Journal of Outdoor Recreation and Tourism 12 (2015) 1–13

Contents lists available at ScienceDirect

Journal of Outdoor Recreation and Tourism

journal homepage: www.elsevier.com/locate/jort

The structure and function of angler mental models about fish population ecology: The influence of specialization and target species

Steven Gray [a,b,*], Johanna Hilsberg [a], Andrew McFall [a], Robert Arlinghaus [a,c]

[a] Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
[b] Michigan State University, Department of Community Sustainability, United States
[c] Division of Integrative Fisheries Management, Albrecht-Daniel Thaer Institute of Agricultural and Horticultural Sciences, Faculty of Life Science, Integrative Research Institute for the Transformation of Human-Environment Systems, Humboldt-Universität zu Berlin, Berlin, Germany

ARTICLE INFO

Article history:
Received 6 August 2014
Received in revised form
26 August 2015
Accepted 7 September 2015

Keywords:
Ecological knowledge
Fuzzy cognitive mapping
Mental model
Northern pike
Recreational fishing

ABSTRACT

As devotion to a recreational activity increases with specialization, recreationists' ecological understanding (i.e., mental models) of the resource system is also expected to change. To test this hypothesis, we collected cognitive maps of northern pike (*Esox lucius*) ecology from anglers ($N=235$) and assessed their relation to anglers' level of specialization and preferred target species. We also compared angler cognitive maps with cognitive maps collected from fisheries scientists ($N=17$) to examine if increased specialization among anglers led to similar ecological understanding of formally-trained fishery professionals. Our results indicate that, regardless of target species, as anglers become more specialized they tend to refine their structural understanding of pike ecology by simplifying relations among the ecological factors that affect pike populations. Further, although the refined ecological understanding of more specialized anglers' was found to be structurally dissimilar to experts, the mental models of pike ecology of more specialized anglers, particularly those with experience of the target species pike, were found to be functionally similar to how trained fisheries biologists viewed pike ecology. Our results suggest that more specialized anglers develop simple heuristics to deal with complex ecological issues, which may in turn affect the uptake of information and the acceptability of management actions designed by agencies and managers.

MANAGEMENT IMPLICATIONS

We present a quantitative method for measuring how anglers perceive the ecology of an exploited species (northern pike, *E. lucius*) using a combination of semi-quantitative fuzzy cognitive mapping and network metrics. The key finding is that as angler specialization increases, the knowledge of ecological dynamics is refined leading to mental models that are structurally different from academically trained fisheries biologists, but that behave functionally similar to experts.

- Similar perceived functionality of key management interventions suggest limited conflict potential among pike managers and more specialized anglers with regards to acceptance of management policies.
- Specialized anglers can be expected to perceive ecological dynamics similarly to academically trained fisheries scientists and thus may be allies in support of common management tools.
- The simplification of mental models in highly specialized anglers suggest variation in how different anglers learn and uptake new ecological knowledge, which has implications for the design of outreach strategies.

1. Introduction

The recreation specialization framework constitutes a popular conceptual foundation to explain heterogeneity among outdoor recreationists. Originally developed in the context of freshwater trout angling, specialization assumes "a continuum of behavior from the general to the particular, reflected by equipment and skills used in the sport and activity setting preferences" (Bryan, 1977, p. 175). Three decades of empirical research have tested a range of propositions originating from Bryan's (1977) pioneering work. Scott and Shafer (2001) summarized available literature and report that recreationists differ predictably in a range of co-varying behavioral and psychological traits (e.g., Dorow, Beardmore,

* Correspondence to: Michigan State University, Department of Community Sustainability, Natural Resource Building 480 Wilson Road Room 151, East Lansing, MI 48824, United States.
E-mail address: stevenallangray@gmail.com (S. Gray).

http://dx.doi.org/10.1016/j.jort.2015.09.001
2213-0780/

Haider, & Arlinghaus, 2010; Fisher, 1997; Salz, Loomis, & Finn, 2001; Wilde & Ditton, 1994). Hence, it is safe to assume that as specialization and commitment levels change, so do other characteristics of recreationists including: (a) motives for participation (e.g., Ditton, Loomis, & Choi, 1992; McFarlane, 1994; Beardmore, Haider, Hunt, & Arlinghaus, 2011), (b) harvesting desires (e.g., Aas, Haider, & Hunt, 2000; Dorow et al., 2010), (c) setting and environmental preferences (e.g., Bryan, 1977; Oh & Ditton, 2008; Beardmore, Hunt, Haider, & Arlinghaus, 2013), (d) knowledge and ecological understanding (Morgan & Soucy, 2006, 2008), and (e) preferences for management policies and compliance with rules (e.g., Chipman & Helfrich, 1988; Arlinghaus & Mehner, 2005; Dorow et al., 2010; Oh & Ditton, 2006, 2008).

