Journal of Great Lakes Research 42 (2016) 743–752

Contents lists available at ScienceDirect

Journal of Great Lakes Research

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

Commentary

A perspective on needed research, modeling, and management approaches that can enhance Great Lakes fisheries management under changing ecosystem conditions

Kristen M. DeVanna Fussell[a,1], Ralph E.H. Smith[b], Michael E. Fraker[a,1], Leon Boegman[c], Kenneth T. Frank[d], Thomas J. Miller[e], Jeff T. Tyson[f], Kristin K. Arend[g], Daniel Boisclair[h], Stephanie J. Guildford[i], Robert E. Hecky[i], Tomas O. Höök[j], Olaf P. Jensen[k], Joel K. Llopiz[l], Cassandra J. May[a,2], Raymond G. Najjar[m], Lars G. Rudstam[n], Christopher T. Taggart[o], Yerubandi R. Rao[p], Stuart A. Ludsin[a,*]

[a] Aquatic Ecology Laboratory, Department of Evolution, Ecology and Organismal Biology, The Ohio State University, Columbus, OH 43212, USA
[b] Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
[c] Department of Civil Engineering, Queen's University, Kingston, Ontario K7L 3N6, Canada
[d] Department of Fisheries and Oceans, Bedford Institute of Oceanography, Ocean Sciences Division, Post Office Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada
[e] Chesapeake Biological Laboratory, University of Maryland Center for Environmental Sciences, Solomons, MD 20688, USA
[f] Sandusky Fisheries Research Unit, Ohio Department of Natural Resources, Division of Wildlife, 305 East Shoreline Drive, Sandusky, OH 44870, USA
[g] Old Woman Creek National Estuarine Research Reserve, Ohio Department of Natural Resources, Division of Wildlife, 2514 Cleveland Road East, Huron, OH 44839, USA
[h] Département de sciences biologiques, Université de Montréal, Montréal, Québec H3C 3J7, Canada
[i] Department of Biology and Large Lakes Observatory, University of Minnesota Duluth, 2205 5th Street, Duluth, MN 55812, USA
[j] Department of Forestry and Natural Resources and Illinois-Indiana Sea Grant Program, Purdue University, 195 Marstellar Street, West Lafayette, IN 47907, USA
[k] Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ 08901, USA
[l] Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA
[m] Department of Meteorology, The Pennsylvania State University, 503 Walker Building, University Park, PA 16802, USA
[n] Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, NY 13030, USA
[o] Department of Oceanography, Dalhousie University, 1355 Oxford Street, P.O. Box 15000, Halifax, Nova Scotia B3H 4R2, Canada
[p] Water and Science Technology Directorate, Environment Canada, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, Canada

ARTICLE INFO

Article history:
Received 26 October 2015
Accepted 21 April 2016
Available online 25 May 2016

Communicated by Edward Rutherford

ABSTRACT

The Great Lakes Fishery Commission sponsored a 2-day workshop that sought to enhance the ability of Great Lakes agencies to understand, predict, and ideally manage fisheries production in the face of changes in natural and anthropogenic forcings (e.g., climate, invasive species, and nutrients). The workshop brought together 18 marine and freshwater researchers with collective expertise in aquatic ecology, physical oceanography, limnology, climate modeling, and ecosystem modeling, and two individuals with fisheries management expertise. We report on the outcome of a writing exercise undertaken as part of this workshop that challenged each participant to identify three needs, which if addressed, could most improve the ability of Great Lakes agencies to manage their fisheries in the face of ecosystem change. Participant responses fell into two categories. The first identified gaps in ecological understanding, including how physical and biological processes can regulate early life growth and survival, how life-history strategies vary across species and within populations, and how anthropogenic stressors (e.g., nutrient runoff, climate change) can interact to influence fish populations. The second category pointed to the need for improved approaches to research (e.g., meta-analytic, comparative, spatial translation) and management (e.g., mechanistic management models, consideration of multi-stock management), and also identified the need for improved predictive models of the physical environment and associated ecosystem monitoring programs. While some progress has been made toward addressing these needs, we believe that a continued focus will be necessary to enable optimal fisheries management responses to forthcoming ecosystem change.
© 2016 Published by Elsevier B.V. on behalf of International Association for Great Lakes Research.

