The Underappreciated Livelihood Contributions of Inland Fisheries and the Societal Consequences of Their Neglect

So-Jung Youn
Center for Systems Integration and Sustainability
Department of Fisheries and Wildlife, Michigan State University
1405 South Harrison Road, 115 Manly Miles Building, East Lansing, Michigan 48823, USA

Edward H. Allison*
School of Marine and Environmental Affairs, University of Washington
3707 Brooklyn Avenue NE, Seattle, Washington 98105, USA

Carlos Fuentevilla
Food and Agriculture Organization of the United Nations
Subregional Office for the Caribbean
2nd floor, United Nations HouseMarine Gardens, Hastings BB11000, Christ Church, Barbados

Simon Funge-Smith
Food and Agriculture Organization of the United Nations
Regional Office for Asia and the Pacific
39 Pra Athit Road, Bangkok 10200, Thailand

Heather Triezenberg
Michigan State University Extension
Department of Fisheries and Wildlife, Michigan State University
1405 South Harrison Road, 305 Manly Miles Building, East Lansing, Michigan 48823, USA

Melissa Parker
Department of Global Health and Development
London School of Hygiene and Tropical Medicine
15-17 Tavistock Place, London WC1H 9SH, UK

Shakuntala Thilsted
Consultive Group on International Agricultural Research
900 19th Street NW, 6th floor, Washington, D.C. 20433, USA

Paul Onyango
Department of Aquatic Sciences and Fisheries, University of Dar es Salaam
Dar es Salaam, Tanzania

Wisdom Akpalu
United Nations University-World Institute for Development Economics Research
Institute of Statistical, Social, and Economic Research, University of Ghana
Post Office Box LG 74, Legon, Ghana

* Corresponding author: ehal@uw.edu

GORDON HOLTGRIEVE
School of Aquatic and Fishery Sciences, University of Washington
1122 NE Boat Street, Seattle, Washington 98105, USA

MOLLY J. GOOD AND STEPHANIE MUISE
Center for Systems Integration and Sustainability
Department of Fisheries and Wildlife, Michigan State University
1405 South Harrison Road, 115 Manly Miles Building, East Lansing, Michigan 48823, USA

Abstract.—Inland fisheries provide important contributions to human well-being, but these contributions are often overlooked or undervalued by decision makers. Consequently, inland fisheries are not adequately considered in either global fisheries sustainability initiatives—which are generally marine-focused—or in the use of freshwater resource planning in an era of water crisis. Here we synthesize the state of knowledge of the contribution of inland freshwater fisheries to human well-being. To date, there has been no coordinated global valuation of the ecosystem service contributions of inland fisheries, and it is thus only possible to highlight the range of services they provide from isolated case studies. Throughout these studies, human nutrition emerges as a key value, with freshwater fish providing essential nutrients in countries such as Cambodia and Bangladesh, which are endowed with productive freshwater fisheries. Inland fisheries also provide livelihoods, income, economic autonomy, dietary diversity, cultural identity, and social structure to tens of millions of people around the world. The diversity of fishing methods, conservation strategies, and traditional ways of managing fisheries enriches the human experience and represents a source of cultural and technical knowledge and human institutional ingenuity. In this paper, we review what is known about approaches for assigning values to freshwater fisheries and identify methods to better assess and communicate those values to decision makers and the public in order to increase representation of inland fisheries in natural resource decision-making processes. Most importantly, we focus on the contributions of inland fisheries to food security, nutrition, community cohesion, and improved livelihoods. This paper also explores approaches that consider the knowledge and perspective of fishers, fish workers, other aquatic resource users, and their communities to augment and improve the knowledge and perspective of scientists and resource managers in better managing freshwater fisheries resources. We also stress the importance of ensuring that assessments explicitly consider gender relations and roles in inland fisheries and fishing-dependent societies. Better recognition and valuation of the economic, nutrition, and social benefits that inland fisheries provide to human communities is an essential step toward better incorporating inland fisheries into future water and food security policies.

Introduction

The vast majority of global inland fisheries catch is used for direct human consumption (Welcomme et al. 2010). These important and productive food resources, however, are often negatively impacted because decisions about the allocation and management of inland waters often either ignore or do not include an accurate assessment of the economic, societal, and cultural values that inland fisheries contribute to society (Bartley et al 2016, this volume). This exclusion from decision-making processes partially occurs because information about the valuable contributions of inland fisheries to economic, social, and individual well-being is not well documented or effectively communicated, especially to policymakers. Although a few case studies exist (Béné

and Neiland 2003; Baran et al. 2007; Navy and Bhattarai 2009), no global assessment of the value of inland fisheries has yet been conducted. In instances where there is some estimate of the monetary value of these fisheries (usually in terms of fishing income and profits or license and tax revenues), economic assessments have often ignored the important contribution of freshwater resources to nutrition, health, livelihoods, leisure, individual and societal well-being, as well as the values associated with religious and cultural uses of freshwater resources (UNEP 2010; Welcomme et al. 2010). This incomplete portrayal of inland fisheries contributions lessens their value and importance to decision makers, especially those more distant from the local communities where the fish are captured. The absence of inland fisheries from the decision-making process is also partially due to the inaccuracies and uncertainties surrounding current inland fisheries assessment and reporting (Cooke et al. 2016; Lymer et al. 2016a; both this volume).

