Mille Lacs Lake Walleye Blue Ribbon Panel Data Review and Recommendations for Future Data Collection and Management

Paul Venturelli, Jim Bence, Travis Brenden, Nigel Lester, and Lars Rudstam

DNR Roundtable, Brooklyn Park MN

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Minnesota Department of Natural Resources
MNDNR **NEWS RELEASE**

New DNR plan aims to get Mille Lacs Lake back on track

(Released January 21, 2014)

National review of management part of effort to boost walleye numbers

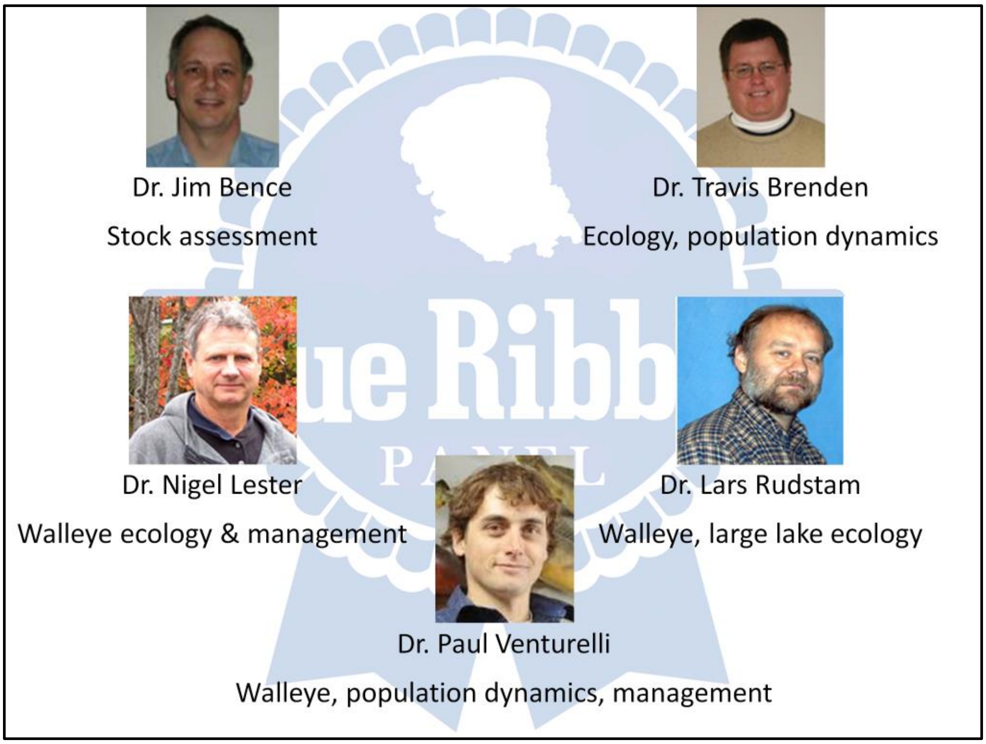
Unprecedented change is occurring at Mille Lacs Lake and the Minnesota Department of Natural Resources is taking unprecedented actions to address it.

The agency will convene a blue-ribbon panel of national fisheries experts to review past and current management practices as part of a new effort to increase the legendary lake's walleye population as quickly as possible with minimal impact to the local community.

"We will have nationally recognized fisheries experts review our work and offer recommendations," said Don Pereira, DNR fisheries chief. "We want the lake back on track. This is one strategy to do that."

Early in 2014, the Minnesota Department of Natural Resources to conduct an independent review of the Mille Lacs Lake walleye fishery

Panel members are Drs. Jim Bence and Travis Brenden, Quantitative Fisheries Center at Michigan State University; Dr. Paul Venturelli, University of Minnesota and the Minnesota Aquatic Invasive Species Research Center; Dr. Nigel Lester, Ontario Ministry of Natural Resources and the University of Toronto; and Dr. Lars Rudstam, Cornell University and Oneida Lake Field Station.



Together, the panel bring many years of fisheries and walleye experience to the table, especially with respect to management and population declines.

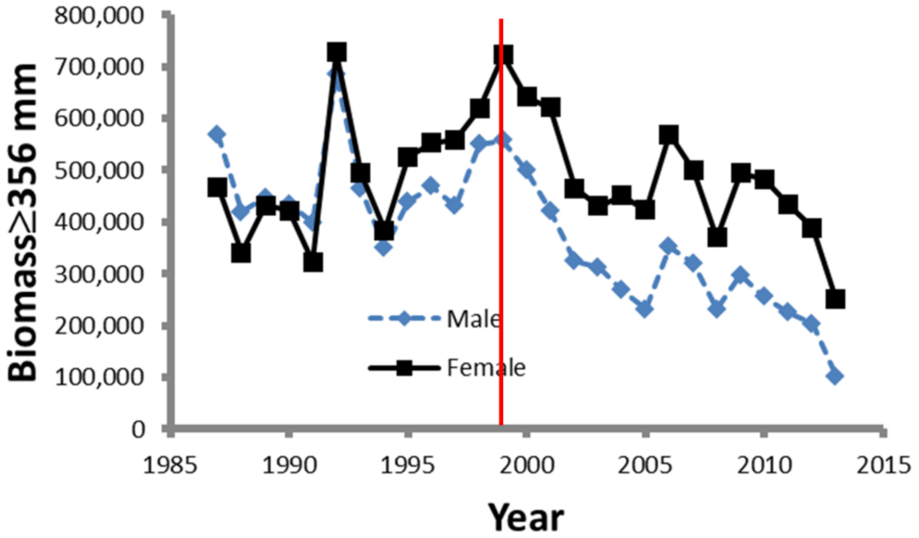
"The review will include examination of available data, a critique of past harvest policies, formulation of hypotheses to explain the current fishery status, evaluation of hypotheses, weighting of hypotheses, recommendation of future data collection and research, and recommendation of management strategies" – *Contract 15A29*

DNR-led conference call and data dump in March 2014

Then operated independent of the DNR
except to ask about data or report on progress

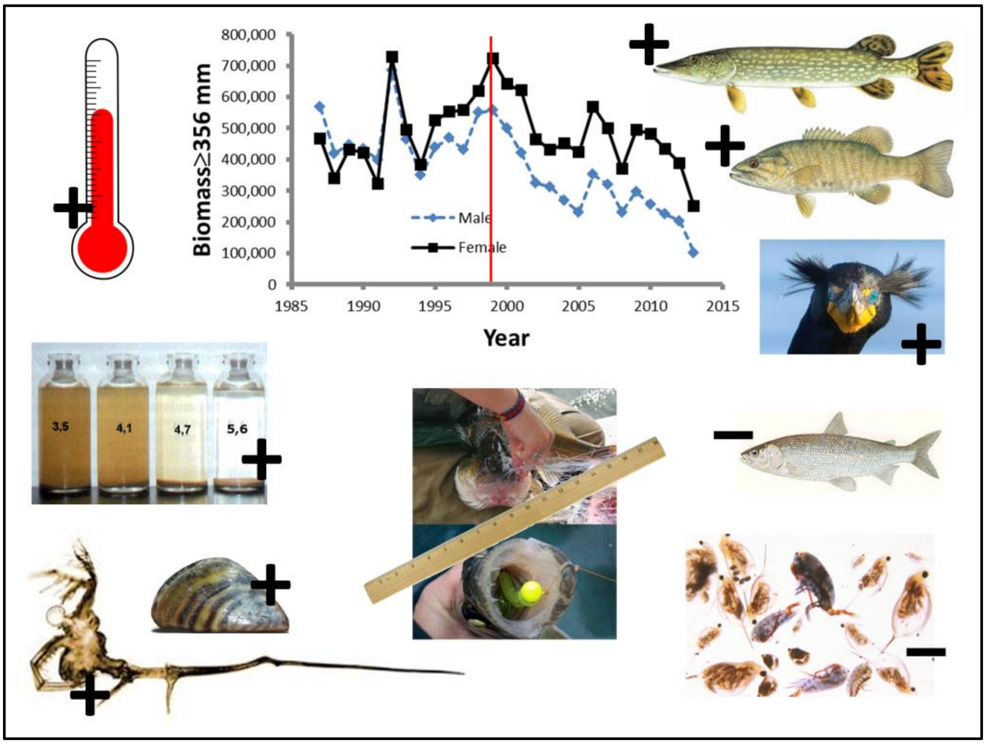
Convened approximately once a month via phone or email

The quote details our charge, most of which is covered in this presentation. The DNR organized the first conference call in March 2014 to outline the panel's responsibilities and provide background information and data. The panel then operated independently of the DNR except to enquire about existing data, request additional data, or informally report on progress. We generally worked as a group to formulate hypotheses to explain the current fishery status, and then evaluated these hypotheses independently or in pairs according to our areas of expertise. We convened approximately once a month to report on progress, discuss results and/or data needs, and plan next steps.

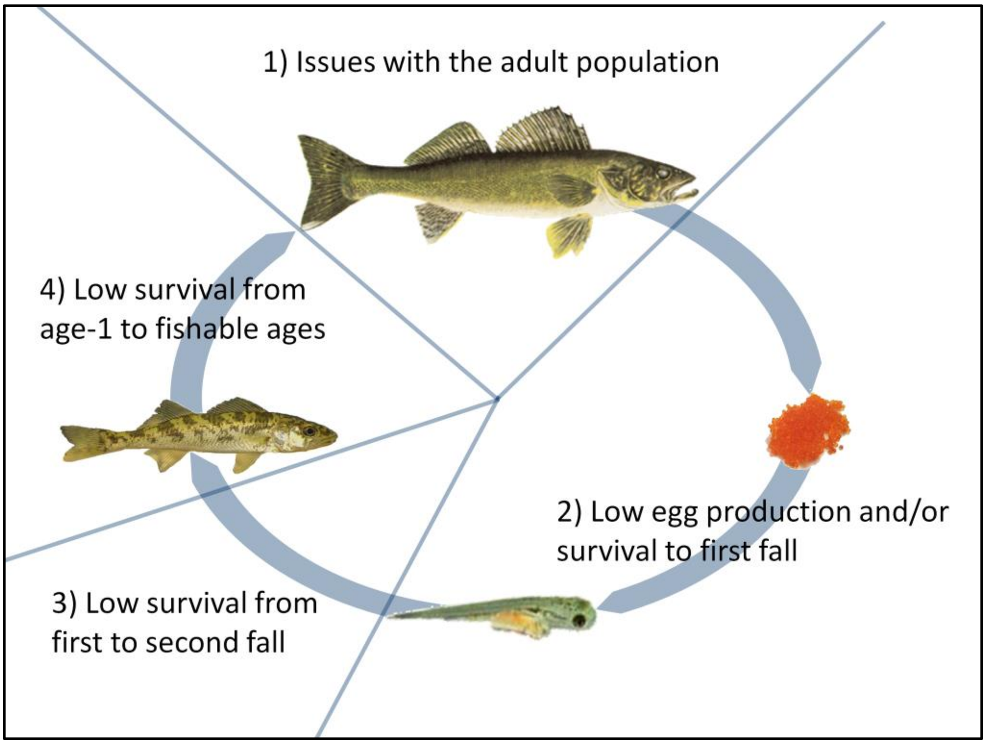


Estimated biomass (kg) of male and female walleye ≥356 mm (14") in length in Mille Lacs Lake, MN (1987-2012). Data were calculated from the base version of the SCAA model that was supplied for the Bence et al. (2014) assessment model review.

