Black Sturgeon River Dam: A barrier to the rehabilitation of Black Bay walleye

Prepared by:
P. Furlong, R. F. Foster, P. J. Colby, and M. Friday

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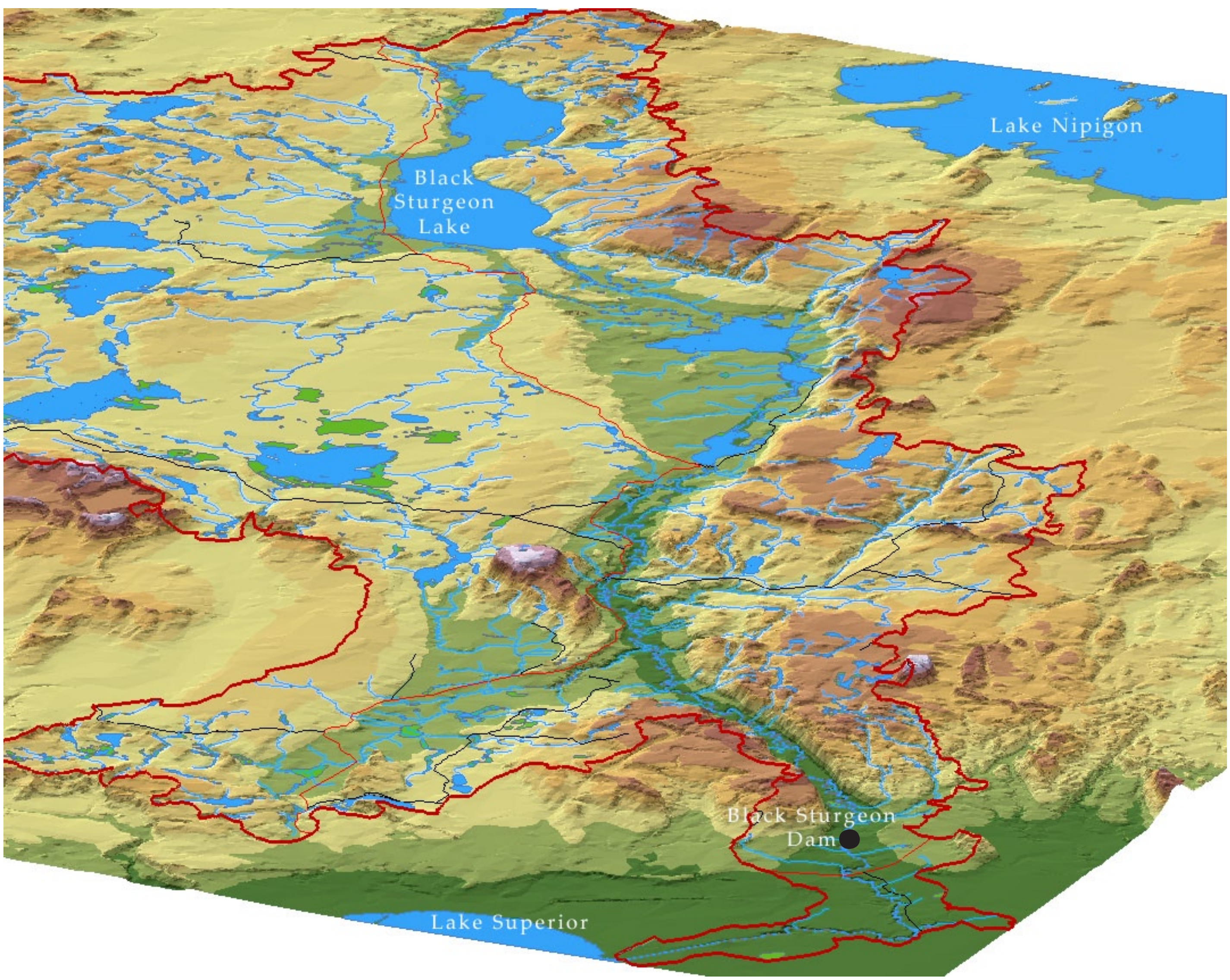
EXECUTIVE SUMMARY

This report summarizes the results of a number of projects designed to identify impediments to the recovery of the walleye population in Black Bay, Lake Superior. Detailed methods and results are included in the attached appendices. For many years Black Bay supported the largest commercial walleye fishery on Lake Superior with the majority of the spring harvest occurring near the mouth of the Black Sturgeon River. Construction of the Black Sturgeon Dam in 1960 was followed seven years later by an abrupt and long term collapse of the walleye population. Since this collapse there are few reports of walleye in Black Bay but a small population still exists in the lower river annually congregating below the dam making them vulnerable to angling and poaching. Habitat surveys reveal limited spawning potential on shoals in the bay, areas reported to have been historical spawning grounds. The vast majority of quality river spawning habitat has been rendered inaccessible by the dam. Fisheries studies on the walleye population below the dam reveal that the population uses both the river and bay on a seasonal basis and that lack of suitable spawning habitat may be a factor limiting population expansion. Comparison of genetic materials from historical samples collected prior to the population collapse in 1966 to samples collected from fish currently found throughout the Black Sturgeon River system, both above and below the dam, reveal that they are consistent with a single spawning population. A collective assessment of these results makes a strong case for the Black Sturgeon Dam being a factor in the collapse of the Black Bay walleye population and its failure to recover over the past forty years.



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INTRODUCTION

Black Bay once supported the largest walleye (*Sander vitreus*) population in the Canadian waters of Lake Superior, and a commercial walleye fishery has existed since the late 1800's (Goodier 1982). The commercial harvest of walleye in Black Bay exceeded that of the rest of Lake Superior from the late 1800's to 1965 (Schram et al. 1991). At its peak in 1966 over 150,000 kg of walleye were harvested, but it collapsed in 1968 after a number of years of intense commercial fishing (Figure 1). The population has not recovered even though commercial exploitation in Black Bay has largely been eliminated (i.e., incidental catches of walleye are still taken as part of the commercial perch fishery).

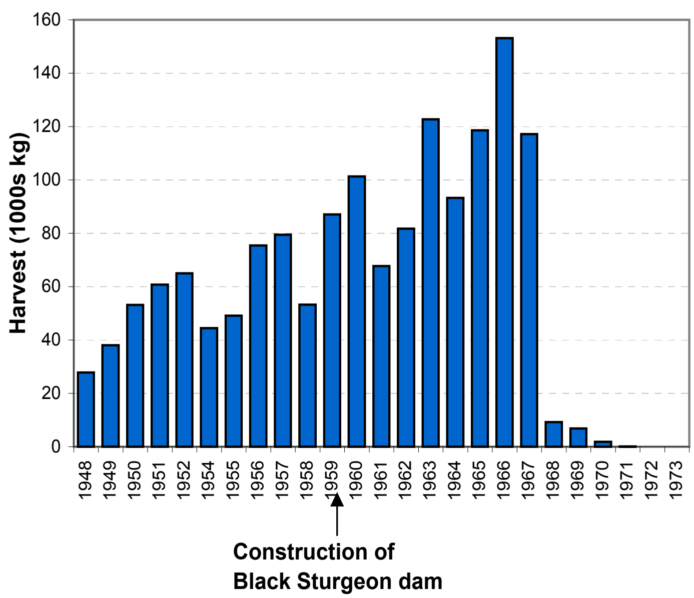


Figure 1. Annual commercial walleye harvest in Black Bay in relation to the construction of the Black Sturgeon dam.

A dam on the Black Sturgeon River, originally constructed to control water levels, prevents access to the upper reaches of the river. It has been speculated that recruitment failure as a result of blocking access to spawning and nursery habitat combined with commercial over-harvest is the most probable cause of the collapse of the Black Bay walleye population.

The purpose of this report is to document how the construction of the Black Sturgeon Dam had a negative impact on the Black Bay walleye population and how it remains a barrier to walleye rehabilitation. We summarize a number of recent studies undertaken by the Ontario Ministry of Natural Resources (OMNR) to determine habitat availability, movement patterns, and genetic relationships between river and bay walleye stocks. We also compiled historical fisheries data and examined the health of the present walleye populations in Black Bay and the Black Sturgeon River. A more detailed description of these unpublished studies are included in appendices to this report. The majority of this work has been made possible through provincial funding under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA).

BACKGROUND

The Black Sturgeon River Watershed

The Black Sturgeon River is approximately 100 km long, originating at Black Sturgeon Lake and emptying into Lake Superior at Black Bay (Figure 2).

The Black Sturgeon is the seventh largest tributary to Lake Superior with a mean annual flow of approximately 19 $m^3 \cdot s^{-1}$ (Swainson 2001). There are four lakes in the upper half of the river, including Black Sturgeon Lake at the northern end and progressing south through Nonwatin, Nonwatinose and Eskwanonwatin Lakes.

The Black Sturgeon watershed covers about 266,000 ha of bedrock-dominated terrain. Soils are predominately glaciolacustrine or glaciofluvial silts and clays along the river corridor, with coarser morainal soils over bedrock uplands (Jones et al. 2002). The river can be divided into sections, which vary considerably in terms of gradient, flow and substrate type (Figure 3). The majority of the river below the Black Sturgeon Dam is slow and deep with silt, clay, and sand bottom. Apart from a 3 km section immediately below the dam, most of the coarser substrates are found in higher gradient sections of the river.

Black Bay encompasses approximately 60,000 ha, of which 30% (18,000 ha) consists of water less than 5 m and 50% (29,000 ha) is from 5 to 15 m in depth. Mean and maximum water depths are 8.3 m and 64.5 m respectively (Cullis 1985). Deeper water is largely restricted to a narrow channel in the southern two thirds of the bay.

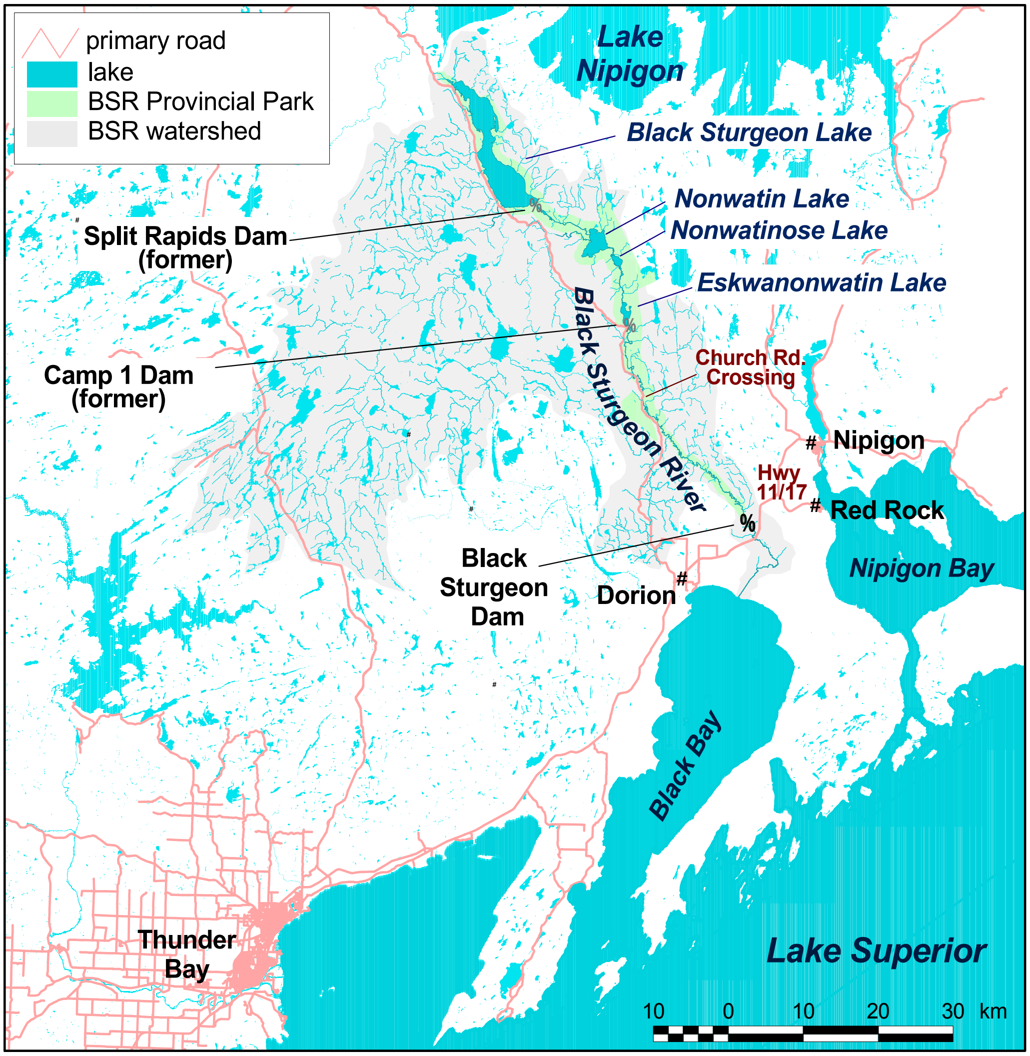


Figure 2. Regional context of the Black Sturgeon River and it's watershed.

