ideas between marine and freshwater realms based on the diverse knowledge of the author team. We hope that by doing so this exercise will foster greater interaction, advance sustainable fisheries policy formation and implementation in both environments, and help to eliminate the largely artificial divide between marine and inland realms.

1. Engage in habitat management and protection as the foundation for fisheries

For decades, habitat has been regarded as the foundation for fisheries management and the conservation of productive ecosystems, particularly in inland systems and coastal marine environments, with much research performed on how various anthropogenic activities influence fish habitat and fisheries production (Minns et al. 1996). In light of the pervasive freshwater and marine coastal habitat alteration that has been associated with industrialization, most developed countries today conduct various habitat rehabilitation, maintenance, and protection activities that recognize not only discrete critical habitats but also recognize the importance of connectivity among habitat (Minns 2001). Advances in fish habitat science and restoration ecology in inland fisheries have identified a variety of habitat protection, rehabilitation, and enhancement activities (including direct in-water activities and indirect activities such as preservation of riparian zones; Roni et al. 2008) that also foster productive fisheries or at least aim to rebuild them (Cowx and Welcomme 1998; Welcomme 2001). Similar to the situation in freshwater systems, habitat can also exert a strong influence on the state of marine fishery resources, in particular in coastal areas and for estuarine-dependent fishes (usually nursery areas such as mangroves, reefs, and seagrass beds) where efforts are increasingly focussing on both protecting and restoring habitats (Beck et al. 2001). Benthic marine fish, in particular, have an inherent connection to physical habitat (Peterson et al. 2000).

Although critical habitat or essential fish habitat is important in some marine fisheries management schemes (Rosenberg et al.

2000), marine fish habitat has not historically been actively protected, managed, or restored to the same extent as freshwater systems aside from a few exceptions (e.g., artificial reef programs (Bortone 2006) and the publicity arising from habitat alteration caused by fishing practices (Jennings and Kaiser 1998)). To some degree, this can be explained by the large dependence of many marine fisheries on pelagic habitats, where there is little need to structurally manage habitat other than avoiding pollution (e.g., by microplastics). However, ocean physics and chemistry may still affect pelagic habitat, and in some species, there is a strong link between the physiochemical oceanographic elements of habitat structure (e.g., fronts and eddies) and larval production (Bakun 2006). We are now beginning to develop habitat models that define these often transient pelagic habitat features (Manderson et al. 2011; Palamara et al. 2012). In some cases, governance structures impede habitat protection given that marine fisheries are managed by different entities (e.g., federal agencies or international bodies) than those that are tasked with protecting estuarine or coastal habitats (e.g., state–provincial–regional agencies). Inshore systems, however, are subject to many of the same threats experienced by inland habitats and thus would benefit from similar protections and enhancement efforts (e.g., as has been done for some altered seagrass habitats; Paling et al. 2009). Although habitat management for coastal regions is certainly becoming more common, such as efforts to identify and protect essential fish habitat in marine systems (Benaka 1999), there is an opportunity to better share knowledge (successes and failures) between realms. In fact, meta-analyses in fresh water have shown that many habitat management schemes fail to deliver intended benefits, calling attention to issues of scale and rigor for habitat management to be effective (Stewart et al. 2009). Given that habitat protection is usually more effective and less costly than habitat restoration (Hobbs and Harris 2001), concerted efforts to protect aquatic habitat will benefit freshwater, marine, and diadromous fish, and an experimental, ideally replicated effort is needed to fully understand the effects of habitat management in both marine and inland systems.

