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# Defining community revitalization in Great Lakes Areas of Concern and investigating how revitalization can be catalyzed through remediation and restoration

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ABSTRACT

An international effort to restore contaminated areas across the Great Lakes has been underway for over 50 years. Although experts have increasingly recognized the inherent connections between ecological conditions and community level benefits, Great Lakes community revitalization continues to be a broad and complex topic, lacking a comprehensive definition. The purpose of this study was to generate a testable "AOC-Revitalization Framework" for linking remediation and restoration success, represented by Beneficial Use Impairment (BUI) removal in U.S. Great Lakes Areas of Concern (AOC), to community revitalization. Using directed content analysis, we conducted a literature review and identified 433 potential revitalization metrics and indicators and grouped them into 15 broader community revitalization attributes to develop the following definition of Great Lakes community revitalization: "*locally driven community resurgence resulting in resilient and equitable enhancements to social, economic, and environmental community structures.*" We surveyed experts within the Great Lakes AOC program on the likelihood remediation and restoration success, would positively impact revitalization attributes. Focus groups triangulated survey results. Results identified BUI removal was expected to positively affect revitalization, but the type of revitalization outcome was based on the BUI being removed. The AOC-Revitalization Framework is the first to empirically outline these possible linkages, providing a clear testable structure for future research; it can be used to better understand how environmental improvements are or are not leading to community revitalization and more accurately identify components of revitalization impacted, thus supporting more equitable representation, communication, and measurement of the relationship.


## Introduction

The Great Lakes region has a rich history of industrialization, but following economic downturn of recent decades, it has become known as the "rust belt" of the United States. This historical industrialization in Great Lakes coastal communities resulted in economic prosperity, but also severe environmental contamination and habitat loss in the basin. Contamination to these water bodies, most notably the burning of the Cuyahoga River in 1969, which earned it the title "the river that oozes rather than flows" from Time magazine, helped spur the modern environmental movement (Hartig et al., 2020). In 1972, along with the creation of the U.S. Environmental Protection Agency (U.S. EPA) and the Clean Water Act, the United States and Canada signed a binational agreement – the Great Lakes Water Quality Agreement (GLWQA) – with the purpose of restoring and maintaining the chemical, biological,

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and physical integrity of the Great Lakes Basin Ecosystem (Botts and Muldoon, 2005; Great Lakes Water Quality Agreement, 2012). As a result of the GLWQA, in 1987, 43 highly degraded Great Lakes coastal areas were designated as Areas of Concern (AOC); 26 are United States based, 12 are Canadian, and 5 are shared binationally (Fig. 1). The reduction of the chemical, physical, and biological integrity within each AOC was described through the designation of Beneficial Use Impairments (BUIs; Fig. 2; BUI descriptions are also provided in Electronic Supplementary Material (ESM) Appendix S1.

Significant investments have been made in sediment remediation and habitat restoration to re-establish these beneficial uses. In 2002, the U.S. Great Lakes Legacy Act was signed into law, expediting sediment remediation projects in U.S. AOCs. Prior to 2002, limited progress had been made, and the removal and disposal of contaminated sediment was only accomplished as a secondary benefit of navigational dredging (Tuchman et al., 2018). More recently, the U.S. EPA's Great Lakes Restoration Initiative (GLRI), established in 2010, has enabled significant investment in the U.S. AOC program further accelerating remediation and restoration efforts (Hartig et al., 2020; Tuchman et al., 2018). Remediation and restoration projects include, but are not limited to, removing or reducing contaminants of concern, removing fill or debris, restoring native habitats, and controlling excessive erosion or nutrient inputs. As a result, as of March 2022, 107 of 255 U.S.-based BUIs have been removed and six AOCs have been delisted. However, almost 35 years after their creation, BUIs remain and many AOCs still suffer from the legacy of environmental degradation.

The removal of a BUI indicates a significant environmental improvement that may support restoration of ecosystem services (e.g., water that is clean enough for recreational use or fish that can be safely consumed), and as a result, local waterfront communities may experience various positive community revitalization outcomes (Hartig et al., 2019, 2020; Williams and Hoffman, 2020). For instance, environmental restoration has been linked to positive economic outcomes (Braden et al., 2008; Isley et al., 2011; Krantzberg and de Boer, 2006). Communities may embrace the benefits of their newly cleaned waterways by creating a new water-based identity and further investing in revitalization efforts (Tyner and Boyer, 2020). While community revitalization is not a formal goal of the AOC program, it is beneficial to understand how program driven remediation and restoration activities affect waterfront revitalization (commonly referred to as R2R2R, see also Tuchman et al., 2018; Williams and Hoffman, 2020).

Although noneconomic factors have been anecdotally linked to environmental clean-up efforts, in the AOC context, revitalization has primarily been quantified in economic terms (Angradi et al., 2019; Hartig et al., 2020; Maxwell et al., 2018). However, noneconomic factors such as equity, access, community resilience, conservation, and social participation are required to fully revitalize the community (Wilczkiewicz and Wilkosz-Mamcarczyk, 2015). Furthermore, by contextualizing community revitalization solely in economic terms, inequitable outcomes, such as eco-gentrification (when environmental investments/improvements raise the cost of living such that low-income residents are priced out of their community), are ever more likely (Anguelovski, 2015; Bryson,

