A FEASIBILITY ASSESSMENT OF PROPOSALS FROM NAWASH AND SAUGEEN FIRST NATIONS COMMUNITIES TO IMPROVE THE LAKE HURON LAKE WHITEFISH FISHERY

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For: Saugeen Ojibway Nation

SUMMARY:

During a series of interviews, community members of the Saugeen Ojibway Nation raised concerns regarding the Lake Huron lake whitefish fishery that encompassed nineteen different themes. Herein we discuss several of the most prevalent themes raised by community members including harvest & management, habitat & water quality, invasive species, assisting reproduction & aquaculture/hatcheries, and stocking of other fish species. Within each of these themes, community members identified numerous actions that could be taken or further explored to contribute to the improvement of the Lake Huron lake whitefish fishery. Community members proposed numerous alternative harvesting strategies, as well as stocking of hatchery-reared whitefish. The potential impacts of both alternative harvest and stocking could be investigated further using the individual-based eco-genetic simulation model already available for Lake Huron lake whitefish. Although the Bruce Nuclear Generating Stations on the shore of Lake Huron were identified as a concern, previous assessments have concluded that it does not have a substantial impact on lake whitefish populations relative to commercial harvest. Nonetheless, further

investigation of its impacts may be warranted given current concerns regarding declines in lake whitefish recruitment. Concerns regarding the impacts of other stocked species on lake whitefish, such as salmon and trout species, was also expressed; identifying a need to better understand species interactions in the lake. Increased collaboration among First Nations and with non-Indigenous groups were proposed. It was also identified that steps to increase community involvement in research, monitoring, and management relating to the lake whitefish fishery, habitat and water quality, and invasive species should be explored. Education and outreach activities could also target youth given concerns relating to the transfer of knowledge to future generations.

BACKGROUND:

The Saugeen Ojibway Nation (SON) are a collective of the Chippewas of Nawash Unceded First Nation (Nawash) and the Chippewas of Saugeen First Nation (Saugeen). Fish are an integral part of the culture of SON for commerce, ceremony and food (Andrée et al. 2019). In 1993, the Justice Fairgrieve Decision, known within the SON Community as the Jones-Nadjiwon Decision, reaffirmed SON’s right to a commercial fishery in much of SON’s Traditional Territory (R vs. Jones, 1993). The commercial fishing waters include all the waters to the international boundary from Point Clark around the Saugeen (Bruce) Peninsula to Craigleith in Georgian Bay (Fig. 1). Many community members rely in whole or in part on the commercial fishery to support their livelihoods. For these reasons, community members are greatly concerned by the substantial declines that have occurred in Lake Huron lake whitefish (*Coregonus clupeaformis*). These communities also possess valuable, long-term knowledge gained from fishing and living on these waters since time immemorial. This knowledge has been passed down through many generations, nonetheless this knowledge is not static. SON’s knowledge develops and adapts with the changes within the lake over time. This knowledge can and should be used to guide research and management approaches geared towards ensuring the sustainability of Lake Huron lake whitefish and the fishery.

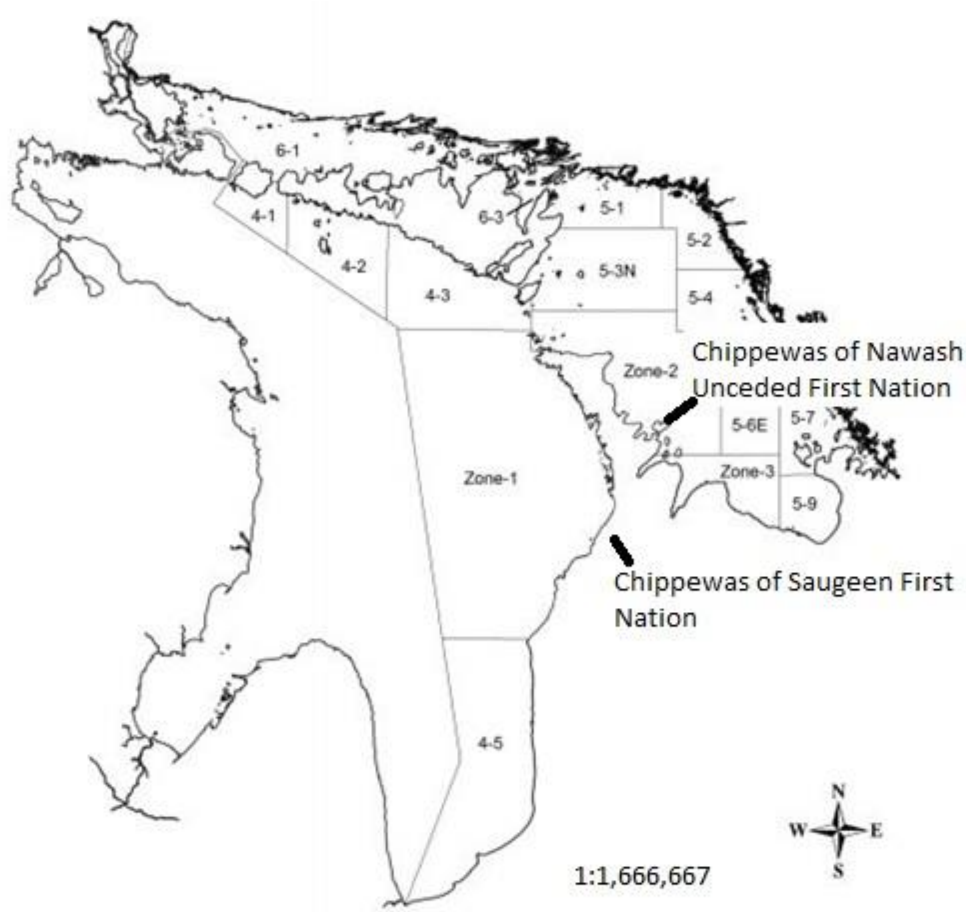

Figure 1: MNRF Quota Management Areas for the purposes of managing the commercial fishery in Lake Huron (Ontario Ministry of Natural Resources and Forestry 2018*)*

The current management of the commercial fishery is through a Substantive Commercial Fishing Agreement (2013) and a Framework Agreement (2011) between the Saugeen Ojibway Nation and Her Majesty the Queen in Right of Ontario as represented by the Minister of Natural Resources and Forestry. The 2013 Agreement was extended to 2023 by an amending the Agreement in 2018. The Governance Committee as defined in the Framework Agreement comprises:

> "… four representatives of SON and four representatives of the Ontario Ministry of Natural Resources and Forestry (OMNRF) ... At least two of the representatives of SON will be the Chiefs of SON and of the four representatives of OMNRF, one shall be an Assistant Deputy Minister (ADM). Quorum of the Governance Committee is two representatives from each Party with at least one Chief and one ADM (2011)."

All major decisions on SON's half of the Governance Committee must be approved by Joint Council. Joint Council consists of the Chiefs and Councils from both sister First Nations. Fisheries committees in both communities provide recommendations to the Joint Council. Decision-making is supported by the Fisheries Assessment Program.

The Fisheries Assessment Program is a long-term data collection program that samples commercially harvested fish from Lake Huron/Georgian Bay. The biological data collected through the Assessment Program is an integral factor in the management of Lake Huron fish stocks and aids SON in sound management and decision-making regarding their fishery. The Assessment database provides a complete and standardized historical record of commercial fish harvest and associated biological data within the traditional waters from 1995 to the present.

The general objective of the program is to provide the Council with current, year-to-date information on the SON commercial harvest. In particular, the Council requires data on (i) the quantity/quality of fishing effort deployed by operations within the fleet, (ii) the quantity/quality of gross harvests of fish species associated with the deployed effort, and (iii) sub-sampled measures associated with the biological condition (e.g. growth, age, etc.) of the gross commercial harvest. Abundance-at-age data, in conjunction with length and weight measurements are used to estimate biological parameters related to growth, maturation, and mortality, and in turn build statistical models of stock composition and production for lake whitefish in Lake Huron.

