Journal of FISH BIOLOGY

fsbi An International Society for Fish Biology

Journal of Fish Biology (2013) **83**, 997–1018
doi:10.1111/jfb.12222, available online at wileyonlinelibrary.com

Failure to engage the public in issues related to inland fishes and fisheries: strategies for building public and political will to promote meaningful conservation[a]

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Generating awareness of environmental conservation issues among the public is essential if there is an expectation of them to alter their behaviour, facilitate informed decisions and engage governments or regulatory authorities to take action. There are, however, exceedingly few public engagement success stories related to inland fishes and fisheries policy and resource allocation decisions. Inland aquatic resources and their associated fisheries provide employment, recreation, culture and, in developing regions, a considerable proportion of human nutrition and food security. Freshwater fishes are incredibly diverse but are among the most endangered organisms globally. Many threats to inland fisheries are driven largely by externalities to inland fisheries. The purpose of this paper is to draw attention to the role and plight of inland fishes and fisheries, and the need to generate the public and political will necessary to promote meaningful conservation. With this paper, the extent to which the scientific and environmental management communities have failed to engage the public in issues related to inland fishes and fisheries is characterized. Next, the barriers or factors that serve as the basis for the problem with public engagement are identified. The paper concludes by identifying strategies, including those focused on environmental education initiatives, for building the public and political will necessary to promote meaningful conservation of inland fishes and fisheries in developed and developing countries. Scientists, environmental managers, non-governmental organizations, politicians, regulatory authorities and the media all have important roles to play in overcoming challenges to inland fisheries. Failure to engage the public in freshwater conservation and management issues will impede efforts to stem the loss of freshwater habitats, fisheries and aquatic biodiversity. Thankfully, there are opportunities to learn from success stories related to other environmental issues and initiatives that have been successful in marine fish conservation.

Key words: biodiversity; conservation; environmental education; policy; sustainable fisheries.

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[a]This paper was presented at the 6th World Fisheries Congress, Edinburgh, in 2012 (sponsored by the FSBI). As a result, its content may not fall within the normal scope of the *Journal of Fish Biology*.

INTRODUCTION

Inland freshwater fishes and associated aquatic systems generate a broad range of valuable ecosystem services (Daily, 1997; Holmlund & Hammer, 1999; Cowx & Portocarrero Aya, 2011). The scientific literature is well populated with examples of the threats faced by inland fishes and fisheries with associated consequences on ecosystem services, and the current state of inland aquatic resources (Allan *et al.*, 2005; Dudgeon *et al.*, 2006; Abell *et al.*, 2008). Unlike offshore marine systems where the primary threat is internal to the fishing sectors (*i.e.* overexploitation and related issues such as by-catch and habitat destruction due to fishing gears), most of the drivers of reduced abundance and loss of freshwater fish diversity are external to exploitation pressures (Richter *et al.*, 1997; Cowx *et al.*, 2010; Gozlan *et al.*, 2010; Beard *et al.*, 2011) and over-exploitation in inland systems (Allan *et al.*, 2005). External threats to inland fisheries can be broadly classified as habitat degradation, water pollution, invasive species, flow modification in rivers and fragmentation through installation of barriers, with anthropogenic environmental changes such as nutrient loading, warming and shifts in precipitation and runoff patterns superimposed upon all of these threats (Richter *et al.*, 1997; Dudgeon *et al.*, 2006; Vörösmarty *et al.*, 2010; Welcomme *et al.*, 2010). Consequently, freshwater ecosystems are some of the most altered and threatened on the planet (Kennish, 2002; Malmqvist & Rundle, 2002). The many additive, and in some cases synergistic, effects of threats have made freshwater fishes some of the most imperilled taxa worldwide with high numbers of such species granted threatened status (Leidy & Moyle, 1997; Ricciardi & Rasmussen, 1999; Powles *et al.*, 2000; Strayer & Dudgeon, 2010). Indeed, declines in biodiversity (including fishes; Moyle & Leidy, 1992) tend to be greater in fresh waters than in most other habitats (Sala *et al.*, 2000; Jenkins, 2003; Vörösmarty *et al.*, 2010), and declines in freshwater fish fauna are strongly correlated with economic activity such as surface water diversion, agriculture, species introductions, urbanization and pollution (Limburg *et al.*, 2011).

Cowx & Portocarrero Aya (2011) noted that current interventions (mostly top-down management activities involving regulations) in inland aquatic ecosystems are not necessarily achieving their conservation objectives despite a growing body of scientific evidence documenting the need to conserve and protect freshwater biodiversity. Two important components for the conservation of aquatic systems are the ability of scientists to communicate such information effectively to the general public, and that of politicians to put these issues on the public agenda and promote evidence-based decision-making (Sutherland *et al.*, 2004). Brummett *et al.* (2013) take this further by arguing that many water resource development activities override fish biodiversity and conservation issues because their benefits are more highly visible in economic terms and thus have political and public support. Unfortunately, all too often scientific evidence is not used in decision-making related to natural resources and the environment (Pullin *et al.*, 2004).

Few papers have explored the need to better engage the public in freshwater biodiversity issues or identified opportunities for using specific instruments to do so (Cambray & Pister, 2002; Monroe *et al.*, 2009). Moreover, none of the papers have focused on understanding why and how freshwater conservation advocacy has fallen short nor have they identified barriers to public engagement and strategies to overcome those barriers. To that end, this paper begins with a brief primer on why it

is important to engage the public in issues specific to the conservation of freshwater biodiversity, followed by a characterization of the extent to which there has been a failure to engage the public in issues related to inland fishes and fisheries. Next, the barriers that serve as the basis for the problem are identified, given that a transparent and complete critique is a prerequisite to identifying opportunities to solve problems (Cooke *et al.*, 2012). The paper concludes with an attempt to identify strategies to overcome barriers and to build the public and political will (and resourcing) necessary to promote meaningful conservation and management (conservation is considered to further include management activities focused on ensuring healthy, productive and sustainable fish populations and fisheries) of inland fishes and fisheries.

