Sub-Indicator: Walleye

Overall Assessment

Status: Good

Trends:

10-Year Trend: Unchanging

Long-term Trend (1975-2020): Unchanging

Rationale: Walleye populations across the Great Lakes are still quite variable, although their status was most often good. In several areas of the Great Lakes, including Lake Superior's Black Bay, the southern main basin of Lake Huron including Saginaw Bay, Lake Erie, Wisconsin's Green Bay, and Lake Ontario's Bay of Quinte, Walleye populations remain stable or are improving, supported by natural reproduction. However, in areas like the North Channel and Georgian Bay of Lake Huron, high exploitation rates and inconsistent recruitment has resulted in little to no improvement in the status of Walleye.

Lake-by-Lake Assessment

Lake Superior

Status: Fair

10-Year Trend: Improving

Long-term Trend (1980- 2020): Improving

Rationale: Walleye population assessment efforts have increased in parts of Lake Superior over the reporting period, although data gaps continue to exist. Index surveys in historically relevant areas such Black Bay, Nipigon Bay/River, ON and the St. Louis River MN/WI indicate that populations exhibit natural reproduction and have generally shown that Walleye populations have remained stable or improved over the time series. This includes increases in relative abundance (Black Bay), consistent recruitment and relatively low mortality (Black Bay, Nipigon Bay, and Chequamegon Bay). Efforts have been made throughout the lake to address management concerns for Walleye populations including stocking efforts in Wisconsin waters, limiting commercial and recreational harvest as well as improving nearshore and spawning habitat in tributaries.

Lake Michigan

Status: Good

10-Year Trend: Unchanging

Long-term Trend (1985-2019): Unchanging (2020 data are not available for all jurisdictions due to staff shortages)

Rationale: Walleye populations are highly variable across Lake Michigan, as shown by harvest patterns for waters of Green Bay, which provide over 95% of the Lake Michigan's Walleye harvest. Estimates of angler harvest for the Wisconsin waters of Green Bay during 2010-2019 are higher than levels during the 1990s and 2000s, while angler harvests for the Michigan portion during 2010-2019 have been considerably lower than levels during the 1990s

and 2000s. Walleye recruitment in southern Green Bay is entirely from natural reproduction, while that in northern Green Bay includes both wild and hatchery contributions. Walleye fisheries in the main basin of Lake Michigan are relatively small and with limited contributions of naturally-reproduced fish.

Lake Huron (including St. Marys River)

Status: Good

10-Year Trend: Unchanging

Long-term Trend (1971- 2020): Unchanging

Rationale: The Michigan waters of Lake Huron remain dominated by the Saginaw Bay stock of Walleye which numbers 5.68 million age 2+ fish (in the spring of 2020). At least 37% of this stock typically migrates into the main basin of the lake during the open water months creating or substantially contributing to coastal fisheries. Some of these contributions likely also include some main basin Ontario fisheries. Predictions are for lower recruitment in 2021 and perhaps beyond because of high current stock density. The Saginaw Bay Walleye stock remains at recovery targets. A new recreational fishery management plan for Saginaw Bay is in development and new commercial legislation that may or may not affect Walleye is also under consideration. In Ontario waters, the dynamics of Walleye populations are basin distinct, with the southern main basin comprised primarily of transient fish originating from Saginaw Bay and western Lake Erie whereas the North Channel and Georgian Bay support local stocks associated with inflowing tributaries. Harvests and catch rates from the commercial fishery in the southern main basin have been stable over the past 10 years with variable catch rates and relatively high mortality rates. In the North Channel, commercial harvests remain relatively low but stable with slightly increasing but variable catch rates with most contributing stocks experiencing high mortality rates in both the commercial and recreational fisheries. In Georgian Bay Commercial harvest and catch rates remain depressed with no long-term change and with contributing stocks also experiencing high mortality rates in both the commercial and recreational fisheries. A recently completed technical report on the status of Walleye stocks in Ontario waters will contribute to the development of a Walleye Management Plan for Ontario waters of Lake Huron which is in progress.

Lake Erie

Status: Good

10-Year Trend: Improving

Long-term Trend (1975-2020): Unchanging

Rationale: Walleye abundance estimates in Lake Erie have fluctuated widely around the average of 53.1 million fish over the 40+ year time series, with no significant improving or deteriorating long-term trend (WTG 2021). In the last 10 years, the estimated Walleye abundance in Lake Erie has nearly tripled from 33.5 million fish in 2011 to 95.5 million fish in 2020. Three large year classes of Walleye drove this increase, as a strong 2015 year class was followed by record-setting levels of reproduction in 2018 and 2019. Walleye fisheries during this period were predominately supported by the 2015 cohort, with minor contributions from the 2010 and 2014 cohorts. The 2018 and 2019 cohorts should continue to increase the estimated abundance of Walleye in Lake Erie and support sustainable commercial and recreational fisheries for years to come.

