# LAKE SUPERIOR TECHNICAL COMMITTEE INVESTIGATION ABOUT INFORMATION NEEDS RELATED TO SPLAKE STOCKING

## EXECUTIVE SUMMARY

On July 12, 2018, the Lake Superior Committee (LSC) tasked the Lake Superior Technical Committee (LSTC) with providing a fuller technical understanding of the extent that splake may affect native lake trout or brook trout populations via interspecific competition and genetic introgression (Appendix 1). The LSC charged the LSTC with compiling existing technical information to address several questions, including:

1) what is the probability that splake will introgress with either lake trout or brook trout,
2) if introgression occurs, what are the long-term risks to the lake trout fishery and impact on brook trout rehabilitation,
3) what are other ecosystem impacts of splake on lake and brook trout,
4) what is the magnitude and distribution of fisheries supported by splake, brook trout, and lake trout, and
5) what are the most critical information gaps, and recommendations for addressing those information gaps.

The LSTC conducted a literature review and compiled data from the respective agencies to respond to the specific questions outlined from the charge into the following report. Here, we present the findings of a review of splake reproductive capacity, probability of introgression, ecosystem impacts, magnitude of splake fisheries, and splake distribution and movement in relation to brook trout and lake trout populations. We also identify gaps in the collective knowledge of splake ecology, life history, behavior, and potential ecological effects.

It is believed that the probability of splake introgression with brook trout and lake trout is high given that 1) splake are fertile and fully capable of successfully reproducing with both parental species and 2) ripe and spent splake have been routinely captured on spawning sites in streams and the lake, overlapping with both spawning brook trout and lake trout. That said, there is limited evidence of introgression, which simply could be that we have not looked for evidence and therefore, additional research is warranted to investigate whether introgression has occurred and, if so, at what level is it occurring. The charge specifically mentioned the need to look for introgression in Cherry Creek (Michigan), but we lack data to address this location. It is suggested that Copper Harbor (Michigan) should be used for future research into introgression. Due to the limited evidence suggesting that introgression has occurred, estimating the long-term effects specific to lake trout or brook trout is difficult. Brook trout stocking across the southern Appalachians has not resulted in introgression in most wild populations (Kazyak et al. 2018). However, introgression of hatchery fish with wild populations has reduced fitness and created hybrid swarms in many fish species (Araki and Schmid 2010). Therefore, additional genetic analysis on splake, lake trout, and brook trout from Lake Superior may help determine if introgression has occurred and highlight differences in population characteristics in areas with and without introgression. This genetic work coupled with increased attention to diet studies and

appropriate identification could help further our understanding of the interactions that may have negative consequences for lake trout and brook trout population recovery in Lake Superior.

## POTENTIAL IMPACTS OF STOCKED SPLAKE ON LAKE SUPERIOR BROOK TROUT AND LAKE TROUT FISHERIES

Development of a brook trout (*Salvelinus fontinalis*) x lake trout hybrid (*S. namaycush*), the splake (*S. fontinalis* x *S. namaycush*), began in hatchery settings as early as the late 1800s (Martin and Baldwin 1960). However, it was not until the mid-1900s, when overharvest and the sea lamprey invasion induced dramatic declines in brook trout and lake trout populations that agencies began to experiment with a fertile splake strain that could be stocked into the Great Lakes. By 1966 the Ontario Ministry of Natural Resources had established a captive splake brood stock and began stocking splake into Lake Huron (Knight and Bocking 2016). Splake stocking in Lake Superior followed in the 1970s, with the goal of creating a self-sustaining (i.e. naturally reproducing) fishery in place of the devastated lake trout population (Michigan Department of Natural Resources; Jarvis 1962). At that time, managers believed that splake would grow faster and mature sooner than brook trout or lake trout, thereby reaching reproductive age and harvestable size prior to becoming vulnerable to sea lamprey predation (Knight and Bocking 2016). Moreover, it was thought that, because splake is a hybrid, its behavior and life history would be intermediate to those of lake trout and brook trout and splake would not overlap fully with either parental species (Ontario Department of Lands and Forests 1957).

Literature evidence suggests that splake do, in fact, grow more quickly and maintain higher gross energy content than either parental species (Budd 1957; Berst and Spangler 1970; Gunther et al. 2005), both in a hatchery setting and in the wild, thereby presenting the potential for higher returns from splake plantings (Fraser 1972). However, because splake are fertile, this hybrid poses a threat to recovering lake trout and brook trout populations in Lake Superior (Scribner 2004). Splake fertility and their potential to backcross with both parental species to produce viable, fertile offspring (Buss and Wright 1958) have generated concerns of introgression, to the detriment of brook trout and lake trout population recovery. Brook trout populations are currently a particular focus of conservation and rehabilitation, and any introgression of splake with these vulnerable populations may hinder efforts to recover brook trout under the Lake Superior Brook Trout Rehabilitation Plan (Newman et al. 2003). Additionally, splake introgression with lake trout would be counter to stated management goals seeking to maintain healthy, wild lake trout and may affect the genetic and demographic health of lake trout populations. Moreover, increased sea lamprey control and recovering lake trout populations may render splake stocking obsolete (Michigan Department of Natural Resources 1968).