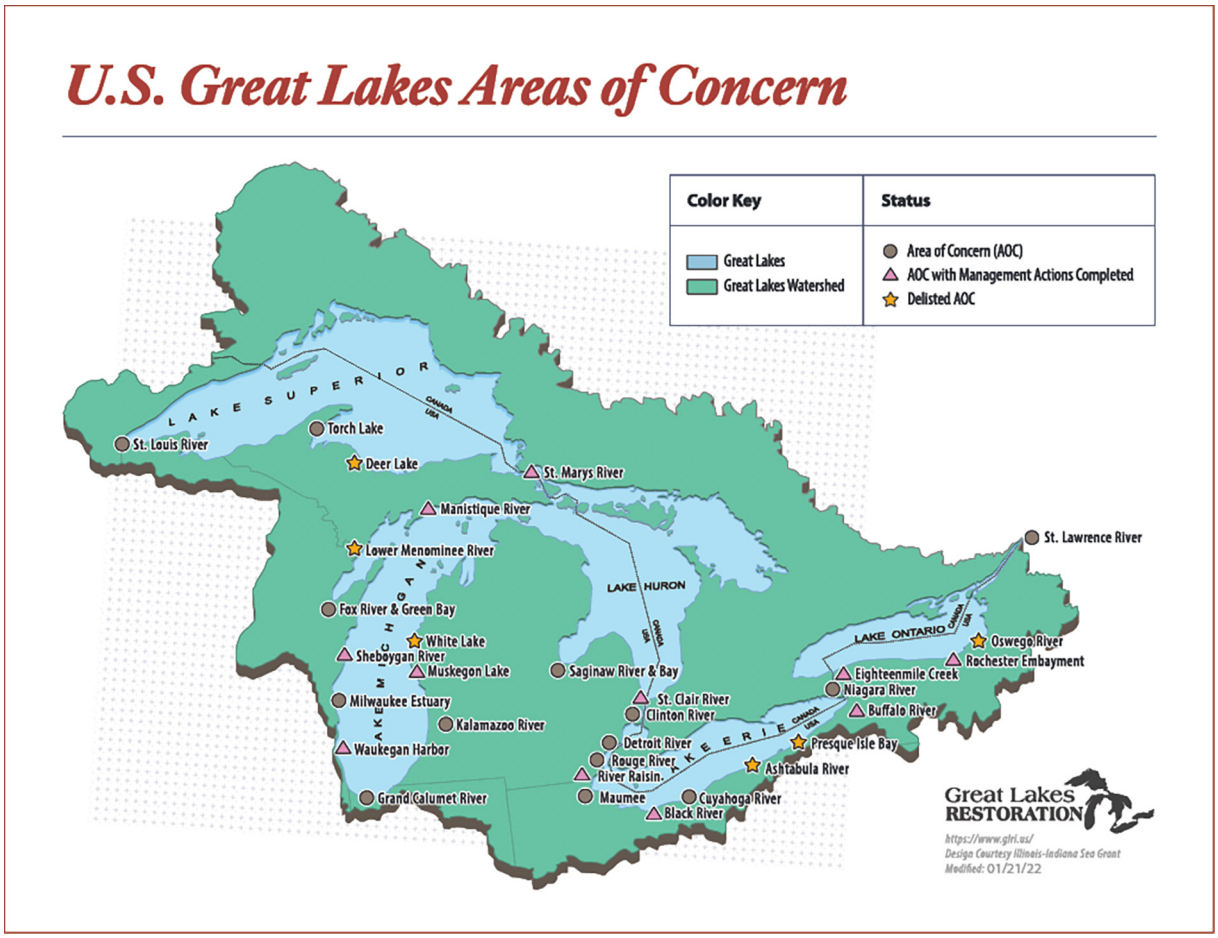


**Fig. 1.** A map showing the location and status of the U.S. Great Lakes Areas of Concern, the focus of this study.

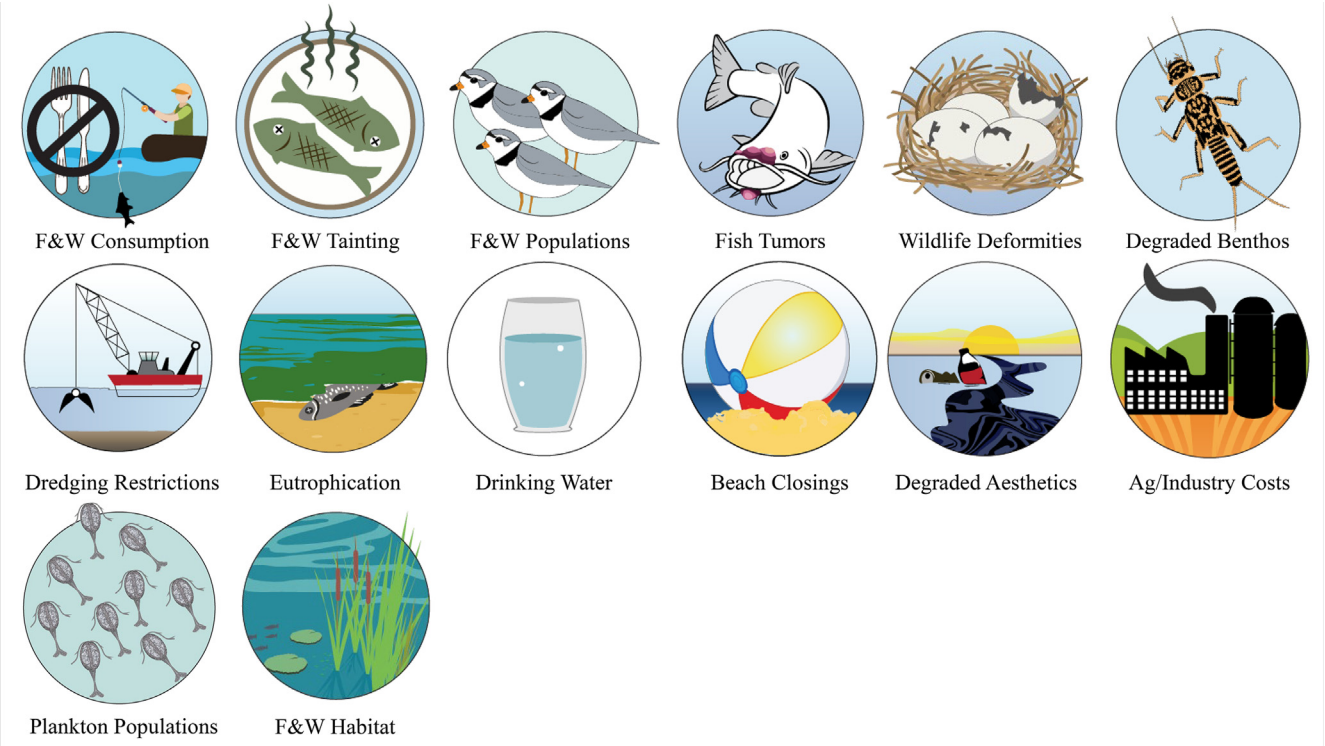


**Fig. 2.** The 14 Beneficial Use Impairments that may be designated for a Great Lakes Area of Concern (with shortened names in parenthesis): Restrictions on Fish and Wildlife Consumption (F&W Consumption), Tainting of Fish and Wildlife Flavor (F&W Tainting), Degraded Fish and Wildlife Populations (F&W Populations), Fish Tumors or Other Deformities (Fish Tumors), Bird or Animal Deformities or Reproductive Problems (Wildlife Deformities), Degradation of Benthos (Benthos Degradation), Restrictions on Dredging Activities (Dredging Restrictions), Eutrophication or Undesirable Algae (Eutrophication), Restrictions on Drinking Water Consumption or Taste and Odor Problems (Drinking Water), Beach Closings, Degradation of Aesthetics (Degraded Aesthetics), Added Costs to Agriculture or Industry (Ag/Industry Costs), Degradation of Phytoplankton and Zooplankton Populations (Plankton Populations), Loss of Fish and Wildlife Habitat (F&W Habitat).

2012; Tiboris et al., 2019; Pearsall and Anguelovski, 2016). Additionally, without a comprehensive definition and quantification, long-term benefits of remediation and restoration, beyond economic benefits, may not be fully realized nor maintained. To better characterize the impact of the substantial remediation and restoration efforts underway in Great Lakes AOCs, economic *and noneconomic* (e.g., social, and environmental) aspects of community revitalization, must not only be established, but also linked to measures of remediation and restoration success (i.e., BUI removal).

In this study, our primary goal was to outline possible linkages between remediation and restoration success (measured as BUI removal) in U.S.-based Great Lakes AOCs and community revitalization in related waterfront communities, and to describe this relationship through a generalizable model (hereafter referred to as the AOC-Revitalization Framework). Although community revitalization is inherently community-based, the AOC-Revitalization Framework conceptualizes these linkages from a programmatic perspective and is a powerful first step in understanding how program driven remediation and restoration activities may affect waterfront revitalization. BUI removal was selected as an indicator because it is the metric for success for the AOC program. It is the result of both remediation and restoration management actions and the associated environmental response. To develop the AOC-Revitalization Framework, we had three specific objectives: first, we used directed content analysis of the published literature to develop an operational definition of Great Lakes community revitalization and delineate revitalization attributes comprised within this definition. The same structure that defines sustainability – which identifies three fundamental factors, or 'pillars', of support: Social, Economic, and Environmental, was used to structure our definition of community revitalization and the AOC-Revitalization Framework (Purvis et al., 2019). Second, we surveyed federal employees with expertise in implementing or studying Great Lakes remediation and restoration to assess program expert opinion on the likelihood that BUI removal would positively impact community revitalization attributes. Third, we performed a qualitative assessment of survey results with survey takers via focus groups. We employed this mixed-methods approach to triangulate results, producing more robust conclusions. Using data from these three specific objectives, we developed the AOC-Revitalization Framework.

## Methods

### *AOC-Revitalization Framework Development Step 1: Defining revitalization and revitalization attributes via. literature directed content analysis*

A literature search was conducted to identify published studies investigating waterfront community revitalization. Google Scholar was queried using the key words: "community revitalization", "community resilience", "socio-economic benefits of sediment remediation", "waterfront redevelopment", "brownfield redevelopment", "socio-economic benefits of habitat restoration", "sustainable community development", "quality of life indexes", or "blue economy." Articles published from 1999 to 2019 were eligible for inclusion. This timeframe was selected to focus on the effects of more recent investments in remediation and restoration such as those made as a part of the GLRI. Included articles spoke directly to (1) the characteristics of community revitalization, (2) the relationships between remediation, restoration, and community revitalization, (3) were accessible, and (4) written in English.