* Corresponding author. Tel.: +1 614 292 1613; fax: +1 614 292 0181.
E-mail address: ludsin.1@osu.edu (S.A. Ludsin).
[1] Ohio Sea Grant and Stone Laboratory, The Ohio State University, Columbus, OH 43212, USA. Tel.: +1 614 292 1613.
[2] Department of Biology and Chemistry, Bethel College, 1001 Bethel Circle, Mishawaka, IN 46544, USA. Tel.: +1 614 292 1613.

Introduction

Human-induced rapid environmental change (HIREC; Sih et al., 2011), which has been driven by habitat destruction (Pimm and Raven, 2000), non-native species introductions (Carlton, 2003; Holeck

http://dx.doi.org/10.1016/j.jglr.2016.04.007
0380-1330/© 2016 Published by Elsevier B.V. on behalf of International Association for Great Lakes Research.

et al., 2004), overexploitation and selective harvest (Pauly et al., 1998; Worm et al., 2009), altered nutrient inputs (eutrophication and oligotrophication; Stockner et al., 2000; Smith et al., 1999), and climate change (Walther et al., 2002; Parmesan and Yohe, 2003; Hayhoe et al., 2010; IPCC, 2013), has modified the physical, chemical and biological properties of aquatic ecosystems across the planet (Vitousek et al., 1997; Halpern et al., 2008). In some cases, HIREC has led to a whole-scale change in the state of an ecosystem (i.e., a regime shift; Scheffer et al., 2001; McGowen et al., 2003; Scheffer and Carpenter, 2003) that has altered the dynamics of its fish populations (Anderson and Piatt, 1999; Hare and Mantua, 2000; Reid et al., 2001; Beaugrand, 2004). In other cases, HIREC has had a more specific impact on fish population demographics by altering the probability of recruitment through early life stages (e.g., Mueter et al., 2011; Brochier et al., 2013). Examples such as these point to the need to consider the state and dynamics of the broader ecosystem when attempting to understand and forecast fisheries production, not just local-scale processes operating in the aquatic realm.

While much has been learned about how humans can drive change in aquatic ecosystems during the past half century, our ability to predict fisheries production under different ecosystem states is still lacking, particularly in large freshwater ecosystems such as the Laurentian Great Lakes (hereafter Great Lakes; Ludsin et al., 2014; Mulvaney et al., 2014). This gap in knowledge is important because large-scale changes in ecosystem conditions have become evident in each of the Great Lakes (e.g., Hecky et al., 2004; Allan et al., 2013; Bunnell et al., 2014), as they have in other large lakes of the world (e.g., East African Rift Lakes: O'Reilly et al., 2003; Hecky et al., 2010). For example, water warming trends during recent decades have been documented in many of the Great Lakes, including its smallest (Erie: Jones et al., 2006) and largest (Superior: Austin and Colman, 2007) members, with the rate of water temperature increase in Lake Superior being twice that of air temperature (Austin and Colman, 2007). Similarly, precipitation patterns have changed, with the frequency of multi-day storm events increasing during winter and spring (Kunkel et al., 1999; Hayhoe et al., 2010) and with the expectation that this trend will continue (Kling et al., 2003; IPCC, 2013; Kunkel et al., 2013; Michalak et al., 2013).

In addition to climate change, humans have altered the trophic status of many of the Great Lakes through multiple pathways (Ludsin et al., 2001; Makarewicz and Bertram, 2001; Bunnell et al., 2014; Scavia et al., 2014; Turschak et al., 2014). For example, long-term data from several of the upper lakes (Lake Michigan and Lake Huron in particular) point to these systems becoming more oligotrophic and regulated by bottom–up forcing in recent decades, owing to the combined effects of nutrient abatement programs, changes in planktivorous fish (e.g., alewife *Alosa pseudoharengus*) abundance, and the invasion of invertebrate grazers on phytoplankton (i.e., *Dreissena* mussels) and zooplankton (e.g., *Bythotrephes longimanus*) (Bunnell et al., 2011, 2014; Vanderploeg et al., 2012). By contrast, a re-eutrophication of Lake Erie has been occurring during the past decade, seemingly owing to increased precipitation during winter through spring and changing farming practices, both of which have increased inputs of dissolved (bioavailable) phosphorus to the lake (Kane et al., 2014, 2015; Scavia et al., 2014).