Information from published reports, journal articles, and internal agency documents regarding splake life history traits, degree of fertility, and probability of backcrossing and introgression with lake trout or brook trout has been synthesized below to illustrate our current understanding of interactions between splake and both parental species. In addition, survey data obtained from

Wisconsin Department of Natural Resources (WDNR), Michigan Department of Natural Resources (MDNR), Minnesota Department of Natural Resources (MNDNR), Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Red Cliff Band of Lake Superior Chippewa, and the U.S. Fish and Wildlife Service (USFWS) were used to estimate splake population distributions in comparison to lake trout and brook trout spawning locations, splake movements from stocking locations, and brook trout, lake trout, and splake recreational harvest to help assess the risks of introgression by splake. For consistency, only data collected 2000-2017 are reported here.

**1) What is the probability that splake will introgress with either lake trout or brook trout?**

Splake fertility and successful backcrossing of splake with both parental species has been demonstrated in hatchery settings. For example, Buss and Wright (1958) showed that viable, fertile $F_2$ splake may be successfully produced from $F_1$ splake broodstock and that splake and brook trout may be successfully crossed to produce fertile offspring. Moreover, agencies have demonstrated splake can reproduce with lake trout when these backcrosses were stocked in Lake Huron and inland lakes, under the belief that this backcross had higher survival and faster growth than $F_1$ splake (Spangler and Berst 1976). However, Anderson and Collins (1995) reported that splake x lake trout backcrosses planted in Lake Huron may experience higher mortality than planted lake trout. There is no evidence that this cross has been stocked into Lake Superior waters.

Hansen (1972) identified splake in brook trout spawning habitats for prolonged periods of time early in the brook trout spawning season. The study showed that splake compete with brook trout for spawning space and that splake presence may exclude brook trout from spawning grounds. Similarly, Quinlan et al. (*in review*) captured splake in reproductive condition in Whittlesey Creek (Wisconsin) alongside spawning brook trout and splake were more abundant than brook trout. Feringa et al. (2016) also captured genetically confirmed splake, including individuals identified as sexually mature, in brook trout and lake trout spawning habitats and documented ripe and spent splake alongside spawning lake trout on spawning reefs in Lake Superior. There is some evidence of natural reproduction of splake on rocky shoals (Martin and Baldwin 1960; Martin 1965; Berst et al. 1981). Berst et al. (1981) recorded descriptive and photographic evidence of splake exhibiting spawning behavior in late October and early November in an inland Ontario lake. Splake have a wide range of spawning behaviors that overlap with behaviors of their parental species, including spawning habitat, timing of reproduction, and clearing areas for redds prior to spawning, (Martin and Baldwin 1960; Kerr and Grant 2000).

Fall lake trout spawning assessments are carried out annually by MDNR, WDNR, Red Cliff Band, GLIFWC, and MNDNR, and splake captures during these assessments are recorded. The sites surveyed in these assessments have been confirmed by reporting agencies as lake trout spawning areas. Between 2000 and 2017, a total of 1,294 splake were captured by these agencies

at a total of 203 sites (Figure 1). Red Cliff Band also reported 119 splake that were captured 2000-2017 in their Joint Commercial Monitoring Program.

In order to estimate proximity of splake captures via agency sampling efforts to potential brook trout spawning sites, the Near function in ArcMap (ArcGIS Desktop, version 10.6.1) was used to estimate the distance between splake capture locations and the nearest potential brook trout spawning site included in the Goodyear et al. (1982) list of historical brook trout spawning locations. This technique yielded a total of 346 splake that were captured within 5 km of a potential brook trout spawning location between 2000 and 2017 (Figure 2). Information concerning brook trout spawning in tributaries was unavailable for this report; however, USFWS and WDNR have reported 301 splake captured at 72 sites in Wisconsin tributaries of Lake Superior between 2000 and 2017, across all seasons and fertile splake have been observed in Whittlesey Creek during brook trout spawning. Additionally, splake have been sampled in streams listed in the Lake Superior brook trout rehabilitation plan (Newman et al. 2003), including 8 of the 15 streams listed for Wisconsin and 1 of 10 listed for Minnesota; Ontario and Michigan data were not available. Moreover, Goodyear et al. (1982) identified a number of locations at which lake trout and brook trout may spawn or may have spawned historically, but it should be noted that the coordinates provided in that report have varying degrees of accuracy. Additionally, splake have been captured in and near the Salmon Trout River, which is the only extant coaster population in the area that splake are stocked.