Using these search criteria, 33 papers were produced and 20 were selected that provided breadth across the three pillars of sustainability; were well cited; and directly focused on indicators of community revitalization (See results, Table 1). Additionally, AOC-specific literature known to the authors, which included 19 case studies, three presentations, five policy papers, and five community planning documents were collected for analysis (See results, Table 1; CSL International, 2013; Great Lakes Commission, 2018; Hartig et al., 2019). These documents were selected based on availability and were representative of a range of BUI challenges, AOC sizes and types, and captured local, state, and federal perspectives. Case studies were from five of the U.S. AOCs and included seven of the eight U.S. Great Lakes states (all but Indiana). While Canada was not the focus of this study, four case studies represented Canadian-based AOCs, as they are part of a larger study reviewed (Hartig et al., 2019). Some studies examined the same AOC. Planning documents represented communities within the Muskegon Lake AOC, the Waukegan Harbor AOC, the Cuyahoga River AOC, and the St. Louis River AOC (City of Duluth, 2018; City of Waukegan, 2015; West Michigan Shoreline Regional Development Commission, 2016; Development Concepts, Inc., and Perkins + Will, 2016; Tetra Tech, 2008). Presentations were conducted by both federal and local entities (personal communication, C. Rosen, Buffalo Niagara Waterkeeper, 2018; personal communication, M. Keenan and P. Shanker, Center for Neighborhood Technology, August 2019; personal communication, J. Grosshans, US EPA Region 5, August 2019). Communities represented by case studies generally ranged in population from ~31,000 to ~558,000 people. Policy papers examined policy recommendations or strategies for equitable revitalization within Great Lakes communities (Devine, 2013; Reece, 2004; Tiboris et al., 2019) or more broadly applicable best practices (Fargione et al., 2016; Rudolph et al., 2013).

Directed content analysis was used to identify metrics (quantitative) and indicators (qualitative) of waterfront revitalization (Hsieh and Shannon, 2005). Metrics and indicators were derived directly from documents in an iterative process and grouped into attributes based on professional judgment regarding similarity. These attributes were then defined based on their contents and thematically organized within the Social, Economic, and Environmental pillars of sustainability (Goodland and Daly, 1996; Purvis et al., 2019). In some cases, research papers did not directly state potential metrics or indicators, but instead described attributes. The social pillar of sustainability was further subdivided for clarity. The pillars of sustainability structure was emulated because this structure was naturally derived over decades of expert agreement and there are inherent connections between sustainability and community revitalization (Hartig et al., 2020; Purvis et al., 2019). Community revitalization was then defined with consideration of all derived attributes. Lastly, revitalization attributes were used in our survey to collectively represent Great Lakes community revitalization. It is important to note, these community revitalization attributes, derived from the literature, represent community characteristics *outside* of the AOC program. Notably, the environmental pillar considers attributes representing continued investment and community prioritization in the environment as AOC work is *completed*.

**Table 1**
AOC-Revitalization Framework community revitalization attributes (established via directed content analysis) organized under the three pillars of sustainability.

| Pillar / Attribute | Description |
|---|---|
| **Economic Development**[1,2,4,5,7,13,17,36] | |
| Recreation[1,2,3,8,10,11,12,13,14,15,16,17,20, 26,27,28, 29] | Activities undertaken for exercise, amusement, or relaxation-utilizing the waterbody in a non-consumptive manner. |
| Tourism[1,2,8,13,15,16,17,23,27] | Actions that stimulate sustainable economic growth via attracting visitors to the community. |
| Stimulated Community Investment[5,6,10,11,12,13,15,16,18, 19,20,21,22,23,28, 31,32,34] | Monetary or human investment in the community outside of AOC program. |
| Land Development[1,2,3,5,6,8,10,11,13,14,16,17,27,28,30,31, 32,34] | Land development based around the waterbody that meets the needs of the present without compromising the ability of future generations to meet their needs. |
| Employment[4,5,8,11,13,15,17,20,23,26,27,29,30,31,32,33,34,35] | Diversified supply and demand of quality jobs providing sustainable wages and the accumulation of wealth. |
| **Social** | |
| *Community Building* [5,6,8,10,12,13,31,32,35] | |
| Waterfront Identity [3,5,8,10,12,13,16,23,25,27,28,29] | Integrating the water body as central to community identity. |
| Community Participation[4,5,6,10,11,12,15,16,26,27, 28,29,31,32,35] | Community influence and authority in public or private actions and decision-making. |
| Cultural Heritage Conservation[2,5,8,10,12,15,16,26, 27,28,32,35] | The preservation of inherited and current beliefs, customs, artistic activity and knowledge. |
| *Quality of Life* [5,8,25,26,29,31] | |
| Health[5,10,11,15,20,26,27,31,35] | Physical, mental, and social well-being. |
| Access[5,8,10,11,13,14,16,20,25,27,28,29,31,35] | Increased opportunity to interact with the water for all interested in doing so. |
| Safety[4,5,12,15,20,26,28,31,34] | A state in which conditions leading to immediate physical, psychological or material harm are controlled in order to preserve the well-being of individuals and the community. |
| Equity[2,4,5,9,10,11,12,15,18,19,20,24,25,26,27,30,31,32,33,35,36] | Equal rewards, opportunity, agency in decision-making, and distribution of advantages and disadvantages for individuals among all groups of the community. |
| **Environmental** | |
| Sustainability Initiatives[2,8,10,12,15,16,17,20,25,26,27,28,29,34,35,36] | Implementing practices of sustainability such as waste reduction and LEED building certification into community development or business practices. |
| Natural Area Conservation[1,3,5,6,10,11,12,13,15,17,20,27,28,29,34] | Protecting and restoring natural areas outside of the AOC program. |
| Climate Change Resilience Building[2,5,10,11,12,15,27,32,34,35,36] | Enhancing the ability of a community to better anticipate, prepare for, respond to, and recover from the multitude of adverse effects of climate change. |

1 Goddard, 2015; 2 Smith-Godfrey, 2016; 3 Personal communication, C. Rosen, Buffalo Niagara Waterkeeper, 2018; 4 Commonwealth Secretariat, 2020; 5 Development Concepts, Inc., and Perkins + Will, 2016; 6 Goodwin, 1999; 7 York, 2006; 8 Great Lakes Commission, 2018; 9 Bryson, 2012; 10 City of Waukegan, 2015; 11 Tiboris et al., 2019; 12 Doick et al., 2009; 13 Hartig et al., 2019; 14 Isley et al., 2011; 15 Fargione et al., 2016; 16 Tetra Tech, 2008; 17 Austin et al., 2007; 18 Personal communication M. Keenan and P. Shanker, Center for Neighborhood Technology, August 2019; 19 Personal communication, J. Grosshans, US EPA Region 5, August 2019; 20 Rudolph et al., 2013; 21 Höchstädter and Scheck, 2015; 22 Jackson, 2013; 23 CSL International, 2013; 24 Dooling, 2009; 25 Devine, 2013; 26 Turkoglu, 2015; 27 City of Duluth, 2018; 28 Hartig and Wallace, 2015; 29 Muskegon Lake Vision 2020, 2016; 30 Haroldson, 2014; 31 Tatian et al., 2012; 32 Reece, 2004; 33 Banzhaf, 2008; 34 Bird, 2016; 35 Anguelovski, 2015; 36 Lerch, 2017.

*AOC-Revitalization Framework Development Step 2: Survey design and population*

To better understand the linkages between BUI removal and revitalization attributes, expert opinion was solicited via a survey with a population of U.S. federal practitioners and researchers. This survey population was selected based on technical and programmatic expertise in remediation, restoration, and BUI removal in U.S.-based AOCs. Practitioners were defined as those who held a primary professional role in AOC program administration and/or AOC project management/implementation. Researchers were defined as those who evaluated AOC project efficacy via a research and development role.