Lake Ontario

Status: Good

10-Year Trend: Unchanging

Long-term Trend (1992- 2019): Undetermined

Rationale: Following declines in juvenile and adult Walleye abundance in the 1990s, associated with reduced young-of-year (YOY) production in the mid-1990s, the Walleye population stabilized in the Bay of Quinte in Ontario and the New York waters of eastern Lake Ontario. Post-dreissenid mussel Walleye performance targets, identified in the Bay of Quinte Fisheries Management Plan (2010) are currently being met or exceeded. Recent YOY recruitment levels should keep the population at current or improved levels of abundance for the next several years.

Status Assessment Definitions

The Walleye is a highly-valued species that is usually heavily exploited by recreational fisheries and commercial fisheries (where permitted). Harvest or yield reference values established for self-sustaining populations are assumed to be proportional to annual production; as a result, harvest or yield reference values for these populations can be taken as surrogates for production reference values. Status reporting will be compared to the previous three-year reporting period, although it is recommended that a longer reporting period would allow for a more accurate trend for fishery harvest across time.

Good: Meets or exceeds attainment of harvest targets in all (most recent) reporting years

Fair: Met harvest target in one year and approached 50% of target levels in all years

Poor: Did not attain 50% of harvest target levels in all years

Undetermined: Data are not available or are insufficient to assess condition of the ecosystem components or harvest target not defined.

Trend Assessment Definitions

Improving: Walleye population estimates have been increasing; harvest rates have been increasing; and natural reproduction has consistently been better than average during 2011-2020. Survival trends are positive and disease outbreaks or occurrences are infrequent even though disease is often density-dependent so it is important to recognize that high population size is representative of a Good status but higher disease transmission is more likely. Growth rates are near historic averages with the understanding that density-dependent compensation occurs.

Unchanging: Populations of Walleye have not significantly increased or decreased; fisheries and catch rate trends remain mixed; and natural reproduction has been inconsistent on an annual basis during 2011-2020. Changes in growth rates, maturity, and fecundity have been occasionally noted and/or disease outbreaks or occurrences are present but not excessive.

Deteriorating: Populations of Walleye have decreased below target levels established for the lake or water body; reproduction, survival and/or growth has been significantly lower during 2007-2017; and there is evidence of a decline in fisheries and catch rate trends during 2011-2020. Disease or contaminant rates may have worsened in recent years.

Undetermined: Metrics do not indicate a clear overall trend, or data are not available to report on a trend.

Endpoints and/or Targets

Appropriate quantitative measures of relative abundance, harvest, diversity, or biomass should be established as reference values for self-sustaining populations of Walleye in each lake. The sub-indicator target(s) for prey fish can be based on the values provided in the Great Lakes Fishery Commission (GLFC)'s Fish Community Goals and Objectives (FCGOs) and/or for desired value(s) gained from analysis of the range and distribution of measures above compared to the ecosystem conditions. Lakes Erie and Superior also have management and rehabilitation plans, respectively, concerning Walleye from which targets can also be obtained.

Lake Superior: Maintain, enhance and rehabilitate self-sustaining populations of Walleye and their habitat over their historical range (FCGO 2003).

The Lake Superior fish community will be managed to maintain, enhance, and rehabilitate habitat for, self-sustaining populations of Walleye in areas where the species historically maintained populations. Management strategies will be implemented to attempt to reach objectives specific to individual Walleye populations and habitats (Rehabilitation Plan, 2001). Rehabilitation targets for Walleye populations may include:

- 7 age-0 and age-1 Walleye/electrofishing hour/index station, and 8 ages classes are represented in assessment catches in the St. Marys River (Michigan) and Tahquamenon River
- The spawning population reaches 1,000 in the Pigeon River
- The spawning population reaches 7,000 in the Bad River
- The spawning population reaches 1,000 in the St. Marys River (Ontario)
- The spawning population reaches 500 in Goulais Bay
- The spawning population reaches 500-1,000 in Batchawana Bay
- The spawning population reaches 5,000 fish in Thunder Bay
- The population reaches either 22,000 adult fish or 41,000 fish over 356 mm in Nipigon Bay
- Catches in index gill nets reach 150 kg/km in Black Bay.

Lake Michigan: Expected annual yield: 0.1-0.2 million kg (100-200 metric tonnes) (FCGO 1995).

Harvest target sustainable levels of 200,000 – 400,000 pounds.