Splake stocking locations provided by WDNR and MDNR were also compared to potential brook trout and lake trout spawning locations that were included in the Goodyear et al. (1982) list of historical brook trout and lake trout spawning locations via the Near function in ArcMap (ArcGIS Desktop, version 10.6.1), and the distance between each stocking location and the nearest brook trout or lake trout spawning site was estimated. Splake stocking does occur near lake trout spawning locations (Figure 3). Most notably, a total of 749,010 splake have been stocked at one site within 1 km of a lake trout spawning site since 2000 (Munising, MI, approximately 659 m from spawning ground). Also, a total of 1,887,417 splake have been stocked at three sites within 2 km of lake trout spawning grounds (Munising, Copper Harbor, and Marquette, MI). Splake are also stocked near brook trout spawning locations, with 25 stocking locations being within 5 km (total of 1,503,809 splake stocked 2000-2017) and five of those being within 1 km (total 255,533 splake stocked 2000-2017) (Figure 4), most notably along the Bayfield Peninsula in Wisconsin. Given that splake are fertile, as well as the presence of spawning splake in brook trout and lake trout spawning habitats during spawning by both species, the probability of splake backcrossing with both brook trout and lake trout is high.

**2) If introgression occurs, what are the long-term risks to the lake trout fishery and impact on LSC's Brook Trout Rehabilitation Plan?**

Although there has been minimal effort directed at investigating splake backcrossing with either brook trout or lake trout, there is evidence that splake introgression into lake trout and brook

trout has occurred. Stott et al. (2004) conducted genetic analysis of 16 unknown fish from Lake Superior, most collected near Munising where splake are stocked annually. Of the 16 fish examined, six were judged to be offspring of splake spawning with brook trout. The paucity of evidence for backcrossing does not preclude that there could be a loss in brook trout and lake trout fitness due to competition for spawning habitat or wasted reproductive effort from spawning with splake. Therefore, further research should be conducted on the genetic and population demographic changes that may result from splake interacting with brook trout and lake trout during spawning. Further, it is an accepted scientific tenet that the result of a hybrid reproducing with the parental species is harmful to the genetic and demographic health of the parental species (Allendorf et al. 2001). As such, continued splake stocking does pose a risk to the health of both lake trout and brook trout populations in Lake Superior and tributary streams. As Allendorf et al. (2001) noted, once hybridization (i.e. splake spawning with parental species) starts, it is difficult to stop and makes recovery of threatened taxa much more difficult.

**3) What other ecosystem impacts do splake have on lake trout and brook trout?**

Splake, similar to brook trout and lake trout, may inhabit waters between the 8ºC and 20ºC isotherms during summer stratification and shallow waters during spring and fall (Martin and Baldwin 1960). This suggests that splake might also compete with brook trout and lake trout during non-spawning periods. However, there has been little study of direct interactions of splake with brook trout, lake trout, or other native fish species, especially within the Great Lakes.

There is considerable variation in splake diets reported in the literature. Observations of splake feeding and diet items include aquatic insects, crayfish, leeches, and fish (Martin and Baldwin 1960; Martin 1965; Kerr and Grant 2000). Splake may also feed on the eggs of other fish, including lake trout (Kerr and Grant 2000). Moreover, Fraser (1980) found that splake diet differed by location in a study area across lakes in Algonquin Park, Ontario, suggesting that splake foraging is plastic and depends on habitat and food resource availability. Although brook trout are reported to consume similar prey items to splake, including aquatic insects, crayfish, and fish (Momot 1965; Rumsey et al. 2007), analyses of dietary overlap between brook trout and splake indicate that brook trout may consume less fish and more invertebrate prey than splake (Rumsey et al. 2007). However, the extent of competition for food resources and associated impacts on book trout and lake trout populations in Lake Superior is not known.

Although few studies from the Great Lakes have reported splake interactions with species other than brook trout or lake trout, evidence from inland lake systems suggests that splake may compete with yellow perch for food resources (Fraser 1978). Furthermore, beyond reports of splake diet overlap with yellow perch, little is known about splake trophic impacts and their influence on prey population dynamics. One notable exception is Rumsey et al. (2007), who suggest the potential of splake to influence yellow perch populations via predation in small, inland lakes.

**4) What is the magnitude and distribution fisheries supported by splake, brook trout and lake trout?**

Splake, brook trout and lake trout creel survey and stocking data were provided by MDNR and WDNR. In WI-1, a total of 55,804 lake trout (average per year ± standard deviation = 4,293 ± 1,625), 3 brook trout (average per year = 0.23 ± 0.83), and 10 splake (average per year = 0.77 ± 1.8) have been harvested since 2005. In WI-2, a total of 170,778 lake trout (average per year = 13,136 ± 4,910), 75 brook trout (average per year = 6 ± 9), and 8,487 splake (average per year = 653 ± 462) have been harvested since 2005. In sum, 226,582 lake trout, 78 brook trout, and 8,497 splake were harvested in Wisconsin waters in 2005-2017. An average of 75,883 ± 44,488 splake are stocked each year by WDNR, totaling 986,484 splake stocked since 2005, with an average return to creel (number of splake harvested/splake stocked two years prior) of 0.86 % ± 0.55.

