Human dimensions information needs of fishery managers in the Laurentian Great Lakes

Nadine Heck ^{a,b,*}, Richard C. Stedman ^b, Marc Gaden ^{c,d}

^a Institute of Marine Sciences, University of California, Santa Cruz, CA, USA

^b Department of Natural Resources, Cornell University, Ithaca, New York, USA and Human Dimensions Research Unit, Department of Natural Resources, Cornell University, Ithaca, New York, USA

^c University of Michigan, Ann Arbor, Michigan, USA

^d Great Lakes Fishery Commission, Ann Arbor, Michigan, USA

* Corresponding author at: Department of Natural Resources, Cornell University, Ithaca, New York, USA. E-mail address: nheck@ucsc.edu (N. Heck).

Abstract

Fishery management is increasingly moving towards ecosystem-based approaches that integrate ecological and human dimensions of fisheries. Studies on the human dimensions (HD) of fisheries have increased in recent years. A gap, however, remains between the nature of available information and the information needed by fishery managers. Our paper addresses this gap for the Great Lakes fisheries. We explicitly explored information needs of fishery managers to better reconcile the supply and demand of HD information. Our study finds that managers need HD information in particular to demonstrate the achievements of management goals and to address management issues. In addition, understanding the purpose and timing of information is important in order to provide timely and relevant information as fishery managers identify distinct information needs for planning, decision-making, and evaluation of management. Fishery managers in our study were particularly interested in direct and indirect economic values of the fisheries as well as values, beliefs, attitudes, and behaviors of users. Interviewed managers were not only interested in the status quo of these factors but also wanted to understand what influences and shapes them. In addition, fishery managers would like to understand the contribution of fisheries to ecosystem services in the basin including cultural values. Our interviews did not detect interest in information on long-term HD trends or the explicit need for interdisciplinary studies. Such information, however, would be critical to understand and predict changes in the human dimensions of the fisheries and to develop management strategies to cope with these changes.

This is the accepted manuscript of a paper published in Journal of Great Lakes Research. The final version may be accessed at

<https://www.sciencedirect.com/science/article/pii/S0380133016000198>.

Introduction

Fishery management is increasingly moving towards ecosystem-based approaches that conceptualize fisheries as social-ecological systems (Berkes et al., 2002; Caddy and Cochrane, 2001; Hilborn, 2007; Norse, 2010; Salomon et al., 2011; Urquhart et al., 2011) (Fig. 1). Fishery managers thus need to consider both the fish resource and the people using it and must also confront the inherent unpredictability of human behavior in addition to the unpredictability of the fishery resource itself (Arlinghaus et al., 2013; Arlinghaus, 2006; Carpenter, 2002; Coll et al., 2013; Haapasaari et al., 2012). Management success or failure is therefore usually determined at least as much by social and institutional factors as ecological ones (Decker et al., 2001; Fulton et al., 2011; Hunt et al., 2013; Mascia, 2003).

Information on the human dimensions (HD) is thus essential to manage fisheries. Understanding stakeholder perceptions, beliefs, and attitudes, for example, can help managers develop relevant management practices, identify and reduce conflicts among user groups, and understand and predict attitudes towards fisheries and management regulations (Caddy and Cochrane, 2001, McClanahan et al., 2006a). The collection of local ecological knowledge can add to the understanding of fish resources and ecosystems that is needed for decision-making processes (Hall-Arber and Pederson, 1999; Maurstad and Sundet, 1998; Neis et al., 1999; Neis and Felt, 2001). Assessing the economic and social importance of fisheries to local culture, heritage, and quality of life in coastal communities helps to predict how communities might be affected by changes in these fisheries and to identify adaptation strategies (Pacific Fishery Management Council, 2005; Symes and Phillipson, 2009; Urquhart et al., 2011).

Fig. 1. General coupled social–ecological system of recreational fishing. (Source: [Hunt et al., 2013](#)).

At the same time, the availability of information on human dimensions does not necessarily mean that managers will use the information. Fishery managers and decision-makers, in fact, might not perceive research outcomes as “useful” if it does not meet their explicit information needs (De Young et al., 2008; Lahsen and Nobre, 2007; Sarewitz et al., 2000). Information needs of a particular audience, such as fishery managers, can depend on multiple factors including the motivation to receive new information, the intended use of the information (e.g., decision-making, problem solving), the characteristics of information users and organizations, and the social, political, and economic importance attached to the desired information (Okwu et al., 2011; Paisley, 1968; Rouse and Rouse, 1984; Mulvaney et al., 2014). Explicit information needs are thus context-sensitive and constantly evolve in response to changes and uncertainties in environmental, social, and political conditions (Devadason, 1996; Jacobs, 2003; McClanahan et al., 2006b; Okwu et al., 2011; Pollnac et al., 2001).

Understanding fishery managers' information needs and how they would use new information is thus critical to produce information that managers perceive as “useful” and are likely to incorporate in the decision-making process. Equally important is the inclusion of managers in the entire research and information-identification process as doing so heightens the perceived relevance and usefulness of new information (Carpenter, 2002; Johannes, 2002; McNie, 2007; Ruddle, 1996). Our study addressed these points for the human dimensions of the Great Lakes fisheries. Based on interviews, we identified fishery managers' views on the role of human dimensions for the management of the fisheries, elicited their explicit HD information needs, and identified why they seek this kind of information. The aim of the project was to improve understanding of HD information needs and their value to fishery management across the Great Lakes. To achieve this aim, our study centered on the following questions:

- (1) What is the role of human dimensions in the management of the Great Lakes fisheries?
- (2) What kinds of HD information do managers seek to improve fishery management?
- (3) What drives fishery managers' HD information needs?

Methods

Study site: the Great Lakes fisheries

The Great Lakes fisheries consist of commercial, recreational, and tribal fisheries in five connected lakes (Superior, Huron, Michigan, Erie, and Ontario) (Gaden et al., 2012). Multiple contemporary ecological and social trends in the basin affect fish resources and fishing activities in the basin. Examples are climate change (Cline et al., 2013, 2014; Farmer et al., 2015), nutrient pollution (Michalak et al., 2013; Scavia et al., 2014), and the spread of pathogens and aquatic invasive species (Bain et al., 2010; Kelly et al., 2013; Kilian et al., 2012). Social and economic trends include a decline in the fishing charter boat industry (Lichtkoppler et al., 2015), a decline in commercial and recreational fishing license sales (e.g., Freedman, 2013; Meyerson, 2014), reduced annual harvest (Hudson and Ziegler, 2014), in addition to demographic changes such as net out migration from the region and an aging population (Méthot et al., 2015). Based on the complexity of these trends, fishery managers need to understand human–environment

interaction in the basin, and integrate human dimensions into management and decision-making (Decker et al., 2012).