2. Rethink institutional arrangements and management for open-access fisheries systems

In many fisheries, overuse of resources has frequently been attributed to "the commons" problem (i.e., "tragedy of the commons"; Hardin 1968). In this economic model, the benefits of resource extraction by fishing accrue to the individual, while the costs of overfishing are shared over all stakeholders, creating an economic incentive for individuals to maximize personal profit over long-term societal sustainability goals (Clark 1990). Cooperative behavior leading to more sustainable resource use can emerge among communities, provided there is trust and social capital developed by long-term interactions, evolution of socially held norms, graduated sanctioning, and long-term rights to organize and co-manage, as well as strong leadership and availability of high quality monitoring information (Ostrom et al. 1999; Gutiérrez et al. 2011; Cinner et al. 2012). We might actually anticipate that resource-conserving collective behavior might be more easily achieved in smaller-scale coastal or inland ecosystems given that interactions of local resource users are generally more intimate and long-term, and the dependency on local resources may be stronger (reducing the potential for "roving bandits" phenomena; Berkes et al. 2006), but there is little empirical evidence that this is actually the case (Daedlow et al. 2011). Concerns about "invisible" collapses of open-access inland fisheries have been accumulating (Post et al. 2002). As such, there have been calls for greater use of effort controls and other regulations in fresh water to curtail the tragedy of the commons similar to the marine environment (Cox and Walters 2002).

Indeed, effort controls (such as limited seasons or days-at-sea and limited entry fisheries) are commonly used to manage open-access marine fisheries, especially when catch monitoring is unaffordable or impractical (Melnychuk et al. 2012). Yet, in inland systems, these tools are utilized much less commonly and are often confronted with much scepticism by the angling constituency (Cox and Walters 2002). Although effort controls frequently underperform more data-intensive output controls in commercial marine fisheries (Melnychuk et al. 2012), they are an important part of a diverse fishery management toolkit. Along with other less data-demanding approaches, such as protected areas (e.g., Halpern 2003; Stewart et al. 2007), effort limitations play a valuable role and can be particularly useful to support data-poor fisheries. Fisheries managers might be able to specifically protect high-exploitation sites through use of these approaches and should increasingly do so in freshwater systems to avoid the tragedy of the commons.

When considering protected areas as one means to redirect effort away from sensitive or depleted populations, marine resource managers and scientists have recognized the geographical and political scales necessary to cover all aspects of organismal life cycles (Botsford et al. 2003), have identified optimal configuration and siting criteria (Rassweiler et al. 2012), and are addressing societal opposition to reduced fishing opportunities (Klein et al. 2008). In some marine protected areas (MPAs), such as the Great Barrier Reef Marine Park, zonation is widely used to achieve multiple stakeholder objectives and satisfy diverse stakeholder needs (Kenchington and Day 2011). Although there are several papers advocating the use of effort controls (Cox and Walters 2002; Arlinghaus 2006) and protected areas in freshwater systems (e.g., Abell et al. 2007; Suski and Cooke 2007), there have been relatively few controlled experiments or published studies to document their effectiveness and utility, and there seems to be the latent belief that harvest regulations (e.g., creel limits, size-based harvest limits) can "do the job" satisfactorily in most inland fisheries without the need for effort controls (FAO 2012). Moreover, in some freshwater systems, there is a lack of enforcement capacity given the dispersed nature of inland fisheries, which makes the use of output controls challenging (FAO 2010). Indeed, because vessels are generally smaller in inland waters, they can get to the resource quickly and then disappear quickly such that monitoring for compliance needs to be constant, which given the value of the resource, is relatively expensive in freshwater systems. While various vessel monitoring systems are now commonplace in marine environments, similar GPS-based systems could become more prevalent at least in the larger freshwater systems.

Conservation of freshwater fishes has rarely been a criterion in the design of existing terrestrial protected areas (Saunders et al. 2002). As a consequence, most are wholly inadequate for conservation of freshwater fishes (Abell et al. 2007). For example, the extensive US National Park system encompasses the habitat of only 18% of highly imperiled freshwater fish species in the USA and is generally open to fishing (Lawrence et al. 2011). Inland protected areas have usually involved seasonal closures to protect spawning populations of fish but have not protected the entire watershed for political reasons. Where protected areas are established in fresh water, they are usually confined to the water body per se, when the threats are often external to the aquatic ecosystem creating a scale mismatch (Arlinghaus et al. 2002). Experiences from the marine realm in particular could rapidly advance the evaluation and potential use of effort controls and protected areas in fresh water for enhancing fisheries sustainability, but the establishment of these measures will need to consider the greater diversity of anthropogenic threats to inland fisheries and the greater fragmentation of their habitats than most of those located in the marine realm (Cowx and Portocarrero 2011).