Taken together, these data allow the Councils to engage in three vital aspects of fisheries management:

1. Monitoring of year-to-date commercial harvests, relative to the total allowable catches (TACs) established by the Governance Committee,

2. Biological analysis of variation (through space and time) in the fleet's deployment of effort and gross harvests,

3. Biological modeling of fish population parameters (e.g., abundance, growth, mortality), and analysis of past and future effects of harvesting on population parameters

It was the SON community's concerns and interest in the future of lake whitefish, that led to a successful application to the Department of Fisheries and Oceans Northern Commercial Fisheries Initiative to investigate this important issue further. The questions posed to the communities and the community events were developed and conducted by the Chippewas of Nawash Unceded First Nation and the Bagida-waad Alliance, with assistance from the Chippewas of Saugeen Fisheries Assessment Program. The Bagida waad Alliance was started as a grassroots non-profit organization by Nawash fishers that were concerned about the lands and waters and wanted to make a positive impact on the issues affecting them. Dr. Jenilee Gobin was hired as a consultant to conduct a qualitative analysis of the interview data and to develop a feasibility report and implementation report as deliverables for SON. The goal of this work was to gain the community's perspectives on the causes of these declines, the current state of lake whitefish and the fishery, and potential solutions.

In the spring of 2019, interviews were conducted with the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation. Responses to the three questions (Box 1) were collected during three separate sessions, two located in Nawash and one in Saugeen. Two of these sessions (one in each location) were conducted as group sessions, where responses were recorded for each of 6 groups of individuals. During the remaining interview session in Nawash, individuals that visited the Fisheries Assessment Program booth at a community event on Heritage Day completed a written survey asking what they felt could be done to help the lake whitefish fishery. Responses from these interviews underwent qualitative data analysis using the RQDA program in R (Huang 2018), revealing nineteen general themes (Fig. 2). The feasibility of recommendations and proposals presented by community members, in order from the most to least prevalent themes, are herein discussed from an ecological standpoint to inform SON decision-making and planning.

Box 1: Questions posed during group interviews:

1) What do you think has caused the recent decline in lake whitefish?

2) What do you believe the fishery will look like in 10 years time?

3) What can we do as a community to help lake whitefish?

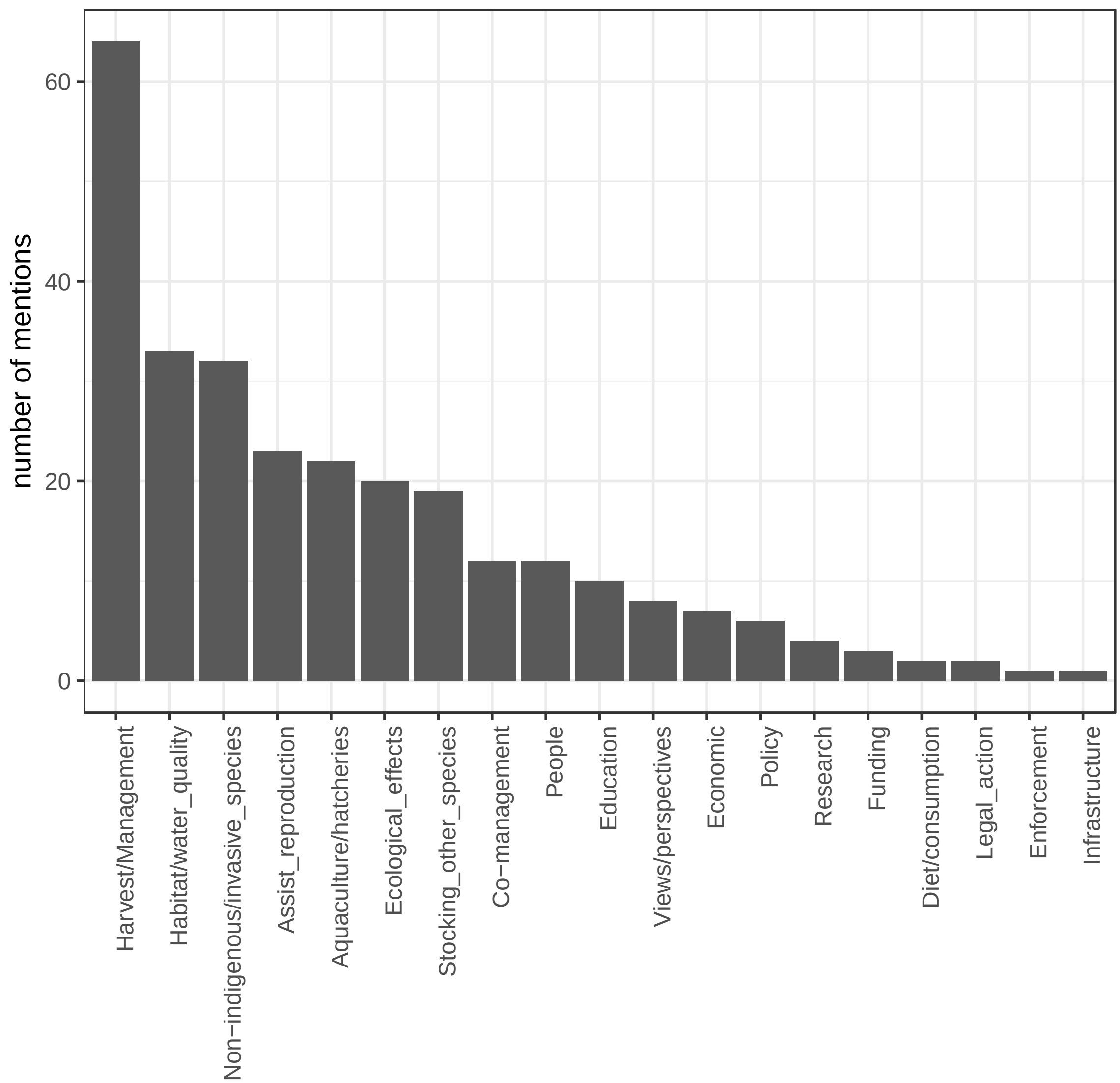

Figure 2. Nineteen themes identified by Saugeen Ojibway Nation community members during group interviews in Nawash and Saugeen and at the Heritage Day event hosted in Nawash.

Regulating harvest

How SON harvests and regulates the lake whitefish fishery was the most prevalent theme discussed during interviews. This theme was discussed both as a cause of fishery declines, and in terms of the future of the fishery and how it could be improved. Almost 25% of all topics discussed were related to this theme, demonstrating the wide range of perspectives that were expressed. Several of those interviewed felt that overharvesting and fishing nets being left out (i.e. ghost nets) contributed to the current diminished state of the fishery.

Community members made numerous specific recommendations of how they felt harvest and fishery management could be changed to improve the fishery in the future that included:

- stop harvest altogether/implement a moratorium
- limit harvest/reduce quotas
- stop harvest during spawning/implement seasonal harvest
- preserve females/do not harvest eggs
- develop sanctuaries
- regulate gear to limit sizes of fish caught (i.e., min. 5” mesh)
- implement a lottery system
- increase monitoring of whitefish and the fishery
- focus on subsistence rather than commercial fishing
- community-based co-management

Lake whitefish have a long history as a key fishery resource in the Laurentian Great Lakes. Indigenous Peoples have been harvesting lake whitefish since before the arrival of European settlers (Cleland 1982, McCullough 1987). Lake whitefish has also been the main species targeted by Great Lakes commercial fisheries since the late 1700s, with the largest yields coming from Lake Huron (Ebener et al. 2008). Lake whitefish stocks previously experienced declines that began in the late 1800s, resulting in collapse during the mid-1900s that was attributed to overharvesting, invasive species, and environmental degradation (Ebener et al. 2008). With improved fisheries and environmental management, lake whitefish recovered from these declines; but are once again at risk of collapse owing to more recent invasive species that have altered Great Lakes ecosystems, combined with continued high levels of harvest (Gobin et al. 2016). One of the objectives of this report is to present the knowledge held by SON, relating to the decline in lake whitefish. It is important to fully understand the cause of lake whitefish decline from the community’s perspective in order to determine what the community can do to limit or mitigate the negative impact of humans on lake whitefish. With this, presents a potential opportunity to bring these concerns to a broader audience.