Acknowledging this need for information on human dimensions, the Great Lakes Fishery Commission developed a HD research theme in 2002 to foster research in this area (Dobson et al., 2005). Based on this theme, the GLFC has funded multiple HD research projects as listed on the GLFC website <http://www.glfc.org/research/rcr.php> (e.g., Lupi, 2008; Dobson, 2006; Riley, 2007; Stedman, 2015; Lauber et al., 2014). Fishery managers were not engaged in the development of the HD research theme and did not necessarily utilize research findings (Heck et al., 2015). To address this point, we conducted this study to develop an update of the HD research theme that explicitly addresses the information needs of fishery managers themselves. We anticipate that managers will perceive research outcomes based on this research theme as useful and utilize research findings that address their particular information needs.

Data collection

We conducted 38 face-to-face semi-structured interviews with fishery managers throughout 2012 to elicit their information needs. The participant pool included members of the Council of Lake Committees (a body of senior managers from all Great Lakes state, provincial, and tribal jurisdictions), members of technical committees (a body of field-level biologists), federal officials, and Great Lakes Fishery Commission staff. All Council of Lake Committees members participated and our interviewees represented all Great Lakes fisheries jurisdictions, from Canada and the United States. We conducted 19 interviews during the Lake Committee meetings in Windsor, Ontario, March 20–24th, 2012. In addition, we interviewed 19 managers face-to-face at their place of work between April 26th and May 24th, 2012.

We used a semi-structured interview guide to ensure that all interviewees answered the same general set of questions while still allowing the researchers to explore each interviewee's unique perspective. Interviews lasted between 40 and 70 min. We assured participants that we would treat their comments as confidential and would not attribute any comment to them individually in any report or publication. The study was approved by the Cornell Institutional Review Board, Protocol No. 1101001927.

Each interview consisted of two parts. The first part focused on fisheries management goals and issues to detect the role, if any, of human dimensions information in fishery management. The second part investigated specific human dimensions information needs and how fishery managers would use the identified information.

Data analysis

With the participants' consent, interviews were audio recorded and transcribed. We analyzed the interviews using computer software (Atlas.ti 7), a software package for qualitative data analysis. Consistent with steps pretested by Miles and Huberman (1984), interview data

were first “pattern coded” to identify broad themes (Auerbach and Silverstein, 2003), contexts, and relationships, and then “open coded” to sort sentiments in detail (Strauss and Corbin, 1990a) line by line, and finally “cluster coded” to reconstitute the detailed codes into more general themes that emerged through the open coding process (Strauss and Corbin, 1990b; Thomas, 2006). Two professors in the Department of Natural Resources at Cornell University with extensive expertise in human dimensions of fisheries cross-checked the codes to increase the reliability of the codes and the coding process. We included interview excerpts to provide evidence and the essence of the perspectives yielded through the interviews. In addition to this qualitative analysis, we calculated frequencies for each code using IBM SPSS 22.0.

To increase the validity of our research, we also presented findings from the interviews to two focus groups during the Lake Committee meetings in the spring of 2013. The focus groups consisted of a subset of the fishery managers who we interviewed in 2012. We accounted for geographic and jurisdictional diversity of organizations in the selection of these subsets. Each focus group involved seven participants and lasted 90 min. (in one focus group, one additional participant joined by telephone). The focus groups provided an opportunity to discuss findings with fishery managers. Participants in the focus groups confirmed that our interpretations of the interviews represented their views and did not require any revisions.

Results

What is the role of human dimensions in the management of the Great Lakes fisheries?

We first asked fishery managers about their management goals for the Great Lakes fisheries. Interviewed managers listed multiple social and economic management goals for the fisheries (Fig. 2). These goals suggest a movement towards ecosystem-based management that integrates social and ecological considerations. Expressed social and economic management goals, however, were very broad such as “provide recreational fishing opportunities”, “sustain economic viability for commercial fisheries”, and “foster local economic development”.

Most frequently cited management goals focused on fish resources and the fishing community, which we expected. Managers, however, also mentioned outcomes that go beyond fishing and focused on the broader ecosystem in the basin (e.g., water quality) and social system in the basin (e.g., contribution to local economies and quality of life).

Fishery managers further pointed out a variety of human-centered management issues (Fig. 3). More than half of all interviewees mentioned a decline in management budgets due to a lower number of fishing license sales. As fishery management budgets depend largely on license sales, particularly in the United States, the decline in anglers affects the capacity of management agencies.

Interviewed managers also frequently mentioned issues that focused on resource users such as conflicts among different fishing user groups (e.g., commercial, recreational, tribal), unrealistic

user demands, and a lack of user knowledge of the resources and the ecosystem in the basin. Catering to multiple interests that all depend on the same resources and are in competition with each other thus seems to pose a significant challenge to management agencies. Conflicts between commercial fishermen and anglers, for example, focused on different opinions about the type and size of desired target species. For instance, “the commercials want to harvest native species whereas the sport guys are focused on introduced salmon or trout”. Another manager said that “a recreational fisherman wants to catch a fish that is big (a trophy fish) but a commercial fisherman wants a fish that will fit on your plate.” Interviewees also noted considerable differences in perceptions about appropriate fishing methods and techniques (e.g., gill net versus live capture gear), and use of physical space in terms of “a net is in the way of a boat that wants to troll a lure” or “anglers get caught in commercial nets.”

Fishery managers also found it challenging to balance the achievement of environmental and social management goal and fulfillment of user demands. One example was anglers' expectations for stocked non-native fish species (e.g., Pacific salmonids, such as Coho salmon *Oncorhynchus kisutch*, and Chinook salmon, *Oncorhynchus tshawytscha*) rather than native self-sustaining species (e.g., lake trout, *Salvelinus namaycush*) that managers seek to restore.

Almost a quarter of managers felt that stakeholders were not participating enough in management. Participatory management is common for ecosystem-based management, and fishery managers apparently were interested in this model. Interviewees in our study, for example, feared that they only receive feedback from a small subset of vocal users instead of the wider stakeholder community. Subsequently, managers were unable to acknowledge and respond to the views of most users because they are unknown.

What kind of HD information do managers seek to improve fishery management?