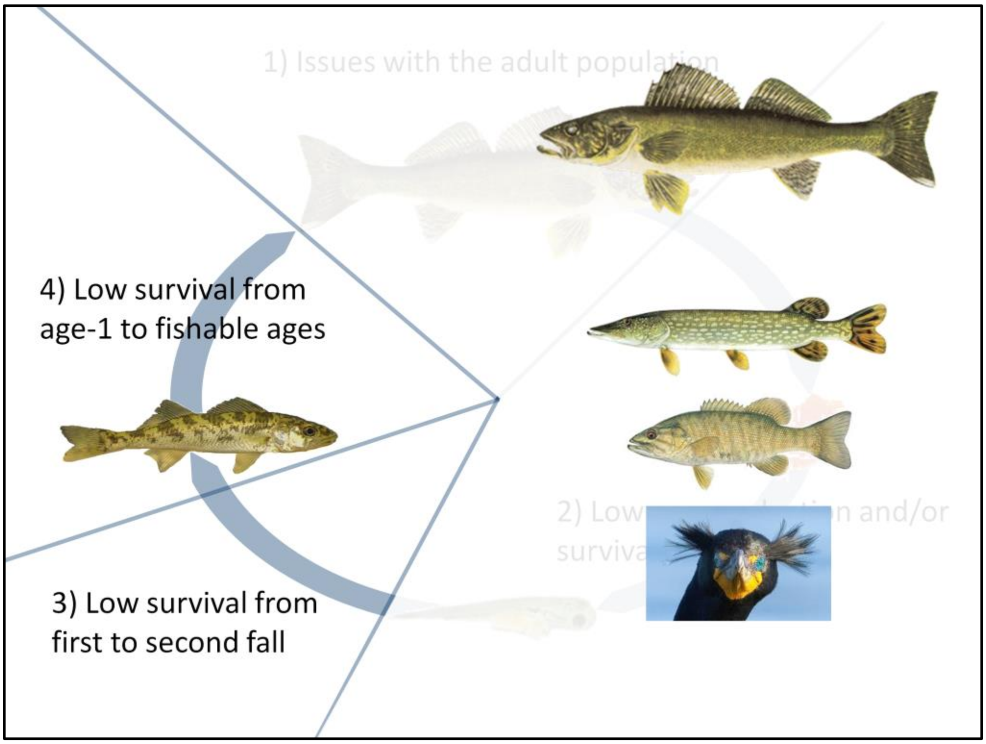
We started by agreeing that the decline in Mille Lacs walleye began around 2000 (red line)



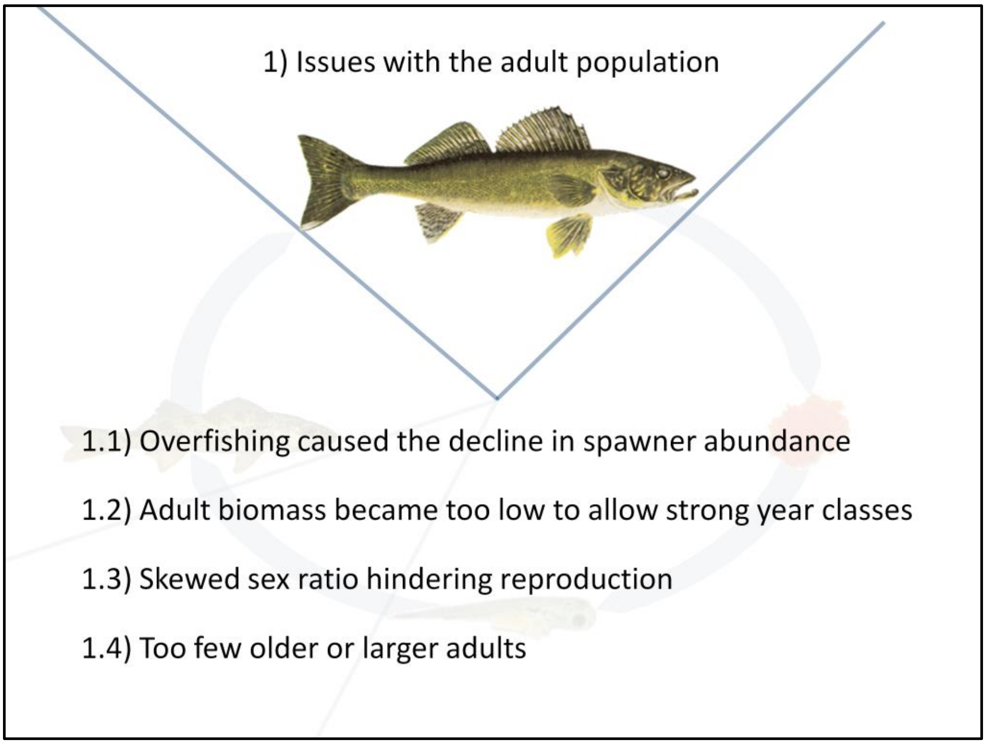
An overview of the data show that the start of the decline corresponds to a period of considerable change for both the walleye fishery and Mille Lacs itself. Significant changes to the walleye fishery included the addition of a tribal fishery in 1997, the introduction of harvestable slot limits to the recreational fishery in 1999, and a switch to protected slot limits in 2003. However, these fishery changes occurred against a backdrop of lake changes related to water quality, species interactions, and invasive species. Northern Minnesota today is ~1.5°C warmer than it was in 1980 and water clarity has almost doubled since the mid-1990s. Potential walleye competitors and predators (double-crested cormorants, northern pike, smallmouth bass) in Mille Lacs have increased since the mid- to late-1990s, while important walleye prey (e.g., lake cisco) have decreased. Invasive zebra mussels and spiny water fleas were first detected in 2005 and 2009, respectively, and zooplankton biomass has been low since 2012. The temptation when presented with such a list is to try to relate each to the decline in walleye. The panel resisted this temptation, at least early on, because walleye abundance results from a complex web of direct, indirect, and interacting mechanisms.



Instead of trying to attribute the decline to an underlying mechanism, we first identified the part (or parts) of the walleye life cycle that are likely contributing to the decline of Mille Lacs walleye. This approach allowed us to shorten the list of underlying mechanisms that are ultimately responsible for the decline. We focused on the four, over-arching hypotheses listed above. Each hypothesis focuses on an important component of the walleye life cycle (with some allowances for data availability) and depends on one or more of the factors listed two slides above.

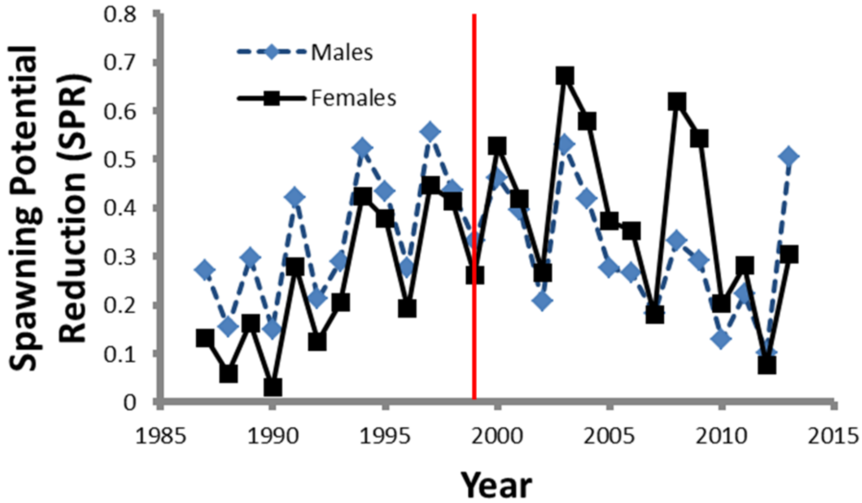


We found that the decline is likely a result of decreased survival over a ~2-year period from the first fall (age-0 fish) to approximately the third fall (age-2 fish). This decrease in survival may be due to an increase in predation by walleye and recently and to a lesser extent, predation by northern pike, smallmouth bass, and cormorants. The rest of this presentation explains how we reached this conclusion, why we think that it's happening, and then describes our suggestions for management.



We considered four sub-hypotheses related to issues with the adult population.

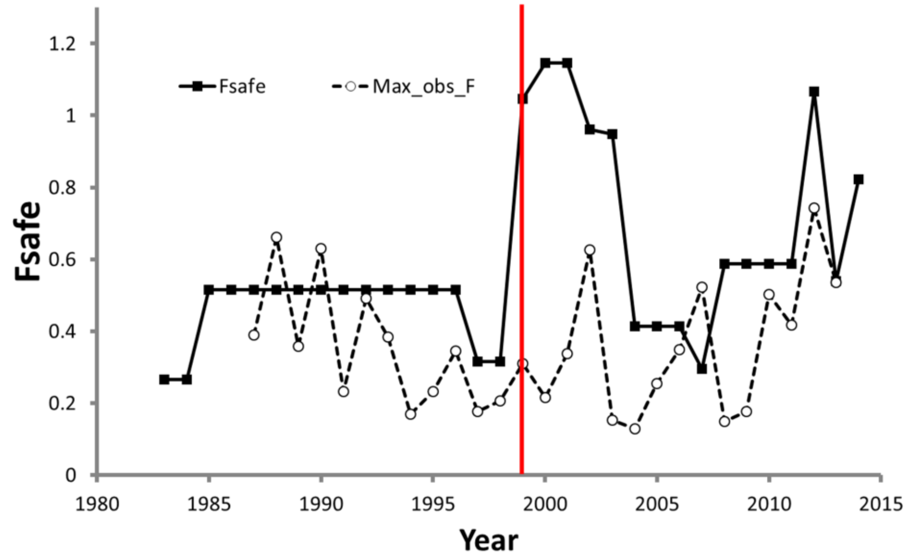
1.1) Overfishing caused the decline in spawner abundance



Estimates of spawning potential reduction (SPR) over time. Higher is better. These rates should be sustainable, although regs from 2010-present focused on young fish (esp. males) and were less sustainable.