PUBLIC ENGAGEMENT, EDUCATION AND COMMUNICATION

The premise of this paper is that if the public were more aware and engaged in issues related to inland fishes and fisheries, then it would lead to stronger conservation actions for aquatic systems. Environmental education (EE) is considered by UNESCO (1980) to have three goals: (1) to foster clear awareness of, and concern about, economic, social, political and ecological interdependence; (2) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment; (3) to create new patterns of behaviour of individuals, groups and society as a whole towards the environment. EE is inherently multifaceted and includes theory from the distinct fields of education and communication. The scientific community has recognized that education initiatives are effective and yield more immediate results than simply publishing results in peer-reviewed journals, and this is particularly salient in the field of EE (Monroe *et al.*, 2007). Additionally, EE (and science communication in general; Wilsdon & Willis, 2004) should not simply be one-way communication (*i.e.* researcher to public); it should include dialogues appropriate for different audiences and be participatory (*e.g.* even including co-management arrangements; Berkes *et al.*, 1991).

Monroe *et al.* (2007) suggested that education is a process that has extensive contact with learners, behavioural objectives, and unbiased or bias-neutral information that does not seek to change behaviour, but prepares learners to make decisions. Conversely, communication activities (Jacobson *et al.*, 2006) that advocate a particular behaviour, such as with mass media, persuasion and social marketing (McKenzie-Mohr & Smith, 1999), are not considered to be from the same discipline, but do broadly fall within the notion of EE. Clearly, there is much theory underpinning efforts to engage the public, but the most relevant point here is that the concept of EE is inclusive of such diverse approaches as social marketing and capacity building and therefore provides the science community with a suite of tools for interfacing with the public. Media interaction differs among developed and developing countries (*i.e.* different forms are required than the multifaceted tools available in industrialized societies). In developing countries, word of mouth and the radio are prominent, although modern technology (*e.g.* Apps through mobile phones) is becoming increasingly used. The differences in communication and education strategies among developed and developing countries are recognized and, thus, attempts to note those differences are made throughout this paper.

Fien *et al.* (2001, 2002) reviewed the World Wide Fund for Nature (WWF) education programmes and identified four types of activities used by WWF to promote EE:

information, communication, education and capacity building. Although the framework was useful for WWF and its specific audience, a number of shortcomings were identified (Fien *et al.*, 2001). The framework by Monroe *et al.* (2007) is proposed because it is particularly relevant to conservation science as it defines four categories of interventions based on specific objectives: convey information, build understanding, improve skills and enable sustainable actions. This framework is used below to identify and address various barriers related to education and to raise awareness about inland fishes and fisheries among the public.

FAILURE TO ENGAGE THE PUBLIC RELATED TO INLAND FISHES AND FISHERIES

It is the perspective of the authors that the scientific and environmental management community has failed to engage the public in issues related to fishes and fisheries in inland waters as effectively as for other environmental issues, such as those dealing with marine fishes. To that end, trends in media coverage were examined to evaluate the extent to which inland fish conservation issues were represented relative to marine fisheries issues. A LexisNexis (a global news item archive; www.lexisnexis.co.uk) academic search was conducted on 9 May 2012 and was used to identify relevant news materials related to inland and marine fishes and fisheries. The search was restricted to the major world publication source, which includes the world's major newspapers, magazines and trade publications for the one-year period prior to the date of the search. The Boolean search string [(saltwater OR marine) AND fish* AND conservation] yielded 1880 news items, *c*. 4·5 times more than that found using [(freshwater OR inland) AND fish* AND conservation] (414 news items). Additional searches were also conducted over longer time periods and the number of marine fish-oriented news items always exceeded that of inland fish-oriented news items by *c*. 50%. A similar search was conducted using Google News (http://news.google.co.uk/nwshp?hl=en&tab=wn) on 12 May 2012 using the same search terms but over a longer period (1990–2012). Google News focuses more on online sources than LexisNexis. A similar pattern emerged with 10 300 marine-oriented items identified compared with 3760 inland-oriented news items that were found. Removing the word conservation from the search string maintained the same trend (*i.e*. 48 300 marine-oriented items *v*. 17 200 inland-oriented items). These structured searches revealed that media attention (as inferred from number of news items found) towards marine fisheries issues is at least double that of inland fisheries, consistent with the supposition of the authors. Perhaps, as importantly, this trend points to the need for action from the scientific and management communities to better promote freshwater issues so that the media can assist with engaging the public.

BARRIERS TO ENGAGING THE PUBLIC IN THE CONSERVATION OF INLAND FISHES AND FISHERIES

Numerous barriers can be found when engaging the public in the conservation of inland fishes and fisheries; nine are considered of highest prominence. Some barriers to engaging the public in inland fisheries conservation are not distinctive to inland fisheries (*e.g*. challenges in developing countries and lack of incentive

for scientists to do outreach) and probably apply to other areas of environmental conservation (Novacek, 2008).

BARRIERS NOT DISTINCTIVE TO INLAND FISHERIES

Unique challenges in developing countries

Environmental conservation cannot be a priority for impoverished people until basic survival needs are met (Dunlap & Mertig, 1995). Such poverty-driven scenarios can potentially lead to environmental degradation where communities strive to survive from day to day and thus have little regard for their local environment (Cowx & Portocarrero Aya, 2011). Poverty-driven environmental scenarios are the antithesis of sustainable livelihoods and should be a major theme for social and cultural engagement in conservation, especially because so many lower-income people are dependent on freshwater fishes as their primary protein source (Welcomme *et al.*, 2010). Creation of a sustainable approach to inland fisheries will have to account for tension between environmental conservation and poverty (Millennium Ecosystem Assessment, 2003). Indeed, environmental conservation will probably be particularly important where fresh water is a limited resource and under threat from multiple users.