To enhance the ability of Great Lakes agencies to understand, predict, and ideally manage variation in fisheries production in large aquatic ecosystems such as the Great Lakes, the Great Lakes Fishery Commission (GLFC), a bi-national agency that coordinates fisheries research and cooperative fisheries management within the basin, sponsored a multi-day workshop that focused on how human-driven changes in climate and nutrient inputs might alter fish populations and the fisheries that they support. This workshop sought to enhance our understanding of how ecosystem state change resulting from these forms of HIREC (i.e., climate change and trophic status change) would independently and interactively influence key physical and biological factors important to the fish recruitment process. This information gap has been previously identified as a research priority by the GLFC (http://www.glfc.org/research/FRra.php) and also has relevance to other large aquatic ecosystems, both freshwater and marine (see Ludsin et al., 2014). Herein, we report on some key findings from this workshop.

Workshop topic and approach

The workshop—entitled "*Physical–biological coupling as a driver of fish recruitment under changing ecosystem states*"—was held in Huron, Ohio during 12–14 August 2013. It was attended primarily by North American marine and freshwater (primarily Great Lakes) researchers ($n = 18$) whose expertise includes aquatic ecology, physical oceanography, limnology, climate modeling, and ecosystem modeling (including physical–biological modeling). Twelve people affiliated with management agencies also were invited to attend the workshop; however, most could not attend ($n = 10$). Consequently, the management perspective was only represented by the two people with fishery management experience, one from the Great Lakes and the other from outside of the region.

Within the general context of understanding how an altered ecosystem state, induced by climate variation and changed nutrient dynamics (i.e., oligotrophication, eutrophication), influences the role of physical–biological forcing in the fish recruitment process, attendees were asked to reflect upon five specific questions both before and during the workshop: (1) What physical processes should increase/decrease in importance as an ecosystem shifts to a new state? (2) As physical processes change, what are the implications for physically driven recruitment variations as compared to other processes important to population dynamics, such as predator–prey interactions and overlap with suitable habitat/prey resources? (3) To what degree can fish life-histories accommodate these changes in physical and biological processes? (4) What are the management implications of changes to the physical–biological forcing of recruitment variability? (5) Will physical forcing of recruitment vary the same way in response to nutrient state change as to climate state change, and will responses be similar in freshwater and marine systems?

All participants were required to complete a series of pre-workshop activities to ensure maximal progress during the meeting period. Attendees were first asked to recommend two relevant papers (e.g., peer-reviewed publications, gray literature reports, undrafted manuscripts), which were made available to all participants prior to the workshop. From this list, the workshop's steering committee selected a subset to be read prior to the workshop, with each participant asked to read four papers: (1) Ludsin et al. (2014), which discussed the importance of physical processes to fish recruitment in the Great Lakes; (2) Bunnell et al. (2014), which provided an overview of recent changes in Great Lakes ecosystems; (3) Magnuson et al. (1997), Najjar et al. (2010), or Ficke et al. (2007), each of which discussed climate change impacts on aquatic ecosystems; and (4) Massol et al. (2007), Winder and Schindler (2004), or Durant et al. (2007), each of which provided an example of how climate change and/or altered ecosystem productivity could influence fish recruitment. Participants also were required to craft short papers and presentations that illustrated the foundation/evidence for their views.

While numerous additional activities occurred at the workshop (e.g., small-group discussions, outlining manuscripts), two key activities led to the outcomes that we present below. First, after every five participant presentations, group discussions ensued, which integrated across individual views and sought broad consensus. Second, after the final presentation discussion period, participants were required to identify in writing (20 min allotted time) three needs that could most improve the ability of agencies to manage their fisheries in the face of ecosystem state change. These needs could have emanated from individual experiences, pre-workshop writing activities (writing, reading), the presentations, or the post-presentation discussions.

Download English Version:

https://daneshyari.com/en/article/5744743

Download Persian Version:

https://daneshyari.com/article/5744743

Daneshyari.com