Lake Huron: Re-establish and/or maintain Walleye with populations capable of sustaining an annual harvest of 0.7 million kg (FCGO 1995)

Lake Erie: Manage the western, central and eastern basin ecosystems to provide sustainable harvests of valued fish species, including Walleye (FCGO 2020).

This is done within the construct of objectives stated or implied in the Lake Erie Committee's Walleye Management Plan (Kayle et al. 2015). These objectives are:

1. Maintain Walleye spawner biomass at levels greater than 20% of an unfished population (SSB20%) in the Total Allowable Catch (TAC) area
2. Maintain sport catch rates at or above 0.4 Walleye per angler hour
3. Maintain commercial harvest at or above 4 million pounds annually.

Additionally, the age and size structure of the fishery should be sufficient to:

- Promote migration of Walleye towards the eastern basin
- Provide diverse fishing opportunities to anglers

Lake Ontario: Fish-Community Objectives for Lake Ontario (Stewart et al., 2017) sanction action to "maintain, enhance and restore self-sustaining local populations of Walleye", as measured by "maintaining or increasing fisheries, populations, and recruitment of Walleye". Specific Walleye population performance targets are identified in the Bay of Quinte Fisheries Management Plan (2010). Performance targets for YOY recruitment, juvenile and adult abundance are currently being met or exceeded.

Sub-Indicator Purpose

The purpose of this indicator is to measure status and trends in Walleye population abundance and recruitment in various Great Lakes habitats; to infer the status of cool water predator communities; and to infer ecosystem health, particularly in moderately-productive (mesotrophic) areas of the Great Lakes and through their roles in the aquatic food web.

Ecosystem Objective

Protection, enhancement and restoration of historically important, mesotrophic habitats that support natural stocks of Walleye as the top fish predator. These habitats are necessary for a stable, balanced, and properly-functioning Great Lakes ecosystem.

This indicator best supports work towards General Objective #5 of the 2012 Great Lakes Water Quality Agreement (GLWQA) which states that the Waters of the Great Lakes should "support healthy and productive wetlands and other habitats to sustain resilient populations of native species."

Measure

Since Walleye function as apex predators in several of the Great Lakes ecosystems, population abundance and demographic changes in historical, cool water, mesotrophic habitats are important metrics for assessing Great Lakes health. As such, abundance and biological measures can be used to gauge ecosystem health and understand changes over time. Reviewing short-term (i.e., previous 10 years) and long-term (i.e., over the breadth of available data) changes to these measurements is a useful approach for describing the health of Great Lakes Walleye populations. Recognizing survey and financial constraints imposed on management agencies, metrics that describe regional (i.e., discrete stocks or spawning aggregations) status and trends of these Walleye populations may be more meaningful than lakewide indices in some circumstances. Likewise, while annual indices would be the most beneficial, information collected on an intermittent basis may be useful. Each agency makes decisions on the frequency of assessment based on a number of factors that take into account the level of the resources available (capacity) relative to the status of the stock and the social and economic pressure on the resource.

Abundance, spawner biomass, recruitment (i.e., natural reproduction), age/length at maturity, and fishery performance (effort, catch rate, yield) are useful metrics for describing Great Lakes ecosystem and fishery health. However, in the absence of absolute abundance and spawner biomass estimates for all lakes, relative measures from fishery-dependent (i.e., harvest) and fishery-independent (i.e., population assessments) surveys are suitable metrics for reporting on Walleye population health in the event population estimates are lacking.

Ecological Condition

The historical dominance of Walleye in mesotrophic habitats in the Great Lakes provides a good basis for a basin-wide evaluation of ecosystem health. Maintaining or re-establishing historical levels of relative abundance, biomass, or production of self-sustaining Walleye populations throughout their native range in the Great Lakes basin will help ensure the sustainability of this species in the ecosystem and the maintenance of a desirable and balanced aquatic community in cool water, mesotrophic habitats. Historical data can be used to develop status and trend information on Walleye populations. Commercial catch records for Walleye in the Great Lakes extend back to the late 1800s; recreational catch data and assessment fishing data supplement these commercial catch records in some areas in recent decades and sport fishing data are especially useful in areas where the commercial fishery for the species does not operate.

The "mesotrophic" cool-water fish community is associated with more productive waters in nearshore areas and embayments. Mesotrophic communities, along with oligotrophic and eutrophic communities are found to varying degrees in all five of the Great Lakes with more than half of Lake Erie represented by mesotrophic habitat.