3. Establish "reference points" and harvest control rules

Reference points, such as F_{MSY} (rate of fishing mortality that gives maximum sustainable yield) or B_{MSY} (biomass leading to maximum sustainable yield), have a long tradition in marine industrial fisheries (Caddy and Mahon 1995) and have successfully been used to inform the public about the global state of marine fish stocks (Worm et al. 2009). However, despite the existence of reference points, the number of depleted fish stocks has been increasing globally, which suggests that this approach is not entirely effective without proper control and sanctioning (FAO 2012). Nevertheless, reference points serve as transparent benchmarks against which to judge the state of fish populations (e.g., to determine if they are overfished), which in turn triggers pre-agreed management responses, often called harvest-control rules, in many marine fisheries. These rules prescribe responses to curtail fishing mortality to maintain sustainability. The usual approach to inform reference points in marine fisheries is to use some form of stock assessment (e.g., catch-at-age models, virtual population analyses, or surplus production models; Quinn and Deriso 1999), but no such tradition exists in most inland fisheries.

Although limitations of reference points and associated assessments are well-known and most marine stocks still lack rigorous stock assessments (Thorson et al. 2012), assessment of stock status relative to a reference point offers many benefits. In particular, monitoring combined with a reference point and a control rule allows for decisions about transparent, rapid management responses to unfavourable stock status (e.g., low abundance or, less commonly, low average size) to be made before a collapse occurs. This system allows for a more rapid response as the management response has been "pre-negotiated" with stakeholders. Of course, the initial development of the control rule can be quite contentious, but when negotiations with stakeholders about thresholds and management responses to crossing them happen before a crisis and within a transparent, mutually agreed upon decision-making process, it can curtail many future conflicts.

In inland fisheries, reference point-based management is far less prevalent (Welcomme 2001) compared with the marine fisheries in developed countries (Caddy and Cochrane 2001), and some of the common reference points used in marine fisheries, such as B_{lim} (biomass limit), are rarely, if ever, used in inland fisheries. Also, alternative management objectives that may, for example, better serve recreational fisheries, such as optimal social yield, are rarely in operational use (Johnston et al. 2010). Data-hungry process-based stock assessments are unlikely to be implemented in most inland fisheries, simply because there are too many fisheries and an insufficient monitoring capacity (Welcomme 2001; Post et al. 2002). However, there exist a range of less demanding approaches for stock assessment that may be useful when judged against predetermined reference points. For example, length-based metrics may serve as useful indicators of overfishing in inland fisheries (Welcomme 2001).

Developing reference points, even those based on data-poor assessments, that are tailored to particular fisheries within local contexts and budgetary constraints may provide a rigorous decision-making environment. There is particular potential for reference point-based management in the many larger inland fisheries where the local and regional economic importance of the fishery justifies scientific monitoring similar to marine fisheries (e.g., Laurentian Great Lakes, Lake Constance in Germany, Nile perch (*Lates niloticus*, Latidae) fisheries in Lake Victoria).