Additionally, developing countries often have additional challenges related to corruption that can derail conservation issues, particularly during periods of government or political instability and transition (Laurance, 2004). In addition, given that freshwater resources are typically open-access or common-pool, tragedy-of-the-commons-type scenarios can play out, particularly in developing countries (Allan *et al.*, 2005). Even when regulations do exist, there is often a lack of enforcement capability such that compliance is low (L. Vuthy, Y. Dara & P. Degen, unpubl. data).

Many economists and political leaders suggest that perpetual economic growth and technological development will alleviate poverty, maximize human welfare and reduce societal environmental interactions (Rosales, 2008). Technological advancement has, however, not reduced societal environmental effect of economic growth but resulted in further degradation of inland aquatic systems (Cowx & Portocarrero Aya, 2011). Lessening of environmental effects, especially, in the case of developing countries where environmental legislation is weak or unenforced and the concept of perpetual economic growth is paradoxical in terms of protecting biodiversity and ecological integrity (Ehrlich & Pringle, 2008; Limburg *et al.*, 2011). Given that economic and social issues are more likely to inform policy compared to ecological issues (Brummett *et al.*, 2013), and that the same ethics that justify conservation also demand consideration of poverty issues (Chan *et al.*, 2007), there is a need to consider how conservation and sustainable management of fishes can be achieved within the constraints of expanding human demands for food, wealth and technological advancement.

Lack of incentives for researchers to communicate science effectively

In general, researchers lack incentives and often the ability to communicate their science with the public and are often concerned about engaging in advocacy. The argument against advocacy, albeit different than communicating results, by environmental scientists has been going on for some time and the importance of objectivity in science is one of the key reasons (Lackey, 2007; Nelson & Vucetich, 2009). Time and finances are also major factors limiting freshwater scientists from

contributing their full potential towards informing the public debate. Academic scientists find it difficult to focus on outreach over research and publishing when outreach experience is given minimal consideration in the awarding of grants, tenure and promotion (Cooke, 2011). Agency scientists and managers often have some expectations of communicating science at least within their agency, and in some cases to stakeholder groups. In those instances, outreach or communication efforts (*e.g.* U.S. Sea Grant extension) are written into job descriptions or performed by full-time education and communication specialists. Communication effectiveness is difficult to measure relative to bibliometric indices of productivity (*e.g.* impact factor of a journal where a paper is published) and is often paid lip service in the actual performance evaluations. Mechanisms for measuring effectiveness of uptake of research outcomes related to conservation are clearly needed (Schäfer *et al.*, 2011).

BARRIERS DISTINCTIVE TO INLAND FISHERIES

Externalities and fresh water as a limited resource

Unlike offshore marine systems where the primary threat to fisheries (and thus unifying theme) is harvest-related exploitation pressure (Kappel, 2005), the threats faced by freshwater fishes and fisheries are more varied and complex. Although marine and freshwater species are threatened by similar factors, such as climate change, pollution and habitat loss and alteration (Kappel, 2005; Dudgeon *et al.*, 2006), freshwater fishes are additionally threatened by flow-regime or water-level alteration, disruption in migratory pathways (*i.e.* connectivity), alien invasive species (although this is increasingly becoming a problem in marine systems), land-use practices within the catchment and water extraction (Dudgeon *et al.*, 2006; Welcomme *et al.*, 2010; Cowx & Portocarrero Aya, 2011). Unlike overfishing, where stakeholders theoretically serve to benefit directly from protecting fish populations (but in practice, there are lots of examples of where this has failed although there are some positive examples with small-scale fisheries), the principal threats to freshwater fishes and fisheries often involve stakeholders that lack a vested interest in fisheries protection, making the problems less tractable. Furthermore, fresh waters are a critical and often a limiting resource for most human activities (*e.g.* drinking, agriculture, electricity, industrial processes and mining; all uses that can be easily quantified and given economic value), placing freshwater fisheries protection in direct competition with many economic and even subsistence activities. Increased competition for freshwater resources has placed severe pressure on freshwater fisheries production.

Complexity of messaging

In general, there is a lack of understanding of the mechanisms by which human actions affect fresh waters and inland fisheries, particularly for indirect effects stemming from land-use changes in the catchment. Limited public awareness of the scope of the problem (*i.e.* the degree to which freshwater ecosystems are threatened) is partly a result of the difficulty inherent in communicating and understanding a complex set of issues. For example, the urbanization of a catchment can have considerable negative effects on freshwater fish diversity when as little as 10% of a catchment is covered with impervious surfaces (Wang *et al.*, 2001). This occurs in part because runoff volume and flashiness increase with imperviousness, leading to erosion and increased turbidity. Concurrently, pollutants, more common in urban environments,

are no longer filtered by intact riparian zones. Such indirect effects are difficult for the public to grasp when considering a new subdivision or commercial development. Adding to the complexity, these effects are cumulative or synergistic across the landscape; the construction of one parking area or clearance of a small area of forest may have minimal effects on downstream habitats, yet such activities are rarely isolated. Similarly, the deforestation of a plot for agriculture in a catchment may be a minor disturbance, but the cumulative effects of multiple forest-clearing activities can have considerable effects on biodiversity depending on system-specific thresholds (Yuan & Norton, 2004).