In assessing the overall values of inland fisheries, it is essential to focus on both the ecosystem services (e.g., habitat, freshwater, fish, and biodiversity) and the flows to the social and economic sectors (e.g., fishers, processors, and others involved in inland fisheries) that are involved in inland fisheries. To ensure that each of these components are given proper consideration when assessing the value of inland fisheries to human societies, a conceptual framework capable of articulating the various services provided by inland fisheries and methods of how to best to assess these contributions is required. Smith et al. (2013) suggests a framework for linking general economic, social, and ecosystem goods and services to human well-being. The framework has nine domains of well-being: health, social cohesion, education, safety and security, living standards, spiritual and cultural fulfillment, life satisfaction and happiness, leisure time, and connection to nature. We have adapted this framework into a fisheries context to illustrate its utility in linking the economic, social, and ecosystem goods and services provided by inland fish and fisheries to human well-being (Lynch et al. 2016b; Figure 1).

Each of the nine domains of well-being is important to gain a full understanding of the role and importance of inland fisheries to economic, societal, and environmental well-being, which combine to describe overall human and societal well-being. These nine domains relate to inland fish in many ways:

- In the context of inland fisheries, the domain of health focuses on outcomes of personal well-being, life expectancy and mortality, and physical and mental health conditions from reliance on inland fisheries for nutrition, including micronutrients during the first months of life from conception to 24 months.
- The domain of social cohesion focuses on outcomes such as identity, family demographics, and social norms, stemming from social network ties among individuals and within communities, enhancing the quality of life for those dependent upon inland fisheries.
- The domain of education focuses on outcomes derived from formal and informal education and skills transfer, which enhance basic capabilities that lead to the expansion of other capabilities necessary for well-being development. In the context of inland fisheries, education capabilities are an antecedent to the ability to adjust effectively to market or technology changes.
- The domain of safety and security focuses on outcomes related to overall freedom from harm, promoting personal physical security, national security, and financial security. In our context, reliance on inland fisheries can promote financial security, especially for women or children, by providing for enhanced livelihoods and income.
- While the domain of living standards is largely economic in nature, this domain focuses on outcomes related to income, living conditions, home ownership, and household assets accessible as a result of inland fisheries activities.
- Cultural values of inland fish or symbolism related to fish may promote the domain

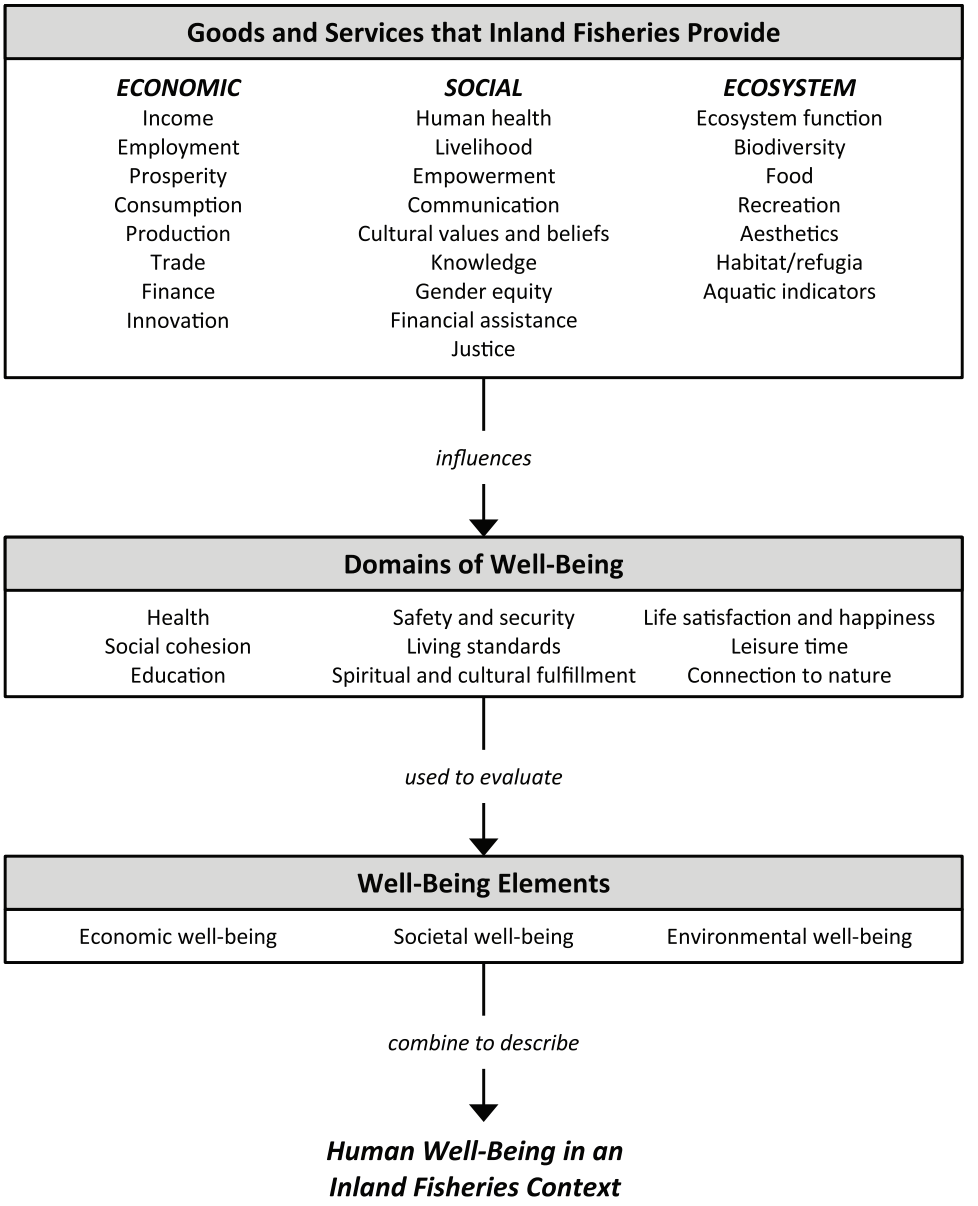

Figure 1.—Elements of a framework that link economic, social, and ecosystem goods and services provided by inland fish and fisheries to human well-being. (Adapted from Smith et al. 2013).

of spiritual and cultural fulfillment, which focuses on outcomes related to interconnections between one's self and others and the environment as a result of access to religious activities, cultural interests and identity, and a connection to nature.