To make the updated HD research theme more responsive to fishery managers' information needs, we asked interviewees to cite any HD information that would help them to improve the current management. The most frequently mentioned information needs are presented in Fig. 4 and Table 1. As the new HD theme will guide funding for future research, we also included a table that summarizes the identified information needs as research questions that could be answered in future research projects (Table 2). The following sections will expand on these information needs in more detail.

Fishing-related information needs

More than half of all interviewees pointed out the need for social and economic studies related to fishing. These information needs centered on the direct (e.g., income for commercial fisheries, license sales) and indirect economic values of the fisheries (e.g., multiplier effect for local communities), and user attitudes, beliefs, expectations, and use of the resource.

Fishery managers were not only interested in the status quo of the economic value, attitudes, and behaviors, but also wanted to understand what influences these factors. For example, they

wanted to know the “social and economic pressures that (commercial fishermen) are undergoing” and how these pressures affect the economic viability of the commercial fishery including their profit margins. In addition, managers wanted to understand how users' beliefs about the state of the fish resources and the ecosystem in the Great Lakes shape attitudes towards fishery management.

Fig. 2. Fishery management goals for the Great Lakes as cited by managers in this study (based on 38 interviews with fishery managers).

Fig. 3. Fishery managers' concerns about existing human dimensions management issues in the Great Lakes (% of fishery managers at end of each bar, $N = 38$).

Due to the ongoing decline in anglers, fishery managers were also keen to understand what influences anglers' use of the resource and their decision whether and where to fish. At the moment, they seemed to lack knowledge about anglers' behavior in terms of timing (e.g.,

number of days, hours per day), locations and volume of fishing activities (size and amount of target species and by-catch), and users themselves (e.g., age, gender, race-ethnicity, and income). While some of this information is collected in creel surveys, interviewees felt the need for more systematic and rigorous sampling and data collection on these parameters. Such information would be critical to understand spatial and temporal pressures on the fish resources. Fishery managers further hypothesized that the quality of the fishing experience (e.g., perceptions in fish abundance, fish size, fish species available to catch, or fear of contaminants in fish) and/or broader environmental, demographic, and economic trends in the basin could influence individual decisions to go fishing. Examples included the continued presence and spread of aquatic invasive species, an aging population, changes in available leisure time, reduced discretionary income, changes in the ethnic makeup of residents in the basin, and urbanization that might make people become “isolated from the outdoors”. All these factors could potentially drive the current decline in fishing and information on this point is still lacking.

Fig. 4. Fishery managers' human dimensions information needs for the Great Lakes fishery (% of fishery managers at end of each bar, $N = 38$).

Table 1

Human dimensions information needs to improve management of the Great Lakes fishery based on interviews with fishery managers ($N = 38$).

Broad information needs	Detailed information needs	Additional considerations
Economic value	Commercial fishery	Direct value, economic pressures for individual fishers
Non-market economic value	Recreational fishery	Direct and indirect value
	Ecosystem services	Scenic beauty (Willingness to pay) Wetlands Habitats
Social and cultural values	Fish species	Use and non-use of the resource
	Fishing as a heritage Existence value	Proximity of place of living to the coast Vested economic interest in the fishery
Beliefs	Ecological condition of the fishery	
Expectations	Fishery management	
	User issues, desired directions of the fisheries	Preferred target species, management regulations
Attitudes	Quota allocations	
	Fishery regulations	
Anglers fishing patterns	Number of days	Age, income
	Hours per day	Quality of fishing experience
	Fishing locations	Social, economic, environmental trends in the basin
	Amount and size of harvest	
	Number of license sales	
Stakeholder engagement	Socio-economic profiles	
	Stakeholder analysis	
	Communication means	
Ecological knowledge Evaluation	Engagement strategies	
	State of fish resources	Traditional and local knowledge
	Ecosystem health	
Funding model	Indicators	Social, cultural, economic indicators
	Alternative funding models	Public funding for fishery

Non-fishing-related information needs

Almost half of all interviewees mentioned the need for information on the social and cultural value of the fisheries including the value of native versus non-native species, and species that are of no interest to commercial or recreational fishing. Interviewees also raised the existence value of the fisheries as a heritage, and the perceived aesthetic and intrinsic value of simply having fish in the lakes. Said one manager, “what's the value of scenic beauty or the happiness or good feelings people have about having that resource here?” In addition, fishery managers were interested to understand the non-market economic importance of some of these values in terms of ecosystem services. Examples included information on the economic value of wetlands and habitat restoration, and the willingness to pay for “having a lake that functions properly and is clean [to swim in] and having drinking water.”

Information needs to improve management

Fewer managers mentioned the need for information to improve the management process compared to social, cultural, and economic information. Still, interviewees asked for information on how to improve the engagement of stakeholders, and how to sustain relationships with stakeholders over time. Interviewees felt that more institutionalized engagement strategies such as regular workshops or round tables might help to sustain stakeholder engagement long-term, and were eager to know if such an approach would be representative and account for vocal and non-vocal users. A thorough stakeholder analysis might shed light into the composition of stakeholders in the basin and provide information on how and to what degree to include different stakeholder segments in the management of the fisheries.

Table 2

Summary of human dimensions research questions, developed by the researchers but informed by interviews with fishery managers ($N = 38$).

-
1. What is the economic value of the Great Lakes fishery?
 - What is the economic value of the fishery at the lake level and basin-wide and how does it compare to other sectors?
 - What is the contribution of fisheries to provincial, regional, and local economies?
 - What is the economic value of ecosystem services (e.g., wetlands, habitat restoration, clean, healthy, and more resistant freshwater ecosystem)?
 - What is the economic value of non-use values?
 2. What are the values, beliefs, and attitudes towards Great Lakes fishery?
 - In what ways do fishers, non-users, and municipalities value the Great Lakes fishery?
 - What are expectations towards fishery management?
 - What are fishers' and public's beliefs about the Great Lakes fishery?
 - What influences values, expectations, and beliefs?
 3. What are current user patterns and how will they change in the future?
 - What are the current patterns of recreational fishing?
 - What are the projected changes in these patterns due to social, economic, and environmental trends in the basin?
 4. How can traditional and local ecological knowledge inform fishery management?
 - What contributions can local and traditional ecological knowledge make in the different stages of Great Lakes fishery management?
 - How can local and traditional knowledge be integrated into fishery policy and decision-making?
 - What are the barriers to doing so and how can they be overcome?
 5. How to engage a broader stakeholder community effectively in the planning and management of fisheries?
 - How can managers elicit opinions of vocal and non-vocal stakeholder groups?
 - What is the best way to sustain relationships between stakeholder groups and managers?
 - How can poorly organized groups increase their participation and/or influence in the decision-making process?
 6. Who should pay for (and have a voice in) fishery management?
 - What funding mechanisms would be more equitable and capable of distributing costs of fishery management among the general public?
 - How would a change in funding strategy or other payment mechanisms affect governance and management?
 7. Is Great Lakes fishery management effective?
 - How do human dimensions management statements translate into management objectives?
 - Which measurable social science criteria and indicators can be used to assess effectiveness of fishery management?
 - How does management perform vis-à-vis these indicators?
-

Fishery managers also noted that recreational and commercial fishers might know a great deal about the fisheries and the ecosystem in the basin and could offer useful information to managers. Interviewees acknowledged that commercial fishermen and anglers spend more time “on the water” than managers and might know firsthand “what the fishery is like and what

the ecosystem is doing.” Information on local ecological knowledge thus could extend natural science data on ecological and biological parameters of the resource to improve decision-making.