In Michigan waters, a total of 360,493 lake trout (average per year = 20,027 ± 4,001), 144 brook trout (average per year = 8 ± 14), and 28,648 splake (average per year = 1592 ± 767) have been harvested from 17 ports since 2000. On average, 105,767 ± 21,558 splake have been stocked by MDNR each year since 2000, for a total of 1,903,806 splake stocked and an average return to creel of 1.64 % ± 0.76.

In addition to recreational harvest, Red Cliff Band also reported 119 splake that were captured by commercial fishers 2000-2017 in their Joint Commercial Monitoring Program.

The Near function in ArcMap (ArcGIS Desktop, version 10.6.1) was used to estimate distance traveled by splake following stocking in Lake Superior. Locations at which splake were captured via agency sampling efforts 2000-2017 were compared to splake stocking locations over the same time period to calculate the minimum distance that each sampled splake must have traveled from the nearest stocking location. This provides an estimate of how far splake are capable of moving within Lake Superior. Of the 1,553 splake that were sampled via agency assessments 2000-2017, 1,024 individuals were found within 5 km of a splake stocking site (Figure 5). However, six splake were found over 100 km from any stocking location, suggesting that these fish are capable of traveling relatively long distances. Such large movements of splake have also been reported in the literature; for example, Berst and Spangler (1970) observed splake up to 322 km from their stocking location.

**5) What are the most critical information gaps to address, and what are some recommended steps that agencies can take to address those gaps during the next 5-10 years?**

Stott et al. (2004) identified some apparent backcrosses of splake with brook trout using mtDNA analysis. However, little is known of the degree of introgression, if any, of splake with either parental species. There is also a lack of knowledge about what degree of introgression would damage lake trout or brook trout populations in Lake Superior. Nevertheless, because splake

have been shown to produce viable offspring with brook trout and to spawn over brook trout and lake trout spawning grounds (Buss and Wright 1958; Martin and Baldwin 1960; Martin 1965; Berst et al. 1981), the likelihood of hybridization and potential introgression may be high, but the risk to lake trout and brook trout populations remains unknown.

The faster growth of hatchery-reared splake relative to hatchery-reared brook trout or lake trout has been documented (Budd 1957; Berst and Spangler 1970; Gunther et al. 2005). Additionally, there is some evidence of competition for spawning areas between splake and brook trout (Hansen 1972). However, there has been little study of competition for food or space during non-spawning times between splake and either parental species. There is currently little evidence to suggest that splake presence may affect survival or condition of either brook trout or lake trout, although Martin and Baldwin (1960) report generally higher recovery of splake when stocked with lake trout and brook trout. Furthermore, the bulk of the studies of splake natural history and behavior that are currently available were conducted in small, inland lakes, which may differ environmentally and ecologically from Lake Superior. Thus, future assessments of splake diet and behavior in Lake Superior may be useful in determining their effects on naturally occurring trout species.

Positive phenotypic identification of splake in the field by experts has been corroborated genetically (Feringa et al. 2016; Dowell and Bartron 2018), and splake are known to have a different number of pyloric caeca than either brook trout or lake trout, allowing splake to be differentiated by the trained eye from both parental species. In addition, several identification keys exist to aid the general public in splake identification, including webpages maintained by WDNR and the Wisconsin Sea Grant Institute. However, there is no recorded analysis of the public's ability to correctly identify splake, which may influence creel reporting. Moreover, there is evidence of issues with splake identification by the public for tournament and record-keeping purposes as early as the 1960s (Michigan Department of Natural Resources, internal communication 1966) which hampers enforcement when fishing regulations differ for splake, brook trout, and lake trout. For example, in Michigan waters of Lake Superior the minimum size limit (MSL) for brook trout is 20" but for splake and lake trout the MSL is 15". These concerns continue as agencies work to protect recovering lake trout and brook trout populations, as anglers may inadvertently harvest brook trout believing them to be splake. Increased public information regarding splake identification and supplemental training of creel clerks may help to mitigate this issue.

**Summary**

Splake have been stocked into Lake Superior since the 1970s in order to provide a supplemental trout fishery for anglers. However, the co-occurrence of spawning splake with both spawning lake trout and brook trout on the species' respective spawning grounds, in combination with the fact that splake are fertile and will reproduce with both parental species is strong evidence that splake pose a threat to the genetic integrity and demographic health of Lake Superior lake trout and brook trout populations. However, genetic evidence of splake backcrossing and

introgression with either parental species is limited, and further genetic analyses of Lake Superior trout populations may be warranted. Moreover, although observations of spatial overlap between splake and both parental species have been reported, there is little-to-no evidence of competition between splake and either lake trout or brook trout, possibly due to lack of research. In addition, splake recreational harvest was found to be low in both Wisconsin and Michigan waters, relative to the number of splake that are stocked by both WDNR and MDNR each year, suggesting that splake stocking may provide little benefit to Lake Superior trout fisheries and continued stocking should be weighed against the risks splake stocking present to both lake trout and brook trout management goals.