The value of reference point management approaches for inland fisheries have been demonstrated for walleye (*Sander vitreus*) fisheries in Wisconsin. During the late 1980s, the State of Wisconsin was tasked with development of a management strategy to allow for joint harvest of walleyes on 861 lakes by tribal spear fishers and recreational fishers in lakes in Wisconsin's ceded territory in response to tribal treaty obligations (Hansen et al. 1991). The Wisconsin Department of Natural Resources (WI DNR) chose to develop a management strategy based on harvest quotas (a distinctly marine fisheries notion), because tribal spearing was classified as a highly efficient method of harvest, akin to commercial fishing (Hansen et al. 2000). The tribal spear fishery had a direct harvest quota based on maintaining a one-in-forty risk of exceeding a 35% exploitation rate on walleye (Hansen et al. 1991). Additionally, inland recreational harvest was modified by reducing daily bag limits to account for the tribal harvest (i.e., utilizing the self-regulatory notion that is the backbone of inland fisheries management; Hansen et al. 2000). Using regulatory approaches from both marine and inland fishery experiences allowed the WI DNR to maintain acceptable risk levels of maximum sustained exploitation with minimal risk to the walleye populations and allowed the State of Wisconsin to maintain management authority over ceded territory fisheries. Learning and using approaches from both inland and marine management realms (including reference points that rarely are used in inland systems; Mace 1994) can have beneficial results for long-term sustainability of fisheries.

4. Engage in integrated management approaches

Freshwater and coastal systems are socially and ecologically complex; there are numerous nonfishing related sectors that compete with fisheries production and impact access to clean and abundant water and fish (e.g., municipal use, agriculture, energy production, urbanization; Richter et al. 1997; Cowx et al. 2010). In fact, in freshwater systems, the fisheries sectors (including recreational) and their associated harvests represent just one of the many water resource users (Arlinghaus et al. 2002). Consequently, integrated catchment-based management involving multiple sectors is common in fresh water (Collares-Pereira and Cowx 2004). However, it is important to note that the main objectives of many of the catchment-based initiatives do not often include inland fisheries enhancement or sustainability, so there is still room for more inclusive processes (FAO 2012). For example, for many lake basin and river basin authorities, fisheries issues are often not included in their mandate (FAO 2006). Yet, there are obvious benefits from including fish production impacts into these integrated multiple sectors management plans, not the least of which is the resolution of many stakeholder conflicts (Arlinghaus 2005).

Conversely, in pelagic marine systems the commercial fishing sector has frequently been regarded as the sole or primary user of fisheries resources (Halpern et al. 2008). However, this is changing as offshore energy development, marine aquaculture, transportation, telecommunication, and other human priorities exert a growing influence on marine ecosystems (e.g., Pelc and Fujita 2002; Benetti et al. 2006). Marine systems may involve as many sectors as the freshwater realm if one were to look at the issue at an appropriate spatial scale, noting that this scale is typically much larger in the offshore marine realm. Indeed, the multiple sectors in the marine realm typically operate over much greater areas (e.g., ocean shipping, oil exploration) and often, but not always, are spatially segregated (i.e., shipping channels generally not adjacent to oil platforms). As such, there may be less direct association among marine sectors compared with freshwater or inshore systems where sectors physically operate more closely together. Moreover, marine systems are inherently larger, which makes the attitude that there is "room for all" more prevalent. Addressing multiple impacts on marine resources demands integrated management plans similar to those existing in some freshwater catchments.

Although an ecosystem approach to assessment, governance, and management is currently a hot topic in marine systems (Link 2002; Jennings 2004; FAO 2003) and has perhaps been most successful in terms of integrated coastal zone management (Forst 2009), the concept has also been practiced for quite some time in freshwater systems (Garcia 2008), often under the auspices of integrated management approaches not principally motivated by fisheries (e.g., Heathcote 1998). Watersheds supporting Pacific salmon (*Oncorhynchus* spp.) have benefited from an ecosystem approach (Spence et al. 1996), as well as the Laurentian Great Lakes (Vallentyne and Beeton 1988).