Fishery management agencies around the world use SPR as a measure of the overall level of fishing mortality and generally seek to keep values above thresholds that vary from 0.2 to 0.5. Lower, more aggressive, thresholds are applied to more productive fish stocks. SPR values average 0.32 for males and 0.31 for females. These values, while not especially conservative, should be sustainable. However, the fishing strategy used during 2010 through the start of the 2013 season, which focused on young fish, produced lower SPR values, especially for males.

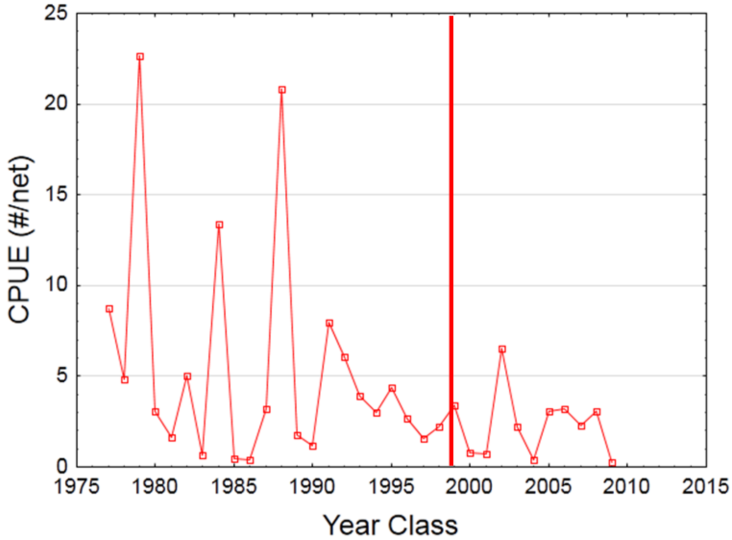
1.1) Overfishing caused the decline in spawner abundance



Annual estimates of F_{safe} (varies with reg) and F (maximum estimate across all female ages). F across *all* age classes is lower. Because $F_{safe} > F$, fishing unlikely cause of decline

We also conducted an alternative analysis that calculated a safe fishing mortality rate (F_{safe}). This analysis used Mille Lacs walleye regulations (Table 1), local temperatures, and the expected change in walleye growth following a severe population decline to derive annual estimates of the maximum rate of fishing mortality that a typical walleye population can sustain. F_{safe} is half of this rate and is therefore risk-averse. In general, actual fishing mortality rates (estimated via the DNR assessment model) have been substantially below F_{safe}. What this figure shows, similar to the SPR analysis, is that a typical walleye population should not have collapsed in the face of the fishing rates (and regulations) that occurred on Mille Lacs. This argues that obviously inappropriate levels of fishing were not the root cause of the decline.

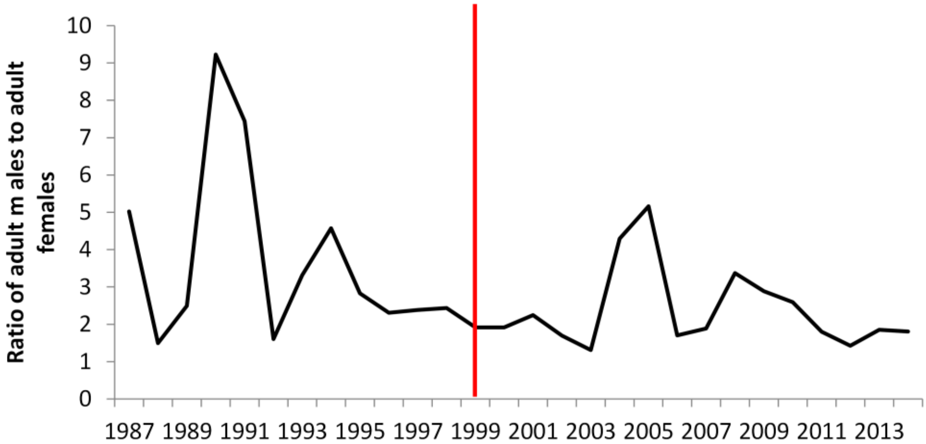
1.2) Adult biomass became too low to allow strong year classes



Recruitment of walleye to the recreational fishery (# of 3- and 4-year olds per gill net). If 1.2 is true, recruitment should not have declined ~15 years before adult biomass declined.

There is no evidence that adult biomass reached particularly low levels prior to the substantial decline in year class strength (i.e., CPUE). This figure shows that the occasional very strong year classes seen during the 1970s and 1980s were not seen during the 1990s, but this change occurred 15 years before the decline in the biomass of walleye 356 mm (14") or longer. The moderate year classes produced in the later 1980s and early 1990s were sufficient to maintain biomass of harvestable fish 356 mm

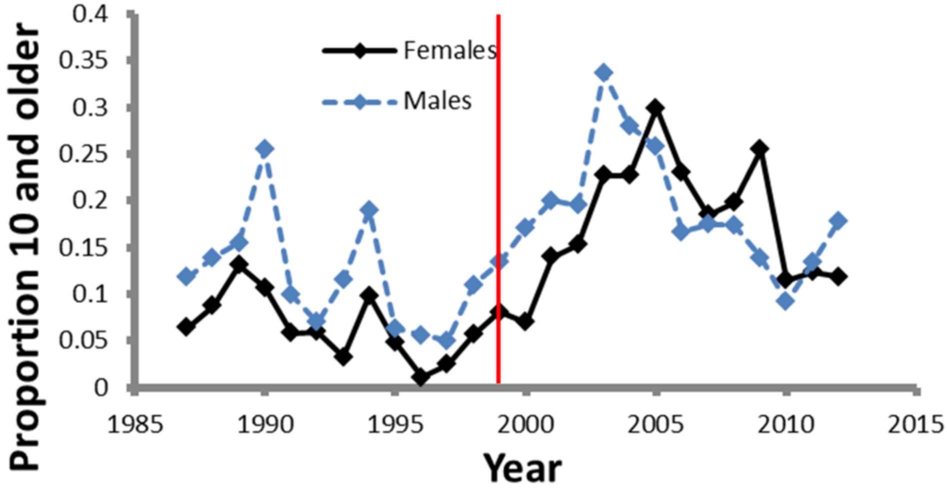
1.3) Skewed sex ratio hindering reproduction



The ratio of adult males to adult females. Except for 1990 and 1991, has varied between 1.5 and 5.0. Lower ratios more common after 1998 but not low enough to be a concern

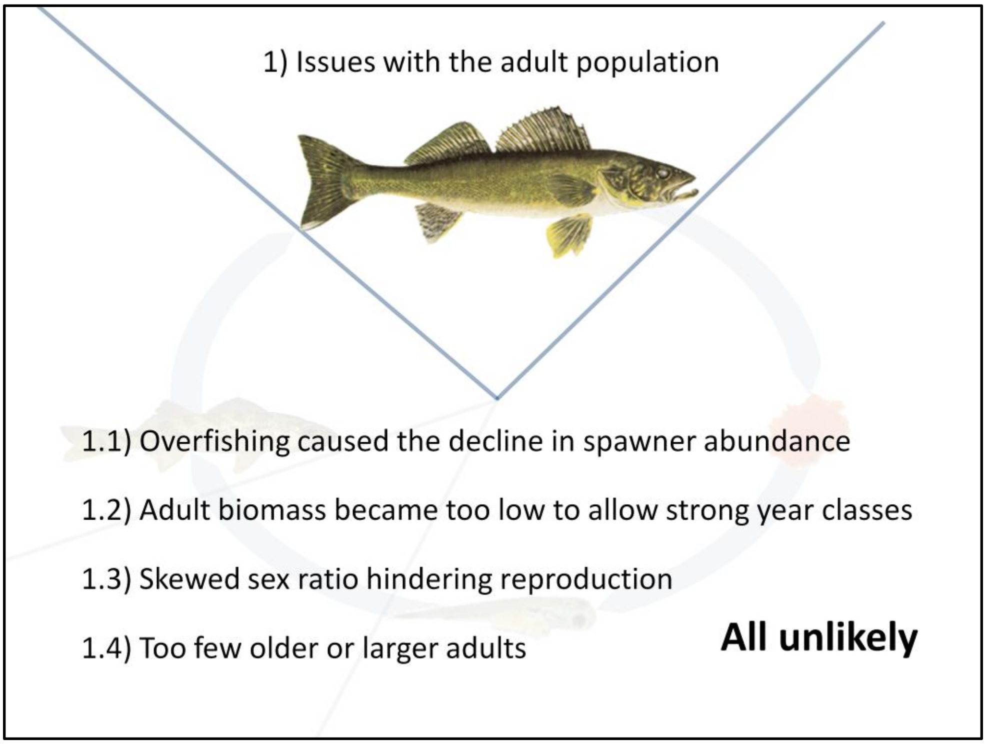
The estimated M:F ratio of adult walleye in Mille Lacs has varied consistently between 1.5 and 5.0 over the period 1987-2014 with the exception of two unusually high ratios in 1990 and 1991. Although it appears that lower ratios were more common after 1995, we suspect that the observed ratios are not skewed sufficiently to be a concern. [Note that adult males appear to be more common than adult females because male walleye mature approximately 2 years younger than female walleye and because abundance is higher at younger ages]