- The domain of life satisfaction and happiness focuses on outcomes related to self-reported happiness and whole-life satisfaction. Life satisfaction and happiness with inland fisheries in the developed world may occur at higher rates than in the developed world, in part because life satisfaction tends to plateau in the wealthier, developed world. Perhaps more appropriate to the developed world than the devel-

oping world, inland fisheries may be a focus of pleasurable activities that people are able to engage in outside of their work or other responsibilities (e.g., fishing, fish ing clubs), resulting in outcomes in the domain of leisure time.

- The domain of connection to nature focuses on outcomes related to biophilia—an emotional attachment of human beings to other living organisms (Wilson 1984; Smith et al. 2013). Measures of biophilia can describe the connection people have with inland fisheries or their ecosystem services. In the developing world, the relationship among humans, inland fisheries, and their ecosystem services may be curvilinear. People in the developing world likely have strong biophil ia; as their livelihood dependence on in land fisheries wanes so too does biophilia, until individuals rely again on inland fisheries for other reasons such as leisure time.

While the human well-being framework depicted in Figure 1 may be appropriate for a global context, it is essential to clarify which domains are more appropriate for inland fisheries in a developing context than in a developed context, and vice versa. A holistic framework, one that incorporates gender roles, power dynamics, and political ecology, will be more effective for valuing, and in the valuation of, inland fisheries to society. Further, when methods and metrics are solidified and implemented to value the social, economic, and ecosystem goods and services provided by inland fisheries, their contributions become even more prominent in society. However, some challenges exist in the determination of the value of inland fisheries, as discussed in the next section.

Challenges associated with valuing inland fisheries

It is difficult to accurately assign a monetary value to inland fisheries because they are complex, and geographically diffuse and occur largely outside formalized markets (Welcomme et al. 2010). Harvest and use (e.g., consumption, recreation, and livelihood) statistics, particularly in the developing world, are often unavailable or inaccurate (Welcomme 2011). Many areas lack the infrastructure, labor force, or capital needed to generate harvest estimates and check the accuracy of existing estimates (Welcomme 2011). Additionally, because many inland fisheries are so diffuse, many agencies opt to collect data only on larger-scale commercial fisheries and report little or no data on others (e.g., subsistence fisheries, recreational fisheries; FAO 2003; Kang et al. 2009). The livelihood and food security benefits provided by inland fisheries are also difficult to measure since many inland fisheries are subsistence based and thus occur outside of formal markets, rendering the value of most inland fish transactions invisible to normal channels of data collection on economics (Bartley et al. 2015). Some methods, such as indirect-use valuation and the travel-cost method, have been applied to inland fisheries in the Mekong basin (Baran et al. 2007) and the Copper River in Alaska (Henderson et al. 1999). In general, however, very few valuation studies have been done of subsistence inland fisheries.

Compounding the difficulties of valuing inland fisheries are the challenges associated with valuing freshwater ecosystems in general and the impact that external drivers (e.g., changes in land use, climate change) have on inland fisheries (Brummett et al. 2013). The complex interactions of climate, water, and land use challenge creation of projections of the impacts that climate change will have on inland fish and those who rely on them (Lynch et al. 2015). Illegal and destructive fishing methods, coupled with inadequate enforcement of fishing regulations, complicate assessment of inland fisheries and further challenge the assessment of actual catches (Allan et al. 2005). Improved low-cost approaches for estimating fish harvests and methods to trace flows of inland fish through ecological and human systems would help to reveal the largely invisible values of inland fisheries.

The contribution of inland fisheries to health and food security

Food and nutrition security is one of the most important ecosystem goods and services pro-

vided by inland fisheries, the majority of which are used for direct human consumption (Youn et al. 2014). It is generally accepted that direct consumption of inland fish plays an important role in the diets of many population groups, particularly in the developing world (Roos 2016; Funge-Smith 2016; Lymer et al. 2016b; all this volume). Exploring and supporting this generalization, however, is very difficult due to lack of reliable data on direct human consumption, indirect human consumption (e.g., use of inland fish in animal feeds), and nutrients present in inland fish (Welcomme 2011; FAO 2014; Bartley et al. 2015).

Freshwater ecosystems and the inland fisheries they support are diverse and can have high productivity of fish and other aquatic species that feature in people's diets or can be sold to support food and livelihood security (Dudgeon 2000; Kang et al. 2009). This diversity of inland aquatic organisms, especially the smaller fish species, is an important nutrition source for human communities. All fish species are a rich source of animal protein (Beveridge et al. 2013). Additionally, small fish, which are eaten whole (bones, organs, and head), contribute essential minerals and vitamins, such as calcium, phosphorus, zinc, iron, and vitamin A, to the human diet (Roos et al. 2003). Due to their size, it is often difficult to consume large fish whole, and thus, large fish do not provide these same nutrients. The micronutrients provided by freshwater fish are often inaccessible to local communities in other forms, either due to price or unavailability of substitutable food sources that contain these nutrients.