The survey assessed the likelihood that BUI removal would positively impact a community revitalization response (attributes derived via directed content analysis) with the statement: "Provide your opinion on the likelihood that removing this BUI will positively impact the following revitalization attributes." Each statement was accompanied by a brief description of the BUI (adapted from BUI descriptions provided in ESM Appendix S1) and a matrix of the 15 revitalization attributes (e.g., community participation or equity) established in the above process (See results, Table 1). Revitalization attribute definitions were provided via the hover feature. Responses were given on a 5-point Likert scale (Sullivan and Artino Jr, 2013) from "very unlikely" (1), "somewhat unlikely" (2), "neutral" (3), "somewhat likely" (4), to "very likely" (5). The above statement was presented for each BUI, generating 210 potential responses from each participant.

Question order and revitalization attribute order (within each question) were both randomized among participants to minimize carryover or other non-random effects that can occur in surveys with a repetitive matrix format (Dillman et al., 2014). To minimize respondent burden, revitalization attribute order within the matrix remained the same between questions for the individual respondent (Rolstad et al., 2011). Additional details on survey design, procedures, and analysis are provided in ESM Appendix S2 and a copy of the full survey is available in ESM Appendix S3.

*AOC-Revitalization Framework Development Step 3: Survey data analysis*

To directly address if individual BUI removals would be likely to positively affect individual revitalization attributes, mean Likert scores were calculated for each BUI across each revitalization attribute. We considered mean response scores > 3.0 (neutral) as the cutoff to determine if removal of a BUI would likely positively affect a revitalization attribute.

We next tested whether the removal of some BUIs might differentially affect the likelihood of positively affecting the revitalization attributes. To determine if all BUI removals are expected to positively affect revitalization attributes equally, we used permutational ANOVA (PERMANOVA) to test the effect of BUI on responses. In the event of a significant effect of BUI on responses, indicating that the effect on revitalization attributes is not equal among all BUIs, we calculated centroids of BUIs and performed hierarchical clustering analysis to determine if there were groups of BUIs whose removals were expected to affect revitalization attributes similarly, under the assumption that seemingly related BUIs (e.g., Benthos Degradation and Fish Tumors) might be expected to affect the same attributes of revitalization. Hierarchical clusters were tested for significant statistical differences (similarity profile analysis, SIMPROF; Whitaker et al., 2014).

The AOC-Revitalization Framework was developed to describe the hypothesized effect of BUI removal on catalyzing revitalization attributes. Considering that BUI clusters cannot uniformly be applied across all AOCs, because not all AOCs have all BUIs, mean Likert response data was preferred over multivariate clustering approaches for framework development. When creating the framework, mean Likert scores were rounded to the nearest tenth. The framework was developed using mean Likert scores with mean responses $\geq$ 4 (somewhat likely to very likely), to demonstrate higher expected likelihood of a positive BUI-revitalization attribute relationship. Additional information on survey data analysis, including response consensus, the differing effect of BUI removal and the effect of participant professional role, is provided in ESM Appendix S2.

*AOC-Revitalization Framework Development Step 4: Focus groups*

Focus groups enabled triangulation, the use of multiple methods of data collection, to support data richness and permit confirmation or corroboration of results (Johnson et al., 2007). Focus groups were used to provide richness to survey data and add further context to BUI removal as a representation of AOC remediation and restoration actions. Focus group participants were asked if any survey results were surprising and shown survey summary statistics (see results Table 2 and Figs. 3 and 4). Participants were also asked to interpret relationships established between BUI removal and community revitalization and if any BUI-revitalization attribute relationship was particularly easy or difficult to conceptualize. Focus groups were conducted three weeks after the close of the survey to allow time for survey data analysis. Each focus group was over-recruited by two participants to account for no-shows with a target of six to eight participants (Forrestal et al., 2015). Focus groups were moderated by a trained facilitator with assistance from a co-moderator and a note-taker. Each focus group lasted 60 min and was recorded to allow the larger research team to assess responses (NOAA, 2015). The co-moderators used a semi-structured focus group approach (NOAA, 2015) to allow for flexibility in addressing additional and relevant topics of collective interest that emerged between specific BUIs and revitalization attributes. Immediately following each focus group, the co-moderators and note-taker debriefed to discuss their general impressions of participant responses and key themes that emerged from the session (McMahon and Winch, 2018). Researchers not involved in the live discussion watched each recording, via a secured shared drive, within three days of the focus group meeting. These members then met with each other to discuss themes and key points independent of co-moderators and note-taker. Within one week of the focus groups, the entire research team met to compare independent interpretations and generate a consensus on themes and key points of focus groups (McMahon and Winch, 2018). Additional detail on focus group methods is provided in ESM Appendix S2.

## Results and Discussion

*AOC-Revitalization Framework Development Step 1: Defining revitalization and revitalization attributes via. literature directed content analysis*

We identified 15 diverse attributes (community revitalization outcomes) and from these attributes defined community revitalization within Great Lakes AOCs as: *locally driven community resurgence resulting in resilient and equitable enhancements to social, economic, and environmental community structures.* Resiliency and equitability were key themes throughout the literature, as such are highlighted in the definition to describe the type of community change applicable. Equity is specifically highlighted as an attribute but is applicable to all attributes. Equity is defined as equal rewards, opportunity, agency in decision-making, and distribution

**Table 2**
AOC-revitalization attributes organized under the three pillars of sustainability. Mean scores under each AOC-revitalization attribute indicate the likelihood (from very unlikely [1] to very likely [5]) that the removal of the associated Beneficial Use Impairment (BUI) would catalyze the attribute's positive response. Mean response $\leq 3$ (very unlikely to neutral) are colored red and mean responses $\geq 4$ (somewhat likely to very likely) are colored blue.

| | Economic Development | | | | | Social | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Community Building | | | Quality of Life | | | | | | |
| BUI | Recreation | Tourism | Stimulated Community Investment | Land Development | Employment | Waterfront Identity | Community Participation | Cultural Heritage Conservation | Health | Access | Safety | Equity | Sustainability Initiatives | Natural Area Conservation | Climate Change Resilience Building |
| Drinking Water | 4.9 | 4.7 | 4.3 | 3.9 | 3.8 | 4.7 | 4.4 | 3.6 | 4.6 | 4.6 | 4.3 | 4.1 | 3.4 | 3.6 | 3.3 |
| F &W Habitat | 4.4 | 4.3 | 4 | 3.5 | 3.4 | 4.2 | 4.1 | 4.1 | 3.8 | 3.6 | 2.9 | 3.6 | 3.7 | 4.5 | 3.8 |
| Beach closings | 4.4 | 4.2 | 4 | 3.6 | 3.3 | 4.4 | 3.8 | 3.5 | 4.2 | 3.9 | 3.9 | 3.5 | 3.5 | 3.8 | 3.6 |
| Degraded Aesthetics | 4.5 | 4.4 | 4.1 | 4 | 3.5 | 4.4 | 4 | 3.8 | 3.7 | 3.7 | 3.4 | 3.7 | 3.4 | 3.9 | 3 |
| F & W Populations | 4.5 | 4.4 | 3.8 | 3.3 | 3.5 | 4.1 | 4 | 4 | 3.6 | 3.4 | 2.9 | 3.5 | 3.6 | 4.2 | 3.4 |
| F & W Consumption | 4.4 | 4.1 | 3.7 | 3.1 | 3.3 | 3.8 | 3.7 | 3.7 | 4.5 | 3.2 | 3.8 | 3.8 | 3.1 | 3.7 | 2.6 |
| Eutrophication | 3.4 | 3.5 | 3.8 | 3.3 | 3.2 | 3.3 | 3.5 | 3 | 4.3 | 3.1 | 3.8 | 3.8 | 3.2 | 3 | 3 |
| F & W Tainting | 4.1 | 4 | 3.5 | 2.9 | 3.1 | 3.6 | 3.6 | 3.6 | 4 | 2.8 | 3.2 | 3.5 | 2.9 | 3.4 | 2.6 |
| Dredging Restrictions | 3.7 | 3.5 | 3.8 | 3.8 | 3.6 | 3.8 | 3.1 | 2.5 | 3.3 | 3.6 | 3.4 | 2.8 | 3 | 3 | 2.8 |
| Degraded Benthos | 3.9 | 3.8 | 3.3 | 2.8 | 2.7 | 3.6 | 3.5 | 3.7 | 3.6 | 2.9 | 2.9 | 3.1 | 3 | 4 | 3 |
| Fish Tumors | 4 | 3.6 | 3.3 | 2.8 | 3 | 3.5 | 3.4 | 3.7 | 4 | 2.8 | 3.2 | 3.2 | 2.7 | 3.3 | 2.7 |
| Wildlife Deformities | 3.4 | 2.9 | 2.8 | 2.7 | 2.7 | 3.2 | 2.9 | 3.1 | 3.5 | 2.7 | 3 | 2.8 | 3 | 3.5 | 2.9 |
| Ag/Industry Costs | 2.7 | 2.6 | 3.5 | 3.6 | 3.6 | 2.8 | 2.9 | 2.6 | 3.2 | 2.5 | 2.9 | 3.2 | 3.3 | 2.8 | 2.8 |
| Plankton Populations | 3.5 | 3.1 | 2.8 | 2.7 | 2.8 | 3.3 | 2.8 | 3 | 3.3 | 2.5 | 2.8 | 2.7 | 2.7 | 3.3 | 3 |