The Walleye is the top predator in the cool nearshore and offshore waters of the Great Lakes and is selected as an indicator because they represent one of the original fish species in these different habitats. As a native apex predator, Walleye balance the fish community through top-down processes -adding value to the ecosystem and to fisheries, and they are the focus of fisheries management and restoration efforts. Being co-evolved with the rest of the fish community and the natural ecosystem of the Great Lakes, Walleye represent an important component to the natural biodiversity of the lakes. They have been subjected to the full slate of environmental effects resulting from human disruption of the Great Lakes ecosystem including habitat loss, nutrient pollution, exploitation, and water quality degradation, persistent toxic pollutants, and invasive species. While restoration efforts like stocking can complicate interpretation of their status, the successes of this species are indicative of progress toward the goals of the GLWQA. Walleye support large commercial and recreational fisheries throughout Lakes Erie and Huron; consequently, trends in harvest are useful for assessing ecosystem health. However, in Lakes Michigan, Ontario, and Superior, where Walleye are constrained to less abundant cool water habitats, harvest information may not be as reflective of ecosystem health as in Lakes Erie and Huron due to their limited spatial distribution. Rather, harvest trends may only reflect the ecosystem health of particular areas of suitable habitat in Lakes Michigan, Ontario or Superior because of the limited data available.

Lake Superior

Walleye populations in Lake Superior are limited to shallow embayments and lower gradient tributaries. As such, population assessments are conducted at appropriate scales. Thunder Bay (Kaministiquia River, ON) contains a small but healthy self-sustaining population, with evidence of consistent recruitment. In Black Bay, assessment work is showing an increase in the relative abundance of Walleye along with consistent recruitment and low mortality. Ongoing acoustic telemetry work suggests Walleye from Black Bay exhibit a range of movement patterns, including extended forays outside of Black Bay. In Nipigon Bay and Nipigon River, Walleye are low in abundance, but assessment work is showing signs of increasing density (high growth rates and low mortality). The St. Louis River (Minnesota/Wisconsin), supports one of the largest self-sustaining Walleye stocks in the Lake Superior basin, with an estimated population size of 50,000 adult Walleye (Olson et al, 2018). Populations in Chequamegon Bay, WI are comprised primarily of hatchery strain Walleye, while surveys indicate low levels of mortality. Due to limited assessment surveys, it is difficult to assess if population targets were met in other parts of the lake during the reporting period.

Lake Michigan

The trends for Walleye in Lake Michigan are largely driven by populations in the Wisconsin and Michigan waters of Green Bay, which constitute over 95% of the lake-wide harvest. A strong north-south productivity gradient in Green Bay has resulted in contrasting trends in Walleye abundance and harvests. For instance, estimates of angler harvest of Walleye from Wisconsin's portion of Green Bay during the 2010s were the highest since surveys began in 1986, while lowest harvests from Michigan waters of Green Bay occurred during the same decade. Walleye recruitment in southern Green Bay is entirely from natural reproduction, while that in northern Green Bay includes both wild and hatchery contributions. Young-of-year Walleye assessments in the Wisconsin waters of Green Bay show above average production in most years of the 2010's (Hogler and Surendonk 2019), but catch-at-age based estimates of age-1 abundance in Little Bay de Noc, the primary juvenile Walleye habitat in northern Green Bay, show relatively weak year classes during the 2010's despite significant stocking contributions (Zorn 2015; Zorn et al. *In prep*). Consistently low densities of zooplankton available to larval Walleye in Little Bay de Noc and Big Bay de Noc suggest prey availability as a potential limitation to strong year classes of Walleye (Zorn et al. 2020). Recent higher water level conditions in Lake Michigan may be positively impacting Walleye populations in Green Bay. Higher water levels are creating additional fish spawning and nursery habitat (i.e. emergent and submergent vegetation) along shorelines that may benefit inshore forage fish and potentially increase survival and recruitment of young-of-year Walleye. Walleye are very sparse in Wisconsin waters of Lake Michigan's main basin, with no natural reproduction and no stocking since 2007. Similarly, angler harvest estimates of Walleye from Michigan waters of the main basin have remained at relatively low levels compared to the 1990s, with harvest estimates of fewer than 1000 Walleye per year in 8 of 11 years during 2010-2020.

Lake Huron

Much of the trends of Walleye in Lake Huron are driven by the status and trends of the Saginaw Bay stock, the single largest population in Lake Huron and among the largest in the Great Lakes. The dynamics of the recovery of that stock is believed to be driven primarily by the collapse of the invasive Alewife (Fielder et al. 2007). Lake Huron's Alewife population declined dramatically in 2003. Now after 17 years of low abundance, it appears the forces behind its decline are on-going and resurgence seems increasingly unlikely. However, if Alewives were to become abundant again, it is expected that the Saginaw Bay stock of Walleye would decline and fall back into a depressed status and would likely require stocking to sustain. Changes in existing invasive species or new invasions remain the single largest threat to the status of the Saginaw Bay stock and probably all Walleye in Lake Huron. Walleye reproduction appears to remain dependent on tributary spawning but a reef restoration project (Coreyon Reef) in Saginaw Bay was completed in 2019 and is under evaluation to determine its efficacy in diversifying sources of recruitment. Two dam failures on the Tittabawassee River (which is believed to be the single largest source of Walleye reproduction for the population) occurred in spring 2020 and it is unclear how that may affect Walleye reproduction in years to come.