Weak valuation of inland fisheries

The true value of inland fisheries and the role of freshwater fishes in aquatic ecosystems have not been properly quantified, beyond several examples in developed countries, so their contribution to the well-being of society is largely ignored (Parkkila *et al.*, 2010; Welcomme et *al*., 2010). In fact, even the contribution of inland fisheries to human nutrition has been largely ignored, at least until very recently (Welcomme, 2011). In the developed world, recreational fisheries contribute significant economic benefits that have been quantified using various survey approaches (Parkkila *et al.*, 2010) often at the scale of a specific region or waterbody and on occasion at a national scale (Navrud, 2001; Peirson *et al.*, 2001). Recreational fisheries are the dominant fishing sector in inland waters in developed countries (Arlinghaus *et al.*, 2002) but are often not accounted for in global fish-harvest estimates (Cooke & Cowx, 2004; Welcomme *et al.*, 2010). The extent of the economic significance of these fisheries is not well understood by the broader public, except perhaps inland recreational fisheries in some developed regions (Arlinghaus & Cooke, 2008; Cowx *et al.*, 2010). The lack of a generic model for valuing inland fisheries applicable to both developed and developing countries to assist when deciding on the uses of inland water systems makes it difficult to evaluate tradeoffs and to identify win–win, win–lose and lose–lose decisions (Beard *et al.*, 2011). Basic cost-benefit approaches are unlikely to succeed given that one could argue that, for example, a portion of the funds generated from a hydropower scheme could be used to replace lost fisheries production with intensive agriculture. Proper valuation of inland fish production at a global scale (Beard *et al.*, 2011), along with the other services provided by inland water systems, would go a long way towards engaging the public and supporting informed decision-making for management of inland fishes (Brummett *et al.*, 2010).

Job security and economic importance of inland fisheries

Since the Food and Agriculture Organization (FAO) of the United Nations started collecting fisheries catch statistics in 1950, inland fisheries production (exclusive of aquaculture and recreational fisheries) has increased steadily at a rate of 3% year^{-1} and hit a record high of 10·2 million t in 2008 (FAO, 2010; Welcomme, 2011) and global production of inland fisheries is widely thought to be underreported (Beard *et al.*, 2011). Historically, inland fisheries have contributed only 5–10% to the global annual fisheries production, with the bulk of inland fishes (*c*. 90%) being caught in developing countries (FAO, 2010). Although there are (or were) large inland commercial fisheries producing important export commodities [*e.g.* caviar, sábalo and Nile perch *Lates niloticus* (L. 1758)], the majority of extant

inland fisheries are small-scale, subsistence activities driven by contributions from Asia and Africa, whose production (except aquaculture) is mainly consumed and traded locally or regionally (Welcomme *et al.*, 2010; Cooke *et al.*, 2011). In more developed regions such as Europe, North America and Oceania, trends are towards recreational fisheries, with less reliance on inland harvest as a food source (Arlinghaus *et al.*, 2002; Welcomme *et al.*, 2010).

By contrast, most marine fisheries' production is generated by commercial activities and involves the trade of high-value commodities (*e.g.* tunas, salmonids and shrimp) in the international market (FAO, 2010). Furthermore, marine fisheries contribute the vast majority of protein from all fish sources to the world and represent the greatest source of protein consumed, at least in the developed world (Welcomme *et al.*, 2010). Due to the potentially large negative effects that a reduction in marine fisheries production can cause to the global economy and food security, it is not surprising that scientific and media reports of diminishing marine fish stocks are highly publicized worldwide while inland fisheries are largely overlooked despite their importance to rural livelihoods and food security in many parts of the world. Moreover, public awareness of the collapsing state of marine fisheries has been recently enhanced by the emergence of ecolabelling, certification and awareness campaigns, particularly in the developed world (Jacquet & Pauly, 2007). Ecolabelling programmes have sparsely considered inland fisheries, contributing to the lack of public awareness of the precarious state of many inland fish stocks (Cooke *et al.*, 2011).

Urbanization and lack of connection to fishes in freshwater systems

Connectedness to nature has been defined as the extent to which an individual includes nature within his or her cognitive representation of self (Schultz, 2002). Feeling a sense of belonging to the broader natural community may be a prerequisite for increasing stewardship of freshwater biodiversity. Clearly, in some regions such as developing countries where freshwater fishes are critical to food security and livelihoods, individuals possess inherent connections to fresh water; however, this is not universal. Within developed countries, there has been a shift away from outdoor recreation activities that create the strong connections to the environment (Pergams & Zaradic, 2008). As the rate of urbanization is expected to increase, maintaining strong connections to fish and fisheries will be a challenge. The challenge is that freshwater biota are unseen by most people (Monroe *et al.*, 2009) and some of the most diverse freshwater biodiversity hot spots are in particularly turbid waters (*e.g.* the Amazon and Mekong Rivers). Second only to the importance of direct observation of freshwater biota for developing connectedness to nature are visual media. Although celebrated game fishes are seen in popular media (*e.g.* television and magazines), these images are mostly aimed at anglers whereby fishes are usually depicted as being landed (*i.e.* extracted from their natural environment; Monroe *et al.*, 2009) and this image may impede an empathetic perspective for aquatic habitat and diversity (Monroe *et al.*, 2009). Video media (television in particular) play an important role in connecting the public to the aquatic realm. For example, Jacques Cousteau's television documentaries and, more recently, David Attenborough's *The Blue Planet* (BBC, 2001) provide images of marine environments, whereas freshwater equivalents to these marine documentaries are lacking.

Outdoor recreational activities in marine environments, such as scuba, snorkelling or surfing, may allow direct interaction with fishes; however, the freshwater

equivalents to these activities often take place in relatively colder water (at least in temperate and north temperate regions) or those with lower visibility (sometimes zero visibility) and, therefore, are generally less appealing. In general, freshwater biodiversity is highly obscure (Harrison & Stiassny, 1999); however, there are some notable exceptions. For example, the Pantanal region of South America offers snorkelling in a clear tropical freshwater wetland that may rival marine snorkelling experiences (although it is currently under threat from cattle ranching).