We also detected the need for information on how to measure the performance of fishery management beyond ecological, physical, and biological indicators. Interviewees mentioned that governments and agencies “promote things like vision statements but they don't translate that into what it means on the ground.” Fishery managers thus seem to need help to translate management goals into detailed management objectives, targets and measurable indicators to evaluate the achievement of social and economic goals.

Less than a quarter of interviewees mentioned the need for information on alternative funding models despite the fact that more than half of fishery managers cited a decline in budgets as a management issue. This finding suggests that managers might first like to understand the reasons behind the decline in anglers and try to increase participation and license sales. A radical change of the funding structure of agencies might not be easy and could take a long time. Examples for a change in funding focused on letting the public in the basin pay for management instead of the fishing community alone. Fishery managers justified this suggestion with the fact that they were “contributing to a quality of life” in the basin. They felt that conservation and management funded by anglers caters to a variety of non-consumptive users such as beachgoers, boaters, swimmers, and coastal community residents. Funding for fisheries thus could potentially come from taxes (e.g., state income or sales taxes) or even revenues from other natural resource sectors (e.g., natural gas development).

What drives fishery managers' HD information needs?

A number of information needs related directly to existing management goals and management issues (Table 3). Examples included direct and indirect economic values of the fisheries to assess if fisheries contribute to economic development in local communities and are able to provide viable income to commercial fishermen. Another example was the assessment of recreational fishing patterns to judge the successful provision of recreational fishing opportunities. One example of an information need to address a management issue was the interest to understand values and expectations of users to solve user conflicts. We also found that information needs depended on the purpose and timing for its use as managers identified distinct information needs for each stage in the management cycle including planning, decision-making, and evaluation (Fig. 5).

Table 3

Relationship between management goals, management issues, and HD information needs developed based on information collected in interviews with fishery managers ($N = 38$).

Management goals (G) and issues (I)	HD information needs
Provide recreational fishing opportunities (G)	→ Values attached to fisheries
Sustain viable commercial fishery (G)	→ Fishing patterns
Allocation of quota (I)	→ Economic value
Provide satisfactory angler experience (G)	→ Fishermen expectations and attitudes towards management
Educate about ecosystem and fishery (G)	→ Angler satisfaction
Unrealistic user demands (I)	→ Angler expectations
User and public do not understand ecosystem	→ Beliefs about fisheries, ecosystem, and management
Foster local economic development (G)	→ Indirect economic value
Contribute to quality of life (G)	→ Non-economic value
	→ Non-market value of ecosystem services
Decline in agency funding (I)	→ Funding models not dependent on license sales
Declining anglers (I)	→ Angler patterns (profile and spatial use)
User conflicts (I)	→ User expectations
Lack of stakeholder engagement (vocal & non-vocal) (I)	→ User expectations
Scientific uncertainty about resource	→ Effective stakeholder engagement models
Lack of political support (I)	→ Local ecological knowledge
	→ Economic value
	→ Evaluation of social and cultural management performance

Fig. 5. Fishery managers' use of identified information on human dimensions (based on 38 interviews with fishery managers).

Examples of information needed in the planning stage included values, beliefs, expectations, and attitudes. Interviewees hoped that this kind of information would help to prevent wasteful use of management resources, e.g., “if we're spending a lot of money developing a great fishery for channel catfish in the Great Lakes but nobody is fishing for them, then that is money we are wasting.” Understanding “what the fishery means to them,” and where people fish seemed important to develop management goals and objectives with users in mind. Such information would also help to reduce conflicts among users, and to balance environmental and social management goals. Managers would further use information about beliefs about the fisheries to tailor education and information campaigns that aim to address any misperceptions or knowledge gaps. Managers hope that increased knowledge and understanding would prevent unrealistic expectations towards the fisheries that are not ecologically feasible.

In the decision-making stage, fishery managers would like to receive local ecological knowledge to reduce uncertainty about the fish resources, and to revisit management decisions. For example, one manager mentioned that “when fishers are adamant that you are wrong, you need to go back and relook at your data and rethink exactly the decisions you are thinking of making since we go out for only a couple of weeks once a year.” Information on governance and stakeholder engagement models would help to make decision-making more participatory.

Finally, information is needed in the evaluation stage to increase management transparency and to communicate “how well the management regimes that are put in place are working” to achieve management goals. This information is important to adapt management if necessary, and to demonstrate management achievements to users, the public, and politicians. During our interviews, fishery managers also worried that fiscal constraints often cause government

priorities to shift towards “the economy, health, and education” and that “the environment has become relatively low priority these days.” Interviewees believed that economic information would help to defend management decisions about agency spending in the political arena and potentially increase future investments in specific programs, as “ecological arguments have not been as persuasive as monetary arguments.”

Discussion and conclusions

Fishery management incorporates not only the environmental complexity of fisheries and existing and emergent environmental changes such as a spread of pathogens and aquatic invasive species, climate change, or nutrient pollution, but also complex challenges regarding users of the resource (Fulton et al., 2011). An understanding and integration of information on the human dimensions of fisheries, however, is still lacking in many fishery management agencies including those in the Great Lakes basin (Heck et al., 2015). Our study aims to increase the supply of relevant HD information for Great Lakes fisheries and its subsequent use by fishery managers.

We found that human dimensions play a vital role in the management of the Great Lakes fisheries. Interviewed managers mentioned that they aim to achieve multiple social and economic management goals and have to address a variety of HD management challenges. These day-to-day challenges and the need to achieve stated management goals were major drivers for managers' information needs. Academics and other suppliers of information thus might have to familiarize themselves with management goals and issues to provide salient information to managers.