Freshwater fish also have been reported to enhance the bioavailability of micronutrients from the other foods consumed during the same meal since nutrients in the fish enhance bioabsorption of nutrients present in the food (Tontisirin et al. 2002). Micronutrient contributions from inland fish are especially vital to economically disadvantaged people as they tend to suffer disproportionately from micronutrient deficiencies, which have debilitating effects on human nutrition, health, and survival, due to decreased access to nutrient-rich foods (Fischer et al. 1999; Combs and Hassan 2005; Roos et al. 2007). Traditional knowledge of local communities on the nutritional and health attributes of many inland-capture fish species also points toward the great value given by these communities to inland fish and people's desire to ensure the continued use of these fish as part of their families' diets and livelihoods (Roos et al. 2003).

Even though exact data regarding harvest, transactions, and consumption of fish from inland fisheries are scarce, it is generally accepted that inland fish contribute significantly to the consumption of animal-source foods in rural populations in Africa and Asia, especially during the peak fish-capture season (Belton and Thilsted 2014). Fish consumption varies widely across countries, seasons, and population groups, and there are very little data for household fish use (e.g., different forms of consumption, bartering) beyond national economic surveys. National data may mask the critical contribution of inland fish to the food security of a particular region or population. Equally important, there is limited understanding of intra-household food dynamics regarding the quantity and parts of the fish that different members of the household consume. For instance, gender may be an important aspect influencing consumption of inland fish within a household because there is evidence from many countries that females consume smaller portions of fish and other animal-source foods compared to males (Béné and Heck 2005; Kawarazuka and Béné 2010). As a result women, compared to men, often do not receive the same nutrient and food benefits from inland fish, which can exacerbate nutrient deficiencies in women, particularly pregnant or lactating women. In some cases, these are real differences due to cultural factors, where males eat first and have larger portions; elsewhere, this may be due to reporting bias in the survey methodology (Gittelsohn 1991; Geheb et al. 2008). Real differences in the amount of fish consumed would affect household food security and the nutrients each household member receives from inland fish.

Another important aspect regarding consumption of fish is people's access to markets or other fish sources. Studies in Bangladesh

show that in communities close to water bodies with productive capture fisheries, only one-third to one-fourth of fish consumed was self-caught and the majority of fish consumed was bought from nearby markets (Hels et al. 2003), suggesting that local fisheries are an important source for community food security. Again, gender and social roles are an important aspect to consider as the power to purchase fish, and thus access its nutritional benefits, may not be realized equally among different socioeconomic groups and within households (Béné and Merten 2008; Belton and Thilsted 2014).

In many areas, women and children take part in capturing inland fish, and these fish are generally used for household consumption (Bose et al. 2009). Infants and young children can also significantly benefit from consumption of inland fish (Roos 2016). There is growing recognition of the positive impact fish, via nutrients found in fish, can have on growth, development and cognition in infants and young children (Daniels et al. 2004). The role of essential fats, especially the importance of omega-3 fatty acids for brain development, is well known (Horrocks and Yeo 1999; He et al. 2004), and some freshwater fish (e.g., Rainbow Trout Oncorhynchus mykiss and Common Carp Cyprinus carpio; Guler et al. 2008; Gogus and Smith 2010) have high amounts of these nutrients. Studies on developing fish-based products using small indigenous species with high micronutrient content have been conducted in Bangladesh, Cambodia, and Kenya among pregnant and lactating women and young children up to 24 months of age (Andersen et al. 2003; Longley et al. 2014). These studies illustrate the important benefits that the nutrients in inland fish provide to these vulnerable groups. The first 24 months are considered the first 1,000 d of life, a window of opportunity for ensuring optimal child growth and development that can lead to long-term optimal nutrition, health, and development for the individual child and better national and global development for society (Roos 2016). However, the nutrient content of many inland fish species, even frequently consumed fish species, is not well known (Bogard et al. 2015) as nutritional profiles have tended to focus on larger fish, typically from aquaculture, which may have different nutrient profiles than wild fish and fish on lower levels of the food web. Determining the nutrient content of fish species and thus their contribution to nutrition is an important first step to understanding, analyzing, and promoting the present and future potential of inland fisheries to improve global food and nutrition security (Roos et al. 2007).

Valuing the contribution of inland fish to human society

Freshwater ecosystems support a diversity of livelihoods and cultural values. For instance, freshwater recreational fisheries in the United States are known to support more than 500,000 jobs generating more than US$30 × 109 in retail sales and contributing more than $9 × 109 in tax revenues (Southwick Associates 2012). Inland fisheries also support commercial fishing industries, such as in the Laurentian Great Lakes (Cooke and Murchie 2015) and the African Great Lakes (Okeyo 2014), and remain important in some European countries, despite shifts in dietary preferences and multiple pressures on freshwater use and allocation. Commercial fishing in France (Boisneau et al. 2016, this volume) was estimated to produce 1,186 metric tons valued at €10,470,000 (EU 2011).

Livelihoods reliant on inland fisheries, whether recreational or commercial, are also vulnerable to social, biological, environmental, and economic changes that can reduce access to inland fisheries or decrease the productivity and value of the fishery (Cowx 2015). Because inland fisheries provide different livelihood benefits to different people (e.g., fisheries are not always a livelihood of last resort), policies regarding inland fisheries need to account for the different livelihood values that fishers obtain from inland fisheries (Smith et al. 2005). It is not sufficient to assume that fishers are a homogenous group and that this allows the blanket application of policies for management, development, or conservation.