1.4) Too few older or larger adults

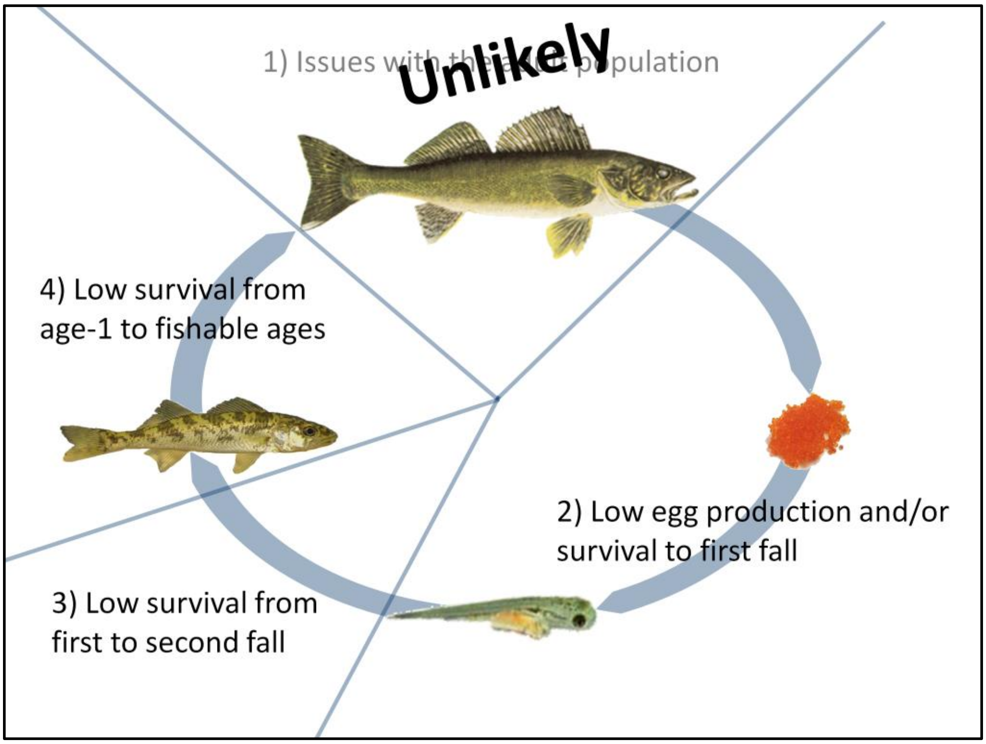


Proportion of walleye ≥age-10. On average more older, larger walleye in Mille Lacs after the start of the decline vs. before. This increase probably reflects both improved aging practices and the protection of older, larger walleye by regulations

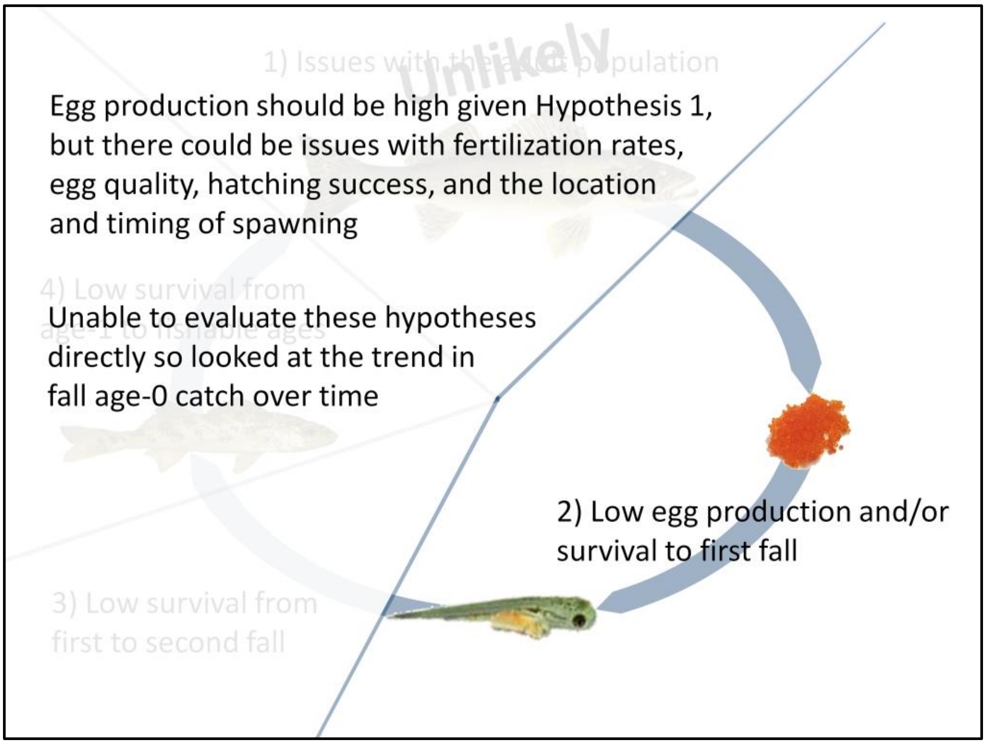
We evaluated this sub-hypothesis because there is increasing evidence in walleye and other fishes that older adults are important to the health of a population, even if younger adults are abundant. In fact, recruitment to the fishery can be twice as high when older walleye are present. We found no evidence of a sustained decline in the relative abundance of older or larger adults or the average age of adults. More old, large walleye after the decline.



Based on this evidence, we concluded that all four sub-hypotheses were unlikely

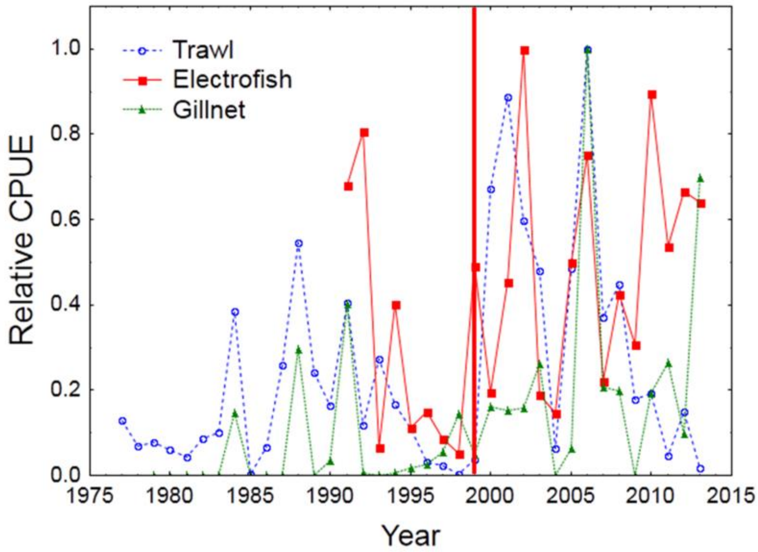


And that there are no issues with the adult population. In fact, with the exception of the figure that shows a decline in recruitment, all of the sub-hypothesis point to a healthy walleye population.



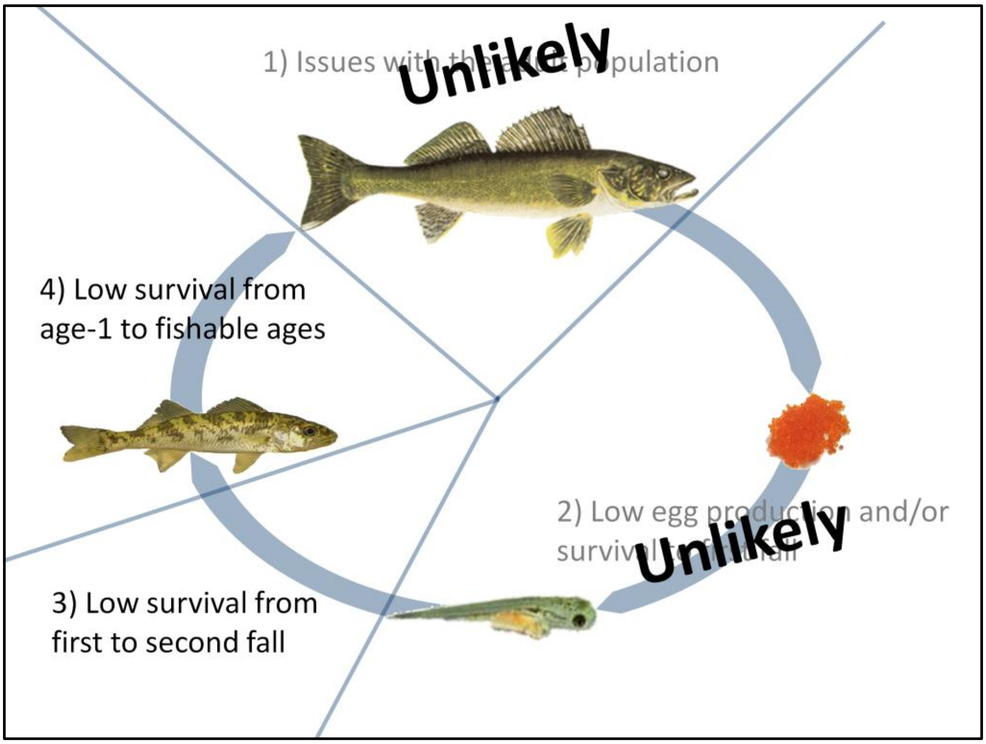
Next we looked at survival to first fall (data unavailable to evaluate hypotheses related to egg production, fertilization success, etc.

2) Low egg production and/or survival to first fall

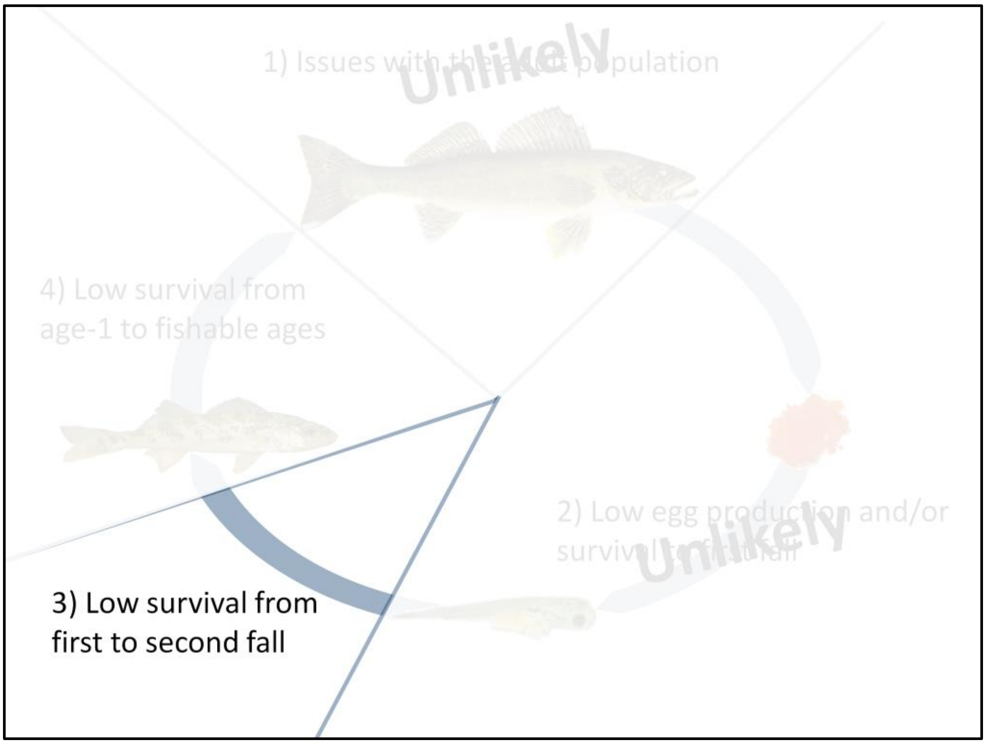


Index of variation in age-0 abundance based on fall surveys. Some of the highest fall abundances have occurred within the last decade. Adults have declined but remain capable of producing strong year classes

None of the age-0 abundance indices showed a declining trend in recent years. On the contrary, both the trawl and gill net data (which data back to the 1970s) indicate that some of the highest fall abundances of age-0 walleye have occurred within the last decade. The time series for electrofishing is shorter (since 1991), but also indicates high production of age-0 walleye in the last decade. Therefore, we concluded that Mille Lacs walleye continue to be capable of producing strong age-0 year classes despite declines in adult abundances.