Spatially, Ontario's Walleye populations in Lake Huron are expansive and diverse. The mixed stock aggregation in the southern main basin is comprised of dynamic inputs from western Lake Erie and Saginaw Bay, and supports commercial harvests in the order of 100,000 kilograms annually. Stocks distributed throughout the North Channel and Georgian Bay are characterized by variable status and trends (UGLMU 2019) with only a few showing signs of improved recruitment and most found at depressed levels of abundance and experiencing high mortality rates. Walleye are harvested recreationally, commercially, and by Indigenous fisheries. The exact extent of the mixing of some of these reproductive sources is difficult to assess such that determining impacts of exploitation on localized stocks is difficult. Assessment netting provides trend information on localized reproductive stocks at specific

spawning tributaries. Increased efforts to mark and tag spawning aggregations of Walleye (UGLMU 2019a) have provided insights into home ranges and stock mixing in nearshore and offshore waters but more work is required.

Overall the lake wide trend appears to be unchanging but for the North Channel and in particular Georgian Bay, populations remain depressed and unchanging. The overall status of the Lake Huron Walleye population and fisheries has to be characterized as Good in Michigan waters given the recovery of the Saginaw Bay stock but in Ontario waters, outside of the southern main basin, further improvement from current depressed abundances are desired. Generally, yield across all sources has not fully achieved the historic average or the Fish Community Objective of 0.7 million kilograms/year, but may be beginning to approach that for some parts of the lake.

Lake Erie

The annual Total Allowable Catch (TAC, or international fishery quota) set for the West and Central basins of Lake Erie has been continually increasing since 2013 (no TAC is set for the East Basin), resulting in increased Walleye harvest in both the sport and commercial fisheries. Since 2011, the commercial harvest has annually exceeded the 4 million pound management objective identified in the 2015-2019 Walleye Management Plan (Kayle et al. 2015), which was extended through 2024. In 2021, the spawning stock biomass was projected at 70.7 million kg, well above the 11.8 million kg limit reference point of 20% of the unfished spawner biomass (WTG 2021). Across Lake Erie, annual sport fishing effort remains below the long-term mean of nearly 5 million angler hours but has been trending upwards since 2011. Sport fishing harvest rates have generally increased with fluctuations since 2011, with a record of 0.81 fish/angler hour observed in both 2018 and 2019, nearly double the long-term mean of 0.45 fish/angler hour. Commercial gill net effort across the lake trended upwards from 2011-2016, then slightly decreased and settled at a level just below the long-term average of 18.6 thousand kilometers of gill net from 2018-2020. Lake-wide commercial harvest rates decreased from 2011-2015, when the trend in catch rates quickly rebounded to levels that approached the record 250.4 fish/km of gill net observed in 2006. Commercial harvest rates from 2017-2020 exceeded the long-term lake-wide average of 125.9 fish/km of gill net (WTG 2021).

Lake Erie Walleye fisheries remained largely dependent on the 2003 and 2007 cohorts, with some contributions from the 2010 and 2011 cohorts, until 2015. The mean age of Walleye harvested lake-wide by sport and commercial fisheries continued to rise through 2015 with the average age in the commercial harvest peaking at age-6 and the sport harvest peaking at age-7 in that year. Strong reproduction in 2015, 2018, and 2019 and subsequent recruitment has shifted the age structure of the harvest downward during recent years. In 2020, age-2 (2018 cohort), age-3 (2017 cohort), and age-5 (2015 cohort) Walleye comprised the greatest fractions of the commercial harvest and the harvest mean age dropped to age-4. The catch rate of the 2019 cohort in the Ohio-Ontario West Basin trawl index is the second highest on record (behind 2018) and this year class should further contribute to the fisheries in the coming years. Collectively, these recent strong year classes have led to increased abundance estimates, which in turn have led to increases in the lake's annual Total Allowable Catch (TAC) for commercial and recreational fisheries (WTG 2021) based upon the guidance established in the LEC walleye harvest strategy.