of advantages and disadvantages for individuals among all groups of the community (see Table 1 for a complete list of citations). Whereas resiliency, understood as including characteristics that support a community's ability to respond to, withstand, and thrive against adverse situations, by facilitating adaptation (Lerch, 2017; see Table 1 for a complete list of citations), is used to directly define some attributes such as land development, employment and climate change resilience building, while other attributes such as health, sustainability initiatives and community participation are attributes necessary to support resiliency (see Table 1).

This definition was derived after directed content analysis revealed 433 potential metrics from the literature (ESM Appendix S4), which were grouped into 15 diverse community revitalization attributes representing all three pillars of sustainability (Goodland and Daly, 1996; Purvis et al., 2019; Table 1). This approach was preferred over the common practice to rely solely on economic indicators to conceptualize revitalization (Great Lakes Commission, 2018; Hartig et al., 2019), to reduce the likelihood of potential negative externalities associated with a narrow understanding and quantification.

The complexity of these community revitalization attributes and the need to expand the definition of community revitalization beyond just economics, is best illustrated through the concept of "housing." We found that housing should not only be considered under the pillar of economic development, but also the social pillar of sustainability (Table 1). With regards to community revitalization, housing can and should be described through the lens of land development (under the economic pillar). However, if the definition is limited to the number of houses built or increasing property values (Gamper-Rabindran and Timmins, 2013), important social (quality of life) benefits, such as equity (Banzhaf, 2012; Banzhaf et al., 2019) and access would be ignored (Doick et al., 2009; Lawrence, 1997).

### *AOC-Revitalization Framework Development Step 2–4: Survey and focus group results and discussion*

Overall, survey results revealed BUI removal would have a positive effect on revitalization attributes. Of 210 responses (i.e., all 14 BUIs $\times$ 15 attribute combinations), mean response scores ranged from 2.46 to 4.87 out of a minimum of 1 (not very likely) and maximum of 5 (very likely). Only 56 response means had a score $\leq 3$, while 111 had mean scores between 3 and 4, and 43 responses had means $\geq 4$ (Table 2). Focus groups participants confirmed survey results and reiterated that BUI removals likely catalyze a positive impact on revitalization.

Focus group participants outlined two potential reasons that BUI removals would catalyze positive impacts on revitalization: the environmental changes themselves and the perception of progress they represent. The ability of BUI removals to impact revitalization was primarily interpreted by focus group participants as programmatic "management actions", or large-scale environmental projects (e.g., sediment remediation or habitat restoration). Most spoke of the documented environmental change embedded in BUI removals as the catalyst for community revitalization. However, some respondents also stated that for the community to capitalize on BUI removal, the community must observe the environmental action taking place. This is exemplified by one participant, "the whole is greater than the sum of its parts. I think when we are talking about revitalization we are talking about a social process and perception factors in very, very heavily. People see that things are happening. They see the momentum and momentum builds upon itself." For example, when seeing dredge material or debris removal, the community perceives action and progress, and this stimulates reinvestment particularly when the community was engaged and participated in the clean-up decision (Maxwell et al., 2018).

This could be due to the fact that sediment contamination and remediation can be difficult to conceptualize for those without environmental training (Great Lakes Water Quality Board and International Joint Commission, 2000). While waters may appear clean or the aesthetics of a waterway has improved before remediation has occurred, underlying contamination may still remain. This was demonstrated in research into community perceptions of contaminated sediment in the Sheboygan River AOC. It revealed a disconnect between awareness of the presence of fish advisories and sediment contamination as the reason for these advisories (McCoy and Morgan, 2012). This result may not be able to be