Although, quotas have generally decreased slightly over time, harvest yields achieved remain a fraction of the quotas set since the early 2000s and have continually declined during this period (Fig. 3) (Ontario Ministry of Natural Resources and Forestry, 2018). In 2011, SON Joint Council reduced the Total Allowable Catch in the Main Basin of Lake Huron by 43% due to concerns raised by Gillis about lake whitefish (2011). Notably, in QMA 4-5 which is directly South of the SON waters in Zone 1 (Fig. 1) the quota is currently 1,044,273 RKG Ontario Ministry of Natural Resources and Forestry, 2018). This Quota is 357% greater than the TAC (total allowable catch) in Zone 1. Despite declines in lake whitefish in QMA 4-5, quotas in this management area has only been reduced 12% since 2011. The large difference between Quota/TAC in Zone 1 and QMA 4-5 and the lack of a substantial reduction in Quota in QMA 4-5 has Joint Council extremely concerned. Joint Council feels a concerted joint effort from all those fishing in Lake Huron is required to reduce fishing mortality at this time.

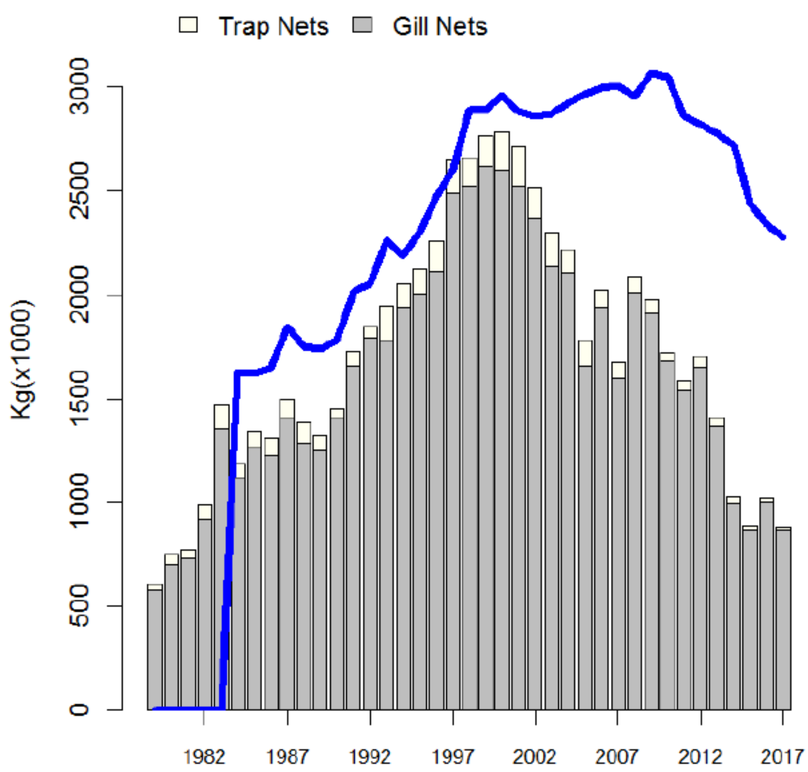

Figure 3. Lake Whitefish quota (line) and harvest (bars) for Lake Huron (Ontario Ministry of Natural Resources and Forestry 2018).

Research suggests that ecosystem changes have reduced the capacity for Lake Huron to support lake whitefish stocks, and hence the harvest yields, that it once could (Kratzer et al. 2007, Wright & Ebener 2005, Gobin et al. 2015, 2016). Using a simulation model developed for lake whitefish in the southern main basin of Lake Huron, Gobin et al. (2016, 2018) found that although reduced harvest levels and harvesting with 5” mesh nets promoted ecological and evolutionary sustainability, population biomass and harvest yield remained limited by ecosystem changes. Given this, simply reducing harvest levels or altering fishing gear may not have a substantial impact on lake whitefish recovery in the absence of further change that promotes growth and/or recruitment of lake whitefish. Model simulations in these studies were run for longer than is typical for informing short-term management decisions (e.g., 100 years of harvest), as this was not the main goal of this work. However, this simulation model could further be used to predict impacts of various harvesting and management strategies over shorter timeframes, such as added protection of females and eggs, and for examining the effects of reduced fishery harvest or closures on the demographic characteristics and dynamics of populations in greater depth.

Although the precise causes of current lake whitefish declines remain uncertain, poor recruitment is believed to be a major contributing factor (Workshop Proceedings, 2018). High catches have been linked to strong year classes for lake whitefish (Lawler 1965), but factors that contribute to recruitment remain poorly understood and is a current research priority (Workshop Proceedings, 2018). Lake whitefish recruitment has been linked to spawning stock size and climate, but these variables alone remain insufficient for reliably predicting lake whitefish recruitment (Lawler 1965, Claramunt et al. 2010). Asynchrony in recruitment trends of lake whitefish across the Great Lakes could suggest that recruitment depends mainly on density dependence and local ecological factors (Zischke et al. 2017). Determining where recruitment bottlenecks may be occurring (e.g. egg, larval, juvenile, adult life stages) also remains unknown and is of particular interest (Workshop Proceedings, 2018). From the standpoint of managing harvest, overharvesting of the spawning stocks could be negatively affecting lake whitefish via recruitment overfishing (Gobin et al. 2018); therefore, management strategies that protect the spawning stock should be examined.

An additional concern not raised during interviews but that relates to minimizing human impacts on the spawning stock is understanding the movements of lake whitefish throughout the lake to prevent overharvesting. SON traditional knowledge that has been shared with the Chippewas of Nawash

Fisheries Assessment Biologist, speaks to the migratory nature of lake whitefish. In Anishnaabemowin, the language of the Anishinaabe, there is a great deal of knowledge that has been passed down through the language and the names of animals. For example, lake whitefish is called either Atikameg or Tikmeg depending on dialect, which means caribou of the sea and describes the noise that caribou make as they walk across stones. This name relates the migratory nature of caribou on land to that of lake whitefish in the water.

The fishermen tell stories that directly relate to the biology of the fish and the physical and environmental characteristics of the waters. These factors dictate fish movements within Lake Huron. In the Main Basin, fishermen have said that lake whitefish go south during the summer to feed on the more productive sands. In the south, there are very few places to spawn, so in the fall the lake whitefish travel north to spawn in the fishing islands. This area also happens to contain many large embayment's like Stokes Bay that provide the necessary conditions for larval whitefish to develop. It is possible these fish move south after they develop further to feed on the sands. The fishermen use this knowledge to track the fish as they follow their migration paths. This kind of knowledge is an important part of being a successful fisher.

The Ontario Ministry of Natural Resources and Forestry have divided the lake into Quota Management Areas (QMA's) that are largely geopolitical in nature, but were based on historical data that suggested lake whitefish stocks were spatially separated within the lake at that time (Casselman et al. 1981). In the past, OMNRF suggested that the Alpena-Ambereley Ridge that runs from Alpena to Point Clark may act as a barrier to fish movement from North to South (OMRNF quantitative fisheries ecologist—Adam Cottrill, personal communication). However, more recent studies using genetic approaches (e.g., Stott et al. 2010, Overdyk et al 2015) and isotopic signatures (e.g., Eberst et al. 2015) to delineate stock structure suggest that current management areas are too small and do not reflect lake whitefish population structure in the lake (Eberts et al 2015). Furthermore, the utilization of boundaries as defined by the current QMA's in Lake Huron is contradictory to SON traditional knowledge about lake whitefish movements.

The lake whitefish fishery in Ontario waters of Lake Huron surrounding the Bruce Peninsula is co-managed by the Sagueen Ojibway Nation (SON) and the Ontario Ministry of Natural Resources and Forestry (OMNRF) through a Substantive Commercial Fishing Agreement, and therefore both governments engage in various aspects of regulation and reporting that includes data-sharing and joint decision-making (Ebener et al. 2008). Currently, total allowable catch quotas for Lake Huron management units and zones are estimated based on a combination of fisheries catch data and independent survey data, and assessment tools including trends in various indices (e.g., catch-per-unit-effort, age composition of the stock), surplus production models, cohort analysis, and output from statistical catch-at-age models (Jones, 2018). SON and the OMNRF are currently exploring the use of a management strategy evaluation approach that explicitly accounts for uncertainty – a significant obstacle in the current estimation process.