Fishery managers in our study, for example, seek information on anglers' motivation to go fishing in order to understand and potentially reverse the current decline in anglers and license sales. Previous studies in other fisheries found that anglers have diverse motivations to go fishing that are not necessarily tied to the availability of specific target species (Chen et al., 2003; Fedler and Ditton, 1994; Johnston et al., 2011). Instead, anglers might also seek relaxation, spending time with friends and family, or experiencing nature surroundings, “escaping”, and being outdoors (Fedler and Ditton, 1994). While these studies provide some initial insights into the reasons to go fishing, research is needed to identify the extent to which these factors apply to anglers in the Great Lakes, their importance in the individual decision-making process, and what other factors influence angling participation. In addition, studies would be important to understand why people leave the fishery. This kind of information might help to develop adaptation strategies to cope with the decline or even reverse it.

Previous studies on commercial fisheries in particular found that fisheries can have strong impacts on local communities including economic impacts (Pacific Fishery Management Council, 2005; Symes and Phillipson, 2009; Urquhart et al., 2011). In our study, information on the economic impact of the recreational fishery is also important since many communities in the basin provide supplies and accommodation for anglers. Understanding the economic contribution of commercial and recreational fisheries to local communities will help to

understand how dependent these communities are on the fisheries, how a decline or increase in fisheries might affect communities, and what kind of management strategies could help to minimize or mitigate any negative impacts on local communities.

In addition, fishery managers requested information on the economic value of the fisheries to demonstrate the importance of this sector to policy makers. Interviewees anticipated that such information would increase the appreciation of the fisheries and increase funds for management agencies. In this case, manager asked for the economic value of each fishery and all fisheries combined, instead of economic information at the community level. Suppliers of new information thus need to understand how managers will use information, e.g., for planning, decision-making, or evaluation and communication purposes to provide timely and salient information. Otherwise, managers might not be able to use the information or even ignore it and put it “on the shelf” (Lemos et al., 2012).

The need to evaluate the economic value of the fisheries also means that an evaluation of fishery outcomes needs to go beyond the assessment of ecological and biological indicators. Evaluation of HD indicators is important to demonstrate HD management achievements and to enable adaptive management that allows learning from past HD achievements and/or failures (Nichols and Williams, 2006). Social, cultural, and economic indicators for the Great Lake fisheries are essential and should be part of a well-designed monitoring program. Federal agencies, such as NOAA, have recently increased their efforts to develop and evaluate social and economic indicators for fisheries. Similar efforts would be critical for state and provincial fish and wildlife agencies in the basin.

Fishery management in the Great Lakes also seems to be moving towards ecosystem-based management that goes beyond the resource and the fishing community. Fishery managers, for example, asked for information on non-market economic values and non-consumptive values of the fisheries. Ecosystem services in the context of fisheries are often measured in terms of food production (Harrison et al., 2014). Our findings suggest that the concept could be extended in the Great Lakes and include ecosystem services such as improved water quality, biodiversity, and aesthetic and cultural values of the fishery. Such information would indicate the contribution of fishery management to society beyond the fishing community and produce a broader accounting of the value of the fisheries (Song et al., 2013; Chan et al., 2012). The demonstration of benefits to the public seems particularly critical in our case as managers expressed the desire to let the public pay for fishery management, e.g., via taxes. In this case, demonstrating and communicating wider societal benefits of the fisheries may be critical to justify such a funding scheme.

Managers in our study did not explicitly ask for information on long-term trends or changes in the human dimensions of the fisheries. Future trends and scenario modeling is a common tool for natural science studies (e.g., Mortsch and Quinn, 1996; Reavie et al., 2014; Rucinski et al., 2014; Watras et al., 2014). Such an approach could be applied to HD studies in the Great Lakes fisheries to lay the groundwork for longterm management strategies, and to reduce uncertainties connected to resource users (Mahon et al., 2008; Hunt et al., 2013). Ideally, the

focus of research would thus move beyond one-time studies that address some immediate information needs (e.g., to inform a specific regulatory or policy decision) to studies looking at long-term trends. Timeseries data on different angler segments and information on long-term ecological, social, and economic trends in the basin and their influence on angler participation, for example, could improve the understanding of the current decline in anglers. Analyzing data on long-term trends could also help to understand relationships between fish resources (e.g., species composition, existence of alien species) and individual fishing experiences as well as the use of the resource over time to understand and potentially predict changing angling patterns (Renner and Huntington, 2014).

Because we only asked managers about information needs to improve current management, it was not clear if managers were not interested in information on long-term trends or did not connect them to current management issues. Raising awareness about the value of long-term trends and changes in the basin (e.g., aging of the population, urbanization), and how fishery managers could utilize such information might increase their interest in long-term studies, as the understanding of information often affects its acceptance and use (Rogers, 2003).

Finally, we recognize that integrating HD information into fishery management can be challenging. It requires the willingness to work across disciplines and engage with different underlying epistemologies and methods that might be unfamiliar to fishery managers and decision makers trained in ecology and biology (Evely et al., 2008; Fazey et al., 2006). Hiring social science staff in state and provincial fish and wildlife agencies and/or collaboration between fishery managers and HD researchers would help to increase agencies' capacity to actually use salient HD information in management and decision-making processes (Heck et al., 2015).

Acknowledgements

The research was funded by the Great Lakes Fishery Commission. The authors want to thank three anonymous reviewers for extensive and valuable feedback on the article.

References

- Arlinghaus, R., 2006. Overcoming human obstacles to conservation of recreational fishery resources, with emphasis on central Europe. *Environ. Conserv.* 33 (01), 46–59. <http://dx.doi.org/10.1017/S0376892906002700>.
- Arlinghaus, R., Cooke, S.J., Potts, W., 2013. Towards resilient recreational fisheries on a global scale through improved understanding of fish and fisher behaviour. *Fish. Manag. Ecol.* 20 (2-3), 91–98. <http://dx.doi.org/10.1111/fme.12027>.
- Auerbach, C., Silverstein, L.B., 2003. *Qualitative Data: An Introduction to Coding and Analysis*. NYU Press.

Bain, M.B., Cornwell, E.R., Hope, K.M., Eckerlin, G.E., Casey, R.N., Groocock, G.H., Getchell, R.G., Bowser, P.R., Winton, J.R., Batts, W.N., Cangelosi, A., Casey, J.W., 2010. Distribution of an invasive aquatic pathogen (viral hemorrhagic septicemia virus) in the Great Lakes and its relationship to shipping. *PLoS One* 5 (4), e10156.
<http://dx.doi.org/10.1371/journal.pone.0010156>.