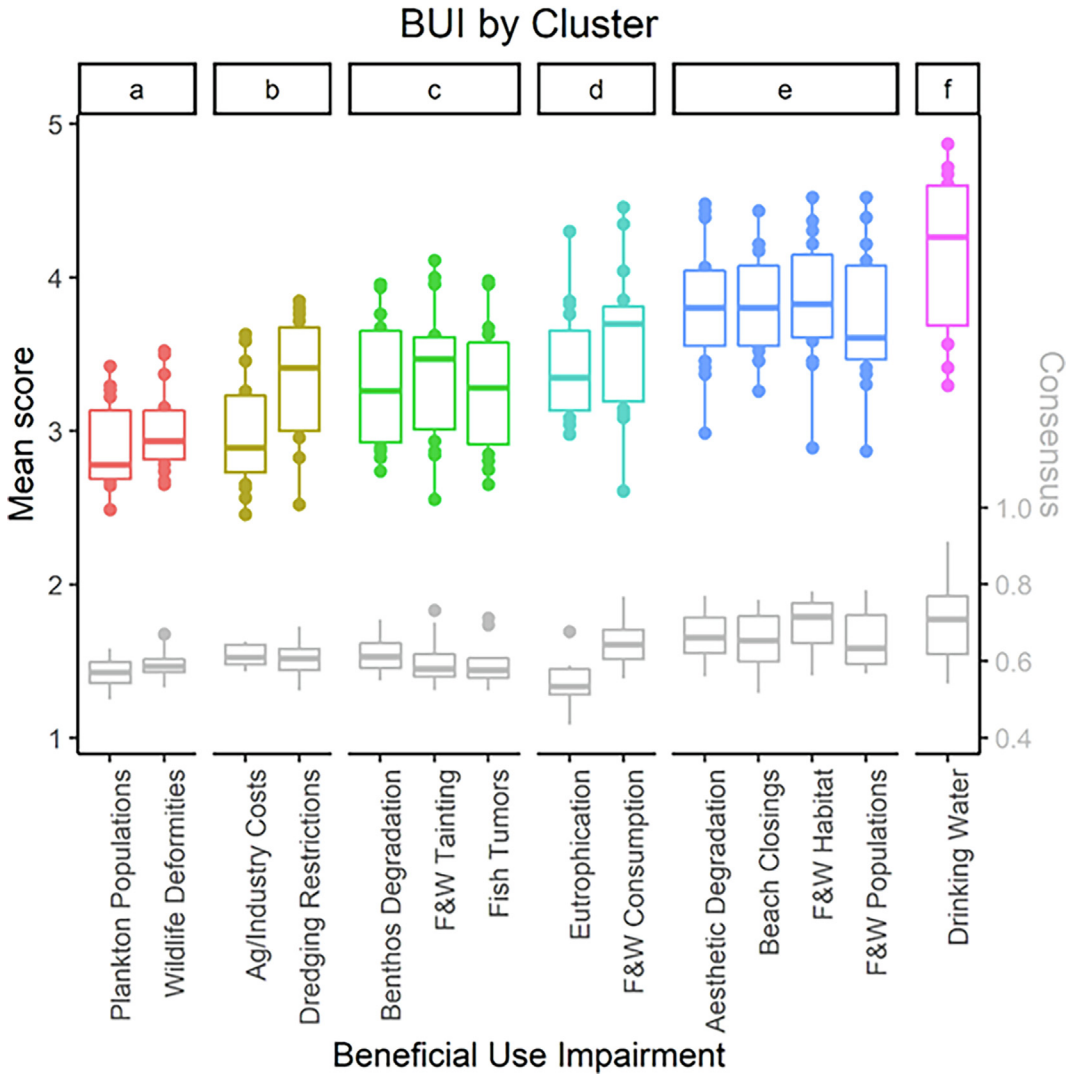


**Fig. 3.** Boxplots of BUI mean likelihood scores ($n$ = 15). Dots represent the mean likelihood scores for each revitalization attribute on a 5-point scale: "very unlikely" (1), "somewhat unlikely" (2), "neutral" (3), "somewhat likely" (4), and "very likely" (5). Boxes represent the interquartile ranges and middle bars represent the median scores. Whiskers indicate the highest and lowest values within the 1.5x interquartile range of the 25th and 75th percentile. BUIs are grouped according to the cluster analysis (colored). Consensus is shown in gray and on the secondary axis.

extrapolated to projects occurring on a larger scale, or to populations knowledgeable about the benefits of sediment remediation and habitat restoration or what successful results look like, but it makes a strong case for communication, outreach, and robust community engagement (Schuett et al., 2020).

Consensus analysis confirmed that participants were largely in agreement on the likelihood that BUIs would positively affect revitalization. Responses can largely be separated as agreement that BUI removal will have a neutral effect (i.e., Consensus > 0.5, Score $\leq$ 3), or agreement that BUI removal will have a positive effect (i.e., Consensus > 0.5, Score > 3), with agreement increasing with expected likelihood of a positive effect (ESM Appendix S2, Fig. S1). We found that only the BUIs – Wildlife Deformities, Ag/Industry Costs, and Plankton Populations had median scores $\leq$ 3, and the Consensuses were in mild agreement (Consensus = 0.57–0.65). A pattern of an increasing Consensus (range = 0.43–0.9; average = 0.63) can be observed as the median response of mean scores increase across BUIs (Fig. 3) and revitalization attributes (Fig. 4). Only two combinations resulted in disagreement (Consensus < 0.5), but a mean response score > 3: the removal of the Eutrophication BUI on the Recreation and Waterfront Identity attributes. While not discussed in the focus group, this could be due to the diversity of BUI removal criteria and management actions, or lack thereof, associated with the Eutrophication BUI across AOCs.

BUI removal was expected to positively affect revitalization differently based on the BUI being removed. Similarity profile analysis (SIMPROF) identified six clusters of BUIs expected to have similar effects on revitalization attributes within clusters but different effects relative to other clusters (Fig. 3): cluster *a.* includes Plankton Populations and Wildlife Deformities, cluster *b.* includes Ag/Industry Costs and Dredging Restrictions, cluster *c.* includes Degraded Benthos, Fish and Wildlife (F&W) Tainting, and Fish Tumors, cluster *d.* includes Eutrophication and F&W Consumption, cluster *e.* includes Degraded Aesthetics, Beach Closings, F&W Habitat, and F&W Populations, and cluster *f.* includes only Drinking Water.

Focus group results confirmed clusters and contextualized them having either a direct effect on revitalization or more indirect effect. In most cases, focus group participants described BUI removals with a more direct effect on revitalization attributes as easier to conceptualize (clusters *d*, *e*, and *f*) than those with a more

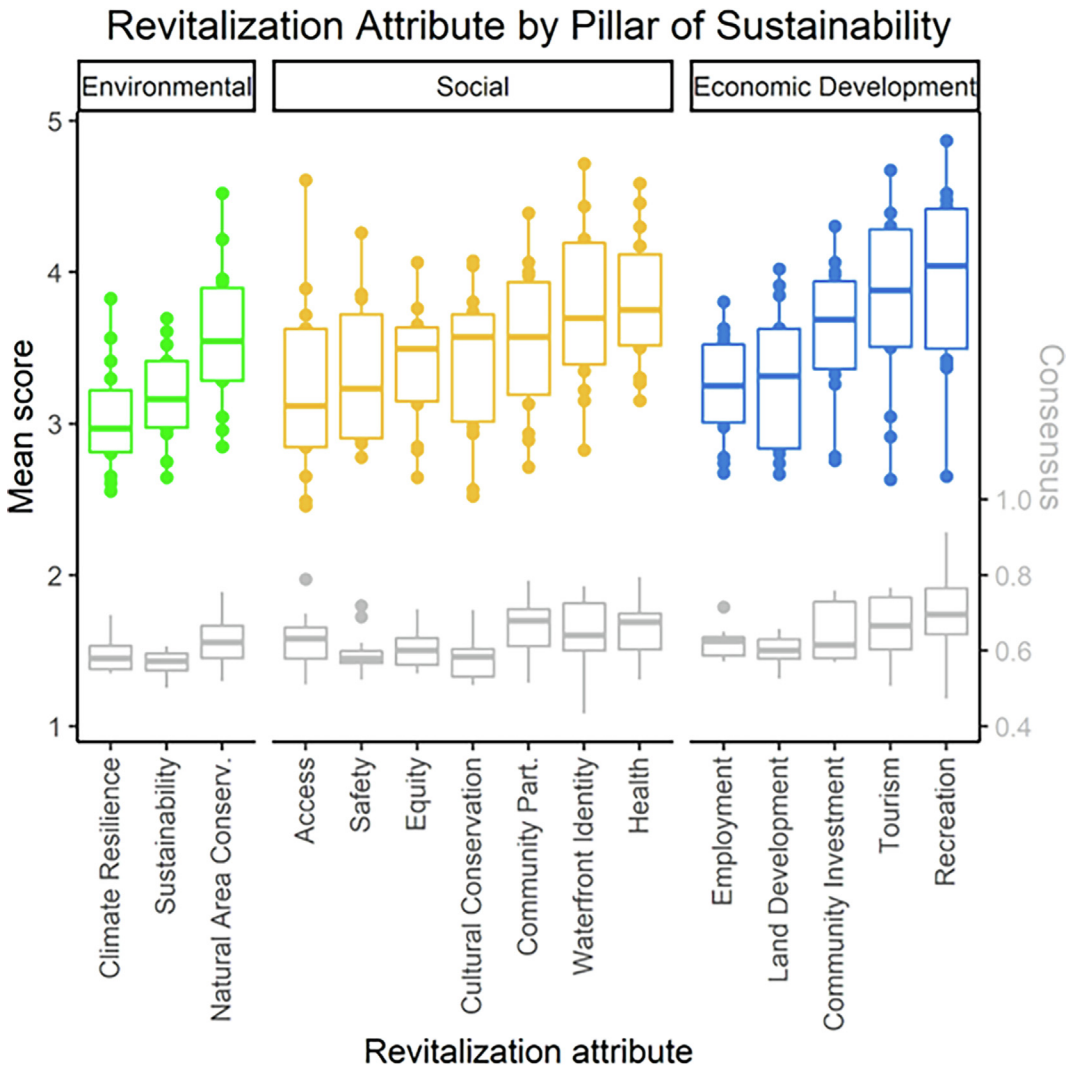


**Fig. 4.** Boxplots of revitalization attribute mean likelihood scores ($n$ = 14). Revitalization attributes are grouped by the 3 pillars of sustainability (colored). Dots represent the mean likelihood scores for each BUI on a 5-point scale: "very unlikely" (1), "somewhat unlikely" (2), "neutral" (3), "somewhat likely" (4), and "very likely" (5). Boxes represent the interquartile ranges and middle bars represent the median scores. Whiskers indicate the highest and lowest values within the 1.5x interquartile range of the 25th and 75th percentile. Consensus is shown in gray and on the secondary axis.

indirect effect (clusters *a*, *b*, and *c;* Fig. 3). Actionable or direct BUI removals scored higher across revitalization attributes in general. For instance, the removal of BUIs like Drinking Water, F&W Consumption, and Beach Closings were described as "anthropocentric" and directly related to the revitalization attributes. However, the Plankton Populations and Wildlife Deformities BUIs were described as "ecological" and considered to have a less direct or nonlinear relationship and thus more difficult to conceptualize. Results of the survey generally support this explanation with few outliers such as the Dredging Restrictions BUI, which would be considered an "anthropocentric" BUI, but had a low likelihood to stimulate community revitalization. One focus group participant stated, "it may be hard to see the change with ecological BUIs, but if local leaders make that known to the community and show that there is an investment in the community to improve the environment that is what leads to these revitalization attributes." This result again makes a strong case for engaging the community and communicating the complex ecological benefits associated with BUI removal.