Inland fisheries and their aquatic environment have essential cultural roles for many rural (Fregene 2016; Ibengwe and Sobo 2016; both this volume) and indigenous cultures (Bartley et al. 2016) that largely rely on traditional freshwater resources (Clarke Historical Library, no date). In the Northwest of the United States, more than 40 tribes have very close cultural and livelihood ties to aquatic resources (Ruby and Brown 1986). In fact, they refer to themselves as the "people of the salmon," and they honor the salmon as their first indigenous food gifted to them by the Creator (Columbia River Inter-Tribal Fish Commission, no date). The rights of the Pacific Northwest tribes to fish for salmon are closely guarded by the tribes. The ongoing struggle by the native people of North America to have their tribal fishing rights recognized has also occurred in the tribal people of South America, specifically the Amazonian region (Barra 2016, this volume). It has been widely reported that the rights and needs of the largely uncontacted tribes of the Amazon River basin are being ignored during development and transformation of the river system by not only corporations, but also by the governments that are supposed to protect them (Shukman 2012). The loss of access to fishing and fishery resources threatens not only food security, but also cultural traditions and historical livelihoods sources; it may result in the long-term loss of cultural identity and reduce the prospects of maintaining a traditional community and lifestyle into the future, particularly when compounded by other environmental threats such as large-scale mining (Malm 1990), oil drilling, and government-driven deforestation (Shukman 2012). Malm (1990) has shown that runoff from illegal, as well as legal, mining and drilling operations releases mercury-based compounds into the Amazon watershed and river system, which results in bioaccumulation within the freshwater fishery resources upon which these tribal peoples depend (Malm 1990). In summary, without representation on the local and global stages, these groups are subjected to health risks and shorter life spans due to reduced access to freshwater fishery resources (McClain and Naiman 2008; UNPFII 2010).

Recommendations to Effectively Communicate the Social and Economic Value of Inland Fisheries

Improving our ability to assess and communicate accurately and effectively the social and economic value of inland fisheries is critical to ensure both ecosystem and human well-being. During the 2015 global conference on inland fisheries, a group of panel experts explicitly focused on this ongoing challenge. This panel agreed that an approach, on local and international levels, that considers the social and cultural aspects of inland fisheries is needed so that valuation of inland fisheries effectively includes the social value of inland fisheries in addition to their economic values. It is also important to understand that fishers are not a homogenous group and thus may vary in regards to the value they place on various aspects of inland fisheries. Indeed, while much research and management effort has been expended on identifying drivers of change affecting inland fisheries productivity and sustainability (Lynch et al. 2016a, this volume), comparatively little attention has been given to understanding the lives of the driven—the people affected by change. In particular, the perspectives and lives of those with unequal social status (e.g., women, small-scale fishers) need greater incorporation into inland fisheries and natural resource governance. They also need to be included in decision-making processes, as inland fisheries are a key social and economic resource for these groups (McGoodwin 2001; FAO 2015). This panel formulated two main recommendations that are now part of the "Rome Declaration: Ten Steps to Responsible Inland Fisheries" (this volume): (1) correctly value inland aquatic ecosystems, and (2) promote the nutritional value of inland fisheries. Below, we expand on these two recommendations and provide suggestions for moving forward.

Improve systems for fish valuation—monetary and otherwise

Value methods that incorporate economic values with sociocultural values need to be used in order to estimate the contributions of in-

land fisheries to human health and well-being. Approaches used elsewhere in the natural resources sector and in the valuing and valuation of ecosystem services may apply to the inland fishery sector (Kontoleon and Swanson 2003; Davidson 2013). Some examples of potential economic methods that could be applied to inland fisheries include shadow pricing, replacement value, and willingness to pay (Smith 1996; Howarth and Farber 2002), which have been applied to other natural resources, such as applying shadow prices to adjust the market value of stumpage (Huhtala et al. 2003). Assessments from a public health, social, or ethnographic perspectives may focus on themes such as understanding livelihoods, assessing health and nutritional status, measuring well-being, the analysis of class and gender dynamics, understanding relations of power and accountability, the functions of governing institutions in fisheries and water-use decisions, and the value of local and indigenous knowledge systems regarding management of, and benefits from, inland fisheries (UNEP 2010).

These methods have rarely been applied to the inland fisheries context, in part because of the limited attention these systems have received to date. Using these methods in the context of inland fisheries to increase knowledge and awareness regarding the ecosystem services inland fisheries will provide and generate both monetary and nonmonetary values (e.g., cultural, human health and nutrition, and livelihood) for the appropriate assessment of the contributions of inland fisheries to human communities.

In addition to applying existing economic assessment methods to inland fisheries, frameworks that are uniquely designed to incorporate traditional ecological knowledge, sociocultural values attributed to inland fisheries, and the contributions of inland fisheries to human ecosystem health and well-being are needed. In order to do this, new approaches of measuring social value must be developed. Some current approaches (e.g., welfare valuation methods, supply chain analysis) exist, but comprehensive valuation frameworks that improve quantification of use and nonuse values (especially how to appropriately quantify the importance and value of culture and beliefs) of inland fisheries need to be developed to ensure that important hidden values are not dismissed or overlooked in favor of simplified monetary cost–benefit calculations.

Valuation methods, such as comprehensive impact assessments, should account for positive and negative spillover effects beyond the fishery (wider impacts). Assessments should incorporate both social and environmental impacts (e.g., social and economic impact assessment) and propose mitigation strategies where negative impacts are likely to occur. Additionally, frameworks that apply across contexts (e.g., geographical areas, waterbody type, and fish species) would help to standardize values assigned to inland fisheries and enable comparison of the values of different fisheries. Such frameworks would also enable freshwater ecosystems to be weighted according to their ecological and, by extension economic, benefits. The most obvious application of this is ensuring that inland fisheries are more effectively accounted for in broadscale planning of water management or rural development.