In 2001, the section of the Black Sturgeon River above the dam to Black Sturgeon Lake was designated as a provincial park. The resource stewardship policy in the park management plan identifies that rehabilitation of degraded fish habitat may occur, including restoring fish passage at dams and other barriers to migration (OMNR 2004). Fisheries and aquatic values within the park are managed in accordance with Nipigon District Fisheries Management Policy in consultation with Ontario Parks.

History of Dams on the Black Sturgeon River

From 1937 to 1965 the watershed was used extensively for log drives (Figure 4). Dams were constructed throughout the system to control water levels. The first of three dams was constructed at the outlet of Eskwanonwatin Lake, commonly referred to as the Camp 1 Dam, followed by Split Rapids Dam built at the outflow of Black Sturgeon Lake. The Black Sturgeon Dam (historically referred to as the Camp 43 or Twin Rapids Dam), was the final water control structure established on the lower end of the system (16.3 km from the mouth) in the winter of 1959/1960 (Figure 4). After the log drives ceased in 1965, the upper dams were no longer operated but remained a barrier to upstream fish passage. In 1966 the Black Sturgeon Dam was modified to prevent the passage of migrating sea lamprey (*Petromyzon marinus*). A spill wall was added to the east end of the dam in 1968, to mitigate effects of a flood in the spring of that year.

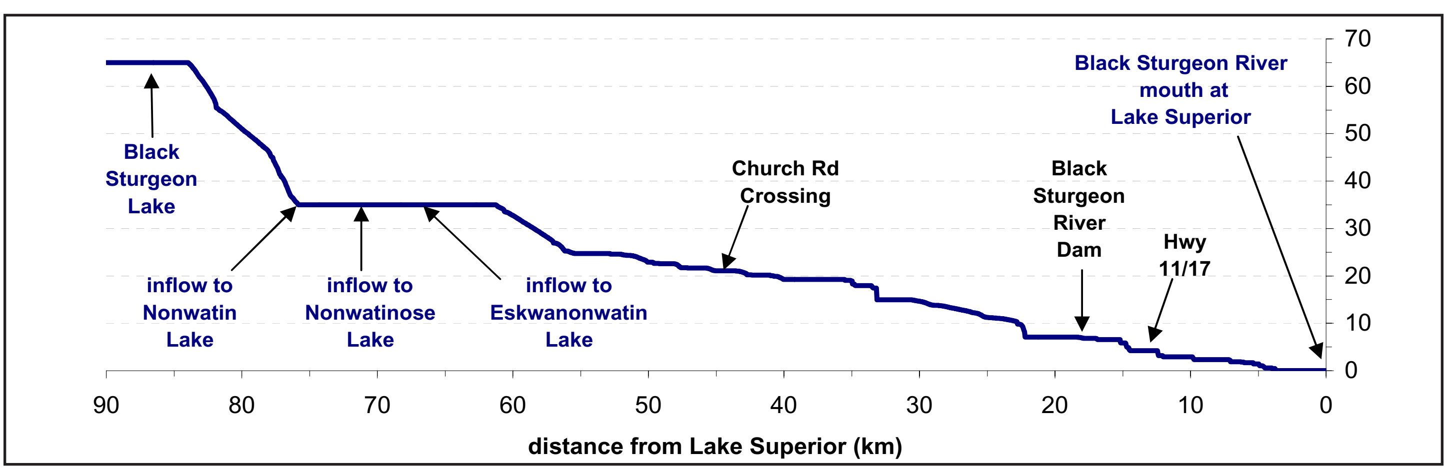


Figure 3. Black Sturgeon River profile.

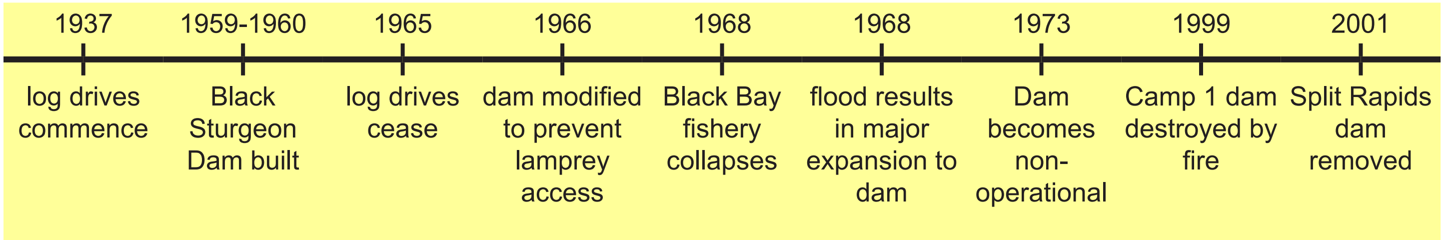


Figure 4. Timeline of events for the Black Sturgeon River System.

Stop logs were used to regulate flows during sea lamprey control treatments until 1973. Since then, the stop logs have been left in place, maintaining an approximately 2 m head of water year round (Sakamoto 2002). In 1999 the Camp 1 Dam was destroyed during a forest fire and in 2001 the Split Rapids Dam was removed by OMNR. The Black Sturgeon Dam is the only remaining water control structure on the river (Figure 4).

Presently, the only function of the Black Sturgeon Dam is for sea lamprey control. Efforts to control this nuisance species have been undertaken since the 1960's by the Great Lakes Fishery Commission. The most effective control measures include barriers to migrating adults and chemical treatments to kill larval lamprey in bottom sediments. Both of these control mechanisms are currently used on the Black Sturgeon River. The Black Sturgeon Dam prevents access of adult lamprey to the productive upper reaches of the river and the area below the dam is treated with larval lampricide.

Fish Community

Black Bay has a diverse fish community with over a dozen species of economic or recreational importance. There are significant populations of lake herring (*Coregonus artedi*), yellow perch (*Perca flavescens*), lake whitefish (*Coregonus clupeaformis*), and white sucker (*Catostomus commersoni*), as well as lake trout (*Salvelinus namaycush*) and introduced salmon (*Oncorhynchus spp*.). Sauger (*Sander canadense*) were once common in Black Bay, but experienced heavy commercial exploitation in the 1960's during the latter stages of the walleye fishery, and are now extirpated (Colby and Foster 2001).

Thirty-five species of fish inhabit the Black Sturgeon River, 22 of which are found above the Black Sturgeon dam (Swainson 2001; Sakamoto 2002). At least 18 species have been recorded below the dam, including both resident and migratory species. Native species (walleye, lake sturgeon (*Acipenser fulvescens*), and brook trout (*Salvelinus fontinalis*)) and non-native species (chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), rainbow trout (*O. mykiss*), and sea lamprey) all migrate from Black Bay into the Black Sturgeon River. Nine non-native fish species are found in the system; smallmouth bass (*Micropterus dolomieu*) and rainbow trout are the only exotics found above the dam.

Rehabilitation Initiatives

The rehabilitation of walleye and other native fish species, and the restoration of degraded habitats, such as tributaries that have been stressed by dams, is supported by the Great Lakes Fishery Commission's Fish Community Objectives for Lake Superior (Busiahn 1990). The Commission has endorsed the Rehabilitation Plan for Walleye Populations and Habitats in Lake Superior (Hoff 2001), which highlighted Black Bay as the first priority area in Lake Superior for walleye rehabilitation in recognition of its historical importance for fish production. Both documents have the same objective; that is, to maintain, enhance, and rehabilitate self-sustaining populations of walleye and their habitat over their historical range.

Previous attempts to rehabilitate this walleye population have included the following:

- transfer of 1,032 adult walleye from the Current and Pigeon Rivers into Black Bay (1972);
- transfer of 768 walleye from local inland lakes into Black Bay from 1998-2000;
- implementation of a closed season for walleye angling in the Black Sturgeon River from the first set of rapids downstream to Lake Superior and in Black Bay north of Bent Island (January 1999);
- stocking of 1,000,000 walleye fry into Black Bay in 2003; and
- stocking of 100,000 walleye summer fingerlings into Black Bay in 2004 and an additional 160,000 in 2005.

CURRENT WALLEYE POPULATION STATUS

Abundance

Since the population crash in the 1960's, there has been little assessment of walleye in Black Bay or the Black Sturgeon River. In September 2002, 81 sites throughout Black Bay were sampled using the Fall Walleye Index Netting (FWIN) protocol (OMNR 1998) (Appendix 1). Only 13 walleye were caught in the multi-panel gill nets, all from the northern third of the bay. The mean of 0.16 walleye per set is significantly lower than the average of 10.7 walleye for FWIN sets in northwestern Ontario (Figure 5) (Morgan et al. 2003). This indicates that abundance remains extremely low. Perch catches were also low, while relatively large numbers of spottail shiners and suckers were collected (OMNR unpublished data).

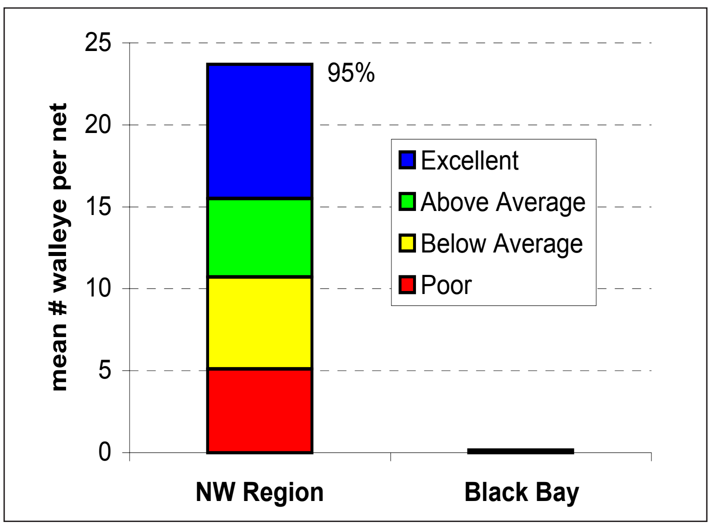


Figure 5. Mean number of walleye per Fall Walleye Index Net (FWIN) set for Black Bay (2002) in comparison to northwestern Ontario benchmarks (Morgan et al. 2003).

Biological Characteristics

Walleye from Black Bay and Black Sturgeon River were sampled during the 2002-2003 telemetry project and Fall Walleye Index Netting program (Appendix 1 and 2).

In 2003, total length of walleye ranged from 166 mm to 675 mm, with a mean (±SD) of 431 (±152) mm. Mean size for fish caught in 2003 using standard FWIN nets were smaller (361 (± 148) mm), but comparable to the mean of 376 mm for Northwest Region FWIN assessments (Morgan et al. 2003).

The length distribution was fairly balanced (Figure 6). Large fish are more abundant than typically seen in a standard FWIN, which may partly be due to a sampling bias that selects for larger spawning fish. The 2003 netting used short-duration sets on the Black Sturgeon River from May 13 to July 17, whereas standard FWIN protocol uses 24-hour, randomly-located sets in the fall. Anecdotal evidence suggests that there is an abundance of large walleye below the Black Sturgeon Dam (M. Klitch and J. George, pers. comm.).

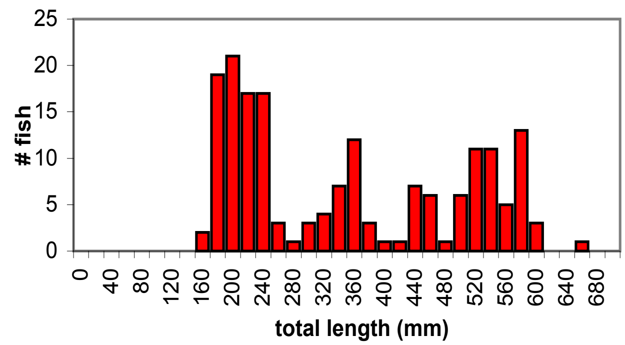


Figure 6. Size frequency distribution of walleye from the Black Sturgeon River using FWIN gillnets in 2003. See Appendix 1 for details.

The fish sampled in 2003 using FWIN nets show higher than average growth rates, which suggests a population that is not limited by intra-specific competition (Figure 7) (Colby and Nepszby 1981).