During interviews, community members expressed a clear desire for the management of the fishery to be community-based, allowing them to be more actively involved. Community-based co-management promotes successful resource management by enhancing knowledge generation, particularly for complex ecological systems (Olsson et al. 2004). Indigenous peoples have a long history of resource use, through which they develop their own knowledge of local ecological systems and sustainable practices to conserve their natural resources (Gadgil et al. 1993). However, co-management is an adaptive process (Olsson et al. 2004, Berkes 2009) that relies as much on fostering relationships as managing the resources themselves (Natcher et al. 2005, Plummer and Fitzgibbon 2006). The Saugeen Ojibway Nation and the Ontario Ministry of Natural Resources and Forestry are actively engaged in an adaptive co-management process and many of the building-blocks to promote successful co-management such as strong community leadership, quotas, social cohesion, and clearly defined roles and responsibilities (Pinkerton 1994, Olsson et al. 2004, Guttierez et al. 2011, MacNeil and Cinner 2013) are already in place. However, strategies that increase the community's involvement in managing and monitoring lake whitefish harvest need to be explored.

Habitat & Water Quality

The second most commonly discussed theme was habitat and water quality, which was mainly in the context of causes of lake whitefish declines. Within this theme, the topics of water pollution/contamination and the effects of nuclear power plants arose most frequently. Concerns relating to water pollution and contamination centered around agricultural run-off, garbage and littering, sewage, and effects of oral contraceptives and other drugs on fish. Concerns regarding nuclear power related to the impact of contaminants such as tritium, intakes and thermal effluent. Other concerns expressed that related to habitat and water quality included the overgrowth of algae, effects of boat traffic, and healthy shorelines.

General recommendations made were to reduce and clean up pollution/contamination in the water and along shorelines, and to regulate thermal effluent from hydropower plants.

Poor water quality (i.e., high phosphorus and nitrogen levels) played a role in historical lake whitefish declines, which greatly improved following the establishment of the Great Lakes Water Quality Agreement in 1978 (Ebener et al. 2008). However, the current challenge is the imbalance of nutrients and productivity between nearshore and offshore environments resulting from ecosystem changes associated with the dreissenid mussel invasion, whereby offshore productivity has declined substantially (Dove and Chapra 2015). These ecosystem changes have affected lake whitefish by altering the depths they occupy (Rennie et al. 2015), as well as their diets (Rennie et al. 2009), growth and condition (Rennie et al. 2009b, Fera et al 2015), and recruitment (Gobin et al., 2015). Dove and Chapra (2015) studied trends in the major nutrient species across the Great Lakes and concluded that phosphorus control is the only viable option for managing such imbalances.

Contamination and pollution in the Great Lakes as it relates to fish is also a health concern (Dellinger et al 1996, Wattigney et al. 2019). Studies in the Great Lakes have revealed that contamination levels vary for different contaminants as well as across lakes and species of fish (Gerstenberger and Dellinger 2002, Shen et al. 2010, Gandhi et al. 2017). These studies generally found that while contaminants were present in lake whitefish; concentrations were not of particular concern with respect to polybrominated diphenyl ethers (Gandhi et al. 2017), and polychlorinated biphenyls, mercury and organochlorine (Gerstenberger & Dellinger 2002) in Lake Huron. Concentrations of dioxins/furans in lake trout in Lake Huron have also declined over time (Ghandi et al. 2019). Such persistent organic pollutants can be introduced and transported through aquatic ecosystems via industrial applications and plastics (Zbyszewski & Corcoran 2011). Few studies have investigated plastics pollution in freshwater systems such as the Great Lakes when compared to marine systems (Zbyszewski and Corcoran 2011, Corcoran 2015) and in benthic environments in general (Corcoran 2015). Belontz et al. (2019) identified plastics pollution as a "wicked problem", being a global issue that requires an interdisciplinary approach to solutions. They further propose that bridging gaps between disciplines including the arts, sciences, social sciences and humanities is the best approach to addressing plastics pollution, and highlight the utility of citizen-science and community events (e.g., shoreline clean-ups) in educating and engaging communities and data collection (Belontz et al. 2019). The Bagida-waad Alliance, has been taking positive steps in this area by organizing shoreline clean ups in the SON Territory and collaborating with others on data collection. SON also collaborated with Trent University to investigate contaminants in Colpoys Bay and Owen Sound Bay, and identified a major contaminants issue in the latter (Buell et al. 2016). These findings are factoring heavily in consultation discussions on Transport Canada's intentions to divest themselves of the Owen Sound Harbour and future dredging for commercial shipping purposes.

Nuclear generating stations impact fish communities primarily through the cooling water intake systems that cause mortality through two pathways. The first pathway is called entrainment, which occurs when intake water is drawn from the lake along with small organisms such as fish eggs, larvae, and small-bodied fish species. Entrained fish are taken in, cycled through the plant, and are discharged with the cooling water. The second pathway is called impingement, which occurs when intake water is drawn from the lake along with adult fish. Impinged fish become trapped against intake screens in the "pump houses" and are disposed of. Various types of models exist to predict the effects of mortality associated with impingement and entrainment on forage fish and fishery production. However, studies have rarely found mortality associated with impingement and entrainment to have a substantial impact on fish stocks relative to other anthropogenic sources (Newbold and Iovanna 2007, Greenwood 2008. Barnthouse 2013). Notably, such models are generally simplistic and do not account for complex ecological processes or interactions with other stressors.

The assessment conducted at the Bruce Power generating station estimated forgone fishery yield due to impingement and entrainment of lake whitefish and other unidentified coregonids to be 2355 kg and 443 kg in 2013 and 2014, respectively (Golder Associates Ltd. 2017). The study also found that estimates of species-specific fishery forgone yield were higher for species with observed entrainment compared to impingement alone (Golder Associates Ltd. 2017). Few lake whitefish eggs were found to be entrained in this study, which could have resulted from very little sampling effort taking place during the late fall and winter months when spawning and egg incubation occurs in lake whitefish. More complete monitoring during these times may be useful for evaluating potential impacts due to egg entrainment on lake whitefish, which is scheduled to occur in 2023/2024 (Kathleen Ryan, personal communication). However, lake whitefish spawning habitat in the areas surrounding Bruce Power intakes and discharge channels is reported to be minimal (Golder Associates Ltd. 2017).

Effluent discharged from nuclear and other types of power generating stations can affect fish communities due to elevated temperatures and chemical additives to prevent bio-fouling. A field study on the effects of thermal effluent from the Bruce Power nuclear generating station on lake whitefish development found larvae to be larger with smaller yolk sacs; whereby growth rates are predicted to be advanced by more than 10% (Thome et al. 2016). Early hatching and decreased survival have also been demonstrated in lake whitefish in response to increased temperatures in the laboratory (Mueller et al. 2015). Advanced development and early hatching could further impact larval survival if this leads to a mismatch in the timing of the hatch with available prey (Patrick et al. 2013, Thome et al. 2016). Further research in this area is needed as some studies have found survival during early life stages to be associated with prey availability (e.g., Freeberg et al. 1990, Hoyle et al. 2011), whereas other have not (e.g., Claramunt et al. 2010).

The effects of two commonly used chemicals to prevent bio-fouling, morpholine and sodium hypochlorite, on lake whitefish embryo development were studied in the laboratory and the risk of impacts was found to be low under normal operating conditions (Thome et al. 2017). However, chronic exposure to morpholine within the industrial discharge limits resulted in embryos that hatched earlier and at smaller sizes, suggesting that regulatory limits may not be sufficient to prevent sub-lethal effects on lake whitefish (Thome et al. 2017). Verma et al. (2007 and 2007b) found that chlorine exposure augmented temperature-induced stress and immunosuppression in common carp (*Cyprinus carpio*). Studies in Europe have also demonstrated negative impacts of thermal effluent on reproduction in several other species including European perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), and northern pike (*Esox lucius*) (Luksiene & Sandstrom 1994, Sandstrom et al. 1997, Luksiene et al. 2000).

A host of collection systems, diversion systems, and physical and behavioural barriers can be employed to reduce impacts of nuclear power generation cooling systems on fish (Taft 2000, Noatch & Suski 2012). Although fish screens are commonly used to prevent fish from entering cooling systems and causing harm, they can still cause substantial mortality and many of the assumptions made regarding their effectiveness for conserving fish populations remain untested (Moyle & Israel 2005). The intake structures for the Bruce Nuclear Generating Stations are designed to minimize fish impingement, such that they are located in deep water, several hundred meters off shore, each of the intake structures are fitted with a velocity cap, and Bruce B has a chain-rope barrier to prevent schooling fish from entering the intake structure (Golder Associates Ltd. 2017) The discharge channels are also designed to minimize the impacts of thermal effluent on flow patterns (Golder Associates Ltd. 2017). However, Bruce Power will be required to undertake a comprehensive mitigation measures analysis relating to impingement, entrainment and thermal effluent (Kathleen Ryan, personal communication).