East basin Walleye stocks remain difficult to independently evaluate largely because migration of West and Central basin Walleye stocks masks trends of East Basin stocks when using traditional assessment approaches (Kayle et al. 2015). Research continues to examine the variability in the migration rates of fish among Lake Erie's basins to help address this issue. In the East Basin, fishing effort has more than doubled since 2011 to 674,000 angler hours in 2020, a time series high. Similarly, harvest rates in the sport fishery tripled between 2011 and 2019, dropping in 2020 but remaining more than 1.5 times higher than the long-term mean of 0.27 fish/angler hour. Commercial catch rates in the east end of the lake are at record or near-record levels and remain well above the long-term mean of 76.1 fish/km of gill net. Similar to West and Central basin fisheries, age-5 (2015 cohort) fish significantly

contributed to the East Basin fishery in 2020 (WTG 2021). Like the other regions of the lake experiencing strong recruitment, the mean age of Walleye in the sport and commercial harvest has decreased from age-8 to ages 5 and 4, respectively.

Lake Ontario

The northeastern region provides most of Lake Ontario's warm and cool water fish habitats, including warm-water rivers, extensive embayments, and complex shorelines. These habitats provide the most potential for Walleye spawning, nursery and feeding habitat, and it is in northeastern Lake Ontario that the largest Walleye population, fishery, and assessment focus occurs. The Bay of Quinte provides the greatest quantity of Walleye spawning and nursery habitat in Lake Ontario. Walleye spawn in the four major rivers and along the shoreline of the Bay of Quinte. Walleye mark-recapture and acoustic telemetry studies indicate that young Walleye (less than 4 or 5 years of age) remain in the Bay of Quinte year-round while larger, older Walleye migrate to eastern Lake Ontario proper for the summer months. Annual bottom trawling (August) in the Bay of Quinte provides a long-term index of YOY abundance. Annual summer gill netting in both the Bay of Quinte and eastern Lake Ontario (Ontario and New York waters) provides excellent long-term abundance trends for juvenile and adult Walleye. Catches in eastern Lake Ontario are likely comprised of both migrating Bay of Quinte fish as well as Walleye produced in other nearby embayments, rivers and nearshore areas. The recreational fishery Walleye harvest averaged about 48,000 lb (21,772 kg) annually over the 2010-2019 decade (Data not available for all years). A small Walleye commercial fishery (less than 50,000 lb or 22,680 kg total annual quota) averaged about 26,000 lb (11,793 kg) harvest annually over the same time period.

Smaller, local Walleye populations exist in other areas of Lake Ontario. Some embayment areas support small but healthy and self-sustaining populations (e.g., Wellers Bay, West Lake) while other areas with degraded habitat require on-going rehabilitation efforts (e.g., Hamilton Harbour), including Walleye stocking. Stocking to restore Walleye populations in waters they formerly occupied serves to help diversify fish community trophic structure and to enhance recreational fishing.

Linkages

Walleye populations across the Great Lakes are affected by many other biotic (e.g., prey fish abundance) and abiotic (e.g., annual ice cover) variables.

Habitat and Species

- Aquatic Habitat Connectivity

A potential impediment to the continued health of Walleye populations in the Great Lakes is the connectivity between riverine spawning grounds and juvenile habitat. Often this phenomenon may be the result of human-induced alterations (e.g., dam construction) to the landscape.

- Phytoplankton, Zooplankton and Native Prey Fish Diversity

Phytoplankton, zooplankton, and prey fish collectively form the base of each Great Lakes' food web. Consequently, any changes in their population dynamics (e.g., seasonal abundance) and demographics (e.g., condition) may affect predatory fishes such as Walleye (including fish at larval, juvenile and adult stages), which are dependent on these as forage.

Nutrients and Algae

- Nutrients in Lakes
- Harmful Algal Blooms

Nutrient loading (e.g., phosphorous runoff) and their associated consequences, such as harmful algal blooms, can impact Walleye in some of the Great Lakes. For instance, harmful algal blooms in Lake Erie alter the foraging environment for Walleye and create areas of reduced dissolved oxygen that fish must navigate to find preferred habitat.

Invasive Species

- Impacts of Aquatic Invasive Species
- Dreissenid Mussels
- Sea Lamprey

Walleye across the Great Lakes are impacted by aquatic invasive species and the changes these species have brought about. For instance, establishment of Dreissenid mussels has caused shifts in nutrient cycling and water quality, which in turn alter phytoplankton, zooplankton, and prey fish abundance. Similarly, Sea Lamprey act as predators of large-bodied fishes such as Walleye, despite a successful control program administered by the Great Lakes Fishery Commission.