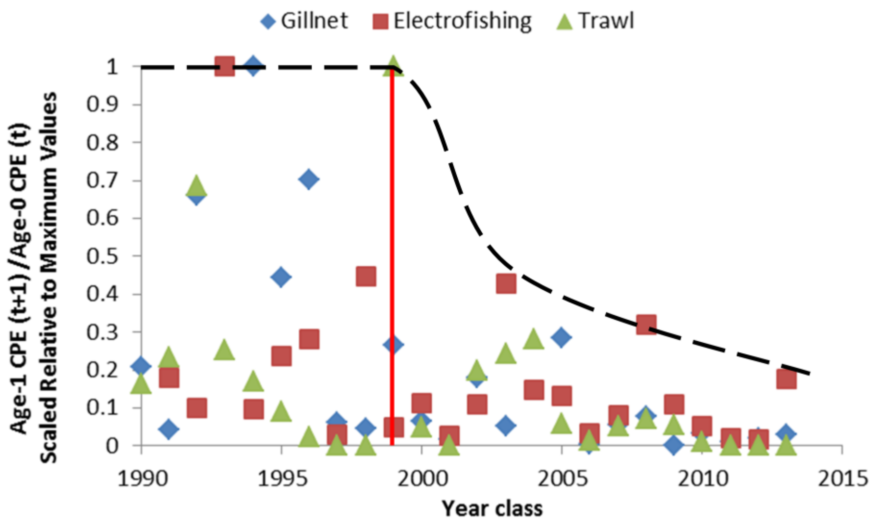


Based on the evidence, it appears unlikely that the decline is due to low egg production and/or survival to first fall



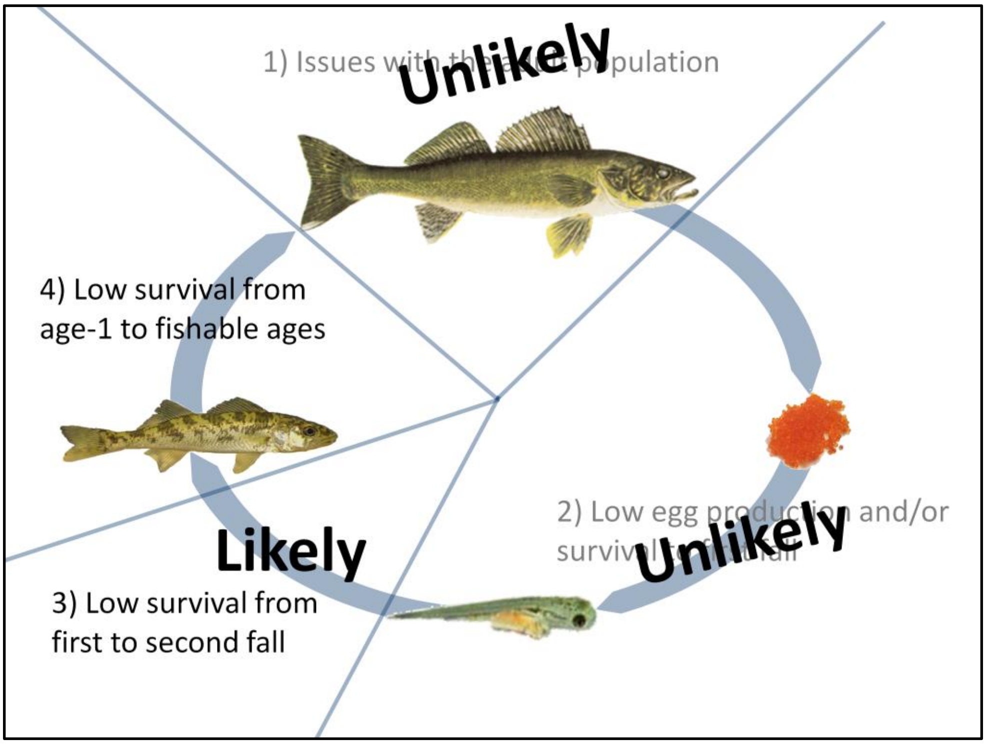
Next we looked at survival from first to second fall.

3) Low survival from first to second fall

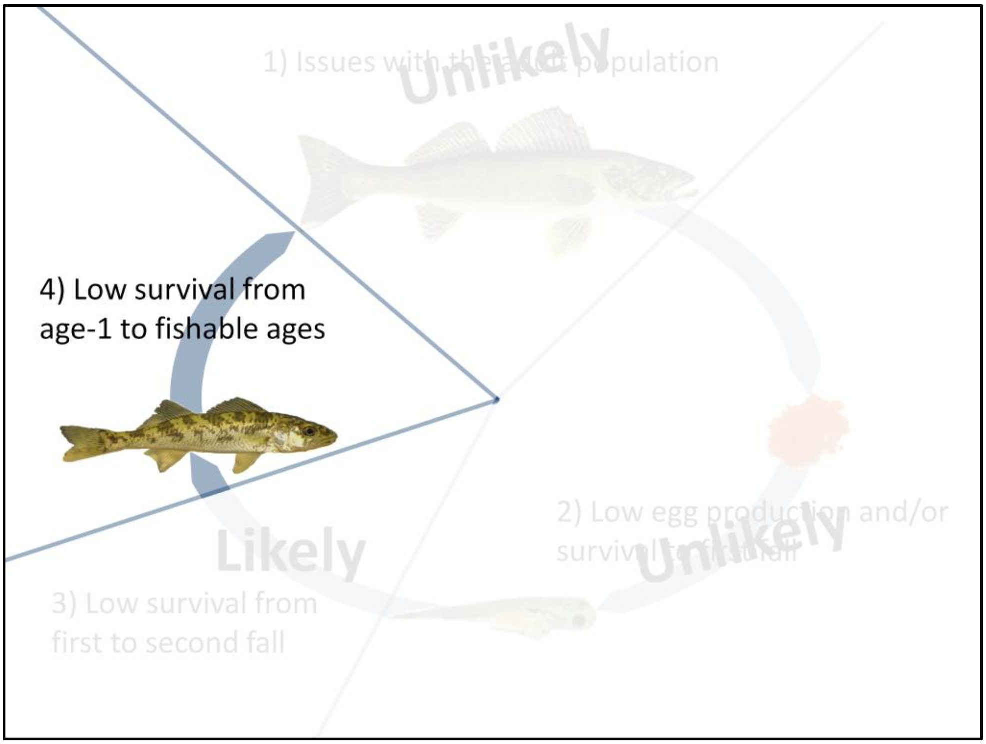


Relative age-0 survival for 3 gear types. Relatively low and declining since ~2000; consistently low since 2005 for two gear types.

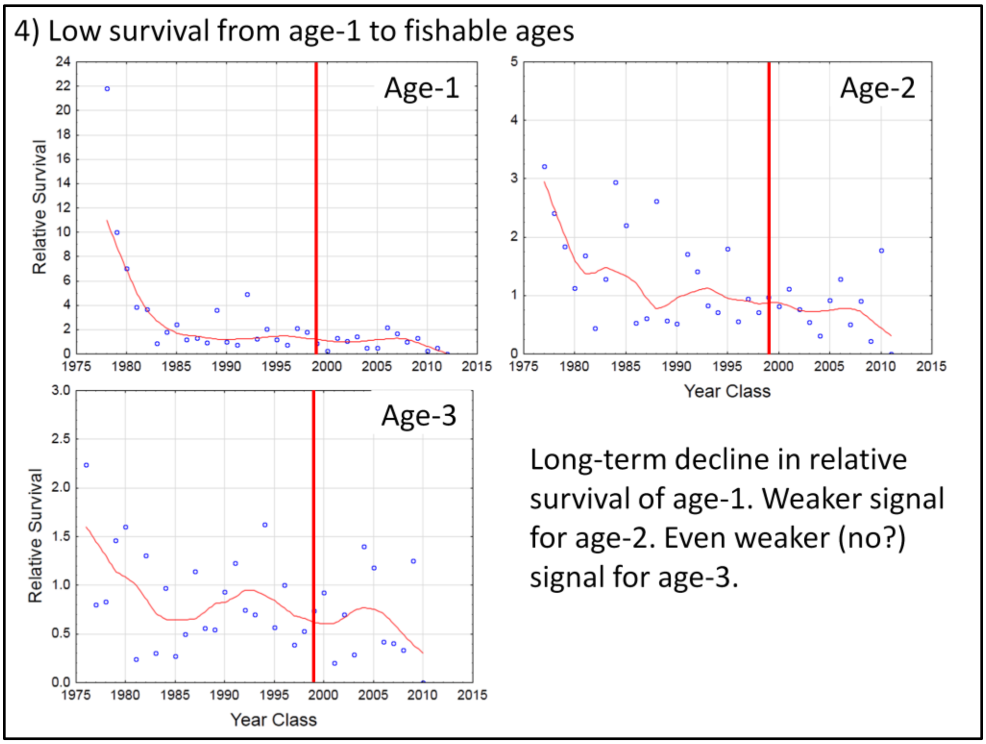
The relative survival of age-0 walleye has been highly variable over time, but relatively low (and declining) since ~2000. Two (gill net and trawl surveys) out of the three survey methods also suggest that age-0 survival has been consistently low since 2005. I've added the black line to show that the *capacity* for high survival seems to have disappeared. Given strong evidence that Mille Lacs walleye can still produce strong year classes that persist through summer, we conclude that low offspring survival between first and second fall is very likely contributing to the decline.