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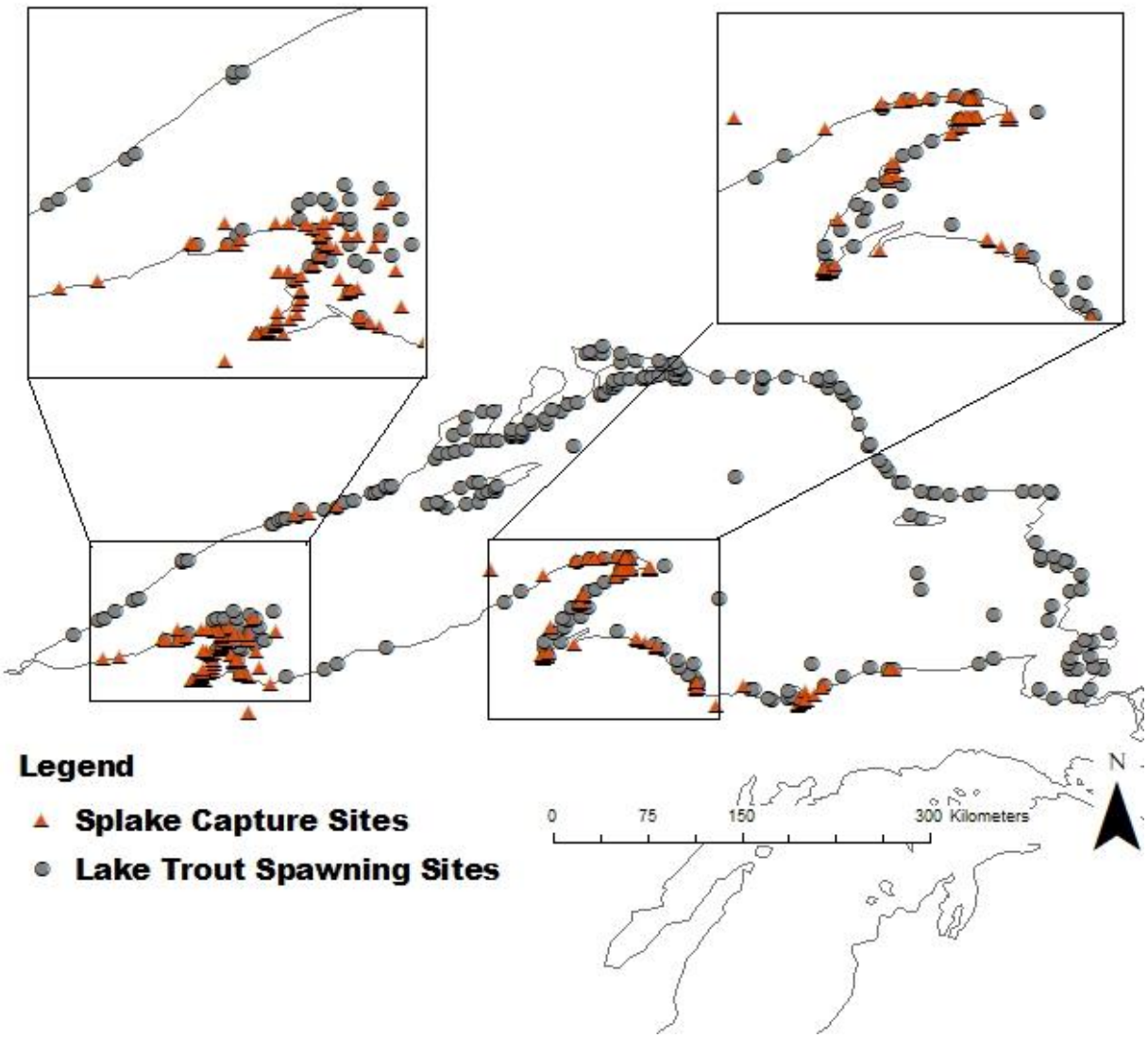


Figure 1. Splake capture sites (▲) in relation to identified lake trout spawning sites (●) based on Goodyear et al. (1982).