In a study conducted by Graham et al. (2016), lake whitefish stocks in the vicinity of the Bruce Power generating station were not found to be ecologically or genetically distinct from those in adjacent areas not affected by the thermal plume; it was therefore been recommended that future research focus on effects related to development and recruitment (Graham et al. 2016). Additional research in these areas is warranted given the potential effects of power generating systems and the current concerns surrounding lake whitefish recruitment.

SON has been taking positive steps in addressing the community's concerns about the impacts from the Bruce Nuclear Generating Station with the creation of the SON Coastal Waters Environmental Monitoring Program. The purpose of the program is to better understand the coastal environment, the impacts of the Bruce Nuclear generating Station, provide the proper respect and place for SON's Traditional Knowledge and "enhance SON's ability to protect our Aboriginal and Treaty Rights as they relate to the lands, waters, human and non-human beings of our Territory" (Ryan 2019).

Invasive Species

This theme was discussed in terms of its current impact on the fishery and its anticipated role in the future. A number of those interviewed felt that invasive species were responsible for lake whitefish and fishery declines. Specifically, dreissenid mussels and the negative impacts on whitefish from feeding on these mussels was a concern; lamprey and phragmites in spawning areas were also mentioned explicitly.

General recommendations were made to remove non-indigenous and invasive species, and prevent introductions in the future. Concerns about the arrival of Asian carp were also expressed.

Over the last century, invasive species have played a substantial role in shaping Great Lakes ecosystems in ways that have greatly affected lake whitefish and the fishery. Historically, sea lamprey (*Petromyzon marinus*) predation contributed to lake whitefish declines (Smith 1972). More recently, dreissenid mussels have altered the distribution of nutrients and energy in the lakes (Hecky et al. 2004, Vanderploeg et al. 2010, Higgins & Vander Zanden 2010), which has affected lake whitefish movement (Rennie et al. 2015), diets (Rennie et al. 2009), growth and condition (Rennie et al. 2009b, Fera et al 2015), and recruitment (Gobin et al., 2015). Ecosystem changes associated with the invasion of dreissenid mussels appear to have reduced the capacity for Great Lakes ecosystems to support the lake whitefish stocks they once did (Kratzer et al. 2007, Wright and Ebener 2005, Gobin et al. 2015, 2016). Shifts in the emergent vegetation characterizing coastal wetlands in the Great Lakes have also occurred with invasive species like phragmites (*Phragmites australis*) and *Tphya* spp. becoming increasingly dominant, particularly in areas that are affected by agriculture an anthropogenic disturbance (Frieswyk & Zelder 2007, Trebitz & Taylor 2007). The potential effects that such invasive emergent vegetation may have on lake whitefish has not been evaluated. However, studies that have compared the use of emergent vegetation stands characterized by phragmites or native species in the Great Lakes found no difference in the fish and invertebrate communities that occupied them (Aday 2007, Wynia 2019). Bigheaded carps (*Hypophthalmichthys* spp.) are predicted to have detrimental ecological impacts on Great Lakes aquatic ecosystems (Cudmore et al. 2012). As filter-feeders that consume phytoplankton and zooplankton, they are predicted to compete with native planktivores; and most fish species feed on plankton during early life stages and subsequently shift to alternative prey (Nunn et al. 2012). In Lake Huron, bigheaded carps will likely occupy productive embayments (Cudmore et al. 2012), which also constitutes larval lake whitefish habitat (Ryan 2012). Using a food web simulation model, Zhang et al. (2016) found that while bigheaded carp generally reduced fish and zooplankton biomass, large impacts on food webs only occurred when carp densities and declines in zooplankton and planktivorous fishes were near the levels that have been observed in the Illinois River, which represented 2% of their simulations. However, Lake Erie is notably more productive compared to Lake Huron. Further research is needed to make specific predictions regarding the impacts of bigheaded carp on plankton and fish communities (Cooke 2016).

Given the challenges of eradicating invasive species once they become established, emphasis is placed on acting early in the invasion process with the goal of first preventing invasive species introductions, followed by early detection and a rapid response aiming for eradication, controlling and containing established invasive species, and finally mitigating impacts and restoration (Hulme 2006). While sea lamprey have not been eradicated from the Great Lakes, populations have been suppressed to 10% of that in the mid-1900s through an integrated approach that targeted their unique physiology, and constitutes one of the most successful invasive species programs in the world (Siefkes 2017). Declines in lake whitefish growth are expected to make them less susceptible to predation by sea lamprey, which primarily parasitize large fishes (Gobin et al. 2016, 2018). Research on dreissenid mussels is on-going to better understand the factors influencing their spread, and to investigate chemical and mechanical means of control that has shown promise at smaller scales (Escobar et al. 2018). Phragmites is primarily managed using herbicides and mechanical removal by mowing and cutting, and new methods are being developed. However, the best approach to managing phragmites is debated, given the cost and inefficiency associated with its removal, and several studies have found that it can provide valuable ecosystem services (reviewed in Hazelton et al. 2014). Hazelton et al. (2014) also identified that additional emphasis needs to be placed on the vegetative species recolonizing sites, rather than simply on eradicating phragmites. Asian carp management is overseen by the Asian Carp Regional Coordinating Committee (ACRCC), a multi-agency working group comprised of government and non-government agencies engaged in research, monitoring and surveillance, and efforts to prevent the spread of Asian carp (ACRCC, 2019). In Ontario, these efforts are led by the Department of Fisheries and Oceans (DFO) with limited partnership from OMNRF and comprises regulation of Asian carp species, monitoring and surveillance, environmental DNA research, implementation of the Asian Carp Response Plan, and outreach activities

While further research is needed on the management of invasive species and their impact on native species in the Great Lakes, integration of local citizens and management agencies is also critical for invasive species managements in the Great Lakes (Escobar et al. 2018). This generally takes the form of engagement and awareness to reduce spread of invasive species, a key aspect of invasive species management; however, as a social-ecological phenomenon, discussion among groups such as managers, researchers, First Nations, and stakeholders surrounding the value-based judgements that guide decision-making and management actions is also important (Kokotovich & Andow 2017).

SON recognizes the impact from invasive species and are seeking a much more active role on this issue. On December 6 and 7, 2017 SON participated in a Great Lakes Aquatic Invasive Species workshop and voiced their concern about Asian Carps and the absence of SON's involvement with the Great Lakes Aquatic Invasive Species Program within SON's Traditional Territory (Cudmore & Wright 2017). A large portion of Lake Huron and Georgian Bay lay within SON's Traditional Territory. It is a reasonable assertion, that due to the close connection to the waters, SON fishers could play a vital role in early detection and broadening monitoring efforts. SON also has an intimate knowledge of the waters and the beings within them that could provide wisdom and a different perspective to the problem. For these reasons SON and DFO have begun the process of collaborating on creating a greater role for SON in invasive species monitoring and decision-making within the SON Traditional Territory. This has already resulted in tangible outcomes, including outreach at Pow wows and an Asian Carp Monitoring Training Program for SON fishermen on June 6, 2019. The fishermen now have tools to identify Asian carp and are an important part of the early detection of Asian carps in SON's Traditional Territory. In the future, SON intends to push for a much greater role on the decision-making aspects of the invasive species issue.

ASSISTING REPRODUCTION AND STOCKING

Community members proposed several strategies for assisting reproduction to help whitefish populations and improve the fishery in the future. The most common suggestions for assisting reproduction included rearing whitefish in hatcheries, and using SON traditional methods of fertilizing eggs and depositing them on spawning shoals. While some community members recommended that stocking be conducted by the Ontario Ministry of Natural Resource & Forestry, others recommended compensating fishers to stock whitefish. Other recommendations to increase reproductive success included releasing female whitefish and eggs from harvest, developing sanctuaries for spawning grounds, installing spawning beds, and controlling phragmites in spawning grounds.