Few high-profile stories of inland fisheries

In recent memory, inland fisheries have lacked high-profile sky-is-falling stories of decline and degradation that have occurred in marine fisheries (Worm *et al.*, 2006) and other taxa and ecosystems (*e.g.* amphibian declines in wetlands, Alford & Richards, 1999; loss of tropical rainforests, Skole & Tucker, 1993). The collapse of Canada's Atlantic cod *Gadus morhua* L. 1758 fishery is one of the most well-known modern examples of fisheries collapse, and it continues to receive mainstream media coverage given the major effects of the closure of the fishery on Newfoundland's economy and culture (Schrank, 2005). Similarly, media coverage of research on declining marine fish stocks and ecosystems (Pauly *et al.*, 1998; Myers & Worm, 2003) has been common and was compiled in the documentary and book *The End of the Line* (Clover, 2004). In contrast, commercial overfishing, eutrophication, pollution and habitat modifications that caused collapse of fish stocks in fresh water largely occurred before the 1960s in the developed world, before the onset of the environmental regulations of the 1970s (*e.g.* Clean Water Act in the U.S.A.). In addition, changes in freshwater fisheries since the development of the environmental movement have generally occurred gradually (Regier & Hartman, 1973), have had only local effects and were not tied to food security (in the developed world). Such fishery collapses have occurred in freshwater commercial fisheries in the developed world, but high-profile examples are scarce and date back to before the environmental movement [*e.g.* extirpation of blue pike *Sander vitreus glaucus* Mitchill 1818, Regier & Hartman, 1973; loss of haplochromine cichlids in Lake Victoria, Africa, Witte *et al.*, 1992; decline of north Atlantic eels *Anguilla anguilla* (L. 1758) and *Anguilla rostrata* (LeSueur 1817), Wirth & Bernatchez, 2003]. Although media coverage of environmental catastrophes does not necessarily lead to strong conservation action, it does bring increased attention to the system in question and can result in reactionary policy changes, especially if there are economic effects (Hansen, 1993). Indeed, unprecedented media coverage of the potential impact of the Mekong mainstem hydropower dams on loss of fish production (estimated to be between 0·7 and 1·3 million t year^{-1}) initially led to 10 year moratorium on construction (http://www.bbc.co.uk/news/world-asia-16085584/), although development of the Xayaburi Dam is now proceeding. Getting the story right is also critical, which points to the need for professional scientific societies to take a leadership role in media relations.

Lack of promotion of charismatic megafauna

Flagship species are often highlighted to provide a unifying symbol for addressing whole-ecosystem conservation initiatives (Mittermeier, 1986; Dietz *et al.*, 1994). Unlike terrestrial and marine systems represented by popular and emotive images

of polar bears *Ursus maritimus* linked to climate change (Derocher *et al.*, 2004), or sharks linked to overharvest (Myers *et al.*, 2007), freshwater megafauna remain vastly underrepresented in the public eye. The few exceptions rarely depict the ecosystem as a whole but portray images of landed fishes (e.g. *Monster Fish* by National Geographic; http://natgeotv.com/asia/monster-fish), thus narrowing the target audience (Monroe *et al.*, 2009). Unfortunately, general global declines of freshwater megafauna, and the resultant shifting baselines that sometimes follow (Turvey *et al.*, 2010), threaten to further impede awareness and knowledge of these species. Non-fish freshwater megafauna such as freshwater dolphins could also be used to generate interest in freshwater conservation issues.

STRATEGIES TO ENGAGE THE PUBLIC IN INLAND FISHES AND FISHERIES

As noted above, the aim of this paper is to begin the discussion on how to engage the public and the higher political arena in issues related to inland fishes and fisheries by identifying potential strategies to overcome barriers. The framework proposed by Monroe *et al.* (2007) defines four categories of interventions that are inclusive of education and communication-oriented activities necessary to engage the public (see Table I). From a practical perspective, these interventions are consistent with the overarching goal of attempting to engage the public in the conservation of inland fishes and fisheries (Table II). In this context, educators include all those with knowledge of freshwater fish conservation (including stakeholders with traditional knowledge) and an interest in engaging the public. Additionally, Monroe *et al.* (2007) noted an overlap such that strategies in the 'Improve Skills' and 'Enable Sustainable Actions' categories almost (Table II) always include aspects of the 'Convey Information' and 'Build Understanding' categories. They also noted that the categories are nested as opposed to hierarchical.

The examples provided in Table II are not intended to be exhaustive nor do they address all of the barriers noted above, given that some barriers require actions that are outside of the realm of EE and beyond the reach of the scientific community. Examples of other actions relevant to barriers are provided in Table I. Some of these actions would generate information germane to education activities (*e.g.* ecosystem services must be quantified before they can be described to the public). A particularly important component is the need to revisit the role of scientists and managers in advocacy, communication, outreach and education, and there are incentives and other mechanisms that can help to achieve that goal (see Table I).

Clearly, the list of solutions provided in Table I is not exhaustive. The importance of the creativity of the scientific community, environmental educators, non-government organizations (NGO) and governments cannot be overstated. To that end, each of these groups should consider how they, as organizations and individuals, can work to overcome barriers to engaging the public in the conservation of inland fishes and fisheries. There have certainly been a number of successes in terms of public engagement related to environmental conservation including the sustainable seafood movement (for marine systems; Jacquet & Pauly, 2007), promotion of reducing, reusing, recycling and composting (Taylor & Todd, 1995) and popularity of shade-grown coffee (Rappole *et al.*, 2003). Many of these successes have hinged

TABLE I. List of proposed solutions associated with barriers to engaging the public in the conservation of inland fishes and fisheries