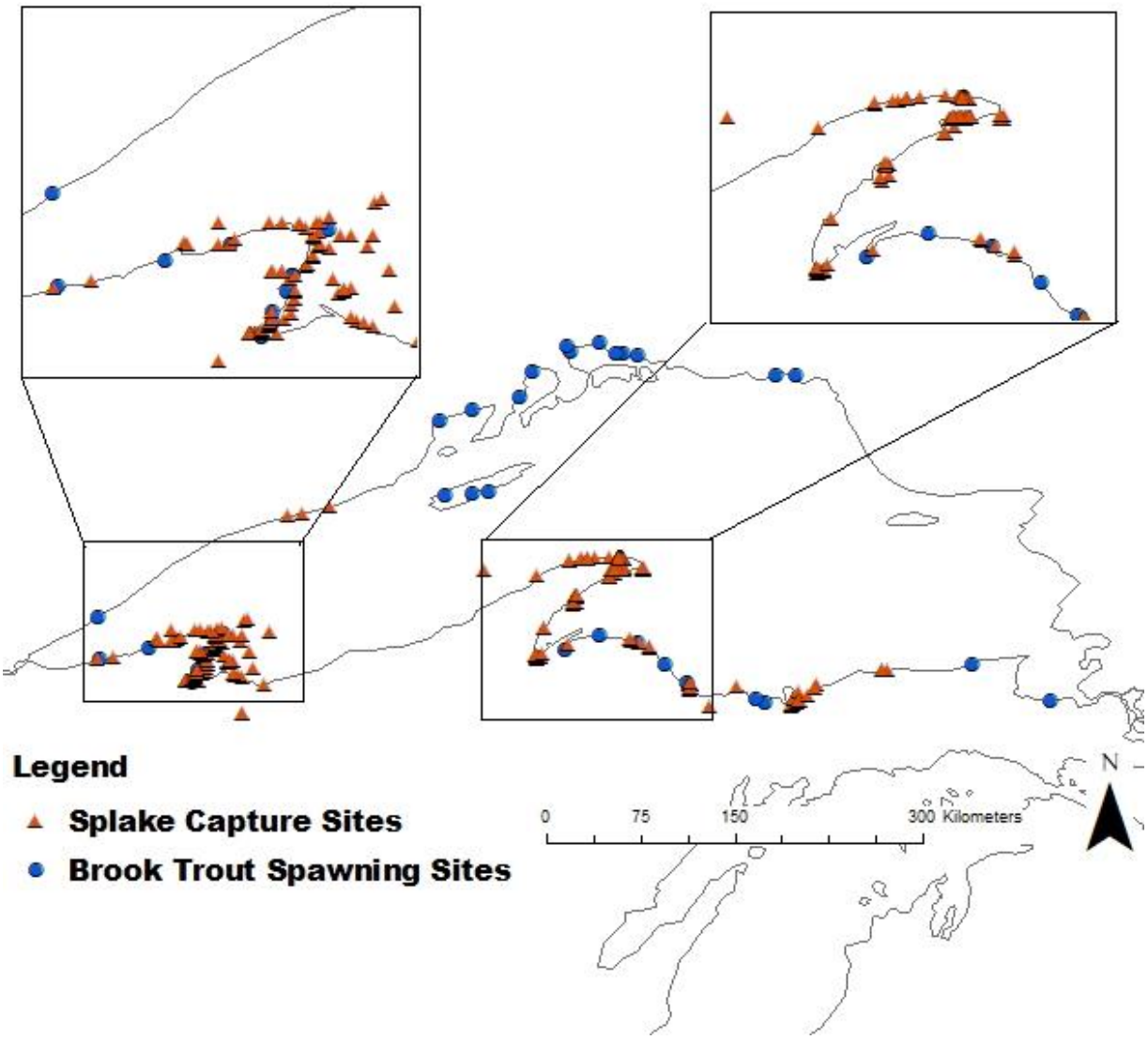


Figure 2. Splake capture sites (▲) in relation to identified brook trout spawning sites (●) based on Goodyear et al. (1982).