Most importantly, the promotion and adoption of approaches that include valuation of inland fisheries along the entire fisheries value chain (e.g., using participatory value chain analysis) should be supported to ensure that the real value of a fishery is captured. Doing so would facilitate inclusion of social processes that affect the value and perception of fish. This may also help explain the price dynamics of inland fisheries products, which can often seem unrelated to local contexts of supply and demand. The lack of value chain considerations often results in the somewhat limited assumption that the whole value of a fishery lies at the first point of sale, rather than acknowledging the value addition and diffusion of economic benefits and nutrition far from the source of fish. In some cases in Africa and Asia, these value chains extend across countries and even into neighboring countries.

Communicate and promote the value of inland fisheries

Improving communication of information to policymakers, freshwater users, and other

stakeholders is equally important in addressing research needs and data gaps concerning the economic, health, and well-being benefits of inland fisheries. Rendering information on the value and functions of inland fisheries in both human and environmental terms in a form that is understandable to stakeholders is critical to ensuring continued access and sustainable use of inland fisheries. Promoting understanding of the real value of inland fisheries (incorporating economic, social, and ecological values) is a crucial advocacy need. All too often, the important contributions of inland fisheries are overlooked or unknown, making it easy to roll out policies and management decisions that can directly compromise the sustainability of inland fisheries and thereby impact human health, well-being, and prosperity at the local, regional, and international levels. To enhance policy change, it is important to focus on the points that resonate with policymakers, such as the economic and social values of inland fisheries and the contribution of inland fisheries to overall food security, human health, and well-being. Additionally, awareness of the benefits of inland fisheries must spread beyond those involved in inland fisheries, requiring collaboration and communication with audiences outside inland fisheries, in particular other sectors that utilize freshwater resources.

References

Allan, J. D., R. Abell, Z. Hogan, C. Revenga, B. W. Taylor, R. L. Welcomme, and K. Winemiller. 2005. Overfishing of inland waters. BioScience 55:1041–1051.

Andersen, L. T., S. H. Thilsted, B. B. Nielsen, and S. Rangasamy. 2003. Food and nutrient intakes among pregnant women in rural Tamil Nadu, South India. Public Health Nutrition 6(2):131–137.

Baran, E., T. Jantunen, and C. C. Kieok. 2007. Values of inland fisheries in the Mekong River basin. WorldFish Center, Phnom Penh, Cambodia.

Barra, C. S. 2016. Recreational fishing and territorial management in indigenous Amazonia. Pages 311–318 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Bartley, D. M., G. J. De Graaf, J. Valbo-Jørgensen, and G. Marmulla. 2015. Inland capture fisheries: status and data issues. Fisheries Management and Ecology 22:71–77.

Bartley, D. M., N. J. Leonard, S.-J. Youn, W. W. Taylor, C. Baigún, C. Barlow, J. Fazio, C. Fuentevilla, J. Johnson, B. Kone, K. Meira, R. Metzner, P. Onyango, D. Pavlov, B. Riley, J. Ruff, P. Terbasket, and J. Valbo-Jørgensen. 2016. Moving towards effective governance of fisheries and freshwater resources. Pages 251–279 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Belton, B., and S. H. Thilsted. 2014. Fisheries in transition: food and nutrition security implications for the global south. Global Food Security 3:59–66.

Béné, C., and S. Heck. 2005. Fish and food security in Africa 28(3):8–13.

Béné, C., and S. Merten. 2008. Women and fish-for-sex: transactional sex, HIV/AIDS and gender in African fisheries. World Development 36:875–899.

Béné, C., and A. E. Neiland. 2003. Valuing Africa's inland fisheries: overview of current methodologies with an emphasis on livelihood analysis. NAGA, Worldfish Center Quarterly 26(3):18–21.

Beveridge, M. C. M., S. H. Thilsted, M. J. Phillips, M. Metian, M. Troell, and S. J. Hall. 2013. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. Journal of fish biology 83:1067–1084.

Bogard, J. R., S. H. Thilsted, G. C. Marks, M. A. Wahab, M. a. R. Hossain, J. Jakobsen, and J. Stangoulis. 2015. Nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes. Journal of Food Composition and Analysis 42:120–133.

Boisneau, P., N. Stolzenberg, P. Prouzet, and D. Moreau. 2016. How to transmit information

and maintain knowledge in the context of global change for French inland commercial fishers. Pages 289–300 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Bose, M. L., A. Ahmad, and M. Hossain. 2009. The role of gender in economic activities with special reference to women's participation and empowerment in rural Bangladesh. Gender, Technology and Development 13:69–102.

Brummett, R. E., M. C. M. Beveridge, and I. G. Cowx. 2013. Functional aquatic ecosystems, inland fisheries and the millennium development goals. Fish and Fisheries 14:312–324.

Clarke Historical Library. No date. Native American treaties: their ongoing importance to Michigan residents. Central Michigan University, Clarke Historical Library, Mount Pleasant. Available: www.cmich.edu/library/clarke/ResearchResources/Native_American_Material/Treaty_Rights/Pages/default.aspx. (April 2016).

Columbia River Inter-Tribal Fish Commission. No date. We are all salmon people. Available: www.critfc.org/salmon-culture/we-are-all-salmon-people/. (April 2016).

Combs, G. F., and N. Hassan. 2005. The Chakaria food system study: household-level, case-control study to identify risk factor for rickets in Bangladesh. European Journal of Clinical Nutrition 59:1291–301.

