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Walleye Ogaawag Spearing in the Portage Waterway, Michigan: Integrating Mixed Methodology for Insight on an Important Tribal Fishery

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Abstract: The Portage Waterway in Michigan's Upper Peninsula supports traditional Anishnaabe walleye (or *ogaawag* in the Anishnaabe language) spear-harvesting for the Keweenaw Bay Indian Community (KBIC). Through reserved Indian treaty fishing rights, KBIC is highly involved in the waterway's stewardship and annual community spear-harvest. Tribal leadership and fisheries personnel have long documented that annual harvests are far below sustainable quotas. The objectives of this research were to 1) understand the values and concerns of KBIC tribal members on Anishnaabe walleye (*ogaawag*) spear-harvesting, 2) examine water temperature patterns during the spring 2018 harvest to seek insight on how harvests may be optimized, and 3) integrate *Anishinaabe gikendaasowin* or traditional knowledge with science and education. We conducted an online survey in February 2018, containing 27 questions, to gain preliminary insight on KBIC's perspectives of the annual walleye (*ogaawag*) spear-harvest. Nearly all respondents highly value the spear-harvest tradition personally and on behalf of the community. Similarly, nearly all agreed that it is important for the KBIC to manage its own fishery resources, and that the Tribe's Natural Resources Department effectively does so. Respondents also expressed concerns about factors that could impact their harvests, including environmental changes and confrontations with non-Native residents. From May 1 to May 19, 2018, we deployed 13 Onset HOBO Pro V2 temperature dataloggers across the Portage Waterway to measure spring warming patterns in locations popular for spear-fishing. This period encompassed the entire KBIC spear-harvest season, with dataloggers recording water temperature every two hours. Temperature data show that management of the harvest season may need revision, as embayments and sloughs where spear-fishing largely occurs warmed significantly earlier than other parts of the waterway. As the presence of walleye (*ogaawag*) in shallow waters depends on temperature, some parts of the waterway should be opened for harvesting earlier. Our findings will be prepared in a formal recommendation for KBIC leadership in efforts to increase harvests for the Tribal community that rely on walleye (*ogaawag*) as a sacred and traditional food source.

Keywords: *walleye, ogaawag, Anishinaabe, spear-harvest, Keweenaw Bay Indian Community*

The Keweenaw Bay Indian Community (KBIC) is part of a larger Native American group known as the Anishinaabe, meaning "original person" (Benton-Benai 1988). They are one of the largest Indigenous groups in North America with nearly 150 different bands living throughout their homeland in present-day United States and Canada. Currently, Anishinaabe are known by various names: Chippewa, Ojibway, Ojibwe, or Ojibwa, as well as Ottawa or Odawa and Potawatomi or Bodewadomi. All of these peoples are bound within the Anishinaabe people, the larger group who migrated from the Atlantic shores of North America and began settling in the Great Lakes Region before 1000 AD.

The KBIC of the historic Lake Superior Band of Chippewa Indians (Anishnaabe), is a federally recognized Native American Tribe in the

United States and is dedicated to the long-term protection of natural resources and preservation of Anishnaabe culture. This dedication has contributed to the peoples' survival and resiliency for many generations. KBIC is located on L'Anse Indian Reservation approximately 65 miles west of Marquette, Michigan in the L'Anse/Baraga Michigan area. KBIC has dual land bases on both sides of the Keweenaw Bay Peninsula in the Upper Peninsula in Michigan which is connected to the Great Lakes. As a sovereign tribal nation, KBIC actively maintains scientifically-sound planning and management of water resources in partnership with many of the region's governance and educational entities. In doing so, KBIC relies on community members to ensure their efforts integrate *Anishinaabe-gikendaasowin,* an Anishnaabe phrase that is translated to mean "knowledge, information, and synthesis of Anishinaabe teachings" into community governance (Geniusz 2009). It is critical that tribes depend on local Indigenous knowledge holders – the fishers, hunters, and gatherers – to guide and inform scientific research, management regimes, and the education of future generations. Through an integration of knowledge systems, tribes and their many governance partners can learn to better understand and interact with water ecosystems. Great Lakes Indigenous communities have an important role in protecting and restoring Basin ecosystems, particularly because their knowledge and practices have been sustained in the region for millennia.

Through a series of 18th- and 19th-century Indian treaties, Great Lakes Indigenous groups retained the basis of their knowledge: the land in which they originally lived and the waters in which they traditionally fished (Doherty 1990). KBIC is signatory to two treaties with the United States. In the 1842 Treaty with the Chippewa, Lake Superior Chippewa reserved existing rights of hunting, fishing, and gathering within more than 10 million acres of ceded land and water territory for their people (Treaty with the Chippewa 1842). The 1854 Treaty with the Chippewa addresses these rights and established the L'Anse Indian Reservation, approximately 59,000 acres of land in Michigan's Upper Peninsula (Treaty with the Chippewa 1854). The region is comprised of large areas of forested land, diverse aquatic and terrestrial plants and wildlife, and vast lake and river systems with more than 160 tributaries and 70 miles of southern Lake Superior shoreline (Sweat and Rheaume 1998). In 1936 the KBIC achieved status as a federal recognized Tribe upon adoption of their Constitution and By-laws, making the KBIC both the oldest and largest federally-recognized Indian Tribe in Michigan (U.S. Department of the Interior 1937; BIA 2020). It was at this time that KBIC was established as a legal and political entity, organized in accordance with the provisions of the Indian Reorganization Act of 1934.