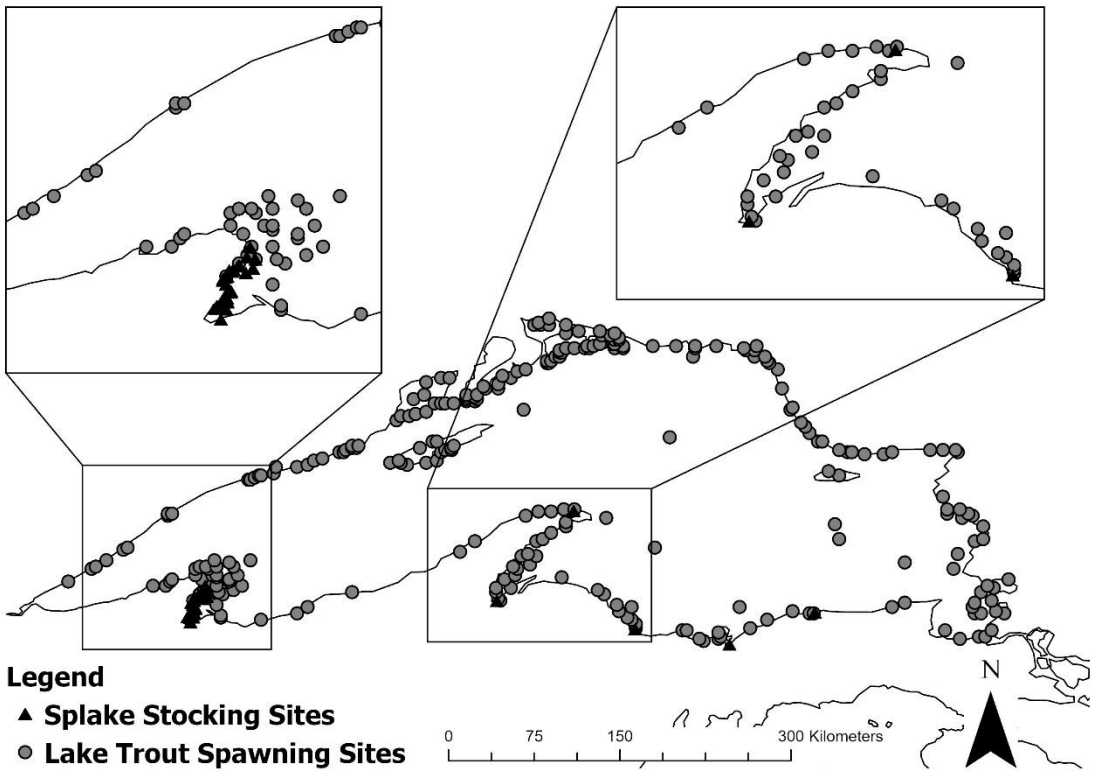


Figure 3. Splake Stocking sites (▲) in relation to identified lake trout spawning sites (●) based on Goodyear et al. (1982).

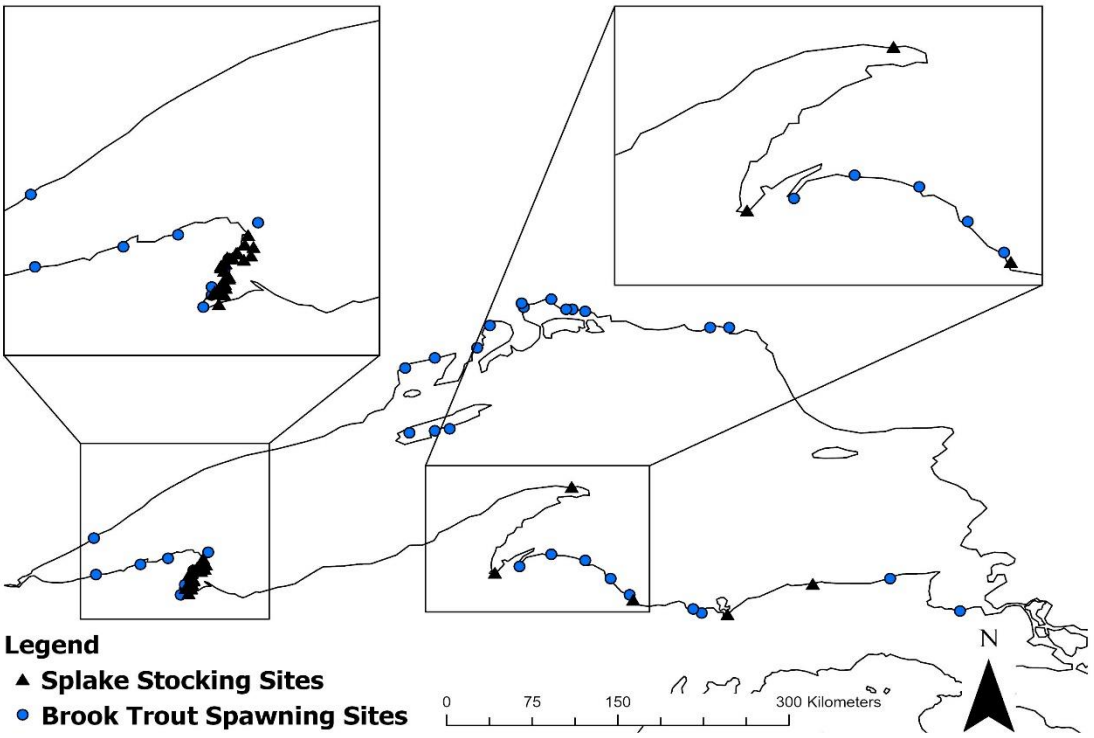


Figure 4. Splake Stocking sites (▲) in relation to identified brook trout spawning sites (●) based on Goodyear et al. (1982).