Focus group participants were asked to resolve the apparent conflict between the high Drinking Water scores, with no direct actions, and the low scores of BUIs with highly visible management actions – like Dredging Restrictions (no mean scores for any attribute $\geq$ 4; Table 2). Focus group participants were surprised by the lower scores of the Dredging Restrictions BUI but reiterated that the effect of drinking water on waterfront communities was easy to conceptualize, while not explicitly describing BUI removal as having a direct or indirect impact on revitalization. Although the Drinking Water BUI in an AOC context does not represent a lack of clean drinking water to the community, rather the added costs to treat drinking water, participants expressed a likely visceral reaction because of the severe consequences of impaired drinking water. One focus group participant outlined the history of the BUI in relation to cholera outbreaks and emphasized, "if you can't even drink the water then how can you do other things. It effects everyone." Another participant added, "the water is a part of people's identity. Businesses boast using pure Lake Superior water. An impairment to drinking water would make this difficult." Recent drinking water crises such as the 2014 harmful algal bloom on Lake Erie which left 400,000 people without safe drinking water in Toledo, and the lead contamination in Flint, Michigan that left residents without clean drinking water for multiple years demonstrate the real possibility of impaired drinking water in the Great Lakes region, which may contribute to the stigmatization of the

Drinking Water BUI (Baum, 2016; Baum et al., 2016; Butler et al., 2016; Pieper et al., 2018; Steffen et al., 2017). As a result of this possible stigmatization, if a Chamber of Commerce is told the Drinking Water BUI has been removed, this might stimulate revitalization through a *perceived effect*; communities feel they no longer have to worry about a potential compromise to a community's basic need (Pierce and Gonzalez, 2016).

*AOC-Revitalization Framework Development Step 5: Putting it all together*

After community revitalization within Great Lakes AOCs was defined, the survey data were used to build the AOC-Revitalization Framework – a generalizable model applicable to all AOCs that describes the relationship between remediation and restoration (measured via. BUI removal) and community revitalization (measured via. revitalization attributes). The framework depicts BUIs as barriers to revitalization and hypothesizes that the removal of these barriers would have a positive impact on the corresponding revitalization attribute (Fig. 5). A key tenant of this framework is the finding: all BUI removals are not expected to have equivalent effects on revitalization. Of the 210 BUI-revitalization attribute relationships, 20.5% were included in the model (mean Likert scores $\geq$ 4). Four of the 14 BUIs (Dredging Restrictions, Wildlife Deformities, Ag/Industry Costs, Plankton Populations) had mean Likert scores < 4 (less than somewhat likely; Table 2) for all revitalization attributes and thus were excluded from the framework. The Drinking Water BUI was associated with the most revitalization attributes (9), and two BUIs, F&W Populations and F&W Habitat, affected at least one revitalization attribute within each of the three pillars of sustainability. All but three revitalization attributes, Employment, Sustainability Initiatives, and Climate Change Resilience Building, had a mean Likert score $\geq$ 4 (somewhat likely-very likely) with relation to at least one BUI. AOC-Revitalization Frameworks for each of the respective 31 U.S. AOCs are provided in Appendix S5. Using the Ashtabula AOC as an example, we hypothesize that the removal of the F&W Consumption, F&W Habitat, F&W Populations, Fish Tumors, and Degraded Benthos BUIs would catalyze the following attributes: Recreation, Tourism, Stimulated Community Investment, Waterfront Identity, Community Participation, Cultural Heritage Conservation, Health, and Natural Area Conservation (see Table 1 for citations). Potential metrics and indicators to measure or represent these attributes, such as "Sense of Place" (Anguelovski, 2015; Doick, et al., 2009; Hartig and Wallace, 2015; Revitalization Attribute: Waterfront Identity), "use of the Commercial Stabilization Tool" (Reece, 2004; Revitalization Attribute: Cultural Heritage Conservation) or "Strength of Network Organizing" and "Rate of Churning Movers" (Tatian et al., 2012; Revitalization Attribute: Community Participation), can be found in ESM Appendix S4.

*AOC-Revitalization Framework and study limitations*

At this point, the AOC-Revitalization Framework includes best professional judgment of AOC program experts (i.e., U.S. federal practitioners and researchers) and does not incorporate the opinion of community planners, elected officials, or members of the public. The AOC-Revitalization Framework serves as an initial framework and an iterative process remains to further refine the model, based on broader complementary perspectives and expertise.

While BUIs are the metric of success used by the AOC program, a more all-encompassing indicator compared to management actions complete or environmental quality data alone, and account for other potential confounding factors such as a perceived effect described in this study, the AOC-Revitalization Framework does not, however, consider some spatially or temporally confounding factors. The relationship presented in the AOC-Revitalization Framework is generalized across all AOCs and assumes that that BUI removal would catalyze revitalization the same way in each community and ignores how spatial variability, other simultaneous community investments, differences in BUI removal criteria, and cumulative effects of multiple BUI removals, may impact the relationship between BUI removals and revitalization attributes. For example, BUI removal is typically focused on the waterbody or watershed, management actions are typically at an even smaller project scale, and revitalization is often expected to occur at the larger community or neighborhood level. For instance, the St. Louis River AOC remedial action plan lists multiple projects across 42 remediation and restoration sites, but the AOC-Revitalization Framework contextualizes the impacts of BUI-removal associated with these projects across the greater Duluth/Superior AOC, not just those living nearest to these project areas (Great Lakes Commission, 2018). Temporally, many years can separate completed management actions and related BUI removals, and subsequent revitalization impacts may take place before BUI removal or much later. For instance, in the Muskegon Lake AOC, substantial actions to remove the F&W Habitat and F&W Populations BUIs have been completed but have not resulted in BUI removals to date (US EPA, 2019). However, subsequent revitalization impacts have already been documented (Isley et al., 2011) and additional revitalization benefits may continue to be realized. These confounding factors may make it difficult to isolate the impact of BUI removal on revitalization. Nonetheless, this framework provides a robust jumping-off-point for future research and supports the ease of programmatic communication.

Lastly, our survey only tested a positive relationship between BUI removal and revitalization attributes and did not address any potential negative effects BUI removal could have on revitalization attributes. We also note that directed content analysis was conducted by one researcher. Codes were not cross-referenced with another coder.

Case studies that consider a broad suite of ecosystem services and health impacts are necessary to ground this framework locally and test the AOC-Revitalization Framework (Angradi et al., 2019; DeWitt et al., 2020; Harwell et al., 2021; Newcomer-Johnson et al., 2020). Such case studies can utilize the diversity of metrics and indicators compiled in this study (ESM Appendix S4). Case studies will better assess the above-mentioned factors potentially confounding the local relationship between BUI removal and revitalization within an AOC, such as timescales, spatial scales, and differing BUI removal criteria. Further research would also inform whether a revitalizing effect increases incrementally with BUI removal and if there are greater cumulative impacts associated with removing all BUIs in an AOC.