Since the treaty-making era, Great Lakes Tribes including KBIC have encountered dire consequences due to federal assimilation policies, state regulatory control over harvesting, and environmental degradation and contamination due to extractive industries (e.g., furs, fish, forests, and minerals) (Wilkinson 2005). Much of this history intended to thwart Indigenous knowledge and practices. For decades, treaty harvesting rights were criminalized. For KBIC, 1842 treaty rights were not reaffirmed until the *1971 People v. Jondreau* decision ruled in favor of KBIC (Supreme Court of Michigan 1971). Since that time, KBIC self-governance has grown to include Great Lakes Indian Fish and Wildlife Commission (GLIFWC) membership, operating a fish hatchery facility, and establishing a natural resources department and management regime. It is imperative to understand this history in order to understand the magnitude of both *Anishinaabe-gikendaasowin* loss and revitalization of tribes in the region, including KBIC.

Community survival and resiliency are rooted in *Anishinaabe-gikendaasowi* and are guided by the seventh-generation worldview. The seventh-generation worldview is that today's decisions should be made considering the well-being of seven generations into the future. KBIC faces many current challenges, including changes in seasonal weather patterns, increases in extreme weather events, habitat degradation, pollution, toxic contamination, and loss of native plant, fish, and animal relatives (species). These challenges are exacerbated by the KBIC's limited capacity (e.g., funds, staff, and expertise) and the influence of non-Indigenous residents on the lives of Indigenous

people in our region. Tribal communities must address ongoing threats while simultaneously revitalizing Indigenous obligations to land and life and recovering and sharing the knowledge needed to do so. These challenges yield negative social, cultural, and economic consequences, particularly due to the loss of subsistence and commercial harvesting opportunities which also impedes transmission of knowledge to future generations.

The importance of traditional ecological knowledge has been increasingly recognized for promoting resilient ecosystems and the health and safety of those who depend on them (Finn et al. 2017; Deloria et al. 2018; Seltenrich 2018). Traditional ecological knowledge encompasses generations of knowledge and worldviews of Indigenous peoples gained by direct interactions with the natural world over millennia. Its practice calls for a broad accounting of and respect for relationships that compose a holistic understanding of the world; in this view, all things are interrelated and interdependent (Kimmerer 2015; Whyte 2017; Zidny et al. 2020). For Indigenous communities, health is deeply embedded in relations to place and comprised of community, cultural, and spiritual relationships (Adelson 2000; Geniusz 2009; Gagnon 2016). Based on these understandings, governance, research, and resource management are evolving to integrate science and Indigenous knowledge aimed towards improving environmental and human health (Donatuto et al. 2011, 2014, 2016). Traditional ecological knowledge can guide, complement, and supplement biological science and management of natural resources (Menzies and Butler 2014; Zidny et al. 2020). Integrating knowledge systems has also been shown to enhance cross-cultural and cross-scale efforts to better understand social-ecological systems (Berkes 2004) and to increase the relevance of research (Berkes 2012). The health and safety of KBIC requires the ability to use and share its knowledge, *Anishinaabe-gikendaasowi,* across Tribal departments, so that traditional knowledge and science can be integrated to strengthen community and ecosystem resilience for current and future generations. Like many tribes, however, the KBIC is aware of past instances of abuses or disregard of its knowledge by outside researchers, and now requires approval by Tribal leadership to ensure that proper protocols are in place, including ownership of data (Chief et al. 2016; Maldonado et el. 2016).

KBIC is acutely aware of harmful environmental trends and increased potential for extreme events that negatively impact Tribal treaty and trust resources, economic well-being, local infrastructure, and the health and safety of KBIC (KBIC 2002; Gagnon et al. 2013; Nankervis and Hindelang 2014; Kozich 2016; TAM Team 2019). The protection and restoration of Treaty resources are a KBIC priority because Tribal members depend on healthy ecosystems for subsistence, commercial, and cultural purposes. Traditional foods and medicines such as fish, wild game, wild rice (*manoomin*), berries, trees, and plants are gathered within water and terrestrial landscapes in both the local and wider region (GLIFWC 2014). Thus, many stories and observations from KBIC Tribal members and descendants inform management practices and implementation of KBIC strategic plans; their insights are also critical for KBIC governance and planning into the future. Harvesting practices are a means of community identity and well-being (Gagnon 2016; Kozich 2016, 2018), and harvesting is also a vast source of traditional knowledge and community resiliency (Wilson 2001; Whyte 2018). Further, sharing knowledge strengthens cultural identity, fostering resilience (Unger 2011; Wexler 2014). Community fishers, hunters, and gatherers have shared their experiences and knowledge about concerning trends in the area such as the disruption of seasonal phenology, the loss of hunting and gathering grounds, shifts in fish, wildlife, and plants' species, and changes in seasonal temperature trends, including ice cover and access to ice fishing. Clearly, the integration of local knowledge is a priority in water research and education in Keweenaw Bay.

In this study we examined current walleye (*ogaawag*) spear-fishing practices, which follow traditional methods, and integrated continuous water temperature data in walleye (*ogaawag*) habitat to assess the effectiveness of management strategies related to the annual spear-harvest tradition. Spear-harvesting occurs after dark, typically from boats cruising through shallow waters that the walleye (*ogaawag*) enter to

spawn at night. Headlamps are worn by fishers, illuminating the eyes of the fish to therefore detect their location. The harvest season occurs in spring during a period of rapid water temperature changes, and the success of the harvest relies on an intimate understanding of walleye (*ogaawag*) behaviors that are linked to specific habitat conditions such as water temperature.

Study Area

The Portage Waterway consists of North and South Entry (connected to Lake Superior), Portage Canal, Portage Lake, Torch Lake, and several smaller bays and connecting waters (Figure 1). The two most popular sites for KBIC spear-fishers are Pike Bay and Dollar Bay, which are small, shallow bays on the south and north sides of Portage Lake, respectively. The total surface area of Portage Waterway is approximately 53 km^2 (Breck 2004). The moderately-developed shoreline totals 145 km, and the 900 km^2 watershed is mostly forested (Hanchin 2016). The waterway bisects the Keweenaw Peninsula that juts into Lake Superior as the northernmost point of mainland Michigan. The peninsula is characterized by billion-year-old geological formations containing among the purest copper in the United States, with peaks exceeding 500 meters in elevation. The peninsula's largest population centers originated as mining settlements in the 1800s. The largest cities, Houghton and Hancock, have a combined population of around 12,000 and are situated on the shores of the Portage Waterway.