Watershed Impacts and Climate Trends

- Surface Water Temperature
- Ice Cover

A changing climate globally will likely increase water temperatures and reduce ice cover across the Great Lakes, which will alter the amount of preferred thermal habitat available to cool-water fishes such as Walleye and allow spawning to occur earlier in the year at sub-optimal conditions.

Assessing Data Quality

Data Characteristics	Agree	Neutral or Unknown	Disagree	Not Applicable
Data are documented, validated, or quality-assured by a recognized agency or organization	X			
Data are from a known, reliable and respected generator of data and are traceable to original sources	X			
Geographic coverage and scale of data are appropriate to the Great Lakes Basin	LO, LE, LM	LH, LS		
Data obtained from sources within the U.S. are comparable to those from Canada	LE	LO, LS	LH	LM
Uncertainty and variability in the data are documented and within acceptable limits for this sub-indicator report*	LO	LH, LE, LS, LM		
Data used in assessment are openly available and accessible	Yes	See Information Sources section below for a list of who to contact to request data		

*Note that the COVID-19 pandemic affected data collection efforts across the Great Lakes basin in 2020, which may add additional uncertainty.

Data Limitations

Walleye abundance can be significantly reduced by overfishing; harvest restrictions designed to promote sustained use are required if the species is to be used as an indicator of ecosystem health. The Walleye sub-indicator cannot reliably diagnose causes of degraded ecosystem health. Target reference values have not been developed for all management objectives in the Great Lakes. The use of yield (especially in metric tonnes harvested) as a target reference value is problematic in that annual yield is not the most commonly assessed parameter across all Great Lakes. For instance, not all components of each lake's Walleye fisheries are assessed annually or on a regular basis (e.g., eastern basin recreational fisheries in Lake Ontario, recreational fisheries in Ontario waters of Lake Erie), which makes use of yield as an indicator potentially less useful compared to long-term fishery-independent surveys. On Lake Huron, Ontario lacks estimates of recreational Walleye harvest limiting full assessment and comparison of that source of extraction. Both Michigan and Ontario regularly use variable mesh gillnets as assessment gears but Ontario includes spring assessments which Michigan limits assessment to fall. Due to spatial limitations, Ontario cannot regularly assess all source populations which trace back to numerous river sources throughout Georgian Bay and North Channel where Michigan principally has only Saginaw Bay to monitor. Ontario and Michigan cooperate on a periodic assessment of the shared St. Marys River and their identical gear is used and pooled for a river-wide analysis. Despite the assessment differences, population level metrics derived from both Ontario and Michigan are comparable (e.g. mortality rates). In the Green Bay, fishery-independent assessment of Wisconsin Walleye

populations employs spring and fall boat electrofishing, while Michigan conducts an experimental mesh gill net survey in fall. Regardless, both surveys provide comparable long-term indices of population abundance and structure.

Additional Information

Fishery yields (Figure 1) are appropriate indicators of Walleye health but only in a general sense. Yield was estimated for the recreational fisheries by multiplying the number of fish harvested by estimating the average size of fish harvested and extrapolating an estimated weight of harvested fish to the total number harvested. Fishery-dependent (i.e., effort and harvest) and fishery-independent (i.e., standard population surveys) assessments are lacking for some Walleye stocks in some years for all the studied areas. Moreover, measurement units are not standardized among fishery types (i.e., commercial fisheries are measured by mass while recreational fisheries are typically measured in numbers of fish), which means additional conversions are necessary which reduce accuracy. Also, "zero" values need to be differentiated from "missing" data in any figures. Therefore, trends in fishery yields across time (blocks of years) are probably better indicators than absolute values within any year, assuming that any introduced bias is relatively constant over time.

Many agencies have developed, or are developing, population estimates for many Great Lakes fishes. Walleye population estimates for selected areas (i.e., Lakes Erie and Huron) would probably be a better assessment of Walleye population health than harvest estimates, thus to the extent that it is possible, future efforts should focus on developing these capabilities.

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Information Sources

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WTG. 2021. Report for 2020 by the Lake Erie Walleye Task Group. Great Lakes Fishery Commission, http://www.glfc.org/pubs/lake_committees/erie/WTG_docs/annual_reports/WTG_report_2021.pdf

Fishery harvest and population assessment data were obtained from the following sources:

Lake Superior: Eric Berglund, OMNRF, eric.berglund@ontario.ca

Lake Michigan: Steve Hogler, Wisconsin Department of Natural Resources, steven.hogler@wisconsin.gov

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List of Figures

Figure 1. Walleye harvest, reported in metric tonnes, split into contributions from tribal, recreational and commercial fisheries in the five Great Lakes, 1975–2020. Fish community goals and objectives for Walleye are: Lake Superior, maintain, enhance, and rehabilitate self-sustaining populations over their historical range; Lake Michigan, maintain self-sustaining stocks, expected annual yield should be 100-200 metric tonnes; Lake Huron, reestablish and/or maintain walleye as the dominant cool-water predator over its traditional range with populations capable of sustaining a harvest of 700 metric tonnes; Lake Erie, maintain populations that support sustainable commercial and recreational fisheries; Lake Ontario, maintain, enhance, and restore self-sustaining local populations.

