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Review

Researcher disciplines and the assessment techniques used to evaluate Laurentian Great Lakes coastal ecosystems

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ABSTRACT

The Laurentian Great Lakes of North America have been a focus of environmental and ecosystem research since the Great Lakes Water Quality Agreement in 1972. This study provides a review of scientific literature directed at the assessment of Laurentian Great Lakes coastal ecosystems. Our aim was to understand the methods employed to quantify disturbance and ecosystem quality within Laurentian Great Lakes coastal ecosystems within the last 20 years. We focused specifically on evidence of multidisciplinary articles, in authorship or types of assessment parameters used. We sought to uncover: 1) where Laurentian Great Lakes coastal ecosystems are investigated, 2) how patterns in the disciplines of researchers have shifted over time, 3) how measured parameters differed among disciplines, and 4) which parameters were used most often. Results indicate research was conducted almost evenly across the five Laurentian Great Lakes and that publication of coastal ecosystems studies increased dramatically ten years after the first State of the Great Lakes Ecosystem Conference in 1994. Research authored by environmental scientists and by multiple disciplines (multidisciplinary) have become more prevalent since 2003. This study supports the likelihood that communication and knowledge-sharing is happening between disciplines on some level. Multidisciplinary or environmental science articles were the most inclusive of parameters from different disciplines, but every discipline seemed to include chemical parameters less often than biota, physical, and spatial parameters. There is a need for an increased understanding of minor nutrient, toxin, and heavy metal impacts and use of spatial metrics in Laurentian Great Lakes coastal ecosystems.

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Introduction

Laurentian Great Lakes coastal ecosystems are hotspots for biological diversity and productivity. These coastal ecosystems contain diverse landforms and ecosystem types including marshes, freshwater estuaries, forested dune and swale complexes, beaches, embayments, and lake plain prairies (Albert et al., 2005). These systems are vital to many macroinvertebrate taxa (Cooper et al., 2012; Uzarski et al., 2009) and sport and prey fish communities (Jude and Pappas, 1992; Stephenson, 1990; Whillans, 1992). Additionally, coastal ecosystems, such as wetlands, provide many functions and values that benefit regional ecosystem health including carbon (Brix et al., 2001) and nutrient cycling (Mitsch and Reeder, 1991). Coastal wetlands also act as biological filters that mitigate chemical runoff, while trapping sediments (Johnston, 1991) and toxicants (Grisey et al., 2012), and preventing shoreline erosion (Fosberg, 1971).

Anthropogenic land use is affecting many coastal habitats throughout the Laurentian Great Lakes (Chow-Fraser, 2006; Danz et al., 2007). Since European settlement, a significant portion of the naturally occurring Great Lakes coastal ecosystem area has been lost (>50%), and coastlines have lost over 95% of their wetland habitat in some areas (Cwikiel, 1998; Krieger, 1992). Remaining wetlands have been further subjected to increased levels of fragmentation, degradation, and invasion of exotic plant species, greatly reducing the biodiversity and overall habitat quality of these valuable ecosystems (Cooper et al., 2012; Tulbure et al., 2007; Uzarski et al., 2009). In addition to wetlands, open water and nearshore embayment habitats (Peterson et al., 2007), rivers (Hoffman et al., 2012), and river mouths (Larson et al., 2013) of the Great Lakes have been impacted by surrounding land-use.

Scientists and managers recognize the important role that coastal ecosystems play in maintaining Laurentian Great Lakes water quality, biodiversity and productivity (Beletsky et al., 2007; Cloern, 2007; EPA, 1995; Robillard and Marsden, 2001; Schoen et al., 2016; Sierszen et al., 2012), prompting recent efforts to assess the quality of remaining habitats in the Laurentian Great Lakes basin. Recent work focused on assessing and monitoring the condition of Laurentian Great Lakes coastal ecosystems, including the development of new methods and techniques to assess coastal health. For example, Niemi et al. (2007) and Uzarski et al. (2004, 2005) have developed chemical, geographical, and biological approaches to quantify the degree of anthropogenic influence on coastal wetland habitats. These and other methods of assessment are critical for successful protection and restoration of coastal waters by allowing managers to identify, prioritize, and monitor areas in need of restoration.