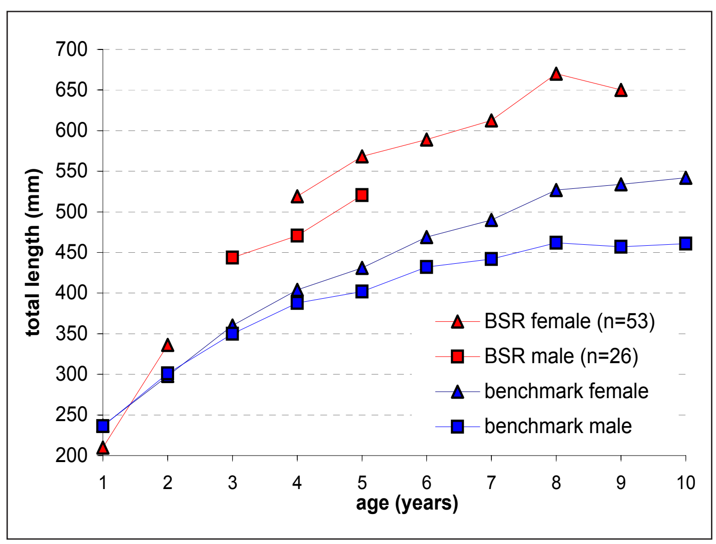


Figure 7. Length (mm) at age (yr) for Black Bay walleye (2001-2003) compared to provincial benchmark (Morgan et al. 2003).

The age class distribution showed a peak at 1 yr and 5 yr, with no fish older than 9 yr (Figure 8). On average, in northwestern Ontario, 50% of females netted during FWIN surveys are mature at 4.8 yr and 50% of males are mature at 3.5 yr (Morgan et al. 2003). The majority of the 5-year-old fish from the Black Sturgeon River are probably mature since sampling targeted spawning fish. The abundant age 5 fish were the result of a strong year class in 1998. This is consistent with reports on other walleye fisheries across northwestern Ontario.

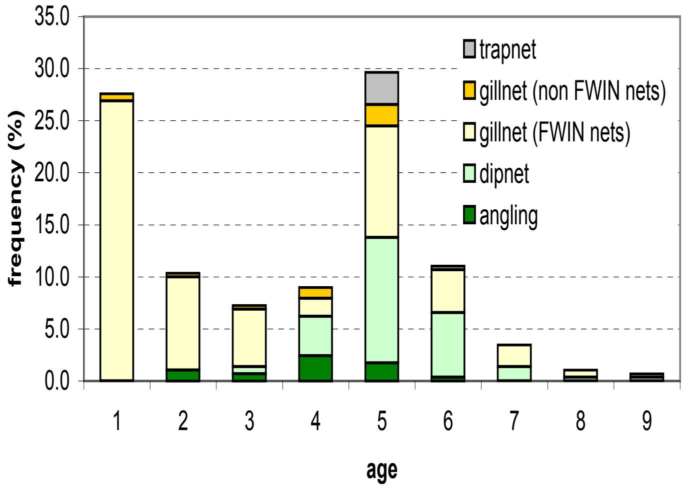


Figure 8. Age distribution for walleye sampled from the Black Sturgeon River by various methods in 2003 (n = 290).

The lack of fish older than nine years is surprising, and may reflect shorter life spans as depicted by the rapid growth rates. In this part of their range, the average life expectancy of walleye is usually 14-16 yr (Colby and Nepszy 1981). However, where walleye grow fast they mature early and their life span is shorter, seemingly following Rubner's hypothesis that longevity is inversely proportional to the intensity of living for cold blooded organisms (Allee et al. 1949). It is recognized that there is significant spring fishing mortality on walleye in the lower river. Rapid growth and truncated age distribution may reflect a population stressed by continued exploitation.

Overall, despite some methodological differences, it is evident that the Black Sturgeon River – Black Bay system has a low density of spawners and recruits compared to the historic Black Bay walleye population and to walleye lakes in northwestern Ontario, and also has an above average growth rate.

GENETIC ASSESSMENT

Historically walleye in Black Bay were thought to be comprised primarily of a shoal-spawning stock and a river population of minor significance. To test this hypothesis, genetic data from walleye collected in 2003/2004 from above and below the dam on the Black Sturgeon River were compared to scale samples collected in 1966 from the west side of Black Bay, as well as samples collected from the remnant Nipigon Bay population (Figure 9).

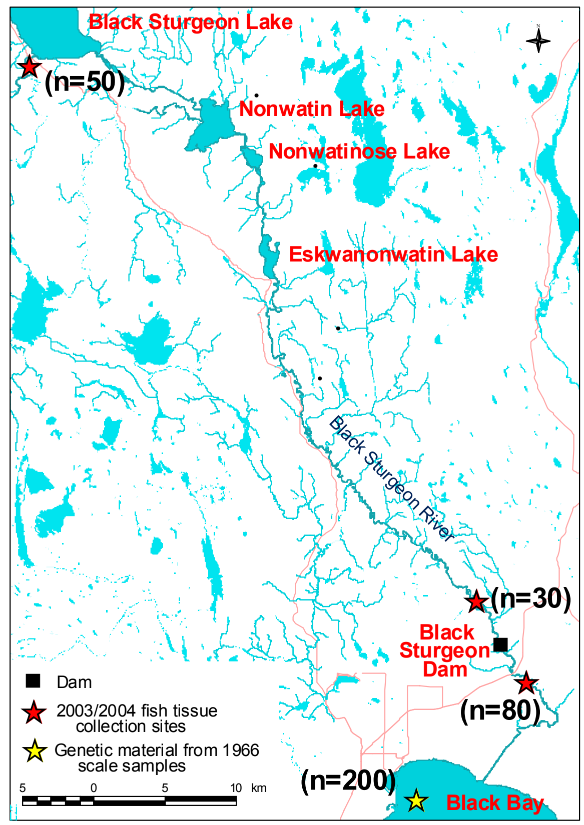


Figure 9. Location of samples used in genetic analyses (Nipigon Bay samples not shown).

Results from both the population- and individual-based analyses showed that walleye in the Black Sturgeon River are very closely related to the historical Black Bay population (Figure 10). The apparent divergence shown by interpopulation genetic distance estimates between these collections (Figure 10) were not significant, and were within expectations for population decline and temporal difference of four decades between the Black Bay and Black Sturgeon sample sets. This was confirmed by the individual assignment tests, which showed that individuals from the Black Bay and Black Sturgeon River sample sets could not be separated, versus all

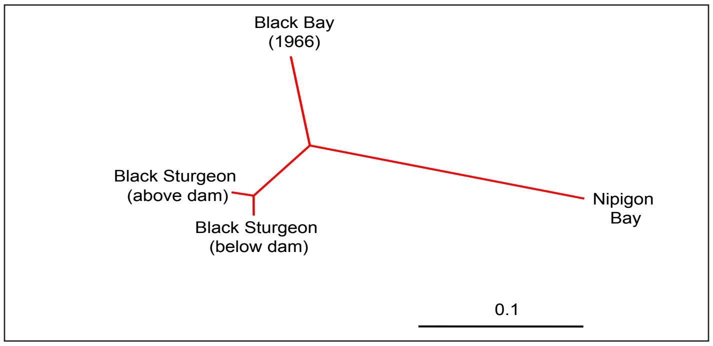


Figure 10. Genetic divergence among walleye populations (historical Black Bay population, Black Sturgeon River above and below barrier dam, and native Nipigon Bay walleye) based on Cavalli-Svorsa and Edwards' (1967) chord distance for five microsatellite DNA loci.

fish from the Nipigon Bay outlying group, which were consistently excluded from the greater Black Bay dataset (Figure 11). These data indicate that the Black Sturgeon River was probably the true spawning habitat for the historical Black Bay population.

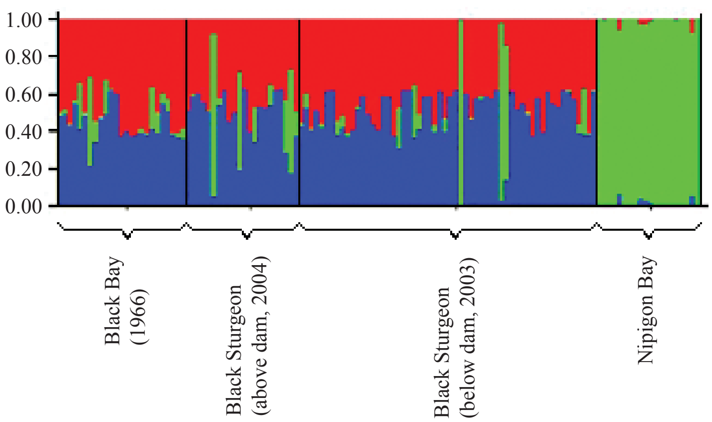


Figure 11. Fractional membership coefficients for individual walleye from the historical Black Bay population, the Black Sturgeon River (above and below the barrier dam), and Nipigon Bay.

MOVEMENT BETWEEN BAY AND RIVER

Recent telemetry work (Appendix 2) demonstrated that walleye move seasonally between the Black Sturgeon River and Black Bay. Twenty adult walleye were radio-tagged and tracked from 2003 to 2005. During the late winter, walleye were located in the northern portion of Black Bay, a possible over wintering site. When water temperatures reached between 4 - 6°C in late April to early May, the tagged walleye moved up the Black Sturgeon River to the rapids just above the highway or to the area just below the Black Sturgeon Dam (Figure 12). This was most likely indicative of migratory behaviour as Scott and Crossman (1998) noted that walleye spawning occurs at similar water temperatures.

Radio-tagged fish moved downstream in late May early June, and typically moved out into the Bay for 2-5 weeks before returning to the lower reaches of the river. During the summer, a number of walleye made repeated nightly forays from the river into Black Bay, possibly to feed. Walleye are predominantly nocturnal feeders (Swenson 1977) and move at night in search of food (Carlander and Cleary 1949). Foraging activity in the bay may be in response to a post-spawning requirement for increased nutrition (Ryder 1977).

Anecdotal reports of walleye caught in the Black Sturgeon River and Black Bay are consistent with this pattern of habitat use. Congregating at the mouth of the Black Sturgeon River pre-and post-spawn would have undoubtedly increased their vulnerability to exploitation.

Commercial fishing records (Appendix 4) demonstrate that, although walleye harvest was typically greatest in the northern portion of the bay near the Black Sturgeon River, walleye were found throughout the bay, particularly later in the open-water season.

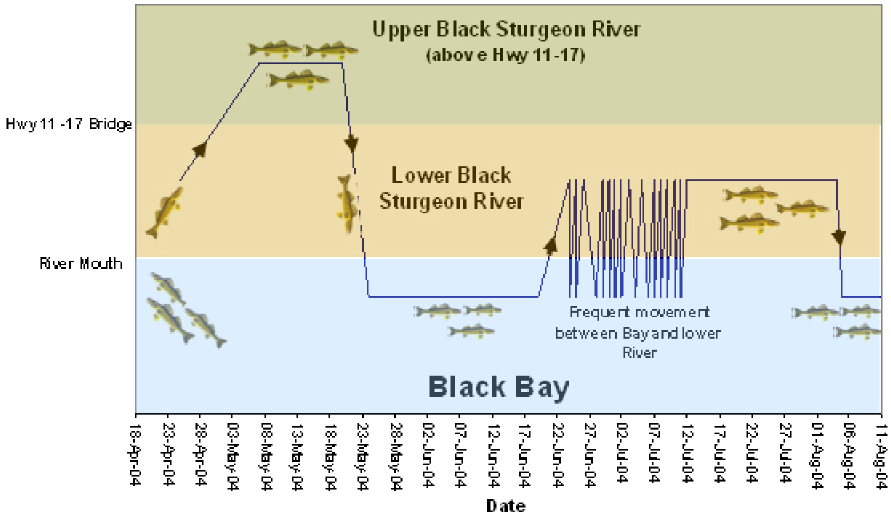


Figure 12. Typical movement pattern of radio-tracked walleye in Black Bay – Black Sturgeon River (2003-2005). Multiple walleye represent seasonal congregations.

HISTORICAL AND CURRENT SPAWNING HABITAT

Spawning Habitat in Black Bay

Historically, walleye were thought to have spawned on shoals in Black Bay, both east and south of Hurkett Cove, along the northwestern shore (Figure 13) (Goodier 1982; Goodyear et al. 1982); however, gill nets set in this area in May 1995 failed to capture any walleye (Colby and Foster 2001). Ryder (1968) also noted a "minor" run of walleye in the Black Sturgeon River, but no quantitative data were collected and the significance of the run is unknown.

Telemetry and genetic evidence presented in this report suggests that discrete river and shoal-spawning stocks do not exist, and that the Black Sturgeon River may have been the primary spawning location. Substrate sampling of supposed historical spawning grounds (Figure 13) (Biberhofer 2006) shows that these areas are not optimal for walleye spawning.

Most of the area mapped as historical spawning grounds by Goodier (1982) along the northwestern shore of Black Bay are predominately silts and clays with only a relatively minor component of sand. Video recordings show a veneer of fine particulate material that has settled over most of the substrate during the winter. This material is re-suspended during the ice-free months, but it may negatively impact potential spawning habitat in the bay.