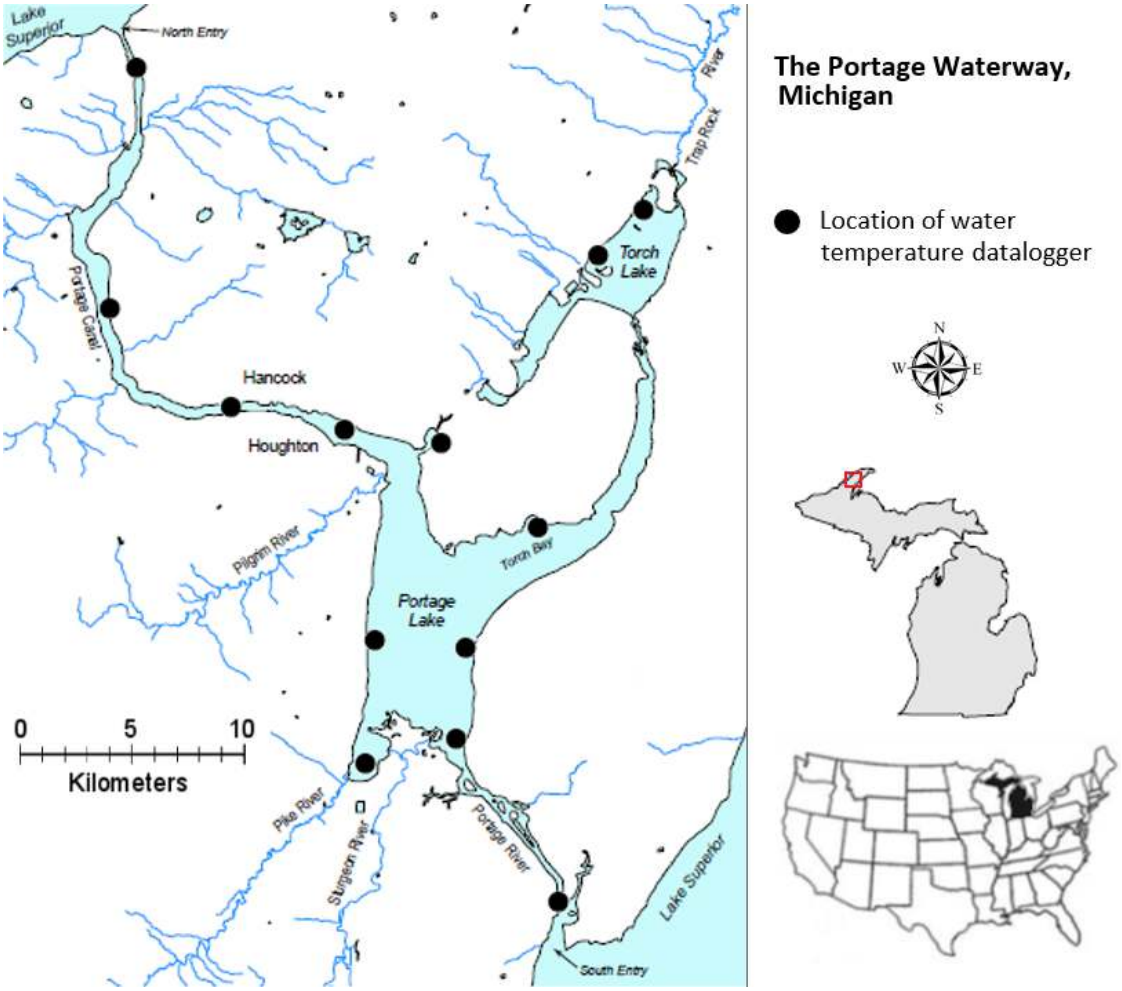

Figure 1. The Portage Waterway system, with dots representing temperature datalogger locations (Image modified from Hanchin 2016).

The waterway is vast and diverse and supports a robust fish community, despite being subjected to a wide range of human-caused disturbances such as shoreline development, dredging and channelization, and industrial contamination (Hanchin 2016). The waterway is located outside the L'Anse Indian Reservation but is within the ancestral homeland of the KBIC. Thus, KBIC members reserve fishing rights to it through the 1842 Treaty with the Chippewa (Treaty with the Chippewa 1842). Walleye (*ogaawag*) are the primary fisheries management species for the KBIC at this site.

The annual Portage Lake walleye (*ogaawag*) harvest is a carefully overseen event. Each fisher is typically allowed to harvest five fish daily. Harvesting is limited to enrolled KBIC members who are required to be in possession of their Tribal identification card. Each fisher's catch is tracked by KBIC Natural Resources Department (KBIC-NRD) personnel stationed at harvest sites. KBIC leadership sets guidelines for the annual harvest in collaboration with the U.S. Fish and Wildlife Service (USFWS), GLIFWC, and Michigan Department of Natural Resources (MDNR). The MDNR plays and important role in this partnership by stocking over one million walleye (*ogaawag*) fry and fingerlings annually. A Total Allowable Catch (TAC) concept is utilized on the waterway, and KBIC is allowed a harvest quota of 2000 adult walleye (*ogaawag*) on an annual basis. This TAC quota has never been reached. A recorded harvest of 1450 walleye (*ogaawag*) occurred in 2010, and since then harvests have typically ranged from 300 to 1000, well short of the TAC. Clearly, KBIC could sustainably harvest many more walleye (*ogaawag*) from the waterway.