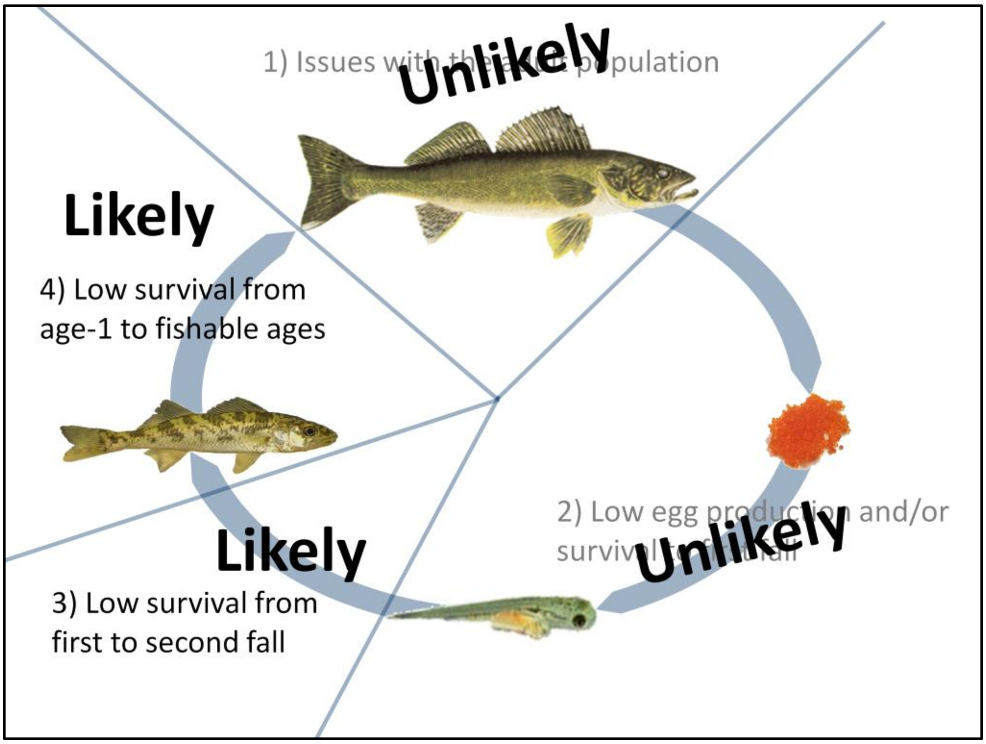
The evidence suggest that survival of age-0 walleye from first to second fall has been relatively low (and declining) since ~2000.



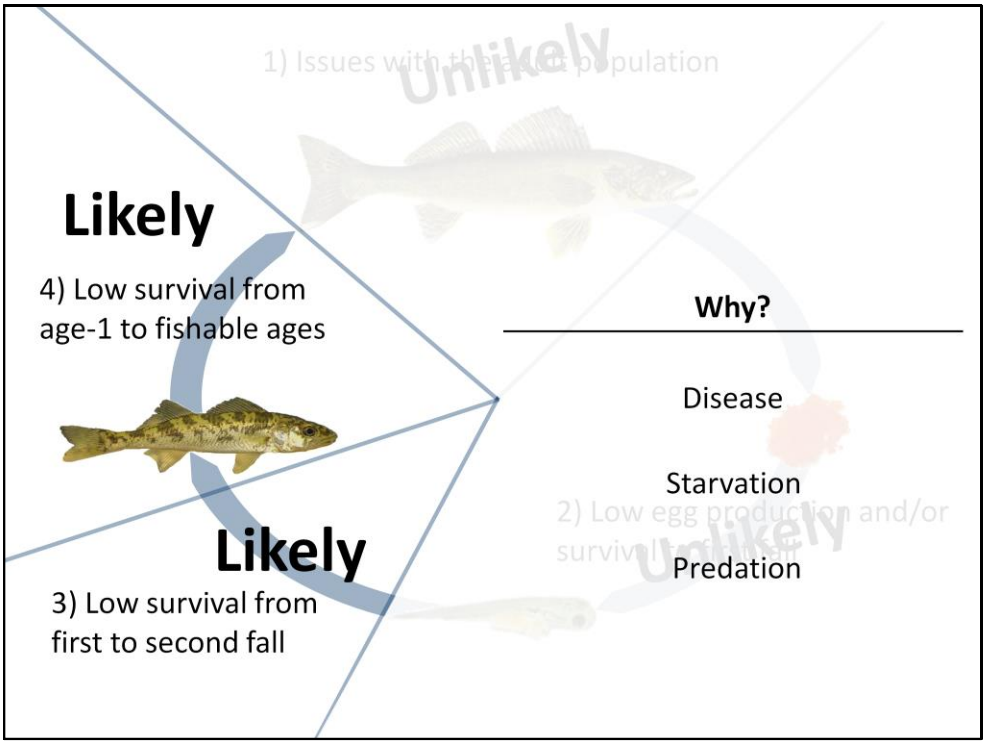
Finally, we looked at survival from age-1 to fishable ages.



The relative survival of age-1, -2, and -3 walleye has declined over time, but the severity of this decline tends to decrease with age. In other words, it appears that the decline in age-1 survival has been greater than the decline in age-2 survival, etc.

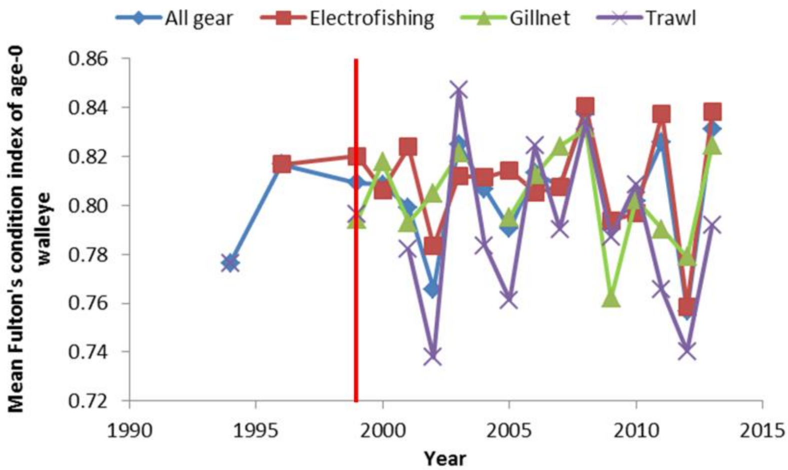


The evidence suggest that age-1, age-2, and perhaps age-3 survival has been declining since before 2000



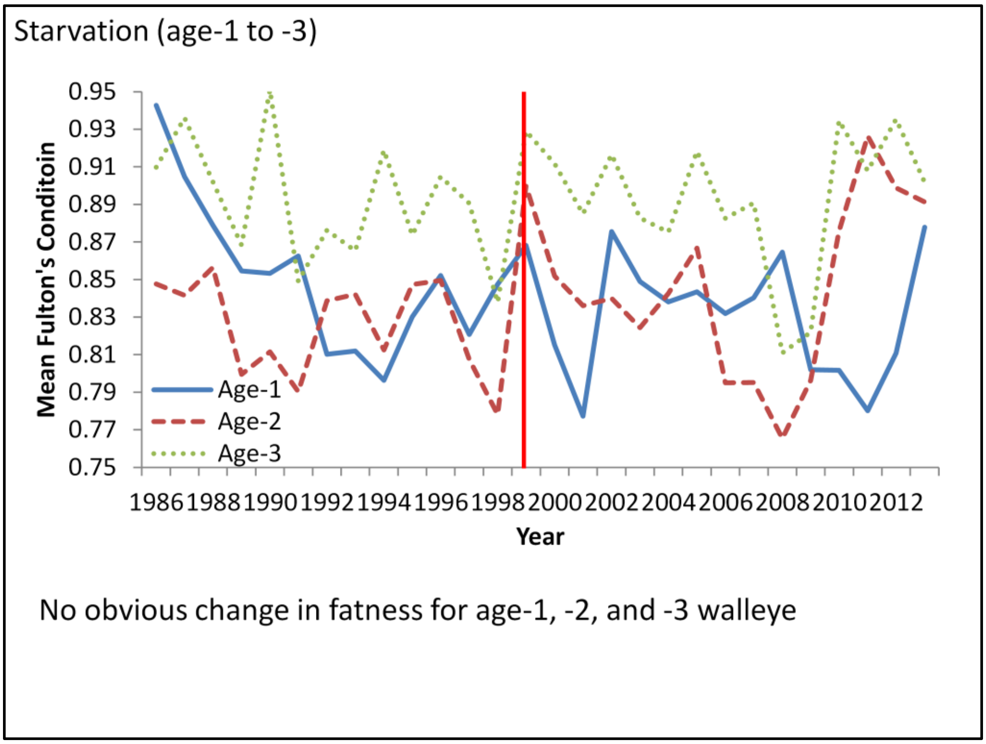
Altogether, it looks like the decline in walleye is primarily caused by low survival starting after the first fall of life and persisting (albeit with declining intensity) almost to fishable ages. Why? Three immediate causes would be disease, starvation, and predation (including predation by walleye). The panel didn't evaluate disease because if disease was an issue we wouldn't need an external review of the data – the annual die-off of young walleye would be obvious.

Starvation (age-0)

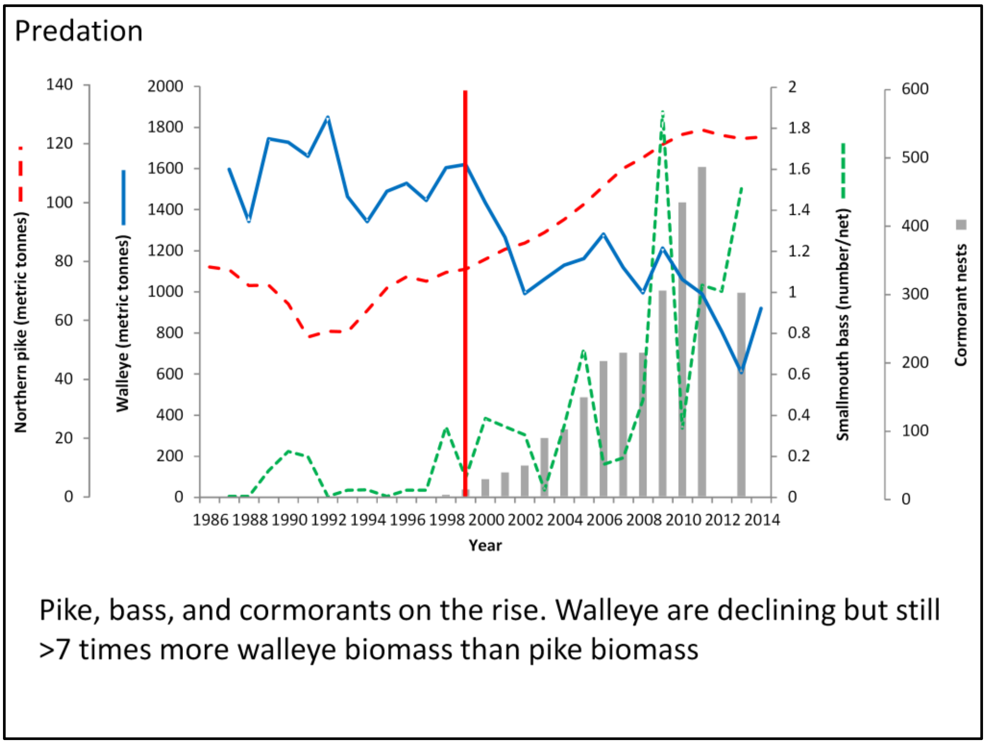


No change in fatness heading into first winter (critical for survival)?
Fatness since 1999 suggests healthy fish

Fatness varied annually and among years and gear types, there was no evidence of a decline. I included the question mark because we only have three data points from before the start of the decline. Regardless, the fatness that we do see post-1999 suggests that age-0 are healthy heading into their first winter.