Small amounts of cobble occur along portions of the shoreline in very shallow water, particularly the central and southern reaches of the survey area south of the spawning grounds mapped by Goodier (1982). There are also narrow bands of cobble along the shoals leading out and around Bent and Nuttal Islands (Biberhoffer 2006). These sites may provide some opportunities for walleye spawning. However, the cobble substrate rapidly transitions from cobble shore to finer-

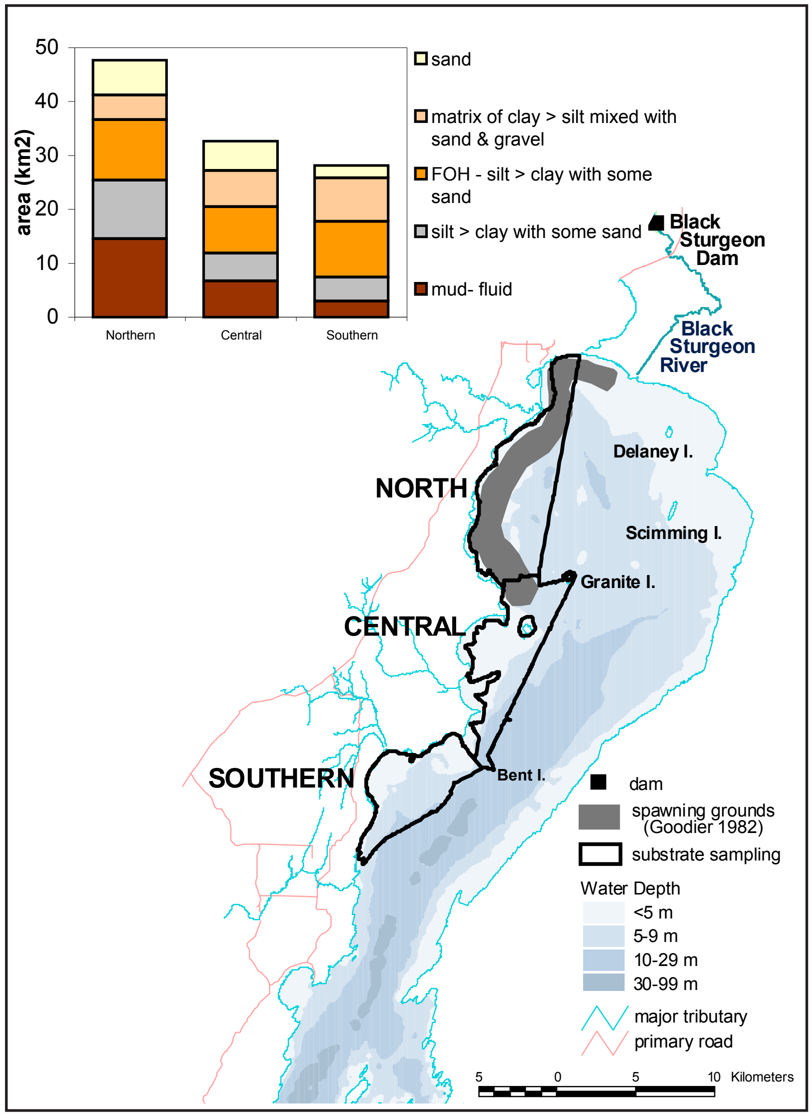


Figure 13. Historical spawning grounds reported by Goodier (1982) and location of 2004 substrate mapping (Biberhofer 2006). Inset figure shows substrate composition of western shore of Black Bay.

Figure 14. Cobble bar near Bent Island in Black Bay.

grained material, and there are fine-grained particles in the interstitial spaces of the cobble, likely deposited during the winter (Figure 14).

Although some cottage/camp development has occurred on the western shore of Black Bay it has resulted in limited aquatic habitat disturbance to date. It appears more likely that the shoals in Black Bay provide sub-optimal habitat to spawning walleye when compared to available spawning habitat in the Black Sturgeon River. Historically the relative importance of the river spawning stock may have been underestimated due to the fact that spawning walleye entered the river while ice still covered the bay. Recent telemetry work confirms the timing of these migrations (Figure 12) during a period when degrading ice conditions on the bay and lower river would make observation of fish movement difficult. The use of the shoals in Black Bay for spawning may have decreased as the walleye population declined and retracted to its core optimal habitat, analogous to the MacCall's basin hypothesis for marine fish stocks (Simpson and Walsh 2003).

Spawning Habitat in the Black Sturgeon River

The Black Sturgeon River above the dam has abundant walleye spawning habitat (Sakamoto in prep.). In the 65 km from Eskwanonwatin Lake to the mouth of the river, as mapped by Sakamoto, there are 17 sets of rapids, most of which are in the upper section (Figure 15). The rapids represent 10.1 km of river or 405,000 m^2 of potential spawning habitat, of which approximately 80% is above the Black Sturgeon River Dam (Figure 16). This is a minimum estimate since it does not take into account potential habitat in tributaries to the Black Sturgeon River or upstream of Eskwanonwatin Lake.

Of the 1,842 km of mapped stream length within the Black Sturgeon River watershed, 98% (1,811 km) is located above the Black Sturgeon Dam. There are

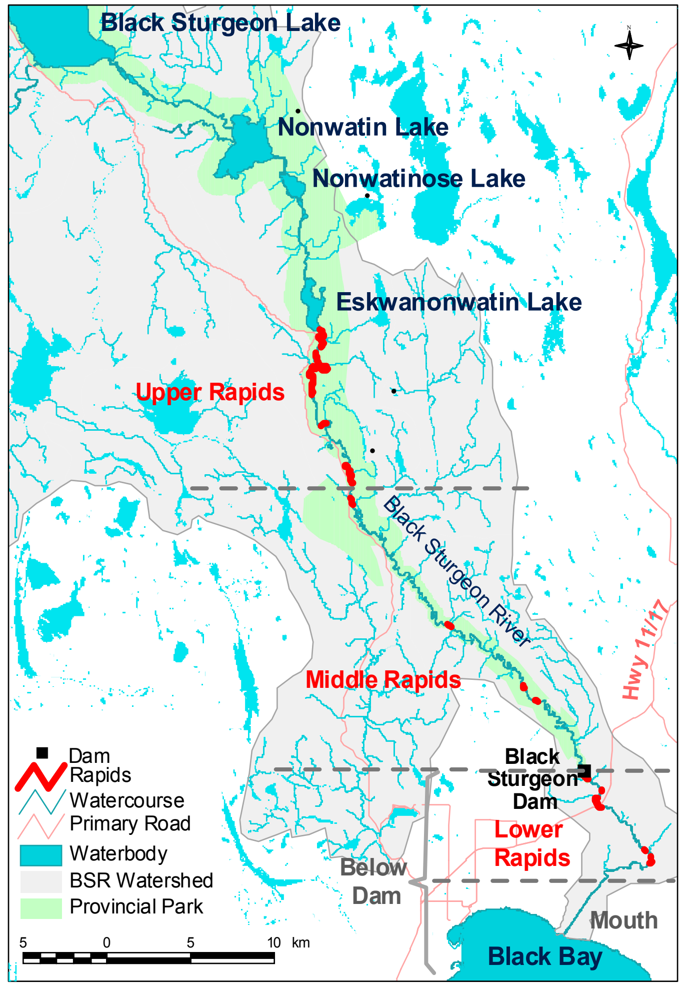


Figure 15. Location of rapids in the Black Sturgeon River below Eskwanonwatin Lake (from Sakamoto in prep.).

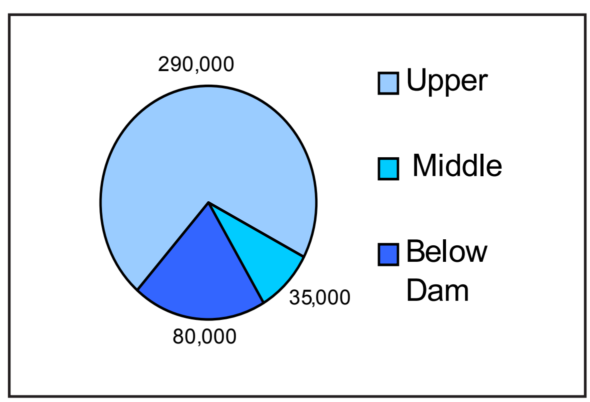


Figure 16. Area of rapids (m^2) by section in the Black Sturgeon River below Eskwanonwatin Lake. See Figure 15 for location of sections.

57 mapped tributaries between the Black Sturgeon River dam and Eskwanonwatin Lake alone. Some of these tributaries are of considerable size, such as the Nonwatin and Spruce Rivers and Shillabeer, Circle, and Larson Creeks.

The majority (79%) of the rapids are predominately cobble or pebble, which are typically preferred by walleye for spawning (McMahon et al. 1984) (Figure 17). The remaining rapids mainly have a boulder, cobble, pebble mixture with minor amounts of sand and silt. Most of the best potential spawning habitat is above the dam, with only about 4,500 m^2 of cobble- and pebble-dominated rapids currently accessible to Black Bay walleye.

Figure 17. Potential walleye spawning area in upper rapids below Eskwanonwatin Lake (K. Sakamoto photo).

Most other Great Lakes walleye stocks spawn in tributary rivers. For example, the Thames River spawning stock was largely responsible for maintaining the Lake St. Clair walleye population and contributed fish to Lake Huron and Lake Erie (Ferguson and Derksen 1971). Adult walleye (>4 yr) from Lake Erie spawn in the lower 42 km of the Grand River, which also has a resident population of younger (<4 yr) walleye (Tom MacDougall, unpublished data). Most of the walleye that are harvested in western and central Lake Erie are thought to spawn in the western basin, utilizing both river and offshore shoal habitat (Baker 1971).

Spawning habitat must be sufficiently close to other habitat required for later life stages (Jones et al. 2003); but in-stream nursery habitat is probably not limiting in the Black Sturgeon River, since most newly hatched walleye may be swept downstream into Black Bay (Petzold 2004). In some Great Lakes tributaries, such as in the Sandusky and Maumee Rivers, larvae are carried by current downstream to river mouths and nearshore areas, where they begin feeding (Houde 1969). However this may be an overly simplistic model of a highly complex system with diverse riverine habitat.

Risk of starvation or physical damage from high flows increases with distance between riverine spawning areas and downstream nursery habitat (Mion et al. 1998). Although the uppermost rapids below Eskwanonwatin Lake are approximately 65 km from Black Bay, there are numerous examples of walleye moving similar or greater distances to spawn. Adult walleye have been known to spawn in tributaries far upstream of nursery grounds in the lake e.g., Fox River 64 km; Wolf River 155 km (Priegel 1970); Muskegon River 63 km (Schneider and Leach 1979); Saganaw River 110 km (Mrozinski et al. 1991); and Valley River 20-70 km (Johnston et al. 1995).

With the possible exception of some bark and woody debris from log drives, the wetlands and nearshore habitats in Black Bay remain largely undisturbed by development. Loss of nursery habitat is unlikely to have contributed to the walleye decline, nor to impede population rehabilitation. Wetlands at Hurkett, Moose Bay, and smaller fringing wetlands provide cover and prey for young-of-the-year (YOY) walleye.

IMPLICATIONS FOR WALLEYE REHABILITATION

Despite almost 40 years and various rehabilitation efforts, walleye populations in Black Bay have not recovered even though commercial exploitation has largely been eliminated. The extremely abrupt stock collapse in 1967 and the failure of the population to recover indicate that recruitment is a continuing impediment. This suggests that the Black Bay walleye stock may have two equilibria, a model proposed by Walters (1986) for Great Lakes lake trout stocks. The combination of excessive harvest, low recruitment due to blocked access to spawning sites, and increased vulnerability to commercial fishing nets led to the catastrophic collapse of the Black Bay walleye population from the higher, historical equilibrium. The population may now be locked in a new, lower equilibrium. If the dam was removed, access to historical spawning areas in the

Black Sturgeon River may allow the equilibrium to move upwards towards the higher historic equilibrium, analogous to Lake Superior lake trout stocks re-invading former spawning shoals (Walters 1986).

Is habitat a limiting factor?

The question of whether or not river nursery or spawning habitat is limiting the production of walleye is critical to making the decision to remove the Black Sturgeon Dam (Petzold 2004).

Although the dam is a barrier to upstream movement, the area below the dam provides a significantly larger area for spawning when compared with other systems (Petzold 2004). Assuming that each female walleye requires 20 m^2 of spawning habitat (Hoff 2001) and there is approximately 80,000 m^2 of spawning habitat below the dam, there may theoretically be sufficient spawning habitat for about 4,000 female walleye.

It is unknown if spawning habitat is currently limiting walleye. Although the 2002 FWIN indicates there is a low number of walleye given the large size of Black Bay, there may be sufficient numbers of spawning walleye in the Black Sturgeon River for spawning habitat to be at a premium.