Low recruitment in recent years is thought to contribute to lake whitefish population and fishery declines (Workshop Proceedings, 2018). The causes of this low recruitment remain unknown and is an area of active research (Workshop Proceedings, 2018), but could result from either low survival during early life stages or declines in the number of recruits being produced. Ecosystem changes associated with dreissenid mussels have reduced primary productivity and zooplankton densities (Higgins & Vander Zanden 2010) that are prey for young lake whitefish; therefore, increased competition for prey may have reduced their survival. Evans & Waring (1987) attributed recruitment declines in Lake Simcoe lake whitefish to competition between young rainbow smelt and lake whitefish, as well as predation of young lake whitefish by adult rainbow smelt to a lesser extent. Environmental changes associated with a warming climate (e.g., warmer fall temperatures, increased wind and wave action, shorter ice cover) could also lead to lower survival of eggs and/or larval lake whitefish (Lynch et al. 2015). Declines in the growth and condition of spawning whitefish, and overfishing of the spawning stock (Gobin et. al. 2018) could also lead to lower recruitment by reducing the number of recruits produced. Depending on the mechanisms underlying recruitment declines, several of the proposed recommendations could potentially have positive impacts on lake whitefish and the fishery.

Stocking can enhance productivity in stocks that are limited by recruitment, which is believed to be the case for most fish populations in general (Lorenzen 2005, 2014). Such enhancement also provides economic opportunities and benefits for stakeholders and communities that depend on fishery resources (Pinkerton 1994). Various types of fishery enhancement systems exist that determine the objectives, approaches/strategies employed, and what constitutes success (Lorenzen et al. 2012). Success also depends on numerous factors — stock enhancements often fail or even cause ecological harm (Lorenzen 2014). The value of stocking remains widely debated given that outcomes are often moderate and highly variable (Lorenzen et al. 2001, Lorenzen 2014), economic viability can be low (Lorenzen 2014, Kitada 2018), and the potential for negative impacts on native communities (Lorenzen et al. 2012). Trade-offs also exist between socio-economic and conservation objectives, as demonstrated in the enhancement of marine recreational fisheries (Camp et al. 2017). When used as a temporary measure to rebuild depleted stocks, stocking is only beneficial when stocks are at low levels relative to their carrying capacity, and should be used to complement harvest limitation rather than as an alternative strategy (Lorenzen 2005). Stocking is unlikely to reverse the impacts of ecosystem shifts that reduce the population carrying capacity (Moloney et al. 2005), as appears to be the case for lake whitefish in Lake Huron (Kratzer et al. 2007, Wright and Ebener 2007, Gobin et al. 2015, 2016). However, Kao et al. (2018) predicted that the population biomass of three salmonids (lake trout, steelhead, and Chinook salmon) could be enhanced thorough stocking in Lake Michigan despite oligotrophication occurring in this system. Notably, stock enhancement was least beneficial for species that were highly impacted by quagga mussels in that study (Kao et al. 2018).

Lake whitefish were historically stocked into the Great Lakes; however, this practice ceased because of uncertainty regarding its impact on the fishery (Ebener et al. 2008). In Lake Simcoe, stocking of lake whitefish into Lake Simcoe began in the early 1980’s due to recruitment failure (COSEWIC, 2005), and continues today (Ontario Ministry of Natural Resources and Forestry, Fish ON-Line). Several decades later, hatchery-reared lake whitefish comprised the majority of the Lake Simcoe stock, but wild lake whitefish persisted (Lasenby et al. 2001). The history of lake whitefish stocking in the Great Lake and Lake Simcoe combined with information available for rearing and stocking of European whitefish (*C. lavaretus*), a close relative of lake whitefish that may actually belong to the same species (Bodaly et al. 1991), could provide a basis for the development of a stocking program for lake whitefish in SON waters. Notably, the Lake Simcoe strain is genetically distinct from those in the Great Lakes and utilizing original stocks for rehabilitation is ideal (Lasenby et al. 2001). A study that examined genetic data for lake whitefish in Lakes Huron and Michigan found that, while genetic diversity was generally low, genetic variation was greatest between lakes and there appears to be some evidence of structuring within lakes (Stott et al. 2010). However, supplemental stocking of lake whitefish at young life stages (e.g., fry, small fingerlings) in waterbodies where natural reproduction is occurring has previously been found to be ineffective and is not recommended (Lasenby et al. 2001). We could not find any studies examining the efficiency of SON traditional methods involving redepositing fertilized eggs on spawning shoals, which could be investigated further.

Given that various biological, technical, social and economic factors contribute to the success of stocking programs, insufficient knowledge of these factors and interactions among them can contribute to failures (Lorenzen 2014, Camp et al. 2017). Modelling approaches are a valuable for predicting potential outcomes (e.g., Camp et al. 2014, 2017, Garlock et al. 2017, Kao et al. 2018) before stocking even begins. Such models should account for key processes like size- and density-dependence that are not always accounted for in conventional fishery models (Lorenzen et al. 2005). A simulation model that accounts for both ecological and evolutionary processes has been developed for Lake Huron lake whitefish (Gobin et al., 2016, 2018) and could be used to explore potential the outcomes of stocking in this system when combined with various harvesting scenarios.

Management practices that protect spawners (e.g., seasonal harvest, fish sanctuaries) can also increase natural recruitment in harvested fish populations where the production of recruits is limited (e.g., by harvesting of the spawning stock). Although less common than in marine environments, freshwater protected areas (including fish refuges/sanctuaries) have successfully been used to protect freshwater environments and the fishes that inhabit them (Suski & Cooke 2007). In the Great Lakes, fish refuges cover 4% of its total area, with the majority of these occurring in the United States (Parker et al. 2017), but other types of freshwater protected areas also exist that offer protection or harvested fish species and their habitat (Suski & Cooke 2007). Protected areas could benefit lake whitefish by buffering against variability in recruitment (Taylor et al. 1987, Zuccarino-Crowe et al. 2016). Refuges developed for lake trout in the Apostle Islands region of Lake Superior have been shown to benefit both lake trout and lake whitefish (Zuccarino-Crowe et al 2016). However, lake whitefish in Superior have not been impacted by dreissenid mussels in the same way that they have in the other Laurentian Great Lakes (Fera et al. 2015, Rennie et al. 2015).

Creating and rehabilitating spawning habitat could also have a positive impact on recruitment if this is limiting reproduction or the early survival of lake whitefish eggs and/or larvae. Although in-lake spawning habitat is thought to remain in good condition due to human densities being relatively low in these areas (Ebener et al. 2008), habitat degradation associated with deforestation and human settlement has negatively impacted spawning and contributed to past lake whitefish declines in the Great Lakes (Smith 1972) and their tributaries (Roseman et al. 2007). Degradation of spawning shoal habitat was also considered a factor in lake whitefish declines in Lake Simcoe (COSEWIC, 2005). The creation of shipping channels in the St.Clair-Detroit River system contributed to substantial losses in spawning substrates for lake whitefish and other species that utilize similar habitat (e.g., lake sturgeon, walleye) (Roseman et al. 2007., Fischer et al. 2018). However, restoration of spawning substrates through the creation of artificial reefs using broken limestone did not increase egg deposition by lake whitefish (Fischer et al. 2018). The impact that invasive plant species like phragmites may have on lake whitefish recruitment is not known. While phragmites displaces native plant communities, a the few studies examining its impact on fish habitat found no difference between fish assemblages occupying phragmites stands when compared to native emergent plant communities (Aday 2007, Wynia 2019). However, lake whitefish were not among the species detected in that study.

STOCKING OF SPORT FISH AND OTHER TOP PREDATORS

Community members were concerned about the stocking of sport fish and top predators in the lake. Many felt that the stocking of salmon and trout species have contributed to whitefish declines and recommended that it be stopped in the future.

Rainbow trout, chinook salmon, brown trout, brook trout, lake trout and walleye have been stocked in Lake Huron by the Ministry of Natural Resources and Forestry and sport fishing clubs (Fish ON-Line). Rainbow trout and chinook salmon have been stocked in the greatest numbers, while walleye have not been stocked since 2013 (Fish ON-Line).

The potential for interactions between lake trout and lake whitefish exist given that they occupy similar habitat. Consequently, lake whitefish harvest management is affected by lake trout due to efforts to reduce by-catch of the latter (Ebener et al. 2008). Given recent declines in lake whitefish recruitment that coincide temporally with the rehabilitation of lake trout in the Great Lakes, this is an area of particular interest (Workshop Proceedings, 2018).