As part of the management strategy for Portage Waterway, there is a declaration of spearing season commencement, and closure, by the KBIC President on an annual basis. The harvest season occurs shortly after ice melt as water temperature warms in the nearshore. This is when walleye (*ogaawag*) move into shallow waters for spawning and are therefore susceptible to spearing. Spawning behaviors begin when water reaches 34°F and peaks as temperature increases to 42-44°F (Rawson 1956; Scott and Crossman 1973; Auer 1982; Becker 1983). As temperature continues warming and approaches 50°F, spawning diminishes and walleye (*ogaawag*) move out to deeper waters. The spear-harvest season ends at this time.

Based on annual harvests falling well below sustainable levels, we hypothesized that the designated timing of the harvest season may not accurately correlate with the peak abundance of walleye (*ogaawag*) in key harvest locations. Tribal management traditionally declares uniform open and close dates for harvesting across the entire Portage Waterway based on singular, daily temperature readings in the main waterway without accounting for system-wide temperature variations (and the corresponding behaviors of walleye, *ogaawag*). The objectives of this research were to 1) understand the values and concerns of KBIC Tribal members on Anishnaabe walleye (*ogaawag*) spear-harvesting, 2) examine detailed water temperature patterns during the spring 2018 harvest to seek insight on how harvests may be optimized, and 3) integrate *Anishinaabe gikendaasowin* or traditional knowledge with science and education in the community.

In 2015 the KBIC-NRD began collaborating with the Keweenaw Bay Ojibwa Community College (KBOCC) Environmental Science Department to better understand relationships between local water temperature trends and populations of culturally-significant fish species. We began by examining on-reservation streams that provide critical habitat for the brook trout, *Salvelinus fontinalis*, or in Anishnaabe *Mookijiwanibi-namegos*. In 2016 efforts expanded to include the Portage Waterway at areas of KBIC member spear-harvesting. This ongoing collaboration combines resources of both KBIC-NRD and KBOCC, including fisheries biologists, college faculty, and numerous student assistants who gain hands-on training and opportunities for independent research. The goal of these ongoing efforts is ultimately to inform KBIC leadership of potential revisions to its fisheries management in light of potential environmental changes and the substantial resources that KBIC invests in its fisheries. The KBIC-NRD actively assesses Portage Waterway walleye (*ogaawag*) populations through regular sampling, and documents in great detail the walleye (*ogaawag*) harvested by Tribal members during the annual spear season.

Methods

Tribal Approved Research

This research was designed and informed by KBIC. It is reflective of KBIC priorities, desires, and values, and its research approaches, results, and applications are intended to support Indigenous sovereignty and promote Indigenous nation-building. It is true that research with Indigenous communities is fraught with historical abuses and ongoing inequitable power dynamics (Geniusz 2009; Smith 2013; Gagnon et al. 2017). However, this study is rooted in a long-term research engagement between established partners with the goal of strengthening partnerships for community benefit. Because we have conducted respectful and equitable research in partnership previously, and have done so relying on community engagement, we employed best practices in community engagement and fostering partnership with the KBIC. Ultimately, the KBIC oversees and approves research conducted on KBIC. Therefore, all proposals and research protocols used in this study were approved by the KBIC Tribal Council and the KBOCC Institutional Review Board.

Survey

An online survey was administered for two weeks in February 2018, using Survey Monkey, to gain preliminary insight on KBIC's perspectives of the annual walleye (*ogaawag*) spear-harvest. Participants were recruited through various community social media outlets, including the KBOCC and KBIC Facebook pages. The inclusion criteria were adults of age of 18 or older and an enrolled member of KBIC. As with much research based on self-reporting, however, we did not include measures to ensure that participants met these criteria. Anonymity was protected by recording only IP addresses of participants. The survey instrument contained 27 questions covering topics of walleye (*ogaawag*) spear-harvest participation, views of KBIC management of walleye (*ogaawag*) fishery, importance of the walleye (*ogaawag*) spear-harvest tradition, and other related concerns (Appendix 1). Aside from demographic questions, most items in the survey instrument were structured using 4- or 5-point Likert scales. Questions were developed collaboratively by KBOCC researchers, KBIC member student assistants, and KBIC-NRD personnel. All protocols, including survey questions, were reviewed and approved by the KBOCC Institutional Review Board that is majority-composed of enrolled KBIC members. Participant were informed of the objectives of our research. Details of our project were clearly described, including our intent to share summary findings in a student Capstone project, with KBIC leadership, and across the broader scientific community through media such as conferences and publications. Participants had the choice of clicking to indicate their agreement and continue to the survey, or clicking to exit the survey. Participants were not compensated for completing the survey.

Water Temperature

In late April 2018, 13 temperature dataloggers (Onset HOBO Pro V2) were deployed across 13 target locations in nearshore areas of the Portage Waterway to measure the water temperature in degrees Fahrenheit (Figure 1). As soon as ice-out occurred, dataloggers were installed at sites, preceding the spear-harvest season by five days (Figure 1). The 13 target locations were selected for study based on known or suspected walleye (*ogaawag*) spawning activity. We hypothesized many of these sites to exhibit early spring warming patterns compared to the larger open-water areas of the waterway. The deployment was led by KBIC-NRD fisheries personnel assisted by KBOCC student interns. Dataloggers were attached to weights and secured to the substrate at GPS-recorded locations at a depth of approximately one meter, corresponding to walleye (*ogaawag*) spawning behaviors and suitable depths for spearing. Temperatures were recorded every two hours from May 1, 2018 to May 19, 2018. This period corresponds to five days before the harvest season, eight days of the harvest season, and five days after the season closed.