Source: Michigan Department of Natural Resources, Minnesota Department of Natural Resources, New York State Department of Environmental Conservation, Ontario Ministry of Northern Development, Mines, Natural Resources

and Forestry, Ohio Department of Natural Resources, Pennsylvania Fish and Boat Commission, Wisconsin Department of Natural Resources

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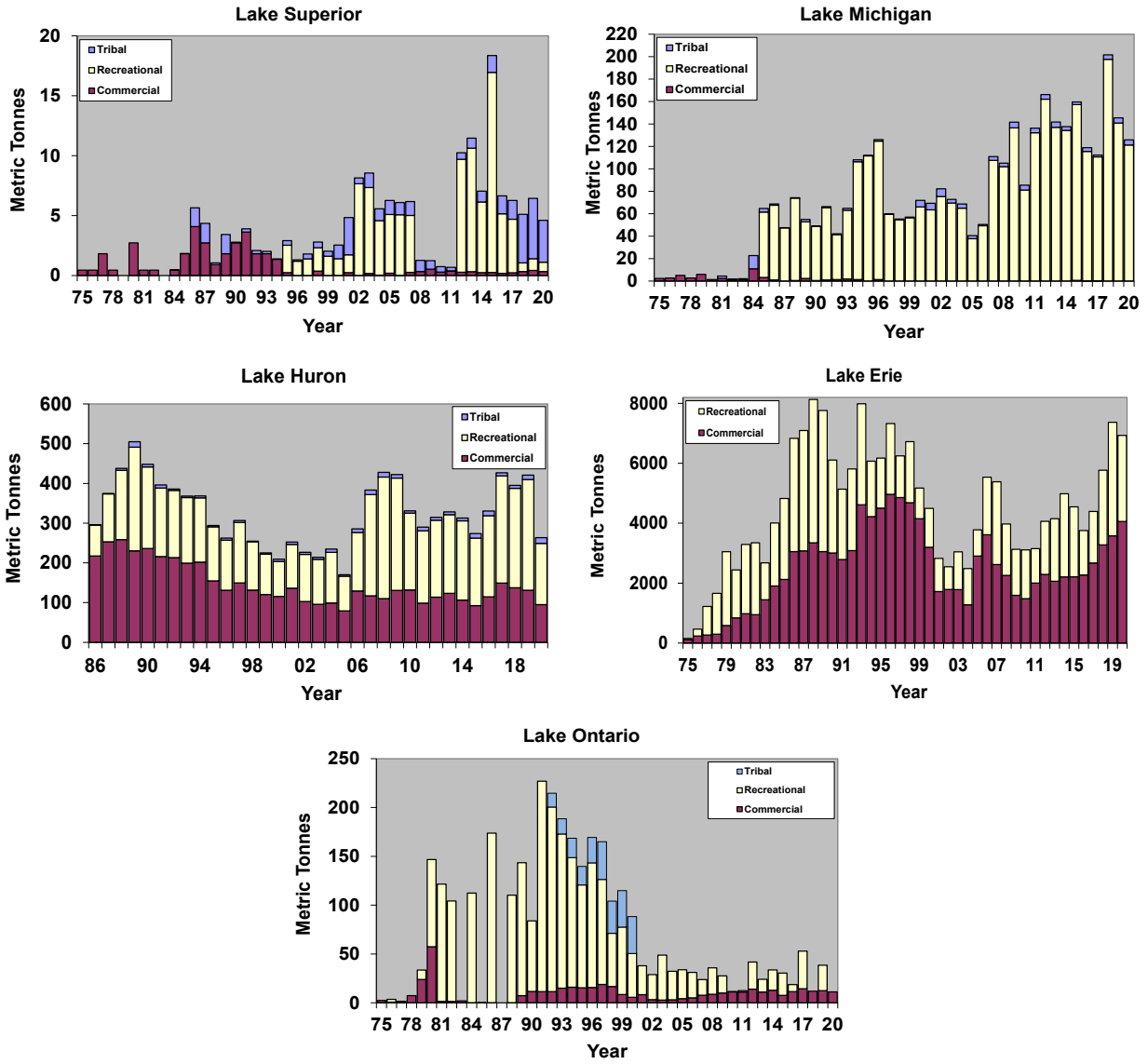

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