## Conclusion

This study generated a comprehensive definition of revitalization that includes all three pillars of sustainability represented by revitalization attributes incorporated under each respective pillar (Goodland and Daly, 1996; Purvis et al., 2019; Table 1). We defined community revitalization within Great Lakes AOCs as: *locally driven community resurgence resulting in resilient and equitable enhancements to social, economic, and environmental community structures.* Developing a definition of revitalization using a bottom-up approach (metric, attribute, pillar of sustainability) allows for a more *comprehensive* understanding of a widely used, yet not often defined term (Hsieh and Shannon, 2005; Kibiswa, 2019). Furthermore, the establishment of a holistic set of revitalization attributes will allow researchers, practitioners, and com-

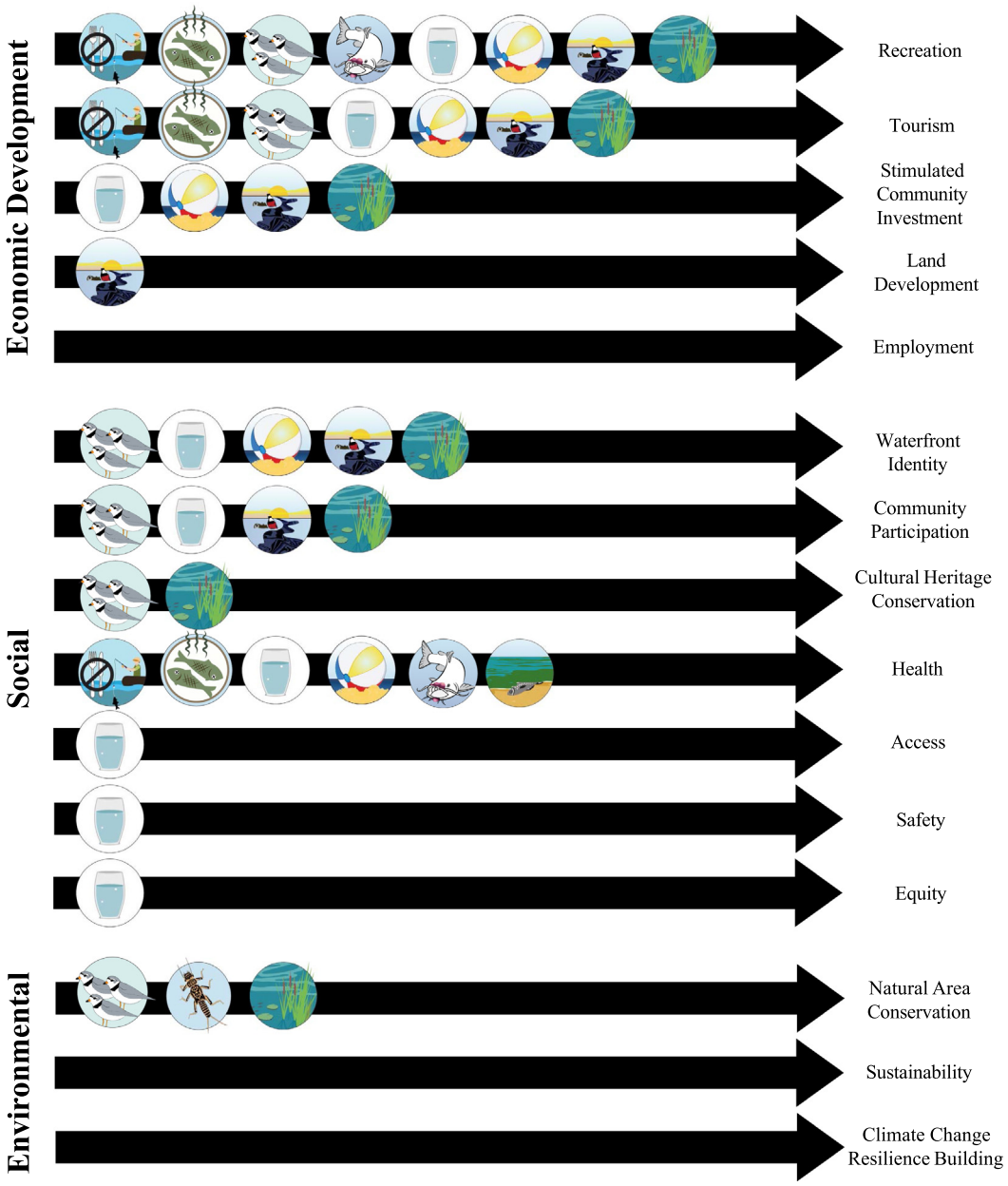


**Fig. 5.** The Areas of Concern (AOC) – Revitalization Framework. Only BUI-revitalization attribute relationships with mean likelihood scores ≥ 4 (somewhat likely- very likely) were included in the framework. BUIs are depicted as barriers to revitalization; the removal of these barriers will likely have a positive impact on the corresponding revitalization attribute.

munity leaders alike to more clearly distinguish the components of revitalization being addressed without overstating or understating extent and impact. Namely, simple and optimistic discourse around revitalization, redevelopment, and city greening that outlines win–win scenarios for environment and society often conceals or invalidates issues of equity, while hindering opportunities to achieve a more inclusive and just conceptualization of revitalization the way it is understood in this paper (Anguelovski, 2015; Pearsall and Anguelovski, 2016).

A survey of AOC researchers and practitioners was used to develop linkages between revitalization attributes and the removal of BUIs in Great Lakes AOCs and create the AOC-Revitalization Framework. Study participants expected BUI removal would have a positive effect on revitalization, but the revitalization attribute impacted was dependent on the BUI being removed. Thus, the makeup of community revitalization is hypothesized to look different in each AOC.

Focus groups brought additional context to survey results to better conceptualize how the nature of different BUIs may contribute to their impact on revitalization attributes. Namely, while the tangible ecological benefits explicitly represented in BUI removal (e.g., the removal of the F&W Consumption BUI stimulates the Health revitalization attribute) have a demonstrated effect on revitalization attributes, the perceived effect of environmental contamination and/or progress represented by BUI removal may also prove to have real implications on community revitalization attributes (e.g., without specific environmental improvements, the removal of the Drinking Water BUI stimulates 9 of 14 revitalization attributes), making a strong argument for community engagement and robust programmatic communication.

*AOC-Revitalization Framework applications and areas of future research*

The AOC-Revitalization Framework formalizes the AOC program's R2R2R hypothesis by conceptualizing AOC expert opinion on how programmatic measures of remediation and restoration activities (e.g., BUI removal) affects community revitalization. Future case studies should test our initial AOC-Revitalization Framework at a suite of AOCs. The AOC-Revitalization Framework can be refined when environmental improvements are or are not leading to community revitalization, but it can be used to identify the components of revitalization (attributes) likely impacted from AOC work. Associated metrics and indicators, compiled during the literature review, can then be used to measure these revitalization attributes. To more equitably assess community revitalization stimulation, metrics from each pillar of sustainability, and ideally from each BUI-revitalization attribute relationship present, should be used during assessment (Tiboris et al., 2019). Future research should take a critical look at potential attributes not being stimulated by AOC work (those excluded from the framework) and why. Local leaders and policy makers could also use the AOC-Revitalization Framework to better understand which components of revitalization are potentially being prioritized at the local level and which are not.

Lastly, the question of "revitalization for who?" is lacking from this research study. Additional work is needed to define who benefits from the metrics and indicators of community revitalization outlined in this study to ensure metric selection in future research is equitable and representative—much as our definition of community revitalization incorporates economic, social, and environmental attributes to support a more equitable conceptualization of community revitalization. Metrics and indicators used to measure each community revitalization attribute, must be selected in such a way to represent the needs and interests of all community members, particularly those of the most disadvantaged community groups.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jglr.2022.05.006.

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