Cooke, S. J., A. H. Arthington, S. A. Bonar, S. D. Bower, D. B. Bunnell, R. E. M. Entsua-Mensah, S. Funge-Smith, J. D. Koehn, N. P. Lester, K. Lorenzen, S. Nam, R. G. Randall, P. Venturelli, and I. G. Cowx. 2016. Assessment of inland fisheries: a vision for the future. Pages 45–62 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Cooke, S. J., and K. J. Murchie. 2015. Status of aboriginal, commercial, and recreational inland fisheries in North America: past, present, and future. Fisheries Management and Ecology 22:1–13.

Cowx, I. G. 2015. Characterisation of inland fisheries in Europe. Fisheries Management and Ecology 22(3):78–87.

Daniels, J. L., M. P. Longnecker, A. S. Rowland, and J. Golding. 2004. Fish intake during pregnancy and early cognitive development of offspring. Epidemiology 15:394–402.

Davidson, M. D. 2013. On the relation between ecosystem services, intrinsic value, existence value, and economic valuation. Ecological Economics 95:171–177.

Dudgeon, D. 2000. Large-scale hydrological changes in tropical Asia : prospects for riverine biodiversity. BioScience 50:793–806.

EU (European Union). 2011. EU intervention in inland fisheries. European Commission, Brussels, Belgium.

FAO (Food and Agriculture Organization of the United Nations). 2003. Review of the state of world fishery resources: inland fisheries. FAO Fisheries Circular 942, revision 1, Rome.

FAO (Food and Agriculture Organization of the United Nations). 2014. State of world fisheries and aquaculture: opportunities and challenges. FAO, Rome.

FAO (Food and Agriculture Organization of the United Nations). 2015. Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication. FAO, Rome.

Fischer, P. R., A. Rahman, J. P. Cimma, T. O. Kyaw-Myint, A. R. Kabir, K. Talukder, N. Hassan, B. J. Manaster, D. B. Staab, J. M. Duxbury, R. M. Welch, C. a Meisner, S. Haque, and G. F. Combs. 1999. Nutritional rickets without vitamin D deficiency in Bangladesh. Journal of Tropical Pediatrics 45:291–293.

Fregene, B. T. 2016. Economic and social analysis of artisanal fishermen in Taraba State, Nigeria. Pages 147–157 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Funge-Smith, S. 2016. How national household consumption and expenditure surveys can improve understanding the fish consumption patterns within a country and the role

of inland fisheries in food security and nutrition. Pages 121–130 in W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Geheb, K., S. Kalloch, M. Medard, A. Nyapendi, C. Lwenya, and M. Kyangwa. 2008. Nile Perch and the hungry of Lake Victoria: gender, status, and food in an East African fishery. Food Policy 33:85–98.

Gittelsohn, J. 1991. Opening the box: intrahousehold food allocation in rural Nepal. Social Science and Medicine 33:1141–1154.

Gogus, U., and C. Smith. 2010. N-3 omega fatty acids: a review of current knowledge. International Journal of Food Science and Technology 45:417–436.

Guler, G. O., B. Kiztanir, A. Aktumsek, O. B. Citil, and H. Ozparlak. 2008. Determination of the seasonal changes on total fatty acid composition and ω3/ω6 ratios of carp (*Cyprinus carpio* L.) muscle lipids in Beysehir Lake (Turkey). Food Chemistry 108:689–694.

He, K., Y. Song, M. L. Daviglus, K. Liu, L. Van Horn, A. R. Dyer, and P. Greenland. 2004. Accumulated evidence on fish consumption and coronary heart disease mortality: a meta-analysis of cohort studies. Circulation 109:2705–2711.

Hels, O., N. Hassan, I. Tetens, and S. Haraksingh Thilsted. 2003. Food consumption, energy and nutrient intake and nutritional status in rural Bangladesh: changes from 1981–1982 to 1995–96. European journal of clinical nutrition 57:586–594.

Henderson, M. M., K. R. Criddle, and S. T. Lee. 1999. Economic value of Alaska's Copper River personal use and subsistence fisheries. Alaska Fishery Research Bulletin 6(2):63–69.

Horrocks, L. A., and Y. K. Yeo. 1999. Health benefits of docosahexaenoic acid (DHA). Pharmacological Research 40:211–225.

Howarth, R. B., and S. Farber. 2002. Accounting for the value of ecosystem services. Ecological Economics 41:421–429.

Huhtala, A., A. Toppinen, and M. Boman. 2003. Testing reliability of stumpage prices as indicators of the scarcity of national forest resources. In XII world forestry congress: forests, source of life. National Resources Canada, Ottawa.

Ibengwe, L., and F. Sobo. 2016. The value of Tanzania fisheries and aquaculture: assessment of the contribution of the sector to gross domestic product. Pages 131–145 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Kang, B., D. He, L. Perrett, H. Wang, W. Hu, W. Deng, and Y. Wu. 2009. Fish and fisheries in the upper Mekong: current assessment of the fish community, threats and conservation. Reviews in Fish Biology and Fisheries 19:465–480.

Kawarazuka, N., and C. Béné. 2010. Linking small-scale fisheries and aquaculture to household nutritional security: an overview. Food Security 2:343–357.

Kontoleon, A., and T. Swanson. 2003. The willingness to pay for property rights for the giant panda: can a charismatic species be an instrument for nature conservation? Land Economics 79:483–499.

Longley, C., S. H. Thilsted, M. Beveridge, S. Cole, D. B. Nyirenda, S. Heck, and A. Hother. 2014. The role of fish in the first 1,000 days in Zambia. Institute of Development Studies Special Collection (September).