After retrieval, dataloggers were returned to the KBOCC science lab for data upload and analysis. Dataloggers were removed from their protective housing and linked to a computer using proprietary HOBO hardware and software. Outliers removed included temperature readings recorded between the time dataloggers were activated in the lab and

when they were deployed in the water. Analysis occurred after individual data files were converted from the HOBO software to spreadsheet format using Windows Excel.

Comprehensive harvest data were collected nightly at harvest sites following established annual protocols approved by KBIC leadership. KBIC-NRD personnel, assisted by technicians and KBOCC student interns, recorded the number of fish harvested as well as the size, weight, and sex of each. As in all annual harvests, findings were integrated into an annual report prepared for KBIC leadership and agency partners and were shared with us as part of this collaboration.

Survey Results

The survey recruitment yielded 53 participants over a two-week period in February 2018. Some respondents did not answer all survey questions; consequently, the details that follow reflect responses ranging from 49 to 53 depending on the question. Results provide valuable insight on the importance of walleye (*ogaawag*) spear-fishing to KBIC. For instance, 33 respondents (63%) stated that they regularly participate in the Portage Waterway walleye (*ogaawag*) spear-harvest, with a plurality stating that they fish five or more nights per season. Forty-six (92%) agreed that walleye (*ogaawag*) spear-fishing in the waterway is important to them personally, while 49 (98%) agreed that it is important to the KBIC in general. Forty respondents (82%) stated that they would sign up for a free walleye (*ogaawag*) spear-fishing mentorship program if one was offered. Table 1 summarizes the reasons for participation in the walleye (*ogaawag*) spear-harvest.

The survey contained two questions related to sovereignty and treaty rights. When asked about the importance of the KBIC managing its own walleye (*ogaawag*) fishery at the Portage Waterway, all 50 respondents agreed that it is important (86% strongly agreed; 14% somewhat agreed). Similarly, all but two respondents (96%) agreed that KBIC-NRD manages the fishery effectively.

Respondents expressed many concerns about the walleye (*ogaawag*) spear-fishing tradition in the waterway. Forty-three (86%) agreed that they are concerned about the safety of eating walleye (*ogaawag*) due to mercury or other contaminants. Most respondents also agreed that their harvests have already been impacted by other environmental stressors. For instance (after removing responses of "I don't know"), 37 of 38 (97%) believe their walleye (*ogaawag*) harvests have been impacted by climate change, 36 of 37 (97%) by aquatic invasive species, and 39 of 41 (95%) by lakeshore urban development. As for future scenarios, 48 of 50 (96%) agreed that they are concerned about the potential for uncharacteristic conditions involving warming water, intense weather events, and changes to ice patterns.

As has been documented in recent decades (e.g., the "walleye war"), confrontations with non-Native residents over Tribal fishing rights appear to remain an issue in the area (Nesper 2002). Thirteen of 50 respondents (26%) agreed that their treaty-protected right to spear walleye (*ogaawag*) is respected by the surrounding non-Native community. Only eight of 50 respondents (16%) agreed that they feel safe from discrimination when spearing walleye (*ogaawag*) at the Portage Waterway. In an optional question for write-in

Table 1. Top five reasons for walleye (*ogaawag*) spear-fishing as reported by KBIC Tribal members. Respondents were allowed to select multiple answers.

Reason	Number of respondents	Percent of respondents
Exercising treaty rights	29	56
Sustenance/food source	27	52
Quality time with family	26	50
Cultural tradition	24	46
Connecting with community	12	23

comments, some respondents reported instances of verbal abuse and threats. Others described examples of non-Native lakeshore property-owners purposely startling walleye (*ogaawag*) fish by throwing rocks or shining excessive light at the water. Similar accounts were reported to KBIC-NRD personnel at fishing sites throughout the duration of the harvest season. These accounts were logged for use in official documentation submitted in a final harvest report to KBIC leadership.

Water Temperature Results

Each datalogger recorded 216 temperature readings during the deployment period. As hypothesized, different parts of the waterway exhibited different warming patterns. We found the nearshore waters of Pike Bay and Dollar Bay to have warmed the fastest of all study sites, exceeding optimal walleye (*ogaawag*) spawning temperatures before the harvest commenced (Figure 2). The rapid warming at these locations was likely a result of relatively shallow depth (4-5 m) and because they are fed by runoff from significant nearby streams. Conversely, the main Portage Lake contains the deepest water (16 m) and greatest surface area of the system and was the slowest to warm. It was the only part of the entire waterway to be mostly near ideal spawning temperatures throughout the harvest season. After the closure of the harvest on May 14, 2018, based on temperatures in the main Portage Lake, the warming pattern in all study sites appeared to stabilize during the five days of additional datalogger deployment (Figure 2).

The comparison of Pike and Dollar Bays to the main Portage Lake shown in Figure 2 is particularly useful to KBIC leadership, based on the popularity of walleye (*ogaawag*) spearing in the bays as determined by harvest data. Temperature data from the six loggers across these sites were grouped (two bay loggers and four Portage loggers), and an unpaired t-test confirmed that the differences in daily mean temperatures between the groups were statistically significant on all days of the harvest season. Data collected from the remaining seven loggers throughout the waterway showed that other sites warmed at rates between those of Pike and Dollar Bays and the main Portage Lake. Findings from these sites are incorporated in our management recommendation, illustrated in Figure 3.

The annual harvest report prepared for KBIC leadership and natural resource partners revealed that the 2018 walleye (*ogaawag*) harvest for the waterway was far below the TAC of 2000 fish. The total catch was 331 fish, representing 16.5% of what KBIC-NRD biologists established as a sustainable harvest. The harvest was impacted by a shorter than usual walleye (*ogaawag*) spearing season due to persistent ice coverage in many parts of the waterway, followed by rapid warming that resulted in turbid runoff from streams impairing visibility of walleye (*ogaawag*) in some harvest locations (as anecdotally reported on-site by KBIC fishers). These details were noted in daily records of KBIC-NRD fisheries personnel who were present at the waterway throughout the harvest.