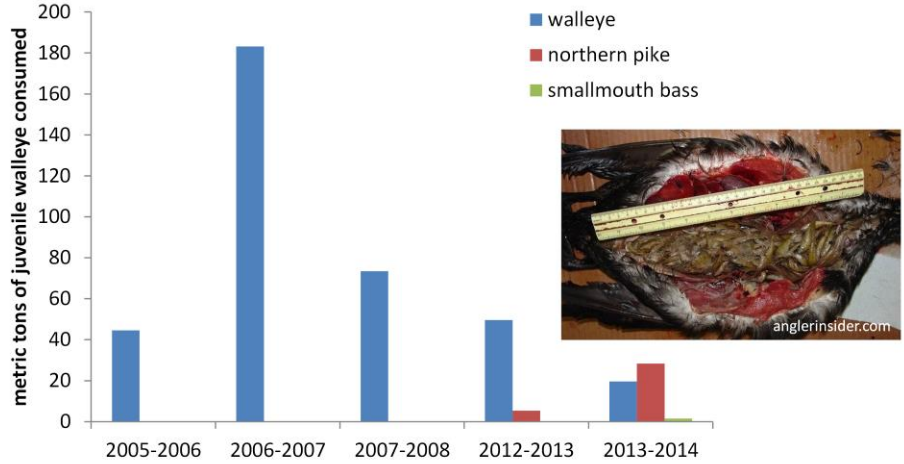


Fatness for age-1, -2, and -3 walleye was variable but there is no obvious trend.



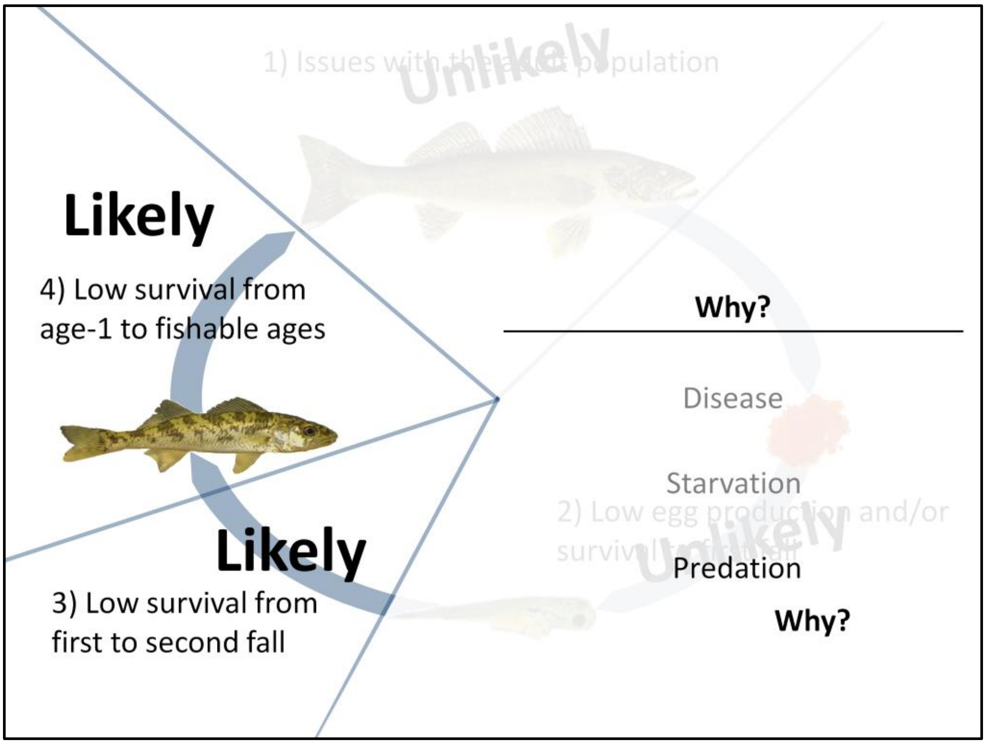
Low survival could be due to predation given that pike, bass, and cormorants are increasing in abundance and walleye still dominate.

Predation



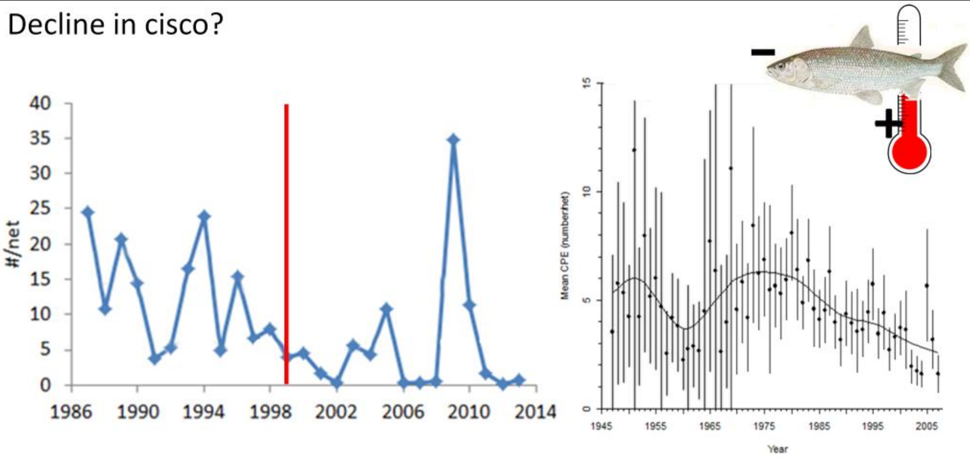
Tyler Ahrenstorff's bioenergetic estimates of consumption of juvenile walleye by walleye, pike, and bass. Rough calculations also suggest that cormorants could be impacting walleye. Unfortunately, we don't know the contribution to overall mortality or how things looked <2005

Tyler Ahrenstorff's bioenergetics work shows consumption of walleye relative to pike and bass. Pike consumed more than walleye in 2014, probably because walleye are declining. Overall, these results suggest that predation by walleye might be responsible for low juvenile survival in Mille Lacs, and that predation by northern pike (and perhaps bass) might be important in the future. Our rough estimate of cormorant feeding days per ha is approaching the feeding days at which effects of cormorants on walleye have been detected in other lakes.



Our review of the available data suggests that the decline is a result of decreased survival from the first winter (age-0 fish) to approximately the third fall (age-2 fish). This decline in survival may be due to an increase in walleye predation and, with increasing numbers in recent years, perhaps predation by northern pike, smallmouth bass, and cormorants. Why?

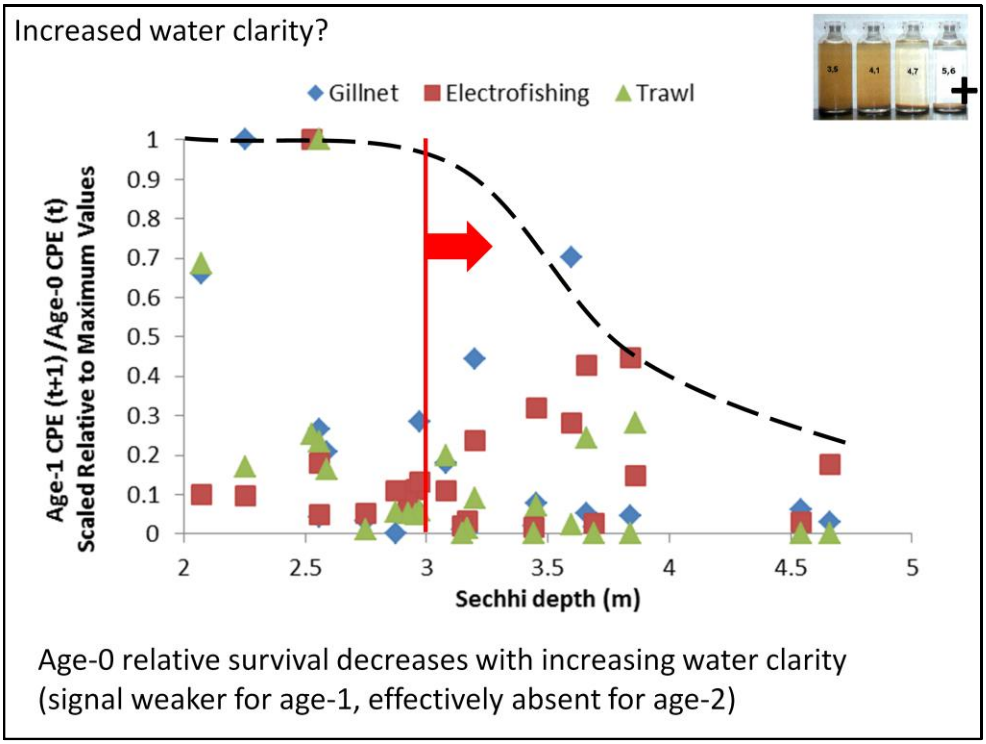
Decline in cisco?