Berkes, F., Colding, J., Folke, C., 2002. *Navigating Social–Ecological Systems: Building Resilience for Complexity and Change*. University Press, Cambridge.

Caddy, J.F., Cochrane, K.L., 2001. A review of fisheries management past and present and some future perspectives for the third millennium. *Ocean Coast. Manag.* 44 (9-10), 653–682.

Carpenter, S.R., 2002. Ecological futures: building an ecology of the long now. *Ecology* 83 (8), 2069–2083. [http://dx.doi.org/10.1890/0012-9658\(2002\)083\[2069:EFBAEO\]2.0.CO;2](http://dx.doi.org/10.1890/0012-9658(2002)083[2069:EFBAEO]2.0.CO;2).

Chan, K.M.A., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. *Ecol. Econ.* 74, 8–18.
<http://dx.doi.org/10.1016/j.ecolecon.2011.11.011>.

Chen, R.J., Hunt, K.M., Ditton, R.B., 2003. Estimating the economic impacts of a trophy largemouth bass fishery: issues and applications. *N. Am. J. Fish Manag.* 23 (3), 835–844.
<http://dx.doi.org/10.1577/m02-014>.

Cline, T.J., Bennington, V., Kitchell, J.F., 2013. Climate change expands the spatial extent and duration of preferred thermal habitat for Lake Superior fishes. *PLoS One* 8 (4), e62279.
<http://dx.doi.org/10.1371/journal.pone.0062279>.

Cline, T.J., Kitchell, J.F., Bennington, V., McKinley, G.A., Moody, E.K., Weidel, B.C., 2014. Climate impacts on landlocked sea lamprey: implications for host–parasite interactions and invasive species management. *Ecosphere* 5 (6). <http://dx.doi.org/10.1890/ES1400059.1> art68-art68.

Coll, M., Cury, P., Azzurro, E., Bariche, M., Bayadas, G., Bellido, J., Chaboud, C., Claudet, J., ElSayed, A.-F., Gascuel, D., Knittweis, L., Pipitone, C., Samuel-Rhoads, Y., Taleb, S., Tudela, S., Valls, A., 2013. The scientific strategy needed to promote a regional ecosystembased approach to fisheries in the Mediterranean and Black Seas. *Rev. Fish Biol. Fish.* 23 (4), 415–434.
<http://dx.doi.org/10.1007/s11160-013-9305-y>.

De Young, C., Charles, A., Hjort, A., 2008. Human dimensions of the ecosystem approach to fisheries: an overview of context, concepts, tools and methods. *FAO Fisheries Technical Paper*.

Decker, D., Brown, T., Siemer, W., 2001. *Human Dimensions of Wildlife Management in North America*. The Wildlife Society, Bethesda, Maryland.

Decker, D., Riley, S.J., Siemer, W., 2012. Human Dimensions of Wildlife Management. second ed. The John Hopkins University Press, Baltimore.

Devadason, F., 1996. Practical steps for identifying information needs of clients. 10th Congress of Sotuh East Asian Librarians. Kuala Lumpur, Malaysia.

Dobson, T., Riley, S.J., Gaden, M., 2005. Human dimensions of Great Lakes fishery management: new research thrust of the Great Lakes fishery commission. Soc. Nat. Resour. 18 (5), 487–491. <http://dx.doi.org/10.1080/08941920590924990>.

Dobson, T., 2006. Analyzing Legal/Policy Rules and Frameworks for Fisheries Management in the Great Lakes Basin: Identifying and Assessing Overlaps, Conflicts and Gaps. Great Lakes Fishery Commission.

Evely, A., Fazey, I., Pinard, M., Lambin, X., 2008. The influence of philosophical perspectives in integrative research: a conservation case study in the Cairngorms National Park. Ecol. Soc. 13 (2).

Farmer, T.M., Marschall, E.A., Dabrowski, K., Ludsins, S.A., 2015. Short winters threaten temperate fish populations. Nat. Commun. 6. <http://dx.doi.org/10.1038/ncomms8724>.

Fazey, I., Fazaey, J., Salisbury, J.G., Lindenmeyer, D.B., Dovers, S., 2006. The nature and role of experiential knowledge for environmental conservation. Environ. Conserv. 33 (01), 1–10. <http://dx.doi.org/10.1017/S037689290600275X>.

Fedler, A.J., Ditton, R.B., 1994. Understanding angler motivations in fisheries management. Fisheries 19 (4), 6–13. [http://dx.doi.org/10.1577/1548-8446\(1994\)019b0006:uamifmN2.0.co;2](http://dx.doi.org/10.1577/1548-8446(1994)019b0006:uamifmN2.0.co;2).
Freedman, E., 2013. Commercial Fishing Decline Hits Economies, Communities. Capital News Service, Washington, D.C.

Fulton, E.A., Smith, A.D.M., Smith, D.C., van Putten, I.E., 2011. Human behaviour: the key source of uncertainty in fisheries management. Fish Fish. 12 (1), 2–17. <http://dx.doi.org/10.1111/j.1467-2979.2010.00371.x>.

Gaden, M., Goddard, C., Read, J., 2012. A history of multi-jurisdictional management of the shared Great Lakes fishery: transcending conflict and diffuse political authority. In: Taylor, W.W., Lynch, A.J., Leonard, N.J. (Eds.), Great Lakes Fishery Management and Policy. Michigan University Press, East Lansing.

Haapasaari, P., Kulmala, S., Kuikka, S., 2012. Growing into interdisciplinarity: how to converge biology, economics, and social science in fisheries research? Ecol. Soc. 17 (1), 135–146.

Hall-Arber, M., Pederson, J., 1999. Habitat observed from the decks of fishing vessels. *Fisheries* 24 (6), 6–13. [http://dx.doi.org/10.1577/1548-8446\(1999\)024b0006:hoftdoN2.0.co;2](http://dx.doi.org/10.1577/1548-8446(1999)024b0006:hoftdoN2.0.co;2).

Harrison, P.A., Berry, P.M., Simpson, G., Haslett, J.R., Blicharska, M., Bucur, M., Dunford, R., Egoh, B., Garcia-Llorente, M., Geamănă, N., Geertsema, W., Lommelen, E., Meiresonne, L., Turkelboom, F., 2014. Linkages between biodiversity attributes and ecosystem services: a systematic review. *Ecosyst. Serv.* (9), 191–203 <http://dx.doi.org/10.1016/j.ecoser.2014.05.006>.