Direct predation of lake whitefish by lake trout in the Great Lakes is reported to be minimal. Roseman et al. (2014) found that lake whitefish comprised less than 1% of lake trout diets in Lake Huron based on the stomach contents of fish captured by anglers between May and October during the years 2009-2011. Happel et al. (2018) similarly did not find lake whitefish comprised a part of lake trout diets in Lake Michigan and Michigan waters of Lake Huron, based on stomach contents and fatty acid profiles. In this study, rainbow smelt were the main prey consumed by lake trout in Lake Huron, and 11.5% of their diet comprised other fish that were generally unidentifiable due to a high degree of digestion. Notably, these studies focused on larger lake trout (generally >30 cm in length) during late spring, summer, and early fall months.

Although lake trout feed in winter (Martin 1954), we could find no studies examining Great Lakes lake trout diet during this time of year. Martin (1954) was the only published study found that examined winter diet of lake trout, and this study was conducted in Lake Opeongo in Algonquin Park, ON. While this study does not provide a measure of the quantity of diet items consumed, Martin (1954) reported occurrences of "whitefish" in lake trout stomachs twice as frequently as perch during the summer and both lake whitefish and round whitefish are among the major fish species found in the lake. Morbey et al. (2007) found that, historically, about 10-25% of lake trout collected in Lake Opeongo during spring and summer months had lake whitefish in their stomachs; the introduction of smallmouth bass in this system resulted in lake trout consumption of fewer but larger lake whitefish that were up to about 25 cm in length.

Indirect interactions between lake whitefish and lake trout were examined by Langseth (2012) using a simulation model, who found these interactions to be minimal beyond the lake whitefish fishery, even when a small amount of direct predation was added. Indirect interactions increased under alternative and plausible scenarios relating to parameters that represent the strength of interactions between predators and prey, such that increased vulnerability of prey to lake whitefish led to lake trout becoming less sensitive to changes in lake whitefish harvest (Langseth 2012). However, increased vulnerability of prey to lake trout had little impact on lake whitefish (Langseth 2012). Nonetheless, other studies have reported potential interactions between lake trout and lake whitefish. For example, Zuccarino-Crowe et al. (2016) found contrasting trends in lake trout and lake whitefish abundance inside and outside of lake trout fishing refuges that could suggest an interaction between the two species.

The only other stocked species that is reported as a predator of lake whitefish by Lasenby et al. (2001) is walleye. However, lake whitefish have been recorded in the diet of brown trout (Kerr & Grant 2000). Other species present in Lake Huron that are known to prey on lake whitefish at various life stages include longnose sucker (*Catostomus Catostomus*) (Nester and Poe 1984), rainbow smelt (Loftus & Hulsman 1986, Evans & Waring 1987), and Northern Pike (Diana

1979 cited in Kerr & Grant 2000). Predation of lake whitefish by rainbow smelt is size-dependent (Gorsky & Zydlewski 2013) and therefore slower growth of larval lake whitefish could result in increased predation rates. Evans & Waring (1987) also suggested that a predatory or competitive relationship exists between young-of-year lake whitefish and yellow perch.

The belief that fish stocking is having a negative impact on the fishery is a longstanding concern. In 2004, former Chiefs, Roote and Akiwenzie, wrote, “We should not be stocking exotic fishes to support an artificial, recreational fishery in the Great Lakes. It is an insult to the Creator. It is wrong.” SON’s ecological concerns about fish stocking, presented by Crawford in his monograph from 2001, remain unresolved:

1. Introduction and distribution of diseases and parasites
2. Predation on native species
3. Competition for limited resources
4. Genetic alteration of native populations
5. Environmental alteration
6. Community alteration

SON community members have reported to the Fisheries Assessment Biologist on the damage being done by stocking. They have seen many lake whitefish in the stomachs of lake trout. In areas once fished by SON for whitefish, they are all but gone, it is believed they have been driven out by the introduced exotics.

SON has expressed concern that with decreased productivity in the lake there is less food at each trophic level and the continued large-scale introductions of predators will only exacerbate the problem. Fish being stocked at the top of the food web and have a direct top down effect on all other trophic levels. It is not only whitefish that are vanishing. SON fishermen report that many of the fish they used to see like suckers are fast disappearing as well. This is seen in the community as a very dangerous signal that there is an ecological catastrophe in SON waters.

SON’s lake whitefish harvest is decreasing dramatically and has become increasingly dominated exotics of low commercial value. SON fishermen are losing their livelihoods and way of life. The number of our fishermen who can no longer make their living in the waters they rely upon is rising. SON’s economy is heavily dependent on the fishery and always has been. Many fishermen have no other trade and are being pushed even further into poverty and despair. However, the impacts of fish stocking go much deeper than economy, these impacts go to the very heart and Spirit of SON’s people.

As explained to the Fisheries Assessment Biologist, there are beliefs that the fish beings are our family, and the Creator gave SON a sacred responsibility to care for and be in relationship with them and the waters. Women honour the fish beings as they continue to practice and maintain their role and responsibility as water protectors, offering prayers to the waters. SON community members pass on the teachings from the Creator on how to maintain their relationship with the waters and animal beings in a good way by providing offerings of tobacco. Native fish like lake whitefish are a key component of the Clan system, SON's Original governance. Fish are also an essential part of our feasts and celebrations. There is a belief that the introduction of exotic species is an affront to the Creator and is directly impacting that sacred responsibility from the Creator to the waters and animal beings.

Fish has always been an essential part of our diet. Food security remains a very real and ever-present issue for the community. Traditionally, SON relied upon our territory to provide food security. Food sovereignty is essential if we are to achieve food security and justice for our people. Fish stocking is seen as an impediment to that goal. The ability for SON to harvest culturally appropriate food is so much more than having enough food to eat; it is an essential component of their identity.

In 2017, SON worked with McGill University to look at fish and its relation to food security for our people (Lowitt et al 2017). It was no surprise to learn that food security was a major issue in the community with 75% of participants experiencing some level of food insecurity and 25 % of participants going hungry due to a lack of food. SON are a fishing People and in the past fish was a major component of their diet. This research indicated that this has changed dramatically: Approximately 30% of participating households indicated eating local fish 1-3 times per month in the winter and summer. Slightly more participants (approximately 40% and 50% respectively) reported eating local fish 1-3 times per month in the fall and spring (Lowitt et al 2017).

As stated in Lowitt et al. (2017):

> "In Indigenous communities, understanding food security issues is complex, involving the interplay of peoples and their cultures, rights, resources, environment, health, and livelihoods (Council of Canadian Academies, 2014). From a public health perspective, the main food security issues facing Indigenous peoples in Canada include rates of household food insecurity that are much higher among Indigenous than non-Indigenous Canadians, and high rates of diet-related non-communicable diseases (NCDs), including obesity and diabetes. In many cases, rising NCD rates are the result of a growing consumption of market foods in place of traditional foods, often driven by environmental dispossession and cultural change (Power 2008, Fieldhouse & Thompson, Rudolph & McLachlan, 2013). Increasingly, efforts to support household and community access to affordable and

> nutritious foods in Indigenous communities are focusing on the importance of traditional foods (including wild-harvested fish, game, birds, berries and other plants), along with the ability of communities to harvest, share and consume them (Willows 2005, Fieldhouse and Thompson 2012, Islam & Berkes 2016, Wesche et al. 2016,). Traditional foods are gaining increasing policy and research attention not only because they are nutrient-dense (Elliot et al. 2012), but also because they may contribute to what Power (2008) calls "cultural food security" due to their pivotal role in maintaining cultural identity, health and survival."

The creation of an artificial fishery with stocked fish has led to increased use of SON's waters for recreational fishing. This is of particular significance in Owen Sound Bay and Colpoys Bay, which have been stocked by local angler clubs under licence from the OMNRF for many years. Owen Sound has established a whole festival called the "Salmon Spectacular" based upon the stocking of exotic fish. SON's well-known opposition to stocking and the commercial fishery is seen as a threat to stocking. This has manifested in many ugly interactions and dynamics, including racist language, violence, threats of violence, vandalism and theft. This issue is so extreme in Colpoys Bay and Owen Sound Bay that many SON fishermen have been driven out so as to not lose their equipment to theft and vandalism.