In both the marine and inland context, communicating the value of fishery resources during integrated plan development is critical because activities by nonfishing sectors (e.g., agriculture, dredging for telecommunication cables) may negatively impact the fish and associated fisheries. To communicate the value of fishery resources, better monitoring and assessment of fish populations, household dynamics, and economic impacts of fisheries is essential. Some assessments have shown that providing for fisheries along with other uses of fresh water can be very cost-effective (FAO 2014). Quantifying the full range of ecosystem services provided by fish could be particularly useful in marine fisheries (early steps under way through the Natural Capitol Project and the Marine INVEST tool), something well underway in freshwater systems at least at a regional scale (Cowx and Portocarrero 2011; Ziv et al. 2012). In marine systems, most information on ecosystem services and biodiversity values are specific to fisheries (Worm et al. 2006) and could thus be broadened (e.g., Duarte 2000). With these values at the table, an integrated management plan would consider the costs and benefits of alternative management interventions and their consequences for all affected parties. Scenario planning exercises and management strategy evaluations may be useful tools to facilitate plan development. When fisheries are at the margin of public exposure, it will be critical to ensure that fisheries interests are well represented, which is of particular concern of the many smaller inland fisheries that are often marginalized in the public discourse (Cooke et al. 2013).

5. Reap conservation benefits from the link to fish as food

Both freshwater and marine fishes provide important sources of protein, essential fatty acids, minerals, and trace elements. However, marine fish products are more commonly traded on international markets (Delgado et al. 2003) and consequently achieve greater societal recognition and partly higher market values. Globalization and associated international trade has broadened the conservation constituency well beyond fishers and their local community, associated with the substantial economic, nutritional, and political value of fisheries. Many conservation organizations have exploited the link between overfishing, trade, consumer demand, and public conservation concern through awareness campaigns and labeling of sustainable seafood (Gutiérrez et al. 2012), a concept only very recently used in inland fisheries (Cooke et al. 2011; FAO 2011). However, what may be most important from these initiatives is the constant subtle reminder of fisheries as an environmental issue in the wider public sphere, which fosters dialogue and political action, including resources, to curtail overfishing and generate sustainable fisheries and allow for dialogue on fish habitat needs for fish production.

Many inland fisheries, by contrast, are marginalized in the public eye and government decision-making, suffering from higher-priority competing water uses, such as agriculture, flood control, or hydropower (Arlinghaus et al. 2002). The result of the lack of public attention on inland fisheries and their essential habitats in many countries, including developed ones, is that the public seems unaware of the links among fish production, habitat change, overfishing, and sustainability for inland fisheries, while the opposite often holds for many marine fisheries (Cooke et al. 2013). For example, every time a consumer picks up a can of dolphin-safe labeled tuna, they are reminded of fishery bycatch in marine systems (Teisl et al. 2002), and market demand for sustainable seafood then serves as a reminder of the importance of fisheries and conservation as a joint endeavour. The resulting labels for marine fisheries are by no means uncontroversial (e.g., Jacquet and Pauly 2007; Froese and Proelss 2012; Gutiérrez et al. 2012), but the strength of the market enables countries to apply trade leverage, an important means to change national and foreign fishing policy (Parker 1999). Though sustainable commercial fishing can be a key driver of political influence, international trade organizations often limit the use of trade sanctions to force fishery conservation measures (e.g., the World Trade Organization ruled against the use of dolphin-safe labeling on tuna sold in the USA). Consequently, we must not underestimate the power of consumer preference and demand or trade sanctions to enforce conservation measures across borders, particularly in the case of many inland fisheries, which are not traded on global markets.

Relative to the marine realm, the economic importance of inland fisheries (dominated by recreational and artisanal fisheries; Welcomme 2011) is often underappreciated and undervalued by society at large (Beard et al. 2011; Brummett et al. 2013), inter alia, because most inland fisheries products are predominately traded regionally, locally, or used for household consumption only. The lack of formal structured markets does not imply, of course, that inland fisheries are any less important for food security, and indeed in many developing countries they are vital (e.g., sub-Saharan Africa, Asia, Amazon basin; FAO 2010; Welcomme et al. 2010). From Asian rice paddies, for example, nearly 100 animal species are used for food and medicine that are simply not recorded in any formal dataset or market analysis (Halwart and Bartley 2005). The lack of explicit economic value makes it difficult to consider inland fisheries when trading off between fisheries and other activities such as hydropower development (Brummett et al. 2013). In addition, inland fisheries statistics reported by the FAO are considered underestimates and largely not reported individually by species but as "NEI" (not elsewhere identified; FAO 2010; Welcomme et al. 2010; Welcomme 2011; De Graaf et al., in press), which also reduces exposure of the importance of inland fisheries to scientists and all users of global fisheries databases.