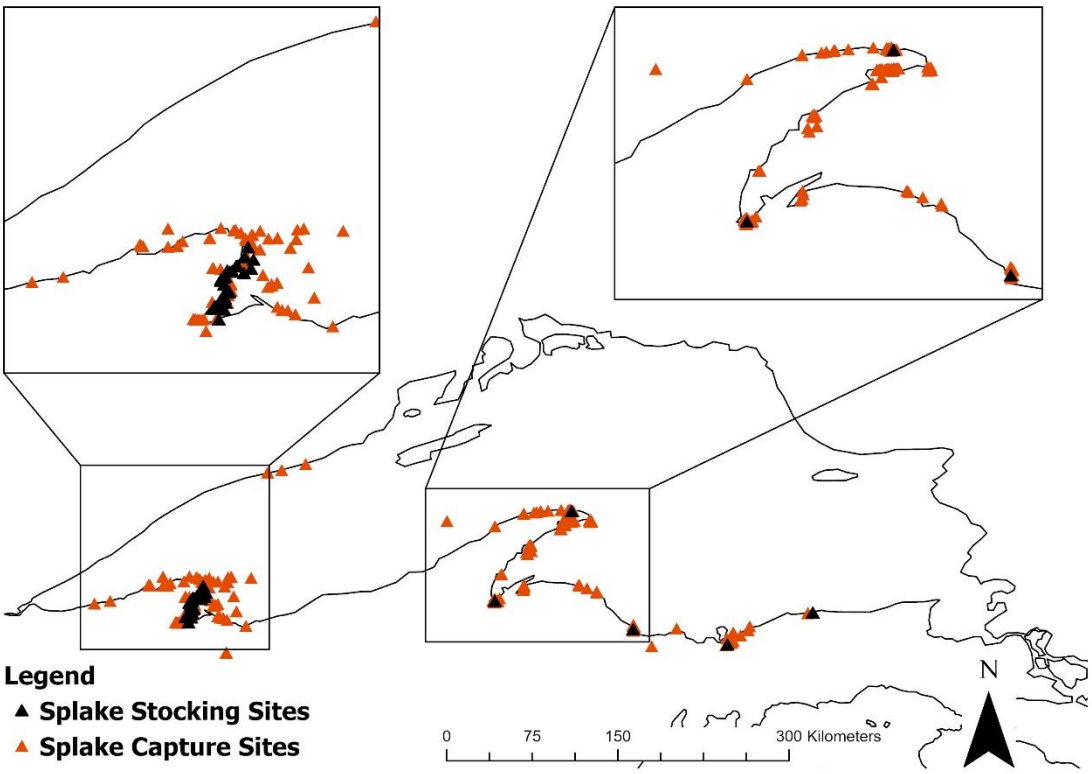


Figure 5. Splake capture sites (▲) in relation to splake stocking sites (▲).

**Appendix 1**

# Lake Superior Committee

REPRESENTING THE FISHERY MANAGEMENT AGENCIES OF LAKE SUPERIOR

2100 Commonwealth Blvd.
Suite 100
Ann Arbor MI 48105-1563
Tel: 734-662-3209

1854 TREATY AUTHORITY

CHIPPEWA-OTTAWA RESOURCE AUTHORITY

GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION

MICHIGAN DNR

MINNESOTA DNR

ONTARIO MNR

WISCONSIN DNR

July 12, 2018

From: Steve Hewett, LHC Chair

To: Tom Pratt, LSTC Chair

Subject: LSC charge about information needs related to splake stocking

Because splake are stocked by Wisconsin and Michigan into nearshore waters of southern Lake Superior to enhance angling opportunities, and because splake have been identified as being present with lake trout during spawning times, the Lake Superior Committee needs a fuller technical understanding of the probability that splake may introgress with either lake trout or brook trout. Specific questions that the LSC seeks information from the LSTC include:

- What is the probability that splake will introgress with either lake trout or brook trout?
  - Is there evidence that introgression has occurred?
  - The LSC notes that a possible place to begin looking at introgression is Cherry Creek, where annual splake escapements have occurred for > 50 years from the Marquette SFH.
- If introgression occurs, what are the long-term risks to the lake trout fishery and impact on LSC's Brook Trout Rehabilitation Plan?
- What are other ecosystem impacts of splake on lake trout and brook trout?
- What is the magnitude and distribution of fisheries supported by splake, brook trout, and lake trout?
- What are the most critical information gaps to address, and what are some recommended steps that agencies can take to address those gaps during the next 5-10 years?

The LSC asks that the LSTC formally answer these questions through a report and/or scientific literature review. If there are other pieces of technical information that the LSTC thinks are important, the LSC would like to discuss those with the LSTC.

Specific information needs:

- Potential for introgression:
  - Distribution/frequency of splake captures (from LSTC agency collections) from Lake and Brook Trout spawning locations during respective spawning seasons
  - Literature (or other evidence) of splake back-cross capability with brook or lake trout
  - Lake Superior evidence of splake back-cross (assessment or is it anecdotal) with lake/brook trout

    - Literature or other of probability of splake reproductive capacity – while fertile what is the fertility/viability rate?
    - What level of introgression would compromise lake trout fisheries and brook trout rehabilitation
- Potential for competitive/predation interactions
    - Distribution/frequency of splake captures (from LSTC agency collections) during non-spawning times vs stocking locations
    - Basic understanding (proportion of captures in non-stocking location vs stocking location, tagging information etc.) and movement rates of splake from stocking locations (if it exists)
    - Information on diet composition for splake, brook, and lake trout
- Other information available to help the LSTC with its work
    - MDNR decision framework for minimizing risk when stocking splake
    - Splake harvest by fishery (if available), distribution, and timing of fishery harvest
    - Splake stocking densities and locations by jurisdiction
    - Lake trout harvest by fishery/jurisdiction
    - Brook trout harvest by fishery/jurisdiction
    - Long-term risks to lake trout fishery and coaster brook trout rehabilitation
    - Probability of mis-identification of splake/brook trout from agency samples