Managers must be able to develop plans for restoration, protection, and monitoring on an ecosystem scale in order to be effective given their limited resources (Dalerum, 2014; Evely et al., 2010; Karlqvist, 1999; Simenstad et al., 2006). Single discipline research can be difficult to implement directly into a management plan that is developed for an entire ecosystem, because it may be limited in its perspective (Brewer, 1999; Dalerum, 2014; Evely et al., 2010; Karlqvist, 1999; Kinzig, 2001). There has been a push for more multidisciplinary research in the last 25 years to promote a more integrated approach to addressing ecosystem issues (Brewer, 1999; Klein, 1990). Conducting multidisciplinary research is an excellent goal, but successful execution is difficult, and many projects are dropped before completion (Brewer, 1999; Pooley et al., 2013). Major obstacles faced when tackling multidisciplinary research are disciplinary prejudices, insufficient or lack of interdisciplinary communication, poor data accessibility and integration, lack of shared values and priorities, and different theories of knowledge (Pooley et al., 2013).

Since 1972, the United States of America (U.S.A.) and Canadian governments have attempted to combat these obstacles for the sake of human and ecosystem health. Both countries signed and subsequently updated (in 1987) the Great Lakes Water Quality Agreement (GLWQA) to align scientists with a common goal to restore and protect the Laurentian Great Lakes (IJC, 1993). To uphold this agreement, it was decided that an understanding of atmosphere, land, biota, and human activities in the Laurentian Great Lakes and their interactions should be integral to coastal ecosystem protection and restoration (IJC, 1993). Since 1981, the reports from the International Joint Commission (IJC) praised multidisciplinary efforts in which scientists worked "across jurisdictions and disciplines to enhance learning, understanding, and the efficient use of resources" (IJC, 1993). Although the obstacle of a shared value (i.e., restore and protect Laurentian Great Lakes) had been overcome, other obstacles remained in the way of multidisciplinary research.

To combat the remaining obstacles, the first State of the Great Lakes Ecosystem Conference (SOLEC) was held in 1994 (EPA, 1995). SOLEC brought together government agencies, conservation groups, health professionals, agricultural community, industry, academia, and citizens from both Canada and U.S.A. to facilitate interdisciplinary communication to uphold objectives of the GLWQA. In subsequent years, SOLEC has also encouraged efforts to make Laurentian Great Lakes ecosystem data more readily available and abundant, addressing another multidisciplinary research obstacle. The SOLEC process and the GLWQA both promote more collaborative research, with SOLEC specifically encouraging multidisciplinary approaches to overcome disciplinary prejudices and communication, improve data accessibility, and add value to the research outcome (Environmental Law Institute, 1995; IJC, 1993; Pooley et al., 2013).

In this study, a literature search and review was performed based on published primary scientific literature directed at the assessment of Laurentian Great Lakes coastal ecosystems. Claudet and Freschetti (2010) provided a similar analysis for the Mediterranean that illustrated gaps in knowledge and pointed out disproportionate regional emphasis, which was useful for future research and management. The primary objective was to survey studies that quantify disturbance and ecosystems quality within Laurentian Great Lakes coastal ecosystems since the first 1994 SOLEC to identify trends and gaps. Additionally, this study sought to uncover evidence of multidisciplinary collaboration through the research parameters measured and/or the knowledge of its pool of contributors for articles studying Laurentian Great Lakes coastal ecosystems (Haapasaari et al., 2012; Karlqvist, 1999; Klein, 1990). This study aims to provide a synopsis of research efforts on Laurentian Great Lakes coastal systems measuring ecosystem quality concerning: 1) where Laurentian Great Lakes coastal ecosystem research is being conducted, 2) how discipline patterns of Laurentian Great Lakes researchers may have shifted over time, 3) how indicative parameters differed among scientific disciplines, and 4) which parameters were used most often.

Methods

Study area

The coastal systems of the Laurentian Great Lakes stretch approximately 17,500 km across USA and Canada (Botts and Krushelnicki, 1987). Great Lakes coastal zones include littoral habitats such as wetlands, beaches and river mouths. Coastal zones of the Great Lakes can be differentiated from offshore habitat by their warmer temperatures, shallow depths and decreased wave energy (Trebitz et al., 2009). These conditions promote sediment deposition and nutrient retention and promote the establishment of aquatic macrophytes (Parker et al., 2012). These macrophytes provide biota with structure and cover, promoting macroinvertebrate and fish richness (Randall et al., 1996). There are 275,748 acres of coastal wetlands as of 2003 in the Great Lakes Coastal Wetland Consortium inventory. In addition to coastal wetland habitat, the Great Lakes contain approximately 1500 miles of shoreline, encompassing river mouths, spawning reefs and beach and embayment habitats (Grady, 2007).