Discussion

Respondents of our community survey clearly demonstrated that treaty fishing rights in the Portage Waterway and the annual walleye (*ogaawag*) spear-fishing tradition are highly valued. Previous interview-based research in the KBIC revealed the same conclusions but questions did not focus specifically on a singular water body or fish species (Kozich 2016, 2018). It is noteworthy that 37% of survey respondents did not report personally participating in walleye (*ogaawag*) spear-fishing, yet nearly all respondents agreed that the tradition is personally important to them. This finding could perhaps be explained by the common (and traditional) practice of harvest-sharing across the community, as well as respondents' satisfaction in knowing that important cultural traditions continue. Clarity on this question would enrich follow-up studies.

Those who do participate in walleye (*ogaawag*) spear-fishing appear to do so enthusiastically, with the majority of those participating stating that they typically fish five nights or more per season (the 2018 season lasted eight days). Furthermore, the high interest in a community walleye (*ogaawag*) spear-fishing mentorship program could be an important finding for KBIC leaders striving to develop community programs intended to restore traditional Anishinaabe culture,

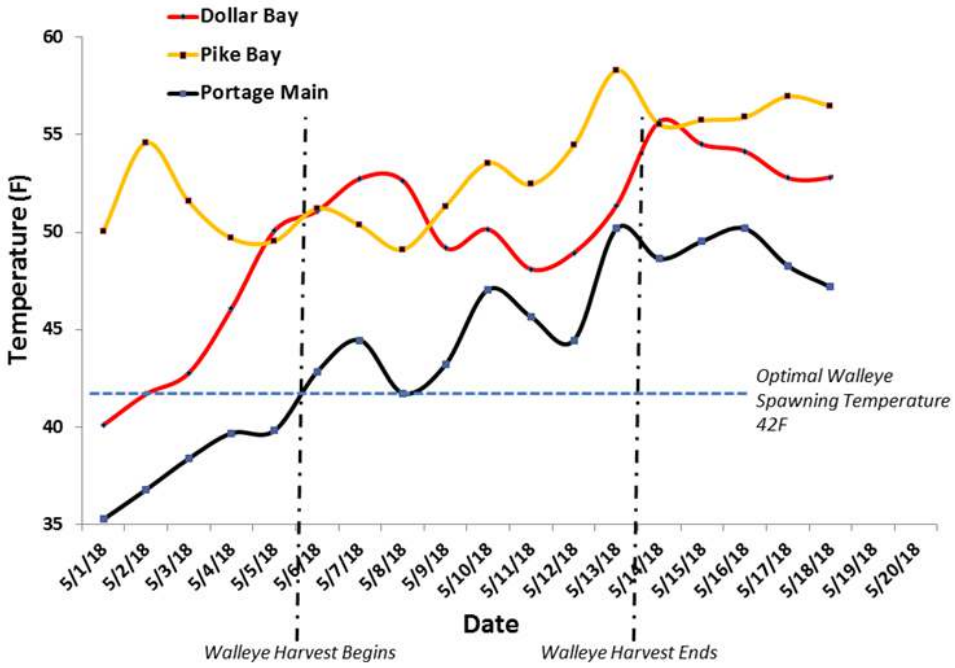

Figure 2. Comparison of water temperatures at 1 m depth in Pike Bay, Dollar Bay, and the main Portage Lake, Michigan.

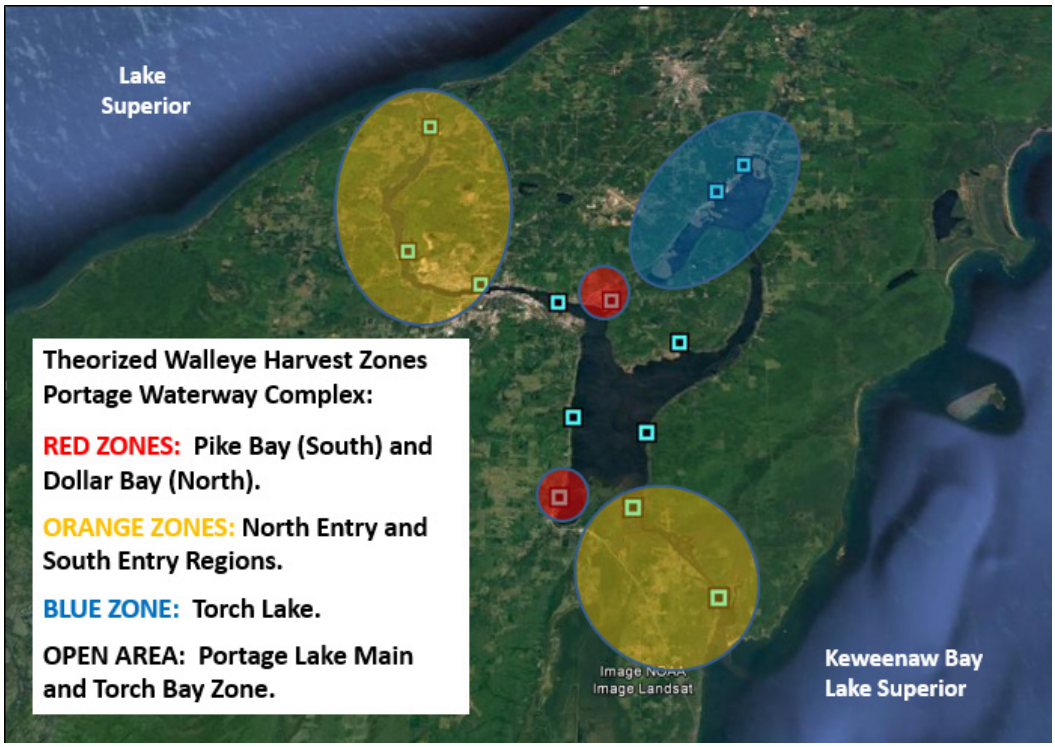

Figure 3. Recommended zoned management of the Portage Waterway system for a potentially increased spring spear-harvest season. Red zones reached optimal temperatures fastest and should be opened for spear-fishing first. Yellow zones were the next to reach optimal spawning temperature and should be opened second. The Blue zone (Torch Lake) would be opened next, ultimately followed by the Main Portage Lake and Torch Bay.