Few studies, however, have examined relationships between specialization and recreationists' understanding of natural resource dynamics, despite the potential influence that ecological knowledge may have on the acceptability of regulations and management preferences (Arlinghaus & Mehner, 2005; Dorow & Arlinghaus, 2012). Although specialization is thought to entail the acquisition of ecological understanding (Bryan, 1977; Morgan & Soucy, 2008; Scott & Shafer, 2001), the exact relationship between specialization and the construction of knowledge about a naturally fluctuating natural resource has so far seen only limited quantitative examination (for qualitative and semi-quantitative studies of variation in anglers' ecological knowledge, see Eden and Bear (2011) and von Lindern (2010)). Understanding these relationships among consumptive resource users such as anglers may shed light on the cognitive assumptions that underlie stakeholders' reactions to proposed management measures and can help explain variation in management preferences (von Lindern, 2010; Biggs et al., 2011). For example, in one of the few studies of anglers' ecological mental models and its relation management preferences, von Lindern (2010) found that anglers who held “additive” mental models (i.e. they considered adding new fish via stocking and natural recruitment to influence harvestable stock sizes independently) tended to think that stocking was more effective than area closures. By contrast, anglers who held “compensatory” mental models (i.e. they perceived compensatory interactions between stocking and natural recruitment) tended to think area closures were more effective than stocking.

We focused our study on angler understanding of the ecology and management of northern pike (*Esox lucius*), which is an important recreational fishery in Germany (Arlinghaus & Mehner, 2004; Arlinghaus, Bork, & Fladung, 2008). Our goal was to examine how variation in the structure and function of angler mental models of pike population dynamics related to angler specialization and experience with an exploited resource (anglers who target pike versus anglers who do not target pike). Further, we sought to compare the ecological understanding of differently specialized anglers with the structural and functional knowledge of fisheries biologists (i.e. representing academically trained experts) to understand the degree that informal and formal expertise align with specialization and species choice.

We use the term “mental model” to refer to personalized, mental constructs that provide interpretation and structure of an external environment (Jones, Ross, Lynam, Perez, & Leitch, 2011), which affect how individuals perceive and interact with the outside world (Craik, 1943; Denzau & North, 1994). Mental models are constructed and modified by individuals over time as they experience the environment around them (Johnson-Laird, 1983; Mohammed & Dumville, 2001). These internal representations of the external world are used alongside other cognitions, such as values and attitudes, and subconscious physiological reactions to mediate between knowledge stored in the long term memory and the short-term requirements of making a context-appropriate decision (Biggs et al., 2011; Nercessian, 2008). Accordingly, mental models within a specific domain are thought to influence human behavior in relation to natural resources (Biggs et al., 2011; von Lindern, 2010) including the perceived impacts of different natural resource policies (Gray, Chan, Clark, & Jordan, 2012; Nayaki, Gray, Lepczyk, & Rentsch, 2014).

In the context of recreational fisheries, mental models involve angler understanding of the factors that influence changes in the qualities and quantities of fish and fish populations (e.g., size of fish and stock, expected catch rates; von Lindern, 2010). Such conceptualization resonates with Bryan's (1977) original proposition that as angler specialization increases, individual understanding of the vulnerabilities of habitats and exploited species also increases. Hence, the changes in ecological understanding that is expected to vary with increasing specialization should be reflected in changes in angler mental models about fish population dynamics. Past research has indeed indicated that as anglers move along a specialization continuum, their perception of the natural resource and the social and ecological role of the angler as agents of ecological change also changes (Oh & Ditton, 2008). As anglers become more specialized, they may pay more attention to the impact of angling pressure on fish populations (Bryan, 1977; Oh & Ditton, 2008; but see Dorow & Arlinghaus, 2012 for an alternative views) and they may more strongly emphasize the role that habitat quality plays in influencing the dynamics of fish resources (Bryan, 1977, but see Arlinghaus and Mehner (2005) for an alternative view). This, in turn, may affect conservation-related behaviors (Oh & Ditton, 2008), stewardship of aquatic resources (Knuth & Siemer, 2004) and preferred management policies (Chipman & Helfrich, 1988; Dorow et al., 2010; Dorow & Arlinghaus, 2012).

In the present study, we examined the relationship between specialization operationalized as commitment to angling, target species selection, and angler mental models of pike ecology using the structural and functional analysis of semi-quantitative cognitive maps created by anglers. We also compared the structure and functions of angler mental models to those of academically trained fisheries biologists assuming that as anglers move along the spectrum of specialization, their ecological understanding becomes increasingly similar to the subjective ecological knowledge held by formally trained fisheries scientists. We tested the following hypotheses:

H1. : More specialized anglers, in particular anglers who targeted pike possess structurally more complex mental models about the factors regulating pike population dynamics compared to less specialized anglers. The angler mental models of specialized anglers are most similar to those of academically trained fisheries biologists.

H2. : More specialized anglers, in particular anglers who targeted pike, identify key ecological factors as more important in influencing pike population dynamics (e.g., high importance of vegetated habitat for pike populations) compared to less specialized anglers. More specialized anglers resemble fisheries biologists more in terms of the importance placed on key ecological concepts affecting pike populations compared to less specialized anglers.

H3. : More specialized anglers, in particular anglers who targeted pike, identify impacts associated with pike conservation measures more similarly to fisheries biologists compared to less specialized anglers.

2. Materials and methods

Study participants were self-selected from a mailed solicitation sent to all angling clubs in the German state of Lower Saxony ($N=461$). Forty one of the 461 total clubs in the state indicated