Inland fisheries systems, like small-scale coastal systems, thus require improved and comprehensive monitoring and reporting efforts to demonstrate their biological, social, and economic status and importance, which has been well developed for many years in large-scale marine systems (e.g., Pauly et al. 2005; Dyck and Sumaila 2010). Of particular importance is the need to document the magnitude and value of inland, as well as small-scale coastal, fisheries in developing countries (e.g., using household surveys to clarify importance of inland fisheries for food security, poverty alleviation and local community prosperity; see Beard et al. 2011; De Graaf et al., in press). Improved information on status and trends in global inland fisheries, similar to current monitoring of global marine fisheries, can then provide compelling information that is of interest not only to formal governance institutions but also to the general public (e.g., FAO 2009; Anticamara et al. 2011) and may foster conservation actions also in the inland realm similar to the situation in the marine environment.

6. Reframe conservation and management of fish to better engage the public and industry

Engaging the public to generate support for national or even global responsible fishery initiatives (e.g., changing human behaviour such as consumer decisions, voting) is valuable, and practitioners in the marine realm have generally had more success compared with the freshwater realm (Cooke et al. 2013). Nonetheless, across both realms there is certainly a need to better engage the public in issues of fisheries conservation. Inland fisheries conservation has often been framed in terms of protecting or restoring local fisheries and ecosystems (i.e., place-based conservation such as "Keep Tahoe Blue" and "Save the Don River"), often focused on species of recreational value (Granek et al. 2008) or on occasion some imperilled non-game species (e.g., Collares-Pereira et al. 1999; Cooke et al. 2005) in developed nations. In part, this focus stems from the primacy of threats to physical habitat of freshwater fishes and the small scales of many freshwater ecosystems. In some cases this may reflect the fact that some threats are perceived to be very specific to a locality (e.g., hydropower dam), with any conservation initiatives being local to the threat. Additionally, the focus on place-based approaches to conservation in inland fisheries may be related to the relative lack of iconic charismatic species among the threatened freshwater fishes or at least how these species have been marketed to the public (Cambray and Pister 2002; Monroe et al. 2009). There are certainly some locally iconic species in freshwater realms (e.g., acipenserids or Mekong giant catfish (*Pangasianodon gigas*)) but few globally iconic ones. The locality-based focus of freshwater conservation creates inherent limits because it is difficult to get the wider society to care about places that are not part of their daily lives. By contrast, marine conservation outreach and public engagement has focused more on species-specific (e.g., charismatic bluefin tuna (*Thunnus thynnus*)), ecosystem-specific (e.g., coral reefs), or threat-specific (e.g., bycatch) examples, rather than on a discrete location, simply because most members of society in one way or another relate to these species (through food) or ecosystems (through tourism).

In this context, industry engagement is also relevant. Industry engagement in fisheries conservation has been strong in the marine realm, and there are many examples of how this engagement has led to positive environmental change (Johnson and van Densen 2007). The inland fishing community is engaged in conservation too (Arlinghaus 2006), but the associated industry is small-scale and diffuse, and often there is little coordination among the different players or even intrasectoral conflict (e.g., between commercial and recreational interests; Arlinghaus 2005). For those working in freshwater systems, there is a need to learn from the many successes to engage the public and industry in fish conservation in the marine realm and work to engage stakeholders on more broad-scale issues to advance responsible inland fisheries at all management scales. Clearly, the approach is only functional if the increased awareness of the public and policy makers to conserve threatened fisheries resources results in a reduction in consumer demand for overfished species and (or) improved ecosystem management. Because many fish stocks of commercial or recreational value in fresh water are threatened predominately by nonfishing activities, such as habitat change (Welcomme et al. 2010), these efforts could provide an immense boost to protect and restore the threatened fisheries. To that end, better cooperation of scientists and marketing experts is needed (e.g., how to use high-quality imagery of freshwater fish to promote conservation; Monroe et al. 2009) along with more effective extension efforts to link science to the public and policy makers in both realms.