The fact that walleye congregate directly below the Black Sturgeon Dam suggests that either preferred spawning habitat is limiting below the dam or that there is a persistent genetic component for walleye homing to upstream spawning areas as walleye spawning habitat preferences have a heritable component (Jennings et al. 1996). Prior to the crash in the early 1960's, walleye were caught in large numbers immediately below the dam, even in August (T. Mosindy, pers. comm.). A 1971 letter on file from the Sea Lamprey Control Centre to the Ontario Department of Lands and Forests notes, regarding the blocking of the fishway "a popular sports fishery for pickerel has developed below the dam" (OMNR Engineering Archive Files, 1971). This suggests that before and after the crash, the dam presented a barrier to walleye trying to access upstream habitat.

Would improved passage benefit walleye?

Although it is uncertain if spawning habitat is currently limiting walleye production, it is doubtful that there is sufficient spawning habitat to sustain a significantly rehabilitated Black Bay walleye population. At least 125,000 kg of adult walleye were harvested each year from Black Bay from 1965-67; therefore, assuming adults with an average adult weight of 1kg and a 1:1 male to female ratio (Petzold 2004), there would have been approximately 62,500 female spawners. If each female uses 20 m^2 of spawning habitat, then over 1.2 million m^2 of spawning habitat would be required to sustain the historical population. This is approximately 15 times greater than the available spawning habitat in the rapids below the Black Sturgeon River dam. While some these assumptions are conjectural, it is clear that there is at least five times as much potential spawning habitat above the Black Sturgeon Dam as below, and that upriver access would benefit an expanding Black Bay walleye population. Walleye have a high fidelity to spawning grounds (Crowe 1962), which means that additional spawning habitat above the dam will likely be colonized as the population grows. Walleye typically migrate beyond currently used spawning habitat as adult abundance increases and spawning areas becomes overcrowded (Jones et al. 2003). In the case of the Black Sturgeon River, the effect may be more immediate given that walleye currently congregate immediately below the dam during spawning.

RECOMMENDATIONS

Many of the rehabilitation strategies and supporting studies recommended during a walleye rehabilitation workshop (Petzold 2005) and by Colby and Foster (2001) have been undertaken (e.g., fingerling stocking, angling restrictions, and cormorant diet study). Habitat restoration, which was considered the second most important impediment by fisheries professionals at the workshop, remains unfulfilled.

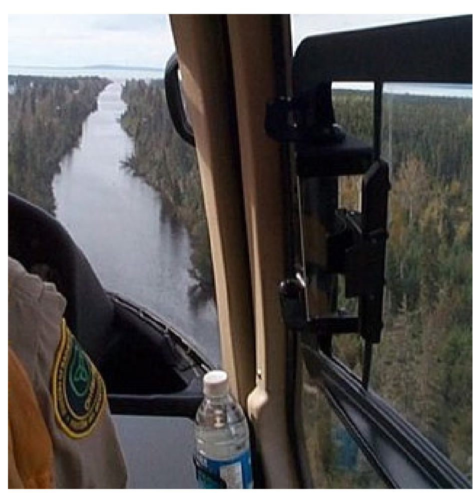
Several lines of evidence indicate that the Black Sturgeon Dam is an impediment to rehabilitation of walleye in Black Bay, namely:

- Analysis of historical commercial catch records confirmed that although walleye were widely distributed in Black Bay, they appeared to be more abundant near the mouth of the Black Sturgeon River during the spring, which would be consistent with a largely river-spawning population;
- Dam construction coincides with the collapse of Black Bay walleye fishery;
- Walleye congregate at the base of the dam during spawning migration;
- Genetic analysis confirms that fish inhabiting Black Bay and the Black Sturgeon River are indistinguishable;
- Telemetry studies show that Black Bay and Black Sturgeon River walleye are not segregated;
- Habitat studies indicate that there is limited high quality spawning habitat in Black Bay and limited riverine spawning habitat below the Black Sturgeon dam in comparison to upstream reaches; and
- Index netting data indicate that there is an existing walleye population in the Black Sturgeon River system that could take advantage of an increase in available spawning habitat.

From the perspective of rehabilitating Black Bay walleye stocks, the removal of any barriers to fish passage posed by the existing Black Sturgeon Dam is strongly recommended.

Until a rehabilitated walleye population can be demonstrated, we strongly recommend that all walleye harvest in the Black Sturgeon River from the dam to Lake Superior be eliminated. The existing walleye population exhibits signs that may be attributed to excessive fishing mortality (i.e., rapid growth and lack of older aged fish). Results from the telemetry study clearly demonstrate that spawning walleye from Black Bay congregate below the dam during the spring, making them extremely vulnerable to angling and other harvesting activities.

We recommend complete removal of the dam, but other options are worth investigating. A recently completed safety assessment of the Black Sturgeon Dam showed that the structure was generally in fair condition (OMNR 2001a). It is expected, however, that the dam will need to be replaced or significantly repaired within the next 10-15 years. It may be possible to resume operation of the dam to allow for the passage of walleye early in the season when there may be limited movement of other species in the system. Incorporating a fish passage system into a rebuilt dam might also be considered; however, walleye do not appear to use fishways very effectively. For example, few walleye have been observed to use a Denil fishway in Dunnville, Ontario that was built to provide upstream passage for walleye from Lake Erie to the Grand River (Bunt et al. 2000). Nevertheless, while it may be possible to pass walleye over low-head dams with certain fishway designs, it is important to reach a consensus on fisheries concerns well in advance of initiating any work on the present structure in order to address potential environmental assessment implications and to facilitate capital planning for this endeavor.



Issues and Potential Benefits

It is recognized that the removal of the Black Sturgeon Dam or modification to permit fish passage would have numerous benefits such as:

- Reestablishment of natural flow regimes and sediment transport on the Black Sturgeon River, and nutrient input into Black Bay;
- Increased access to spawning habitat for native coaster brook trout;
- Increased access to spawning habitat for lake sturgeon (considered a species of Special Concern by COSEWIC), and re-establishing links between populations in Black Sturgeon River system and Lake Superior sturgeon stocks.
- Increased habitat for northern brook lamprey (considered a species of Special Concern by COSEWIC) in the Black Sturgeon River if TFM use is reduced or eliminated;
- Removal of cost and liability of maintaining existing Black Sturgeon Dam;
- Reestablishment of links between walleye stocks upstream (e.g. Spruce River) and downstream of the dam;
- Reduction in poaching of spawning walleye and other migratory species that currently concentrate below the dam; and
- Reduction in vulnerability to harvesting by eliminating a potential bottleneck in the northeastern portion of the bay during the spring. The removal of the dam would allow for a more drawn out and less dense reentry of adults to the bay.

However there may be some negative impacts to dam removal such as:

- Impacts on sea lamprey control efforts; and
- Potential passage of other non-native anadromous fish (e.g. rainbow trout, salmon, rainbow smelt) to the upstream reaches of the Black Sturgeon River.

Of these, perhaps the greatest potential negative impact is with respect to sea lamprey control. Alternative methods of sea lamprey control on the Black Sturgeon River are possible, such as adjustable crest barriers that are used on some tributaries to Lake Superior in the U.S. Research supporting alternatives such as studies on the timing of sea lamprey and walleye spawning (planned for 2006) should be strongly supported.

The Black Bay walleye fishery was once the largest on Lake Superior and was worth hundreds of thousands of dollars annually. Over the 18 years prior to it's collapse the Black Bay fishery averaged almost twice the total annual walleye harvest for Lac des Mille Lacs (OMNR, 2001b). Lac des Mille Lacs is one of northwestern Ontario's most important walleye fisheries, providing substantial economic benefits to the region. Although the historic walleye harvest in Black Bay was clearly not sustainable a rehabilitated fishery would still be of considerable significance. Economic modeling (Appendix 5) indicates that a Black Bay walleye population that is sufficiently recovered to permit recreational angling on Black Bay would be worth several hundred thousand dollars per year to open-water anglers from Thunder Bay alone. Given the ecological and socio-economic importance of the Black Bay walleye population, there is a strong case for reestablishing unimpeded fish passage on the Black Sturgeon River.

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APPENDIX 1
RECENT WALLEYE ASSESSMENT

Methods

In September 2002, 81 sites throughout Black Bay (Figure 1) were sampled using the Fall Walleye Index Netting (FWIN) protocol (OMNR 1998). In 2003 assessment techniques were constrained by the need to live-release walleye for telemetry and due to the presumed small size of the population. A combination of trap, dip, gill and seine nets was used, as well as limited angling (Table 1). The FWIN protocol (OMNR 1998) was not followed, although multi-panel FWIN nets were used. Instead of 24-hour sets, shorter nets sets were used i.e. <2 hours. Nets were set throughout Black Bay in 2002, but in 2003 were set mainly in the lower reach of the Black Sturgeon River, with a few sets near the dam and in the northwest portion of Black Bay where walleye were reported having been caught (Figure 1).

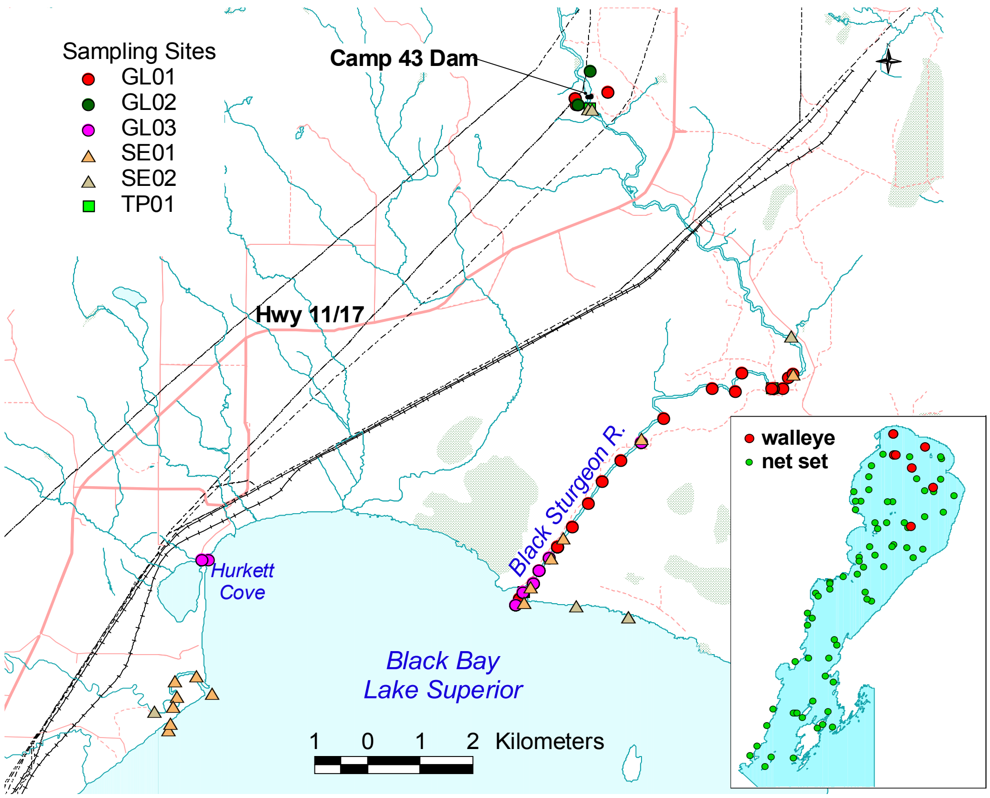

Figure 1. Walleye sampling sites in 2002 (inset) and 2003.

Results and Discussion

Only one young of the year (YOY) and 308 adult walleye and were caught in 2002 and 2003 (Table 1). The gill netting in Black Bay in the fall of 2002 resulted in the capture of only 13 walleye, all from the northern 1/3 of the bay (Figure 1 inset). Standard FWIN sets in northwestern Ontario typically catch more fish: mean 10.7 walleye per 24 hr set compared to 0.16 walleye per Black Bay set. Perch catches were low, but the netting indicated relatively large numbers of spottail shiners and suckers. Meaningful comparisons of biological and effort data from the 2002 FWIN are not possible due to the low sample size.

Table 1. Summary of walleye caught from Black Bay and Black Sturgeon River, 2001-2003. See Figure for locations.