Barrier	Proposed Solutions
Unique challenges in developing countries	Build political will and capacity for fisheries monitoring and management of freshwater resources, particularly in developing countries (it is difficult to generate awareness with little or no information on freshwater resources). Develop valuation approaches for inland fishery resources that are not necessarily market based, and tie that valuation to local prosperity (*e.g.*, CAMPFIRE programme in Zimbabwe; Child, 1996). Promote co-management arrangement to engage fisheries in wider catchment development initiatives. Implement education programmes tailored to the reality of local communities, which have the potential to raise their awareness of issues related to freshwater fisheries (any type of education programme must be able to clearly show community members how they will benefit from getting engaged and taking action in issues related to the conservation of their freshwater resources). Hold and develop summits, conventions or accords that are legally binding global agreements (*e.g.* Ramsar Convention on Wetlands) to protect freshwater ecosystems and biodiversity, backed with support (*i.e.* financial) for developing nations, from developed nations. Initiate bottom-up community-based natural-resource management models that use soft approaches to regulation (*e.g.* peer-pressure) and provide scientific support to these programmes through non-government organizations or governments.
Lack of incentive for researchers to communicate science effectively	In academic settings, revise the hiring, tenure and promotion process to increasingly value outreach. Revise natural resource agency mandates to include implicit educational components (note that many do such as Parks Canada and the U.S. Sea Grant System of the National Oceanographic and Atmospheric Administration). Require that scientific grants dealing with freshwater science (or any conservation issue) include a mandatory public education component.
Externalities and fresh water as a limited resource	Build understanding of how conservation of biodiversity can be achieved within the constraints of human advancement (needed given that economic and social issues are more likely to inform policy than ecological issues and that the same ethics that justify conservation also demand consideration of poverty issues). Build understanding of the many mechanisms by which human actions affect freshwater fishes. Characterize the scope of the problem (*i.e.* the degree to which freshwater ecosystems are threatened). A variety of environmental education (EE) initiatives (see Table II).

TABLE I. Continued.

Barrier	Proposed Solutions
Complexity of messaging	Deliver messages that carry clear and familiar terminology (Novacek, 2008). Relate inland fisheries issues to other environmental problems or issues that may be more familiar to the public (*e.g.* clean water) or use surrogate, high-profile species such as freshwater dolphins or manatees to promote the plight of freshwater fishes. Develop talking points to help scientists answer the main question posed by public: 'Why should we care?'
Weak valuation of inland fisheries	Do a better job at valuing inland fisheries and associated ecosystem services (*e.g.* can we show the effects of large hydropower dams on food security such as in the Mekong Basin? can we make the link between freshwater fishes and cultural values, as has happened for many marine commercial fishing communities?). Provide the public and politicians a more robust scientific basis for trade-off choices (*i.e.* incorporate them into urban and regional planning discussions). Focus on the resiliency of natural ecosystems and native fauna and the benefits that this has for resource users and society on the whole. Develop rapid, reliable and standardized socio-economic evaluation tools to properly nest the importance of inland fisheries to food security, economic activity and cultural services that can be used on a regional basis without need for expensive economic assessment (*e.g.* as done for freshwater use in agriculture; Dabrowski *et al.*, 2009).
Job security and economic importance of inland fisheries	Encourage development of social-marketing campaigns associated with the sustainable seafood movement that include freshwater species (Cooke *et al.*, 2011). Develop better estimates of the scope and scale of inland fisheries and their contribution to food security and the global economy (Welcomme *et al.*, 2010; Beard *et al.*, 2011).
Urbanization and lack of connection to fishes in freshwater systems	Develop a variety of EE initiatives (see Table II). Develop education programmes designed to get people onto and into fresh waters. Use creative strategies for drawing connections between human activities and freshwater fishes (*e.g.* The Yellow Fish Road Programme painting fish shapes on sewer grates to highlight the connection between storm waters and natural waterways; www.yellowfishroad.org). 'Just add water' (Monroe *et al.*, 2009), use images of fishes in their environment rather than using images of fishes out of water captured by recreational anglers. Attempt to generate support from popular media and culture (*e.g.* need celebrity champions); may be an important role for professional societies to serve as a clearing-house for credible information. In Quebec, a micro-brewery developed a beer to raise awareness for endangered copper redhorse *Moxostoma hubbsi* in a local river. Need for children's programming and characters (*e.g.* Nemo) related to fresh water.

TABLE I. Continued.

Barrier	Proposed Solutions
Few high-profile stories of inland fisheries	A variety of EE initiatives (see Table II) Identify success stories to share with the public. Develop a better understanding of the natural history and pre-industrialization state of freshwater habitats.
Lack of promotion of 'charismatic megafauna'	Develop a variety of EE initiatives (see Table II). Identify and promote freshwater megafauna (*e.g.* sturgeons) as symbols for conservation efforts (*e.g.* the Chattanooga Aquarium opened a 'River Megafish' exhibit in 2012). Abundant opportunities for the promotion of charismatic freshwater megafauna as flagship species exist, with potential examples including freshwater sawfish *Pristis microdon*, sturgeons and paddlefishes, freshwater stingrays or giant catfishes. Recently, the spotlight has been turned on some of these species *via* popular media (*e.g.* Animal Planet's *River Monsters*; http://animal.discovery.com/tv-shows/river-monsters and National Geographic and World Wildlife Fund's *MegaFishes*; http://environment.nationalgeographic.co.uk/environment/freshwater/about-megafishes-project/), as public appreciation for these species grows.

on using environmental psychology to help promote environmental sustainability *via* behavioural changes (Steg & Vlek, 2009) coupled with EE initiatives. Environmental psychology can be used to understand the cognitive, motivational and structural factors and processes that threaten environmental sustainability (Steg & Vlek, 2009). By doing so, it is possible to identify pro-environmental behaviours (*e.g.* tree planting and reducing water use) that can be promoted. A search of the literature failed to find any specific examples of how environmental psychology had been applied to issues of inland (or marine) fish conservation, which suggests that such work is needed and would be quite informative.