Lymer, D., F. Marttin, G. Marmulla, and D. Bartley. 2016a. A global estimate of theoretical annual inland capture fisheries harvest. Pages 63–75 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Lymer, D., F. Teillard, C. Opio, and D. M. Bartley. 2016b. Freshwater fisheries harvest replacement estimates (land and water) for protein and the micronutrients contribution in the lower Mekong River basin and related countries. Pages 169–182 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State

University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Lynch, A. J., T. D. Beard, Jr., A. Cox, Z. Zarnic, S. C. Phang, C. C. Arantes, R. Brummett, J. F. Cramwinckel, L. J. Gordon, Md. A. Husen, J. Liu, P. H. Nguyễn, and P. K. Safari. 2016a. Drivers and synergies in the management of inland fisheries: searching for sustainable solutions. Pages 183–200 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Lynch, A. J., Cooke, S. J., Deines, A. M., Bower, S. D., Bunnell, D. B., Cowx, I. G., Nguyen, V. M., Nohner, J., Phouthavong, K., Riley, B., Rogers, M. W., Taylor, W. W., Woelmer, W., Youn, S., and T. D. Beard. 2016. The social, economic, and environmental importance of inland fish and fisheries. Environmental Reviews [online serial] 24:1–7. DOI: 10.1139/er-2015-0064.

Lynch, A. J., E. Varela-Acevedo, and W. W. Taylor. 2015. The need for decision-support tools for a changing climate: application to inland fisheries management. Fisheries Management and Ecology 22:14–24.

Malm, O., W. C. Pfeiffer, C. M. M. Souza, and R. Reuther. 1990. Mercury pollution due to gold mining in the Madeira River basin, Brazil. Ambio 19(1):11–15.

McClain, M. E., and R. J. Naiman. 2008. Andean influences on the biogeochemistry and ecology of the Amazon River. BioScience 58:325–338.

McGoodwin, J. R. 2001. Understanding the cultures of fishing communities: a key to fisheries management and food security. Food and Agriculture Organization of the United Nations, Rome.

Navy, H., and M. Bhattarai. 2009. Economics and livelihoods of small-scale inland fisheries in the lower Mekong basin: a survey of three communities in Cambodia. Water Policy 11(S1):31.

Okeyo, D. O. 2014. Artisanal and commercial fishing gear and practices in the Lake Victoria basin drainage systems of Kenya: a photodiagrammatic verification. Lakes and Reservoirs: Research and Management 19(3):192–205.

Roos, N. 2016. Freshwater fish in the food basket in developing countries: a key to alleviate undernutrition. Pages 35–43 *in* W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard, and R. Welcomme, editors. Freshwater, fish and the future. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; and American Fisheries Society, Bethesda, Maryland.

Roos, N., M. Islam, and S. H. Thilsted. 2003. Small fish is an important dietary source of vitamin A and calcium in rural Bangladesh. International Journal of Food Sciences and Nutrition 54:329–39.

Roos, N., A. Wahab, C. Chamnan, and S. H. Thilsted. 2007. The role of fish in food-based strategies to combat vitamin A and mineral deficiencies in developing countries. The Journal of Nutrition 137:1106–1109.

Ruby, R. H., and J. A. Brown. 1986. A guide to the Indian tribes of the Pacific Northwest. University of Oklahoma Press, Norman.

Shukman, D. 2012. Forests and caves of iron: an Amazon dilemma. BBC News: Science and Environment (June 19). Available: www.bbc.com/news/science-environment-18483647. (April 2016).

Smith, L. E. D., S. N. Khoa, and K. Lorenzen. 2005. Livelihood functions of inland fisheries: policy implications in developing countries. Water Policy 7:359–383.

Smith, L. M., J. L. Case, H. M. Smith, L. C. Harwell, and J. K. Summers. 2013. Relating ecosystem services to domains of human well-being: foundation for a U.S. index. Ecological Indicators 28:79–90.

Smith, V. K. 1996. Pricing what is priceless: a status report on non-market valuation of environmental resources. Pages 156–204 *in* T. Tietenberg and H. Folmer, editors. International yearbook of environmental and resource economics, 1997/1998: a survey of current issues. Edward Elgar, Cheltenham, UK.

Southwick Associates. 2012. Sportfishing in America: an economic force for conservation. American Sportfishing Association, Alexandria, Virginia.

Tontisirin, K., G. Nantel, and L. Bhattacharjee. 2002. Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. The Proceedings of the Nutrition Society 61:243–250.

UNEP (United Nations Environment Programme). 2010. Blue harvest: inland fisheries as an ecosystem service. WorldFish Center, Penang, Malaysia.

UNPFII (United Nations Permanent Forum on Indigenous Issues). 2010. State of the world's indigenous peoples. United Nations, New York.

Welcomme, R. L. 2011. An overview of global catch statistics for inland fish. ICES Journal of Marine Science 68:1751–1756.

Welcomme, R. L., I. G. Cowx, D. Coates, C. Béné, S. Funge-Smith, A. Halls, and K. Lorensen. 2010. Inland capture fisheries. Philosophical Transactions of the Royal Society B 365:2881–2896.

Wilson, E. O. 1984. Biophilia. Harvard University Press, Cambridge, Massachusetts.

Youn, S., W. W. Taylor, A. J. Lynch, I. G. Cowx, T. Douglas Beard, D. Bartley, and F. Wu. 2014. Inland capture fishery contributions to global food security and threats to their future. Global Food Security 3(3–4):142–148.