SON would like an adequately resourced consultation process that includes a plan to identify and address all of SON's issues with fish stocking. There are ways to move forward positively on these issues. For example, SON had a very successful collaboration on a proposal to address lake whitefish and lake trout interactions and are continuing to work towards securing funding for that project.

Other Themes

Other themes that emerged frequently during interviews (>10 mentions), in order from most to least prevalent, include (examples of each are provided in parentheses):

- ecosystem effects (climate change, declines in productivity, predation);
- partnerships (among First Nations and with non-indigenous groups);
- education, community awareness and maintaining spiritual and cultural connections (passing of knowledge from fishers to youth);

Themes that emerged during interviews with community members in lower frequencies (i.e., <10 mentions), include:

- views/perspectives (being respectful, harvesting for subsistence and viewing fishing as a lifestyle rather than an occupation);
- economics/finance (compensation for fishers, consumerism/marketing strategies, investment returns);
- policy (changing existing policy regulating fishery harvest and management);
- research (need for more research on whitefish and fisheries assessment including tagging studies, research funding);
- funding (for training and research);
- legal action (taking ownership of the water);
- diet/consumption (reducing human consumption of fish and eggs);
- enforcement (implementing fines);
- infrastructure (on-water gas station).

Effects of Interview type

The prevalence of themes was consistent whether community perspectives were gathered through group interviews or on an individual basis (i.e., on Heritage Day) (Fig. 3), with a few exceptions. Stocking of other species as a cause of whitefish declines and assisting reproduction to help whitefish populations and the fishery were mentioned more frequently among individuals surveyed on Heritage Day compared to during group interviews conducted in Nawash and Saugeen. On the other hand, the role that ecological effects have played in whitefish and fishery declines was raised frequently during group interviews in both Nawash and Saugeen, but was not mentioned in individual surveys from Heritage Day. The format of questions posed to individuals and during group interviews differed slightly and is likely responsible for these differences.

Community differences

The prevalence of themes was also consistent across the two communities, Nawash and Saugeen, with two exceptions. Invasive species and habitat & water quality were discussed more frequently among community members in Saugeen compared to in Nawash (Fig. 3). Increased concern regarding habitat and water quality among community members in Saugeen is likely related to their proximity to the Bruce Power nuclear generating station.

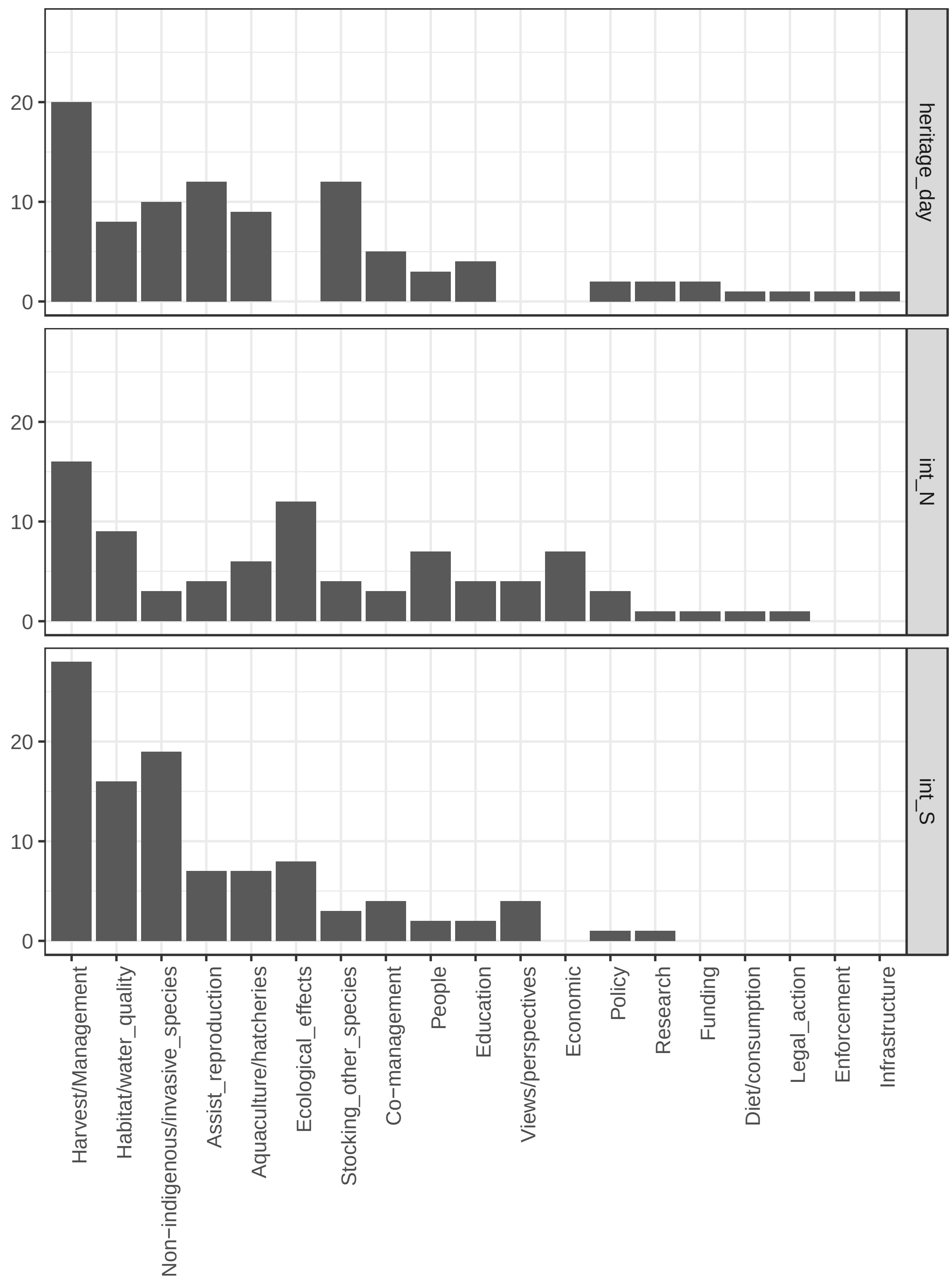

Figure 3. Prevalence of themes broken down by interview location and type. Group interviews were conducted in Nawash (int_N) and Saugeen (int_S), whereas written responses were submitted by individuals at the Heritage Day event hosted in Nawash.

CONCLUSIONS

Engaging SON community members yielded numerous potential explanations for lake whitefish declines and approaches to help Lake Huron lake whitefish populations and the fishery in the future that should be explored.

The existing literature suggests that regulating harvest alone will likely be insufficient to promote recovery of lake whitefish, given the impacts of the ecosystem changes that have occurred in the lake (Gobin et al. 2016, 2018). While further research is needed to identify the causes of recruitment declines in lake whitefish, studies by Gobin et al. (2016, 2018) suggest that ecosystem changes and harvest combined could be limiting lake whitefish recruitment, in which case stocking could be a viable option for increasing productivity in these populations. However, how much the productivity of lake whitefish population may be increased through stocking may remain somewhat limited given the apparent reductions in carrying capacity. Existing knowledge of best practices for hatchery-rearing and stocking of lake whitefish (e.g., Lasenby et al. 2001) and the closely related European whitefish could be used to inform the development of a lake whitefish stocking program for Lake Huron. The eco-genetic model that has already been developed for these stocks could also be used to predict the potential outcomes of stocking combined with various harvesting strategies as part of a cost-benefit analysis.

The Fisheries Assessment Programs, SON Environment Office and the Bagida-waad Alliance have taken steps to address many of the other concerns raised by SON community members. As a co-managed fishery, the Saugeen Ojibway Nation and the Ontario Ministry of Natural Resources and Forestry are collaborating to improve the approaches used to estimate total allowable catch, increase community-involvement in research and monitoring of invasive species), and investigate potential impacts of stocked species (e.g., lake trout) on lake whitefish. SON has also been working to address community concerns regarding the Bruce Nuclear Generating Stations through the SON Coastal Waters Environmental Monitoring Program, and the Bagida-waad Alliance has organized shoreline cleanups and data collection to improve water quality.

Given that regulating harvest and stocking of lake whitefish would most directly impact lake whitefish stocks and their recovery, next steps will include the development plans focusing on further investigation and the implementation of community members’ recommendations in these areas.

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