following generations of assimilation and lost knowledge. Recent community programs have successfully re-introduced KBIC members to traditional gardening, maple sugar harvesting, and wild ricing. The sharing of traditional ecological knowledge can have wide-ranging positive outcomes, not only for community members but also for natural systems (Finn et al. 2017; Deloria et al. 2018; Seltenrich 2018). In this instance, participants would not simply learn how to fish but could also develop respectful and reciprocal relationships with Mother Earth, in keeping with long-standing cultural values (Kimmerer 2015; Whyte 2017). Traditional ecological knowledge is already integrated in the biological management of the Portage Waterway, but a mentorship program led by active spear-fishers could appeal to a new generation of participants who do not have to feel ashamed of their culture in the ways that their recent ancestors did (Berkes 2004, 2012; Menzies and Butler 2014; Whyte 2017, 2018).

Unfortunately, KBIC fishers have long been subjected to harassment or intimidation (or worse) from non-Native residents (Nesper 2002), and similar incidents were again documented in the 2018 harvest report. Details of treaty fishing rights have historically been misunderstood by many non-Natives in the area. Examples of typical behaviors, as included in the 2018 harvest report, include the hurling of objects at walleye (*ogaawag*) spear-fishers from shore, distraction by the shining of bright lights, accusations of depleted walleye (*ogaawag*) populations, and the questioning about why KBIC members are not required to purchase state-issued fishing licenses. These intimidation behaviors likely explain why only 26% of survey respondents agreed that their treaty-protected rights to spear walleye (*ogaawag*) are respected by the surrounding community, and only 16% feel safe from discrimination when walleye (*ogaawag*) spear-fishing at the Portage Waterway.

Survey respondents expressed many concerns about possible negative impacts to the Portage Waterway walleye (*ogaawag*) fishery. Several KBIC departments and partners, including GLIFWC, are dutiful in their efforts to increase community awareness of local environmental issues such as aquatic invasive species and mercury exposure from fish consumption. Survey respondents appear to be quite aware of these and other similar threats, as noted previously (Kozich 2016). Researchers in the community are also aware, however, that potential negative impacts from harmful environmental trends can extend to the viability of treaty and trust resources on which the community depends (Gagnon et al. 2013; Nankervis and Hindelang 2014; TAM Team 2019). Ongoing community insight, revealed through interviews, surveys, and other media, is an essential component of community governance, identity, and resiliency.

Bountiful spring walleye (*ogaawag*) harvests could potentially reinvigorate cultural traditions and alleviate concerns about the well-being of the Portage Waterway fishery, but KBIC walleye (*ogaawag*) harvest quotas have never been approached. Only 331 walleye (*ogaawag*) were harvested during the 2018 spear season, representing 16.5% of the waterway's quota. While this total reflects a decrease from the 2017 harvest, it is not beyond recent norms. Walleye (*ogaawag*) are an important source of sustenance for community members, and the harvest tradition is an important exercise of off-reservation fishing rights guaranteed by the 1842 Treaty with the Chippewa (GLIFWC 2014; Gagnon 2016; Kozich 2016, 2018), yet the fishery resource continues to be under-utilized.

Based on findings from our water temperature data from across the waterway in May 2018 across 13 sites, we believe walleye (*ogaawag*) harvests could be maximized through a revised management plan. We believe our mixed-methods research contained a key link in this regard – survey respondents cited sustenance as an important reason for their participation in the annual spear-harvest, yet the TAC has never been reached. In other words, participants like to eat walleye (*ogaawag*) and there are many more that can sustainably be harvested from the waterway.

We found substantial differences in spring warming patterns across different zones of the waterway where walleye (*ogaawag*) spear-fishing occurs. Shallower bays and inlets warmed much more rapidly than the larger, open zones of the system. While this is not a surprise, the extent of the diverse temperature trends was not fully understood, previously. Rapid warming resulted in

popular spear-fishing locations being too warm for walleye (*ogaawag*) spawning before the spearing season opened. Harvests could likely be increased by opening the season earlier in these sites, instead of having the same opening date for the entire system.

Our pending best-management recommendation is illustrated in Figure 3. Based on our 2018 findings, the red zones in the image represent the fastest-warming areas within the waterway, and the locations to be opened first for harvesting. These embayments were shown to exceed optimal temperature for walleye (*ogaawag*) spawning before the harvest opened in 2018 (see Figure 2). In other words, the majority of walleye (*ogaawag*) had likely departed these sites for deeper waters before anyone arrived attempting to catch them. The yellow zones in Figure 3, North Entry and South Entry of the waterway, were the next to reach optimal spawning temperature and would ideally be opened secondly for harvest. These zones would then be followed by the blue zone (Torch Lake), and ultimately followed by the Main Portage Lake and Torch Bay. Implementing this type of zoned management strategy would require additional day-to-day monitoring of warming trends for maximum effectiveness regarding the timing of the season commencement. However, doing so could potentially result in a maximized walleye (*ogaawag*) harvest while keeping within sustainable limits.