Synthesis and conclusion

We contend that there are many ideas that can be shared between marine and freshwater realms to advance conservation and sustainability of global fisheries resources and thereby improve the food security and livelihoods of local communities. Our approach was based primarily on expert judgement and thus has several inherent limitations. For example, we generated our ideas recognizing the difficulty in achieving the task of harmonization and cross-fertilization in light of the sometimes striking differences in objectives, governance, and scales between marine and inland fisheries. However, so far many obvious lessons between realms have gone unnoticed, a limitation that we hope has been highlighted in our paper. For example, small-scale coastal marine fisheries are not unlike many inland fisheries in developing nations, and some inland industrial commercial fisheries (e.g., in the Laurentian Great Lakes or for Nile perch on Lake Victoria) are not unlike the marine industrial fisheries. Indeed, it is tempting to conflate "marine fisheries" with industrial-scale commercial fisheries and "inland fisheries" with small-scale artisanal or recreational fisheries. We recognize that there are some sectoral differences between the marine and freshwater realms, but that all fisheries types (commercial, recreational, artisanal, and subsistence) operate in each realm and that there is diversity in scale (i.e., small-scale to industrial-scale) within each realm. Hence, the ideas presented here are to be considered generalizations with some caveat that they may not apply to all contexts in either marine or inland fisheries.

There are successes that have already emerged as a result of sharing management concepts between realms as discussed here. However, cross-fertilization is not the norm, as the freshwater and marine science and management communities continue to participate in different conferences and publish in largely different journals. The way forward should include more mechanisms that would facilitate knowledge transfer and mobilization such as joint projects, conferences–workshops–symposia, books–papers, combined graduate student training curricula, exchange opportunities for practitioners to build capacity, and working groups that include members from both the marine and freshwater realms. In addition, there is need for changes to governance structures and institutions that deal with the two realms, ideally moving towards some that have jurisdictions that cross realms and actively consider opportunities to cross-fertilize. In some situations, changes to the scope of research institutes, including naming, is needed to facilitate change. Is it timely to have "Freshwater Ecology" in the name of an institute, such as the case with the Leibniz-Institute of Freshwater Ecology and Inland Fisheries, or could an altered name such as Leibniz-Institute of Aquatic Ecology and Fisheries Science offer more chances for cross-fertilization?

To conclude, many scientific advances occur at the interface between disciplines. The realms we discussed here have essentially become disciplines over time (marine fisheries science versus inland fisheries science), so efforts that result in cross-fertilization of knowledge, theory, paradigms, governance, and practice (including management successes and failures) between realms could facilitate rapid changes that benefit aquatic ecosystems, fisheries resources, and the well-being of those that depend on fish or fishing products. Many other boundaries exist in fisheries and aquatic sciences and management that yield great opportunities for cross-fertilization of ideas (e.g., Salomon et al. 2011). Failure to exploit these interfaces and various inter- and multidisciplinary perspectives will potentially retard the advancement of science and management, impacting the future of the world's fisheries resources.

Acknowledgements

This contribution emerged from one of the themes (i.e., working across boundaries) covered by S.J.C. as part of the J.C. Stevenson Memorial Lectureship at the Canadian Conference for Fisheries Research in Windsor, Ontario, January 2013. S.J.C. is supported by the Canada Research Chairs Program and the Natural Sciences and Engineering Research Council of Canada. R.A. was funded by the Program on Social–Ecological Research by the German Federal Ministry for Education and Research (Besatzfisch, grant No. 01UU0907). We thank Nancy Leonard for comments on the manuscript and Keith Stamplecoskie and Robert Lennox for formatting it. The views expressed in this publication do not necessarily reflect the views or policies of the Food and Agriculture Organization of the United Nations.

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