Heck, N., Stedman, R.C., Gaden, M., 2015. The integration of social science information into Great Lakes fishery management: opportunities and challenges. *Fish. Res.* 167 (0), 30–37. <http://dx.doi.org/10.1016/j.fishres.2015.01.008>.

Hilborn, R., 2007. Defining success in fisheries and conflicts in objectives. *Mar. Policy* 31 (2), 153–158. <http://dx.doi.org/10.1016/j.marpol.2006.05.014>.

Hudson, J.C., Ziegler, S.S., 2014. Environment, culture, and the Great Lakes fisheries. *Geogr. Rev.* 104 (4), 391–413. <http://dx.doi.org/10.1111/j.1931-0846.2014.12041.x>.

Hunt, L., Sutton, S., Arlinghaus, R., 2013. Illustrating the critical role of human dimensions research for understanding and managing recreational fisheries within a social-ecological system framework. *Fish. Manag. Ecol.* 20 (2/3), 111–124.

Jacobs, K., 2003. Connecting Science, Policy, and Decision-making: A Handbook for Researchers and Science Agencies. <http://ciceet.unh.edu/resources/jacobs-2002.pdf>.

Johannes, R.E., 2002. The renaissance of community-based marine resource management in Oceania. *Annu. Rev. Ecol. Syst.* 33 (1), 317–340. <http://dx.doi.org/10.1146/annurev.ecolsys.33.010802.150524>.

Johnston, F.D., Arlinghaus, R., Stelfox, J., Post, J.R., 2011. Decline in angler use despite increased catch rates: anglers' response to the implementation of a total catch-and-release regulation. *Fish. Res.* 110 (1), 189–197. <http://dx.doi.org/10.1016/j.fishres.2011.04.006>.

Kelly, N., Wantola, K., Weisz, E., Yan, N., 2013. Recreational boats as a vector of secondary spread for aquatic invasive species and native crustacean zooplankton. *Biol. Invasions* 15 (3), 509–519. <http://dx.doi.org/10.1007/s10530-012-0303-0>.

Kilian, J., Klauda, R., Widman, S., Kashiwagi, M., Bourquin, R., Weglein, S., Schuster, J., 2012. An assessment of a bait industry and angler behavior as a vector of invasive species. *Biol. Invasions* 14 (7), 1469–1481. <http://dx.doi.org/10.1007/s10530-012-0173-5>.

Lahsen, M., Nobre, C.A., 2007. Challenges of connecting international science and local level sustainability efforts: the case of the large-scale biosphere atmosphere experiment in Amazonia. *Environ. Sci. Pol.* 10, 62–74.

Lauber, T.B., Connolly, N., Stedman, R., Knuth, B., 2014. Pathogens and Invasive Species in the Great Lakes: Understanding Manager and Stakeholder Responses. Great Lakes Fishery Commission.

Lemos, M.C., Kirchhoff, C.J., Ramprasad, V., 2012. Narrowing the climate information usability gap. *Nat. Clim. Chang.* 2 (11), 789–794
<http://www.nature.com/nclimate/journal/v2/n11/abs/nclimate1614.html#supplementary-information>.

Lichtkoppler, F., O'Keefe, D.M., Lucente, J., Gabriel, T., 2015. The Great Lakes charter fishing industry: 2002 to 2011. *Fisheries* 40 (5), 200–212.
<http://dx.doi.org/10.1080/03632415.2015.1029574>.

Lupi, F., 2008. Collecting Angler Behavior Data from Great Lakes Creel Surveys. Great Lakes Fishery Commission.

Mahon, R., McConney, P., Roy, R.N., 2008. Governing fisheries as complex adaptive systems. *Mar. Policy* 32 (1), 104–112.

Mascia, M.B., 2003. The human dimension of coral reef marine protected areas: recent social science research and its policy implications. *Conserv. Biol.* 17, 630–632.

Maurstad, A., Sundet, J., 1998. The invisible cod-fishermen's and scientists' knowledge. In: Jentoft, S. (Ed.), *Commons in a Cold Climate. Coastal Fisheries and Reindeer Pastoralism in North Norway: the Co-management Approach*. UNESCO, Paris, pp. 167–184.

McClanahan, T.R., Marnane, M.J., Cinner, J.E., Kiene, W.E., 2006a. A comparison of marine protected areas and alternative approaches to coral-reef management. *Curr. Biol.* 16 (14), 1408–1413.

McClanahan, T.R., Verheij, E., Maina, J., 2006b. Comparing the management effectiveness of a marine park and a multiple-use collaborative fisheries management area in East Africa. *Aquat. Conserv. Mar. Freshwat. Ecosyst.* 16 (2), 147–165. <http://dx.doi.org/10.1002/aqc.715>.

McNie, E.C., 2007. Reconciling the supply of scientific information with user demands: an analysis of the problem and review of literature. *Environ. Sci. Pol.* 10, 17–38.

Méthot, J., Huang, X., Grover, H., 2015. Demographics and societal values as drivers of change in the Great Lakes–St. Lawrence River basin. *J. Great Lakes Res.* 41 (Supplement 1), 30–44.
<http://dx.doi.org/10.1016/j.jglr.2014.11.001>.

Meyerson, H., 2014. 2014 Fishing license sales lagging in Michigan *The Outdoor Journal*.

Michalak, A.M., Anderson, E.J., Beletsky, D., Boland, S., Bosch, N.S., Bridgeman, T.B., Chaffin, J.D., Cho, K., Confesor, R., Daloğlu, I., DePinto, J.V., Evans, M.A., Fahnenstiel, G.L., He, L., Ho, J.C., Jenkins, L., Johengen, T.H., Kuo, K.C., LaPorte, E., Liu, X., McWilliams, M.R., Moore, M.R., Posselt, D.J., Richards, R.P., Scavia, D., Steiner, A.L., Verhamme, E., Wright, D.M., Zagorski, M.A., 2013. Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. *Proc. Natl. Acad. Sci.* 110 (16), 6448–6452. <http://dx.doi.org/10.1073/pnas.1216006110>.

Miles, M.B., Huberman, A.M., 1984. *Qualitative Data Analysis*. Sage, Newbury Park. Mortsch, L.D., Quinn, F.H., 1996. Climate change scenarios for Great Lakes Basin ecosystem studies. *Limnol. Oceanogr.* 41 (5), 903–911. <http://dx.doi.org/10.4319/lo.1996.41.5.0903>.

Mulvaney, K.K., Foley, C.J., Höök, T.O., McNie, E.C., Prokopy, L.S., 2014. Identifying useful climate change information needs of Great Lakes fishery managers. *J. Great Lakes Res.* 40 (3), 590–598. <http://dx.doi.org/10.1016/j.jglr.2014.06.002>.