Method	Code	Year	Dates	# sets	set duration	# walleye
FWIN net	GL	2002	Sept. 17, 18, 23-25, 30; Oct 1,2,9,10	80	overnight	13
Angling	AN01	2003	May 23, 25, 27; June 14; Aug 11, 18			21
Dip net	DP01	2003	May 13-16,			72
FWIN net	GL01	2003	May 13, 22, 23, 27; June 3-5, 9-13, 17-19, July 8,9	66	<2 hrs.	178
3.5" Gillnet	GL02	2003	May 13, 22, 23	4	"	0
4.5" Gillnet	GL03	2003	July 10, 15, 16, 17	20	"	13
50' bag seine	SEI01	2003	Aug 1, 6, 14			0
20' bag seine	SEI02	2003	Aug 7, 15			1
Trap net	TP01	2003	May 12-15, 27, 28, 29, June 3-5, 10	12	1-6 hrs.	11

Effort from 2003 assessment cannot be meaningfully compared with provincial standards due to the timing (not fall), location (not random), and duration (short) of the sets. Walleye caught in 2003 ranged from 166 mm TL to 675 mm TL, with a mean of 431mm ± 152 (SD). Mean size for fish caught in the 2003 FWIN nets was smaller (361 mm TL ± 148), but comparable to the mean of 376 for Northwest Region FWIN assessments (Morgan et al. 2003). Walleye caught with trap and dip nets were typically larger, spawning individuals (Figure 2). The length distribution was fairly balanced, with peaks at 200, 360 and 580 mm TL (Figure 3). Large fish are more abundant than would typically be seen in a standard FWIN, since adult fish were targeted by the net timing and placement. The northwestern Ontario benchmark is 401 mm TL for the 75% quartile and 504mm TL for the 95%. The age class distribution showed a peak at 1 year and 5 years, with no fish older than 9 years (*see* Figure 8 in main body of report). On average, in northwestern Ontario, 50% of females netted during FWIN surveys are mature at 4.78 years and 50% of males are mature at 3.49 years (Morgan et al. 2003). The majority of the 5-year-old fish would likely be mature. These fish, originating from the 1998 year-class may have benefited from the 1999 closure of Black Sturgeon River to angling.

Overall, despite the methodological differences, the Black Sturgeon River – Black Bay system has a low number of spawners and recruits compared to healthy walleye lakes (Figure 4).

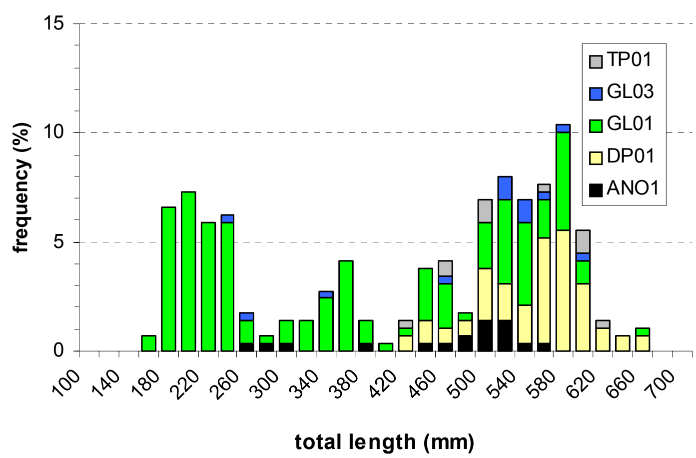

Figure 2. Size frequency distribution for walleye caught in 2003 (all gear) (n = 291).

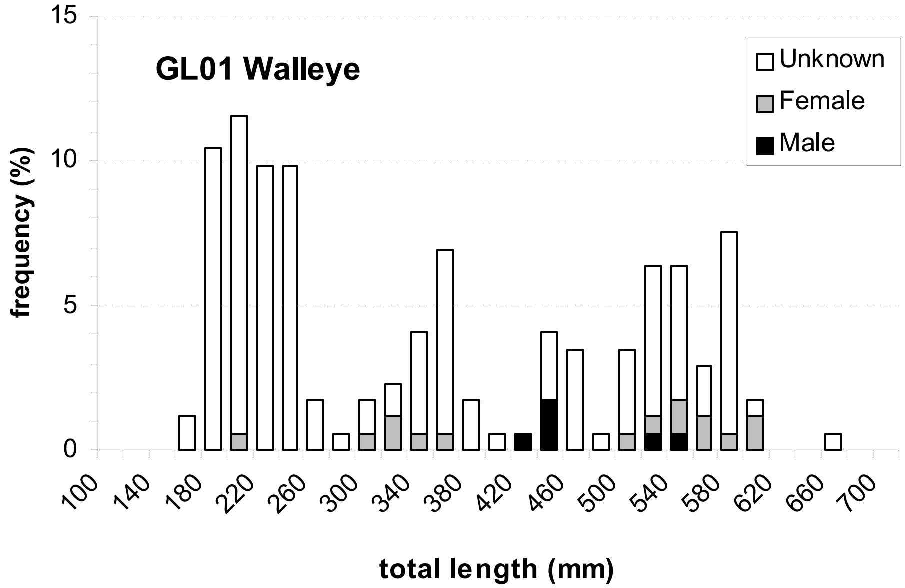

Figure 3. Size frequency distribution for walleye caught in GL01 FWIN nets, 2003 (n = 177).

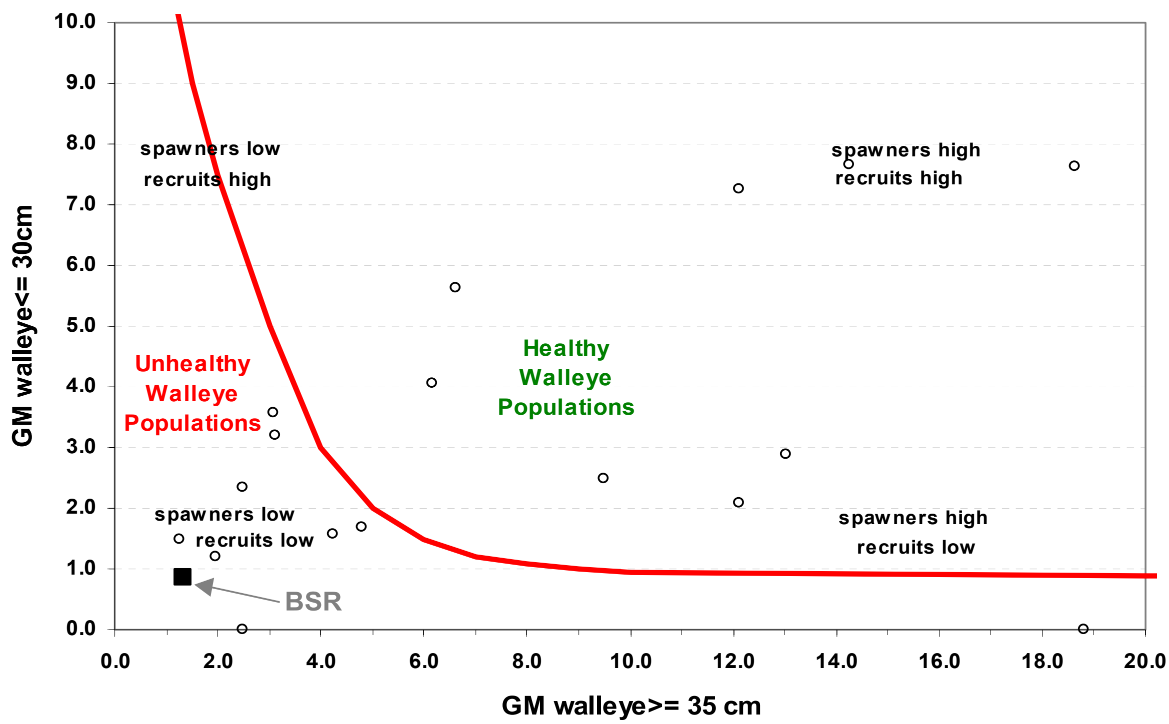

Figure 4. Catch of walleye ≥35 cm vs walleye ≤ 30 cm for Black Sturgeon River FWIN (GL01) in comparison to other Thunder Bay area lakes (OMNR unpubl. FWIN data) (GM = geometric means).

Literature Cited:

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APPENDIX 2
WALLEYE RANGE AND MOVEMENT

This study was designed to examine the seasonal distribution and movement patterns of walleye in the lower Black Sturgeon River with access to Lake Superior; and to identify seasonal habitat using radio telemetry. Information presented in this section summarizes data that was collected from July 2003 to the August of 2005.

Materials and Methods

Tagging

Radio telemetry equipment manufactured by Advanced Telemetry Systems was used in this study. Twenty radio transmitters (model F2060, 20g) with unique frequencies between 150.000 – 151.000 MHz were implanted into adult walleye ranging in fork length from 450-575mm. From July 9 to July 18, 2003 short term gill net sets and angling were used to capture walleye for tag implantation. Walleye were radio tagged just downstream of the Camp 43 dam (N=8), in the lower 500m of the Black Sturgeon River (N=9) and in Black Bay within 250m of the mouth (N=3). The surgical procedure for implanting radio transmitters was adapted from Martin *et al.* (1995) with modifications outlined in Klitch (2003).

Tracking

A shoreline-based data logger (model R4500) was installed at the mouth of the Black Sturgeon River to continuously monitor walleye movements between the river and Black Bay (Figure 1a). The system utilized two directional antennas to interpret the direction of fish movement and was in operation from July 7 to October 30, 2003; April 6 to October 5, 2004; and April 15 to October 10, 2005.

During the open water season, walleye movements between the Camp 43 dam and Black Bay were manually monitored, using a portable receiver (model R-2100) and a hand held antenna (Figure 1b). The upper 2 km and lower 9 km of the river were surveyed by boat. The remainder of the river was monitored on foot at a number of road accessible sections, namely the Camp 43 dam, Highway 11/17 bridge, the CNR bridge and the washout pool at the end of the Everard Road. Fish location was documented with a GPS unit and water depth at location was recorded using a portable sounder. Manual tracking took place from July to October 2003 and May to October 2004. No manual tracking was carried out in 2005.

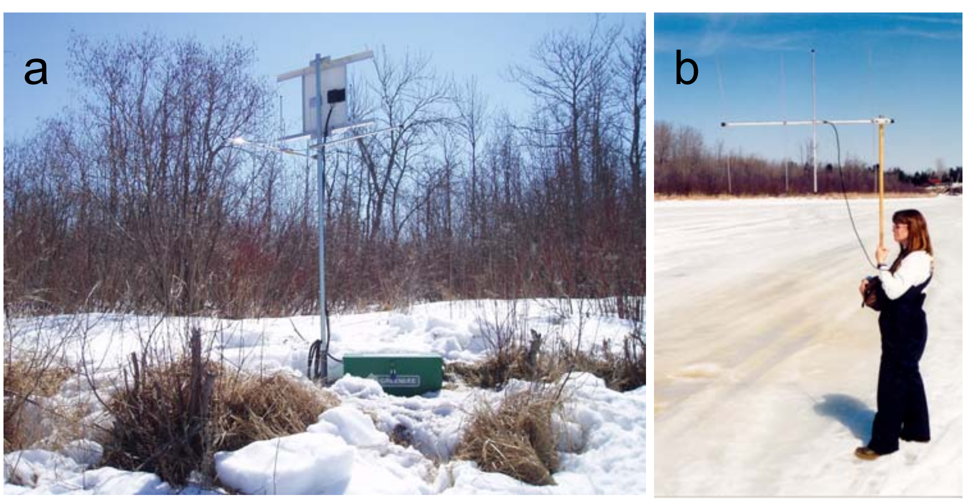

Figure 1. Shoreline based data logger (a) and portable receiver (b).

On September 29 and 30, 2003 a telemetry flight was conducted from the mouth of the Black Sturgeon River upstream to the Camp 43 dam, along the north end of Black Bay and along the outside of Black Bay peninsula. A flight was also carried out on April 19, 2004 from the mouth of the Black Sturgeon River upstream to the Camp 43 dam and along the north end of Black Bay from Hurkett Cove to Delaney and Skimming Islands.

Water Temperature

Water temperature was recorded using a Vemco Minilog- T data logger. In 2004 temperature was recorded hourly below the Camp 43 dam from May 11 to October 4. In 2005 temperature was recorded at the mouth of the Black Sturgeon River from April 7 to October 21.

Results

Tag History

Twenty walleye were radio tagged in July of 2003 (Table 1). Complete tracking records were obtained for 9 fish. Partial records were obtained for the remaining 11, seven of which were found in the same location in 2004 as they were at the end of 2003. These fish were therefore assumed to be dead or having expelled their tags. The remaining four fish were likely harvested with one fish being removed from the river after one month of tracking in 2003 and the other three in June and July of 2004. By mid July of 2005 the tags were at the end of their estimated battery life.

Table 1. Radio tag history and walleye migration dates for 2003 to 2005.