We speculate that the likelihood of increased walleye (*ogaawag*) harvests from spear-fishing could lead to greater community engagement in a tradition that survey respondents identified as important. Respondents were clear in their agreement that walleye (*ogaawag*) are a key source of sustenance and that spear-fishing is a valued cultural and family tradition. For instance, the fastest-warming zones in our study (Dollar Bay and Pike Bay) have been identified as very popular spear-fishing sites for many community members. A better coordination of the harvest season timing with the presence of walleye (*ogaawag*) could not only provide more meals, but potentially introduce new participants to traditional fishing methods, locations, and values, assisted by scientific knowledge from management partners (i.e., KBIC-NRD and KBOCC). This outcome would speak to the concept of community *gikendaasowin* introduced earlier in this paper.

In service to the community and by incorporating Indigenous research methods, we achieved our objective of gaining preliminary insight on water temperature, harvest records, and community sentiment relevant to spring walleye (*ogaawag*) fishing in the Portage Waterway, Michigan. Despite the importance of walleye (*ogaawag*) fishing to the community, recent harvests are very low, relative to management limits. Water temperature data suggest a mismatch between harvest dates and walleye (*ogaawag*) fish spawning and migration, especially for the shallower water bodies that include the community's most popular harvest sites. We are prepared to offer recommendations to KBIC leaders for improving walleye (*ogaawag*) harvests in this valued fishery.

Our findings introduce many intriguing opportunities for potential expansion. Water temperature and walleye (*ogaawag*) harvest data were again collected in 2019, and will likewise be analyzed to see if similar trends occurred as in 2018. Ideas for future project expansion include increased emphasis on walleye (*ogaawag*) population studies, focusing on the spawning phase, as we continue learning about water temperature trends. If local spring weather patterns indicate the likelihood for long-term rapid warming trends (and correspondingly altered snowmelt rates), it could also contribute to better understanding of how runoff intensity and temperature influence the shallow embayments of the waterway. Lastly, semi-structured interviews with KBIC members could provide qualitative enrichment of key findings from our survey. We gained abundant conversational insight during our interactions with community members at fishing sites, but did not incorporate procedures suitable for their inclusion in this paper.

Conclusion

This case study represents an integration of *Anishinaabe gikendaasowin*, science and education, to explore water temperature trends in Lake Superior's Portage Waterway, Michigan, and to use those findings to inform the governance of KBIC fisheries. Our interdisciplinary research incorporates water temperature and fish harvest

data as well as findings from a survey conducted among KBIC Tribal members who fish in the waterway. In further recognition of Indigenous research methods, we also participated in daily harvests, interacting with and documenting shared knowledge from community spear-fishers to learn about relationships between humans, water, and fish (Wilson 2001; Hart 2010). In this article we share the cultural significance of the important fishery and management recommendations that could result in a more productive yet sustainable harvest for community members. The research team is composed of Tribal College faculty, a Tribal fisheries biologist, and KBIC-member Tribal College students.

Our work speaks to many organizational missions, as a collaborative effort to combine multiple ways of knowing to enhance community well-being. Research is an iterative process that extends beyond the life of a study project. Indeed, the term "re-search" conveys Indigenous ways of searching, seeking, and gathering knowledge from an Indigenous perspective. In *Kaandossiwin: How We Come to Know* (2012), Anishinaabe scholar Kathleen Absolon describes re-search as "journeys of learning, being, and doing," in which the researcher, inquiry, and approach undergo transformation throughout, and as a result of, the journey of searching. Thus, research is dependent on the positions of the partners engaged in the process. It is place-based and people-based inquiry, and the discovery process is expected to be as transformative as the resultant set of (re)solutions. In light of community values and anticipated environmental changes, our discovery process will continue.

Appendix 1

Questions included in the 2018 community survey, "Exploring perspectives on walleye (*ogaawag*) spear-fishing in the Keweenaw Bay Indian Community." Questions 6-17 and 26 used a 5-point Likert scale, ranging from "strongly agree" to "strongly disagree."

1. What is your age?
2. Are you an enrolled member of the KBIC?
3. What is your gender?
4. Have you ever participated in spring walleye (*ogaawag*) spear-fishing?
5. Please select the reasons you participate in walleye (*ogaawag*) spear-fishing (check all that apply).
6. It is important for the KBIC to manage its own walleye (*ogaawag*) fishery at the Portage Waterway.
7. The KBIC effectively manages the Portage Waterway walleye (*ogaawag*) fishery.
8. I am concerned about the safety of eating walleye (*ogaawag*) from the Portage Waterway.
9. I am concerned about environmental changes that could impact walleye (*ogaawag*) habitat in the Portage Waterway.
10. Spear-fishing in the Portage Waterway is important to me.
11. Spear-fishing in the Portage Waterway is important to the Tribal community.
12. I believe my spear-harvest has been affected by climate change.
13. I believe my spear-harvest has been affected by aquatic invasive species.
14. I believe my spear-harvest has been affected by pollution.
15. I believe my spear-harvest has been affected by urban development.
16. I believe my treaty-protected right to spear walleye (*ogaawag*) is respected by the surrounding community.
17. I believe I am safe from discrimination when I spear walleye (*ogaawag*) at the Portage Waterway.
18. What does walleye (*ogaawag*) spear-fishing mean to you?
19. How many children do you have?
20. In an average spring walleye (*ogaawag*) spear-harvesting season, how many nights do you participate in the harvest?
21. In an average spring walleye (*ogaawag*) spear-harvesting season, how many nights do your children participate in the harvest?
22. At what age did you learn how to spear-fish for spring walleye?

23. Who taught you how to spear walleye (*ogaawag*)? (Check all that apply)
24. Who taught your children to spear walleye (*ogaawag*)? (Check all that apply)
25. If your children haven't participated in spear-fishing, what has kept them from participating? (Check all that apply)
26. If there was a free mentorship program to teach myself and/or my children how to spear-harvest, I would sign up.
27. Is there anything else you would like to share?

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