One important intervention is the need to identify focal groups that promote the importance, and plight, of inland fishes, aquatic biodiversity and those that depend on these resources for their livelihoods and food security. To this end, lessons can be learnt from broader nature conservation groups such as WWF. There are, however, comparatively few organizations with a focus on freshwater fishes. In the same context, key to the promotion of protecting freshwater fishes are mechanisms to engage with local stakeholders and enthusiasts (*e.g.* working with local NGOs to conserve and promote inland fishes and fisheries). In developing countries, where the emphasis is more on food security and sustainable, small-scale fisheries, integration of fisheries into local co-management arrangements is essential for the consideration of fisheries in any water resources development initiative. Co-management, however, must be properly structured and implemented to be successful (Berkes *et al.*, 1991). Such management arrangements seem to be most effective when the leadership of the local stakeholder organization is strong [Khan *et al.* (2012) provides a coastal marine example]. Irrespective of the mechanism, it is critical that all stakeholders understand

TABLE II. Portfolio of possible environmental education (EE) interventions for the overarching goal of attempting to engage the public in the conservation of inland fishes and fisheries using the framework identified by Monroe *et al.* (2007)

Category	Purpose	Formal learning approaches	Non-formal and free-choice learning strategies
Convey information	To disseminate information, to raise awareness and to inform	Develop curricular content (including text books and videos) on freshwater ecosystems and fish conservation for primary and secondary schools. Promote tertiary level education in freshwater aquatic science and link to engineering and social economic and science programmes. Re-emphasize the importance of taxonomy as a science in education programmes to ensure skills in species identification are not lost in the future. Develop internet resources (structured learning tools) targeted to a range of learners (different audiences).	Develop a high-profile charitable organization that promotes the importance and charismatic elements of inland fishes and fisheries. Generate media interest in freshwater-oriented stories (focusing on some of the unique and charismatic fish species) to increase public exposure to relevant information. Develop co-ordinated and focused information campaigns (including public service announcements, electronic media and brochures) that target different audiences. Create exhibits at museums, parks and other public venues that provide targeted information.
Build understanding	To exchange ideas and provide dialogue, to build a sense of place, to clarify and enhance the understanding of information and issues and to generate concern	Engage audiences to assist them with developing their own mental models to understand values of freshwater fishes. Provide opportunities for the public to interact with those knowledgeable about freshwater issues (*e.g.* nature walks and swims, public presentations and workshops on hot topics such as dam removal). Provide opportunities for members of the public to serve on relevant committees. Incorporate field trips and experiential learning related to fresh water into formal educational programmes.	Expand remit of local wildlife and environment groups to encompass freshwater fisheries concerns. Develop detailed pamphlets, interactive websites or other outreach materials. Provide opportunities for the public to participate in environmental monitoring and restoration activities (citizen science) related to fresh waters or to contribute traditional or stakeholder knowledge.

TABLE II. Continued.

Category	Purpose	Formal learning approaches	Non-formal and free-choice learning strategies
Improve skills	To build and practice skills	Develop citizen science programmes or other volunteer service opportunities that enable the public to connect to freshwater issues and develop skills related to measuring water quality, fish habitat and fish communities. Use project-based education such as provision of hatcheries in classrooms for fish reintroduction programmes. Teach members of the public about the environmental needs of fishes and how to fish *via* clinics.	Use social-marketing strategies that modify social norms to increase commitment to freshwater conservation. Develop incentives (such as valuing the resource) to encourage skills development and behaviour change (*e.g.* training the next generation of responsible anglers and voters). Provide opportunities for the public to develop skills (*e.g.* fish identification websites).
Enable sustainable actions*	To build transformative capacity for leadership, creative problem solving, monitoring and effective citizenship in a complex world	Develop and facilitate community-based EE programmes and adaptive collaborative management. Provide opportunities for stakeholders to provide input that has the potential to influence decision-making processes (*e.g.* sitting on a regional watershed management committee). Enable community leaders and agency educators to work collaboratively to define problems, rank priorities and identify novel solutions.	Provide citizens with the opportunity to participate in democratic processes (*i.e.* voting) through establishment of charitable trusts, co-management initiatives and representation on working groups. Facilitate partnerships and networks related to freshwater conservation

*Note that educator does not direct the process but may facilitate directly or indirectly (*e.g.* through interventions in other categories).

the drivers and motives of each sector and the probable effects of their actions on other sectors to enable equitable distribution of resources and ensure sustainability of ecosystem functioning and services for all (Cowx & Portocarrero Aya, 2011).

DISCUSSION

Greater public engagement in issues related to inland fishes and fisheries could lead to more meaningful conservation actions and resourcing (*i.e.* programme development and funding) that would benefit aquatic systems and associated ecosystem services. Further, the public are not as engaged in freshwater issues compared with the marine realm or with large mammal and bird conservation issues as shown by the results of the present web searches on media inquiries. A number of barriers were identified, many of which relate directly to the need for information sharing and public engagement (Fig. 1). For example, it was noted that few freshwater fish species are commonly perceived as charismatic megafauna, even though unique ichthyofauna exists (*e.g.* Mekong giant catfish *Pangasianodon gigas* Chevey 1931). Weak valuation of ecosystem services provided by inland fishes and fisheries is a major impediment to sharing relevant information with the public and politicians and informing decision-making processes (De Groot *et al.*, 2010). Issues related to continued population growth and associated expanding human demands for food, wealth and technological advancement also require careful consideration and are not specific to issues facing freshwater fishes. Of course, having an informed populace will be critical in the social policy discussions that will certainly be needed in the future.

A number of strategies for building the public and political will necessary to promote meaningful conservation and sustainable management of inland fishes and fisheries are needed. Many of these strategies involve initiatives that are broadly described as EE (*e.g.* citizen science and public awareness campaigns). Particularly relevant here is the ability of scientists and managers to effectively communicate information on ecosystem services and the value of inland fishes to the general public, and of politicians to put these issues on the public agenda and to promote wise decision-making (Cowx & Portocarrero Aya, 2011). It was also recognized that education alone was insufficient for some barriers. For example, better means of valuing ecosystem services provided by inland fishes and fisheries, incentives for scientists to participate in education and the recognition that they are important advocates for inland fishes are all needed to overcome barriers to public engagement. In developing countries, there are a number of specific challenges. For example, there is a need to build capacity so that it is simply possible to document what freshwater resources exist, their status and how they directly or indirectly contribute to livelihoods and food security prior to engaging citizens at a local level to foster resource stewardship, *e.g.* through co-management arrangements (Castello *et al.*, 2009). The specific strategies needed to engage individuals in developed and developing countries are probably quite different; however, the EE framework provided by Monroe *et al.* (2007) is sufficiently generic and flexible that it serves as a template for both.