2003				2004			2005		
Walleye Freq.	Tagging Date	Tagging Location	Date of migration into Black Bay	Date of migration into the River	Date of migration back to River Mouth	Date of migration into Black Bay	Date of migration into the River	Date of migration back to River Mouth	Last detection by logger
594	Jul-10	lower river	Aug-25	Apr-22	Jun-05	Sep-30	Apr-17	May-19	Aug-07
604	Jul-10	Bay	Aug-24	Apr-25	May-24	Aug-04	Apr-15	Jun-15	Jul-21
623	Jul-10	Dam	Aug-24	Apr-27	May-30	Aug-25	Apr-20	May-27	Aug-04
664	Jul-11	Dam	Oct-19	May-02	May-24	Sep-20	Apr-15	Jun-16	Jul-29
684	Jul-16	lower river	Sep-28	Apr-23	May-25	Aug-10	Apr-17	May-26	Jul-29
694	Jul-16	lower river	Sep-25	Apr-23	Jun-03	Oct-02	Apr-18	May-10	Jul-20
714	Jul-16	lower river	Jul-20	Apr-22	May-28	Sep-25	Apr-16	May-28	Jul-14
724	Jul-17	Bay	26-Sep	Apr-25	Jun-08	Sep-17	Apr-19	May-20	Jun-29
754	Jul-18	Dam	Aug-30	Apr-22	Jun-22	Aug-12	Apr-16	May-18	Jul-03
733	Jul-17	Dam	Oct-19	Apr-17	Jun-07	harvested			
744	Jul-18	Dam	29-Aug	Apr-23	harvested				
654	Jul-11	Dam	Oct-13	Apr-19	harvested				
563	Jul-08	lower river	tag stationary in river						
573	Jul-09	lower river	Jul-15	tag stationary in Bay					
583	Jul-10	lower river	tag stationary in river						
614	Jul-10	lower river	Jul-16	tag stationary at Delaney					
636	Jul-11	Dam	Aug-04	tag stationary at Hurkett					
643	Jul-11	Dam	Jul-16	tag stationary in Bay					
674	Jul-11	Dam	harvested						
704	Jul-16	Bay	tag stationary in river						

Movements

Fall

In 2003, the data logger detected all active radio tagged walleye moving into Black Bay from July 20 to Oct. 19 (Table 1). Once in the Bay, these fish did not re enter the river during the period when the data logger was operating (until Oct. 30). During the fall aerial survey (Sept. 29) three of the nine walleye known to be in the Bay were located. One fish was located near the mouth of the Wolf River, one was near Delaney Island and the other was between the mainland and Skimming Island. In 2004, the data logger detected nine active walleye moving from the Black Sturgeon River into Black Bay from August 4th to October 2nd (Table 1). These fish did not re enter the river during the period when the data logger was operating (until Oct. 5).

Winter

During the late winter aerial survey in 2004, 11 of 12 walleye were located in the northern portion of Black Bay. Ten were within 2 km of the mouth of the Black Sturgeon River, one was near Delaney Island and one had already entered the river.

Spring

In 2004 twelve walleye migrated into the Black Sturgeon River between April 17 and May 2 and were located upstream of Highway 11/17 on May 7th (Table 1). The water temperature was 6º C. During six subsequent on foot tracking surveys from May 7 to May 20 these walleye were located in the first and second set of rapids upstream of the highway and in the rapids just below the Camp 43 dam. The mean daily water temperature from May 11 to 20 was 7.6º C. In 2005 nine walleye entered the river from April 15 to April 20. The water temperature on the date when these fish entered the river ranged from 3.7 to 5.8º C.

Summer

In 2004, ten of twelve walleye that entered the river in the spring moved downstream to the mouth of the Black Sturgeon River from May 27 to June 8. The other two walleye were harvested. In 2005 nine fish that entered the river in the spring moved downstream to the mouth of the Black Sturgeon River from May 27 to June 8. In both years, these fish moved out into Black Bay and, for the most part, remained there for an extended period (15 to 35d). In late June these walleye then moved back into the River and, for approximately 1 month, made frequent movements between the river and Black Bay. Most walleye made nightly movements into Black Bay, re-entered the river early the next morning (Figure 2) and moved upstream approximately 7 km. Others moved less frequently utilizing the Black Sturgeon River and Black Bay for longer periods (Figures 3 and 4).

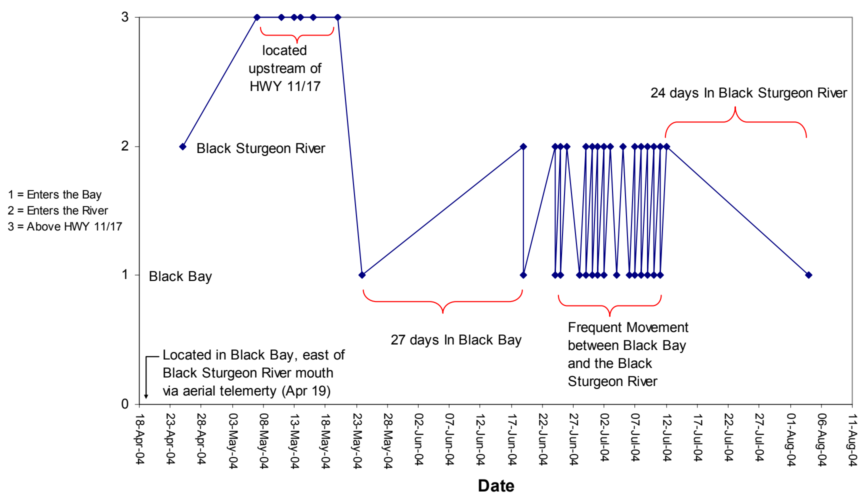

Figure 2. Data logger summary of the movement of walleye 150.604 between Black Bay and the Black Sturgeon River.

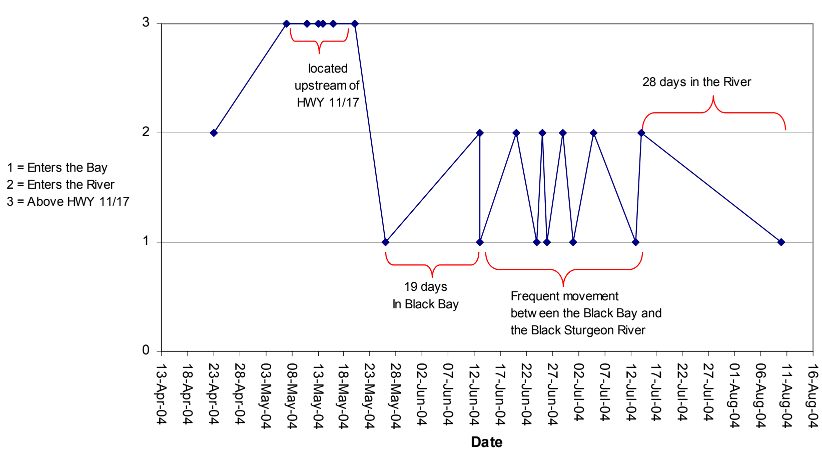

Figure 3. Data logger records of the movement of walleye 150.684 between Black Bay and the Black Sturgeon River.

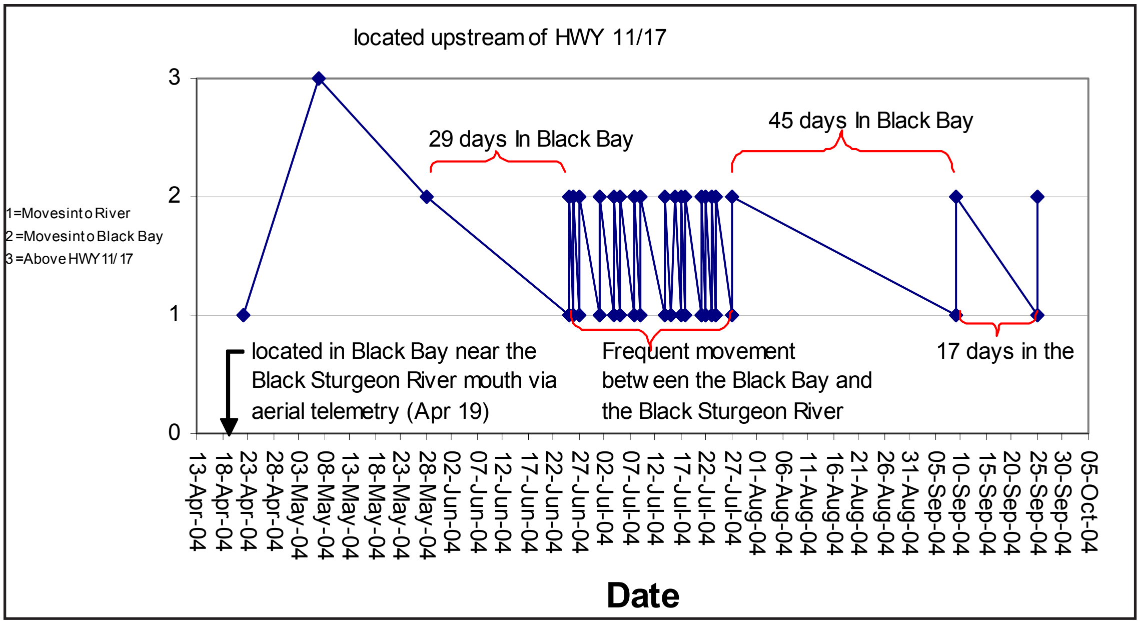

Figure 4. Movement of tagged walleye #714, May to September, 2003.

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APPENDIX 3
GENETICS

The relationship between walleye in the Black Sturgeon River and the historical Black Bay population was assessed using high-resolution genetic markers. Tissue samples for genetic analysis were obtained in 2004 from 80 walleye above and below the dam on the Black Sturgeon River using nonlethal finclips. DNA was extracted from these samples and a historical collection of 80 scale samples from the 1966 commercial fishery using a crude lysis extraction method. Tissues were lysed using TNES lysis buffer and 100 µg proteinase K and incubated for 16 hours at 37ºC. Genomic DNA and degraded proteins were precipitated using 80% isopropanol and rinsed with a 70% ethanol wash. DNA was subsequently resuspended in 50-200 µL of TE buffer and tested for yield using horizontal agarose electrophoresis alongside a molecular mass ladder.

Multilocus microsatellite genotypes were obtained from each sample for five microsatellite loci, using conditions described in Wilson and Gatt (2001). Native walleye from the recovering Nipigon Bay (Wilson et al. in prep) were included as an outgroup for comparison. The resultant data were analysed using population- and individual-based approaches. Allele frequencies within each sample set were pooled to enable population-level comparisons. Genetic divergence among sample sets was estimated using Cavalli-Svorsa and Edwards' (1967) chord distance to provide a conservative estimate of relatedness or divergence. The inter-population comparison was complemented with individual assignment and exclusion tests using Bayesian resampling methods (Cornuet et al. 1999; Pritchard et al. 2000).

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APPENDIX 4
BLACK BAY COMMERCIAL WALLEYE FISHERY

Introduction

The Data Set

Commercial fish data exists for the Black Bay fishery from 1948 through the 1970's documenting the collapse of the walleye fishery in 1968. This data set was compiled from mandatory commercial fish reporting records referred to as CF1's. These reports were submitted on a monthly basis by all licensed fisherman and consisted of daily reports for all commercial fish landings during that period. Information documented include date, location, water depth, gear information, fishing duration etc. and weight of fish species caught. There are approximately 9000 records which identify walleye as the targeted species over this 23 year period.

Many of these records are incomplete and do not contain entries in all fields. From a practical standpoint fishermen tended to complete these forms at the end of each month rather than on a daily basis resulting in the loss of much of the detailed information. These deficiencies limit the value of this data in defining reliable and comprehensive statistics that will demonstrate the cause and effect of the Black Bay walleye fishery collapse. The data does, however provide valuable insight into the timing and location of the fishery before and during the collapse. In the 1990's commercial fish reporting forms were changed to a daily catch reporting format to address concerns associated with inaccurate and missing information.

The Black Bay Commercial Walleye Fishery

The commercial fishery for walleye in Black Bay was primarily a gillnet and pound net fishery with limited use of trapnets in the later years. Pound nets targeted fish in active movement patterns and rely on fish leading into fixed enclosures. Gillnets were more versatile being easily moved to target fish congregations and were used in all seasons including winter. Gillnets accounted for approximately 90% of the total walleye harvest in Black Bay over this period.

In the spring walleye catches tended to be concentrated at the north end of Black Bay, (particularly prior to the 1960's) and peaked in May and June when the majority of the annual harvests (approx. 60%) occurred. During the summer (July and August) limited fishing effort and harvest occurred and pound net accounted for a substantial portion of the harvest during this period. Fall catches were concentrated in the south end of the bay closer to the open lake and typically displayed less intensive harvests over a longer duration (12-14 weeks).

Overall fishing activity and harvest tended to be concentrated along the western shoreline and over the course of the spring and fall fishery covered the entire length of Black Bay (approximately 70 km) and beyond into adjacent zones. Commercial records from adjacent zones show a limited walleye fishery on the outside of Black Bay and Sibley (Sleeping Giant) Peninsulas.

Methods

An analysis of the data set was undertaken to identify any changes that may have occurred as a result of the Black Sturgeon Dam construction. Changes in location, timing or success associated with specific gear types may have occurred and been reflected in this data set prior to the collapse. Therefore harvest statistics were examined and divided into discreet time frames separated by catch locations, which divided Black Bay on a north south basis along the long axis of the bay. Catch per unit effort was also calculated and incidental catches of walleye in small mesh gillnets were examined.

Results

Harvest and Effort

Walleye harvest over the 23-year period prior to the collapse increased throughout the data set. This trend accelerated in the later half of the fishery prior to the collapse. An annual harvest of more than 50,000 pounds was declared in 1948, which increased to a peak of close to 300,000 pounds annually in 1966.