Neis, B., Felt, L., 2001. *Finding our Sea Legs: Linking Fishery People and their Knowledge with Science and Management*. ISER Books, St John's.

N. Heck et al. / *Journal of Great Lakes Research* 42 (2016) 319–327

Neis, B., Schneider, D., Felt, L., Haedrich, R., Fischer, J., Hutchings, J., 1999. Fisheries assessment: what can be learned from interviewing resource users? *Can. J. Fish. Aquat. Sci.* 56, 1949–1963.

Nichols, J.D., Williams, B.K., 2006. Monitoring for conservation. *Trends Ecol. Evol.* 21 (12), 668–673. <http://dx.doi.org/10.1016/j.tree.2006.08.007>.

Norse, E.A., 2010. Ecosystem-based spatial planning and management of marine fisheries: why and how? *Bull. Mar. Sci.* 86 (2), 179–195.

Okwu, O.J., Yahaya, M.A., Obinne, C.P.O., 2011. Analysis of artisanal fisher folk information needs and accessibility in Benue State, Nigeria. *Asian J. Agric. Sci.* 3 (5), 408–413.

Pacific Fishery Management Council, 2005. *Social Science in the Pacific Fishery Management Council Process*. Pacific Fishery Management Council, Portland.

Paisley, W., 1968. Information needs and users. *Annu. Rev. Inf. Sci. Technol.* 3, 1–30.

Pollnac, R.B., Pomeroy, R.S., Harkes, I.H.T., 2001. Fishery policy and job satisfaction in three southeast Asian fisheries. *Ocean Coast. Manag.* 44 (7–8), 531–544. [http://dx.doi.org/10.1016/S0964-5691\(01\)00064-3](http://dx.doi.org/10.1016/S0964-5691(01)00064-3).

Reavie, E.D., Heathcote, A.J., Shaw Chraïbi, V.L., 2014. Laurentian Great Lakes phytoplankton and their water quality characteristics, including a diatom-based model for paleoreconstruction of phosphorus. *PLoS One* 9 (8), e104705. <http://dx.doi.org/10.1371/journal.pone.0104705>.

Renner, M., Huntington, H.P., 2014. Connecting subsistence harvest and marine ecology: a cluster analysis of communities by fishing and hunting patterns. *Deep-Sea Res. II Top. Stud. Oceanogr.* 109, 293–299. <http://dx.doi.org/10.1016/j.dsr2.2014.03.005>.

Riley, S., 2007. Improving Use of Human Dimensions Information in Great Lakes Fishery Management. Great Lakes Fishery Commission.

Rogers, E., 2003. Diffusion of Innovation. Free Press, New York.

Rouse, W.B., Rouse, S.H., 1984. Human information seeking and design of information systems. *Inf. Process. Manag.* 20 (1–2), 129–138. [http://dx.doi.org/10.1016/03064573\(84\)90044-X](http://dx.doi.org/10.1016/03064573(84)90044-X).

Rucinski, D.K., DePinto, J.V., Scavia, D., Beletsky, D., 2014. Modeling Lake Erie's hypoxia response to nutrient loads and physical variability. *J. Great Lakes Res.* 40 (Supplement 3), 151–161. <http://dx.doi.org/10.1016/j.jglr.2014.02.003>.

Ruddle, K., 1996. Traditional management of reef fishing. In: Polunin, N.V.C., Roberts, C.M. (Eds.), *Reef Fisheries*. Chapman and Hall, London.

Salomon, A.K., Gaichas, S.K., Jensen, O.P., Agostini, V.N., Sloan, N.A., Rice, J., McClanahan, T.R., Ruckelshaus, M.H., Levin, P.S., Dulvy, N.K., Babcock, E.A., 2011. Bridging the divide between fisheries and marine conservation science. *Bull. Mar. Sci.* 87 (2), 251–274. <http://dx.doi.org/10.5343/bms.2010.1089>.

Sarewitz, D., Pielke Jr., R.A., Byerly Jr., R., 2000. Prediction: Science, Decision Making and the Future of Nature. Island Press, Washington DC.

Scavia, D., David Allan, J., Arend, K.K., Bartell, S., Beletsky, D., Bosch, N.S., Brandt, S.B., Briland, R.D., Daloğlu, I., DePinto, J.V., Dolan, D.M., Evans, M.A., Farmer, T.M., Goto, D., Han, H., Höök, T.O., Knight, R., Ludsın, S.A., Mason, D., Michalak, A.M., Peter Richards, R., Roberts, J.J., Rucinski, D.K., Rutherford, E., Schwab, D.J., Sesterhenn, T.M., Zhang, H., Zhou, Y., 2014. Assessing and addressing the re-eutrophication of Lake Erie: Central basin hypoxia. *J. Great Lakes Res.* 40 (2), 226–246. <http://dx.doi.org/10.1016/j.jglr.2014.02.004>.

Song, A.M., Chuenpagdee, R., Jentoft, S., 2013. Values, images, and principles: What they represent and how they may improve fisheries governance. *Mar. Policy* 40, 167–175. <http://dx.doi.org/10.1016/j.marpol.2013.01.018>.

Strauss, A., Corbin, J., 1990a. Open coding. *Bas. Qual. Res. Grounded Theory Proc. Tech.* 2, 101–121.

Stedman, R., 2015. Human Dimensions Theme Revision. Great Lakes Fishery Commission.

Strauss, A.L., Corbin, J.M., 1990b. Basics of qualitative research. 15. Sage, Newbury Park, CA.

Symes, D., Phillipson, J., 2009. Whatever became of social objectives in fisheries policy? Fish. Res. 95 (1), 1–5.

Thomas, D.R., 2006. A general inductive approach for analyzing qualitative evaluation data. Am. J. Eval. 27 (2), 237–246. <http://dx.doi.org/10.1177/1098214005283748>.

Urquhart, J., Acott, T., Reed, M., Courtney, P., 2011. Setting an agenda for social science research in fisheries policy in Northern Europe. Fish. Res. 108, 240–247.

Watras, C.J., Read, J.S., Holman, K.D., Liu, Z., Song, Y.Y., Watras, A.J., Morgan, S., Stanley, E.H., 2014. Decadal oscillation of lakes and aquifers in the upper Great Lakes region of North America: hydroclimatic implications. Geophys. Res. Lett. 41 (2), 456–462. <http://dx.doi.org/10.1002/2013GL058679>.