Although this paper is directed largely towards the scientific community, NGOs, governments (including their scientific, management and outreach units) and the media at regional, national and global scales, all have important roles to play in overcoming these problems. Failure to engage the public in freshwater conservation

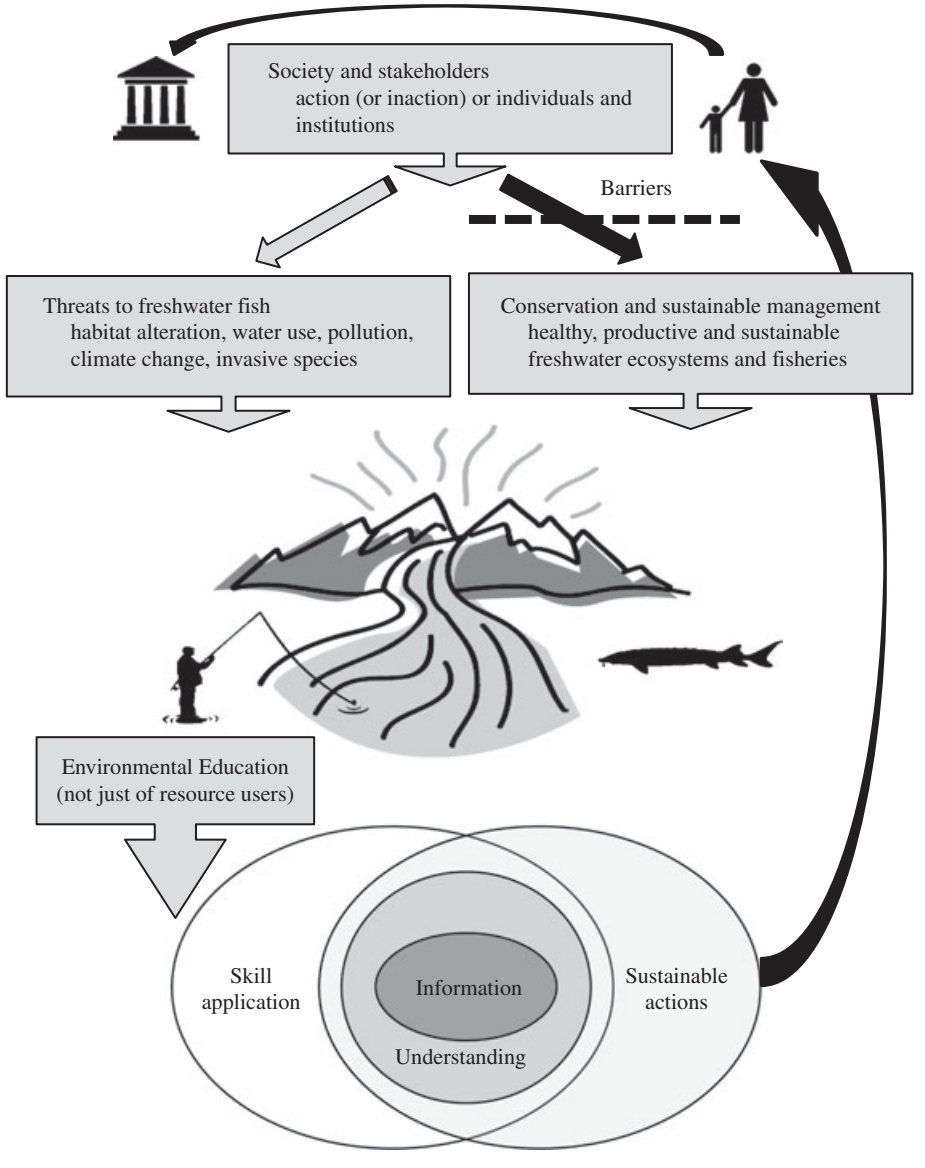

FIG. 1. Schematic representation demonstrating the role of environmental education (EE) in yielding individual-level behavioural outcomes that influence society and its institutions (*e.g.* through voting and participation) and collectively promote conservation and sustainable management of aquatic resources by breaking down barriers (▬▬). The actions or inactions of individuals and institutions are depicted here as distinct arrows (⇨ and ➡) suggesting that there are two distinct paths. Providing society with the information and understanding to stimulate a desire to build skills and ultimately alter behaviour is essential and this paper attempts to do so by identifying the barriers (▬▬) limiting public engagement in freshwater fish conservation. EE and an informed and literate public requires the efforts of the fisheries science and management communities to ensure that the information being shared is accurate. Such fisheries professionals are well positioned to participate in EE (which takes many forms), given their expertise and commitment to freshwater fish conservation. The EE schematic is adapted from Monroe *et al.* (2007) with some aspects (*e.g.* convey information) nested within other categories of interventions. The GIF image of the catchment is courtesy of http://bcn.boulder.co.us/basin/learning/introduction.html/

and management issues will impede efforts to stem the loss of freshwater habitats and biodiversity, but thankfully there are opportunities to learn from success stories in other realms and issues. As noted eloquently by Cambray & Pister (2002), a paradigm shift to pro-active involvement (by scientists) in EE and conservation is required to sustain inland fishes and freshwater ecosystems. Hopefully, the ideas presented here will empower the scientific community to make that paradigm shift happen sooner than later.

S. J. C. is supported by the Canada Research Chairs Programme, the Natural Sciences and Engineering Research Council of Canada (NSERC), the Ontario Ministry of Research and Innovation and the Canadian Wildlife Federation. G. D. R. was supported by an NSERC post-graduate scholarship. We acknowledge the work by Cambray & Pister (2002) as well as by Monroe *et al.* (2009) as being the pioneers in thinking about the importance of engaging the public in issues related to freshwater fish conservation.

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