Fishing effort (length of gillnets fished) during this period also increased and peaked in 1966. Length of net fished also increased steadily throughout the early years and increased greatly in the later stages of the fishery. There is a strong positive relationship between catch in pounds and effort as measured by length of net fished (Figure 1). The accuracy of the effort data is suspect since given the success of the 1966 harvest, one would expect effort to be high for at least the following year.

Catch per unit effort (CUE), calculated as pounds per kilometre of net fished, was quite variable between years but appeared stable over the course of the data set. Spring CUE's were in the order of one 1.5 to 2 times higher than CUE's calculated for the fall fishery. Increasing harvest levels observed over the course of the fishery seem largely related to increases in effort rather than increasing success rates.

The collapse of commercial fishery for walleye was abrupt and permanent with catches falling from an annual harvest of approximately 250,000 pounds in 1967 to zero by 1972. There was only one reported walleye catch in 1979 for the remainder of the 1970's.

Harvest by week vs gear

An examination of the commercial harvest by week associated with various gear types revealed no discernable changes in timing of when catches occurred between years. Spring and fall peak catches continued to occur over similar time frames before and after the dam was established (prior to 1959-1960). Increases in spring catches however did largely account for the accelerated catches observed in the later half of the data set after the construction of the dam. Spring harvests more than doubled after the dam was established when compared with a comparable time frame pre-construction whereas fall harvest showed a more moderate 50 % increase using a similar comparison.

Locations of commercial walleye catches varied widely during the fishing season throughout the large extremely diverse bay (Figures 2 and 3). When annual catches were examined broken down on a weekly basis and by grid locations changes in the location of harvests become evident starting immediately after completion of the dam. Prior to 1959 all of the seven grid groups defining the bay from Hurkett at the north end to the south tip of Edward Island at the mouth to the open lake routinely contributed significant portions of the total annual harvest (Figure 3). After the completion of the Black Sturgeon Dam (post 1961) many of these locations ceased to produce harvest of any significance. In the later stages of the fishery only three areas of the middle portion of the bay contributed

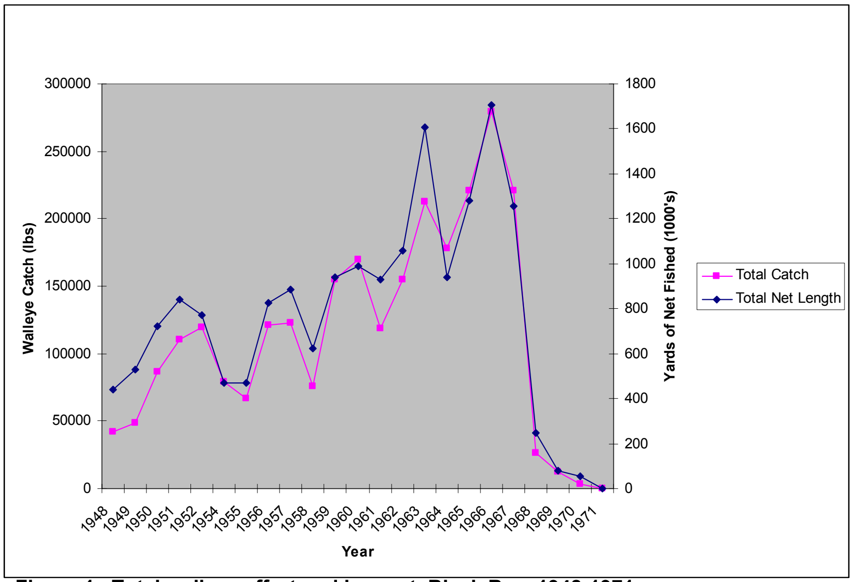

Figure 1. Total walleye effort and harvest, Black Bay, 1948-1971.

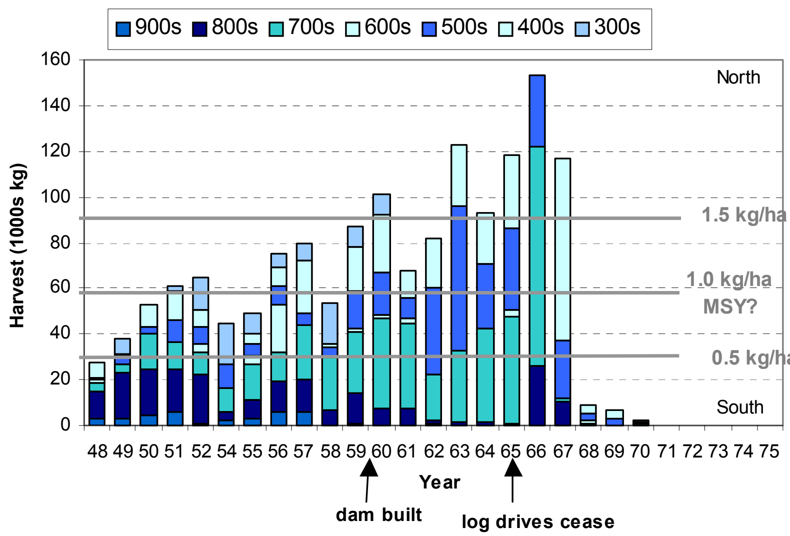

Figure 2. Annual walleye harvest (all gear) in Black Bay by 5' grid cells (300s at north end; 900s at south end).

the vast majority of the catch. The geographic extremes in the northern and southern area that had previously contributed significant harvest were no longer represented during the six to seven years prior to the collapse.

Small Mesh Gillnet Catches

Examination of trends associated with small mesh incidental catches of walleye proved somewhat problematic. Small mesh gillnets were employed over the majority of the data set targeting sauger. These catches were quite substantial averaging almost 50,000 pounds annually and tended to include little or no incidental walleye catches (<10% recorded walleye bycatch). It is unknown to what degree buyers differentiated by species and it is possible that size was the determining factor as to whether fish were classified as a sauger or walleye. Commercial sauger harvests crashed in Black Bay in 1965 three years before the demise of the walleye fishery. Similarly it is unclear whether incidental catches of walleye and sauger captured in nets targeting other species i.e. perch, herring were accurately identified or graded strictly by size.

Had the fishery collapsed due to over-harvest of adults (e.g. greater then age 5 walleye) -- as opposed to habitat loss -- the five year-classes produced by the large population in the years prior to the collapse should have been sufficient to restore the fishery within five years after the closure (i.e., as 6-10 year olds). However, there is no data to indicate a significant deterioration of bay habitat. Secondly, many young walleye could have been killed in the sauger fishery (Goodier 1982) and the small mesh perch gillnet fishery that rapidly developed after the collapse could have killed many of the young walleye.

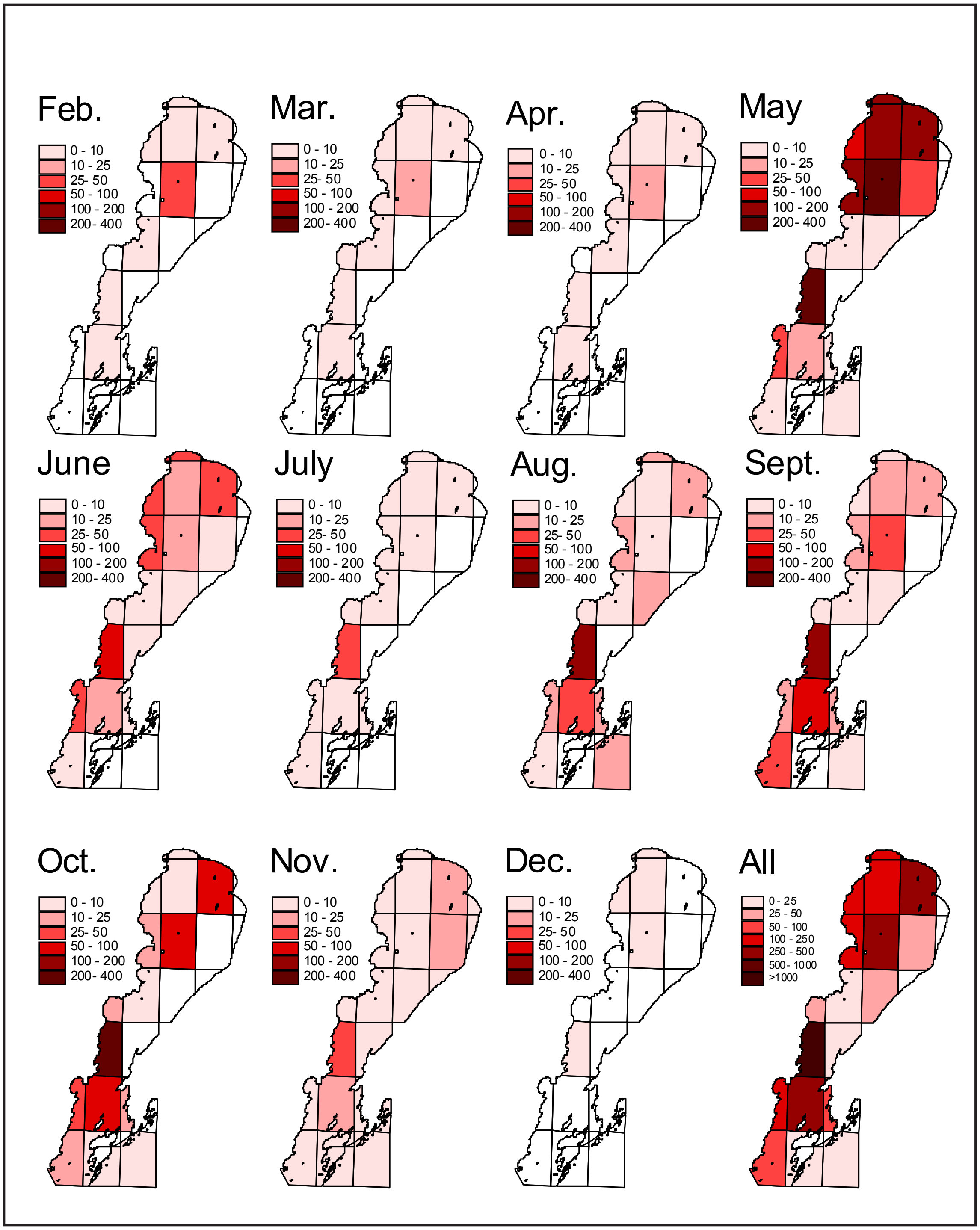

Figure 3. Monthly summary of total walleye harvest (all gear types) by grid cell for 1948-1971 (1000s of lbs.). Note change in legend for all months pooled.

APPENDIX 5
ECONOMICS

A summary for Black Bay economic value estimates is presented:

A model of open water fishing behaviours by Thunder Bay area anglers estimated that these anglers would be willing to pay about $345,000 per year (with a range between $180,000 and $530,000) for a successful restoration of walleye into Black Bay, Lake Superior. This economic value does not include any additional benefits that may arise to other anglers, ice fishers, or tourist operators.

Two pieces of information were used to estimate this willingness to pay value. First, the total number of trips taken by Thunder Bay area anglers was estimated from data from Statistics Canada, the Survey of the Importance of Nature to Canadians, and a telephone survey of Thunder Bay anglers. It was estimated that about 26,000 anglers live in the Thunder Bay area and that these anglers took approximately 250,000 trips during the open water season in 2004. To account for the fact that many of these fishing trips were to cottages, lodges, or for reasons other than fishing, we included only 129,000 of these trips when estimating willingness to pay.

The second piece of information was the change in the per trip value of recreational fishing that would result from walleye restoration in Black Bay. This estimate was derived from a site choice model (see Hunt (2006) for details) based on an angling diary program conducted with Thunder Bay area anglers in 2004. Hundreds of peer-reviewed articles exist that have employed this choice model approach to estimate changes in economic values for outdoor recreational activities.

The choice model estimates the process that anglers use to choose a fishing site. As such, it is possible to estimate how a scenario such as walleye restoration into Black Bay may affect where anglers fish and how they value fishing. One can estimate the change in per trip value of fishing by comparing the expected quality of fishing opportunities before and after the restoration of walleye. Next, one estimates the change in travel costs to anglers that would leave them indifferent between the before and after scenarios. For example, how much more would an angler pay in travel costs to have a successful walleye restoration in Black Bay? Travel costs were estimated as $1.09 per round trip km, which reflected the average operating costs of a large sized vehicle in Canada in 2004. No adjustment, however, was made for the value of travel time to the anglers. It was estimated that anglers would be willing to pay $2.67 per fishing trip in additional travel costs to have walleye successfully restored into Black Bay.

The final estimates of willingness to pay simply involved the multiplication of per trip value by number of trips. The final willingness to pay estimate is conservative since: (i) the number of fishing trips is unaffected by the restoration of walleye; (ii) the value of an angler’s travel time is assumed to be zero; and (iii) the model only considers open water fishing trips by Thunder Bay area anglers.

Literature Cited

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