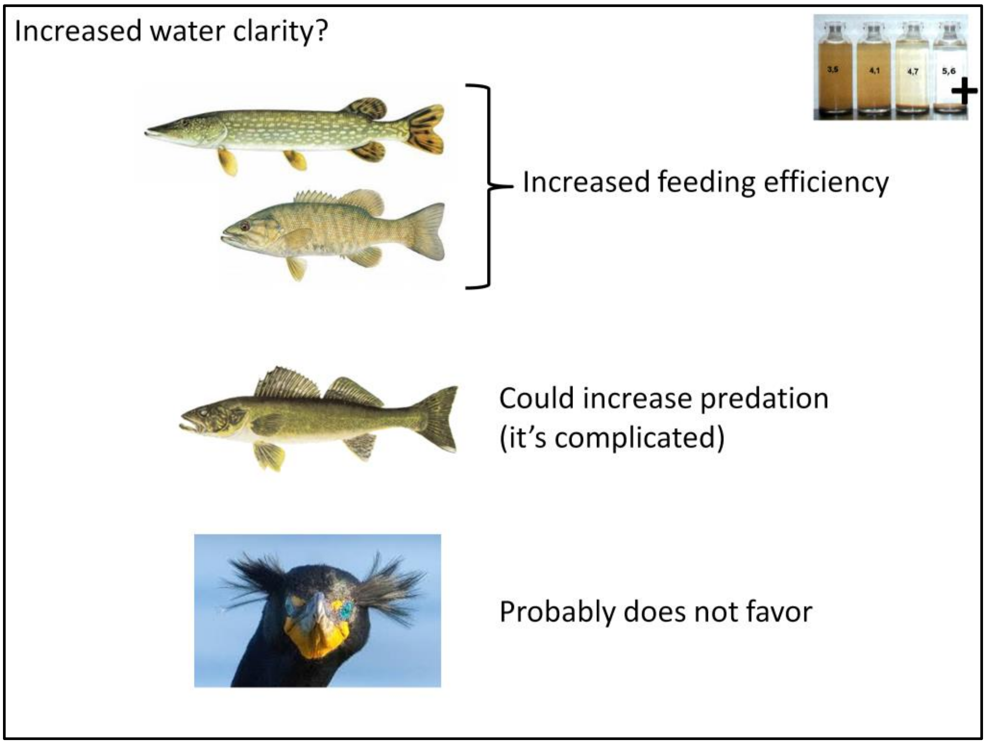
Index of age-0 lake cisco abundance showing decline (with the exception of 2009) that is consistent with the state-wide trend shown on the right.

Cisco are can be an important food item for large walleye (and pike) that buffers juvenile walleye from predation

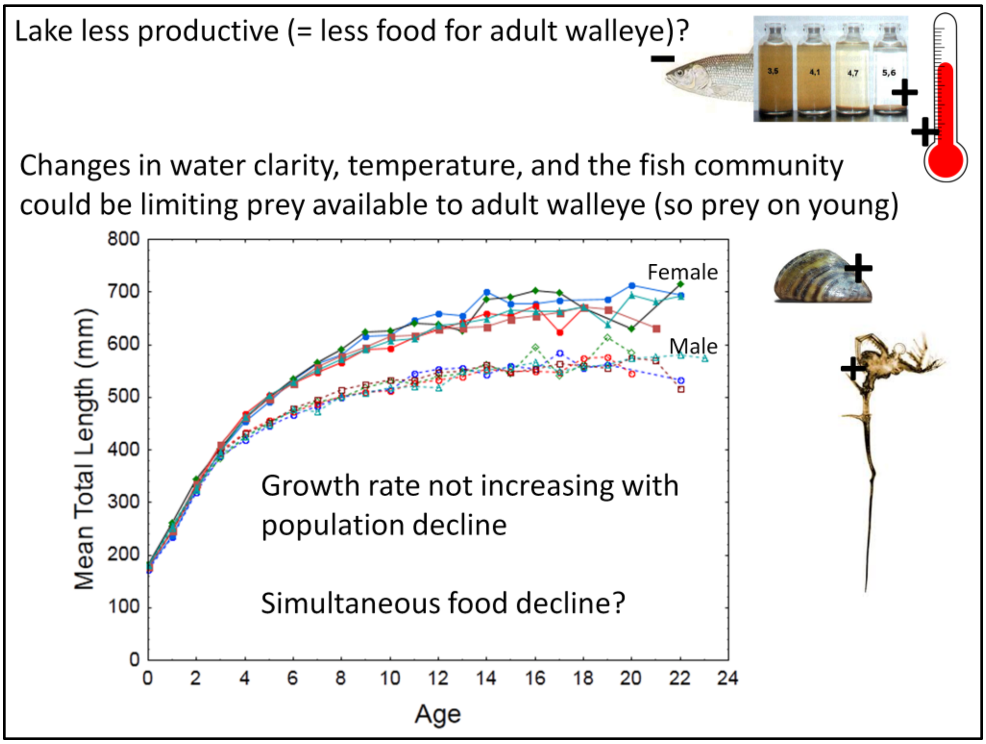
These explanations are largely speculative. The potential increase in predation may be due to a combination of many (large) adult walleye and few cisco. Although walleye are known yellow perch predators, cisco can be an important food item for large walleye (and pike). If Mille Lacs walleye once preyed heavily on cisco (diet data are unavailable to test this hypothesis) but cisco are no longer available, then walleye may have switched to their own (despite increased abundance of yellow perch). Predation by larger walleye has long been known as an important regulator of early walleye survival.



The increase in predation in recent years may be due to a combination of increased water clarity since ~2000 and increased relative abundance of older walleye. The figure shows that age-0 relative survival decreases with increasing water clarity. With few exceptions, Secchi depth since 1999 has been >=3 m. This relationship was weaker for age-1 relative survival and effectively absent for age-2 relative survival. We saw a similar trend in the time series of relative survival (strong decline age-0 that decline with age). This is exactly the pattern that you would expect from predation because vulnerability declines with increasing size.

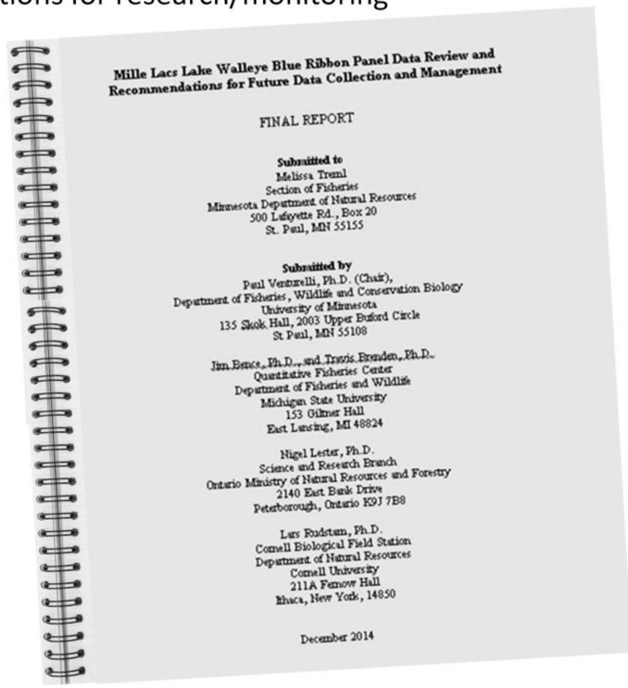


Increased water clarity has been linked to increased feeding efficiency of northern pike, and may increase the feeding efficiency of smallmouth bass. The effect of increased water clarity on the feeding efficiency of double-crested cormorants is less certain; turbidity has been found to have little to no effect on predation efficiency in other cormorant species. The effect of increased water clarity on walleye is also uncertain. Although walleye feeding efficiency is expected to decline, the effect on survival early in life depends on the relative impact on adults and early life stages. If adult walleye feed less efficiently then increases water clarity will results in a decline in predation on young. However, if young walleye feed less efficiently then lower growth rates, higher activity, and deeper may make them more susceptible to predation. Increased plant cover as a result of increased water clarity could also increase northern pike (and smallmouth bass) habitat and predation efficiency (but decrease cormorant and walleye feeding efficiency).



Overall, the decline may be due to changes in the environment of Mille Lacs such that the lake can no longer support as many walleye as it once did. Nutrient inputs into Mille Lacs have likely declined as a result of the 1970s Clean Water Act. The recent establishment of zebra mussels and spiny water fleas (2011 and 2010, respectively) could also be altering nutrient and energy pathways. For example, zooplankton biomass following the establishment of spiny water flea has reached a record low in Mille Lacs, especially in late summer and fall. Low zooplankton biomass does not appear to be affecting age-0 walleye condition or survival to fall (perhaps because they switch from zooplankton to prey fish earlier in summer). In principle, changes in water clarity, temperature, and the fish community could impact the biomass of prey fish that is available to adult walleye. For example, increased water temperatures are probably responsible for the decline in lake cisco, and icreased water clarity can also lead to decreased walleye abundance and productivity via a reduction in walleye feeding habitat. While environmental changes might ultimately reduce the individual growth of adult walleye through the mechanisms described above, current data suggest that walleye size at age has not declined [the figure is mean total length versus age by sex. Data are partitioned into 5-year periods (1985-1989, 1990-1994, 1995-1999, etc.)]. Suggests a decline in the biomass of walleye that the lake can support.

Recommendations for research/monitoring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FINAL REPORT

Submitted to
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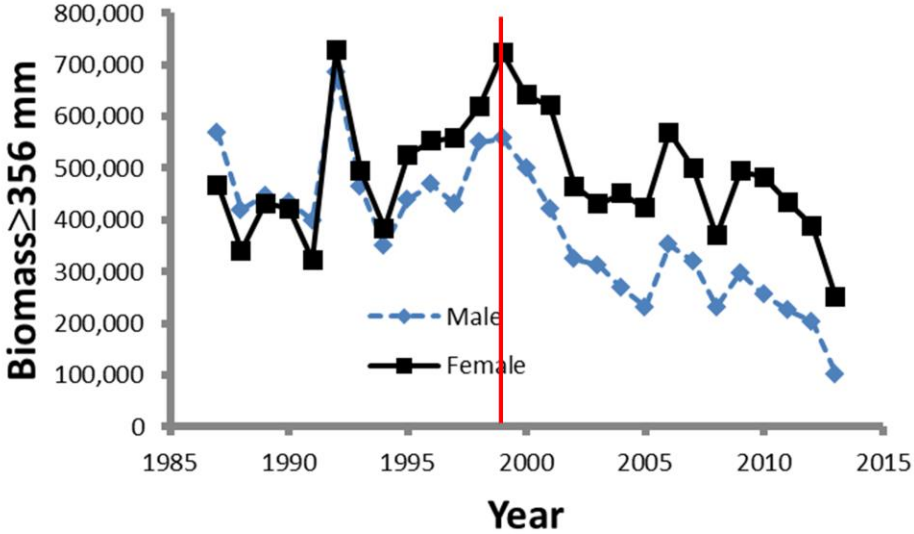
December 2014

So what do we do? The committee made recommendations for research and monitoring but in the interest of time I refer you to the report so that we can focus on recommendations for management.

Recommendations for management



It is unlikely that fishing caused the decline in walleye, but fishing is one of the only drivers of abundance that we can control

It is unlikely that fishing caused the decline in walleye, but fishing is one of the only drivers of abundance that we can control

Recommendations for management

1) Move **away** from what is effectively a fixed harvest policy of 24% of fish over 14” per year and **toward** a policy that also considers the impact of harvest on the population.

Our review found that 24% harvest produced markedly different population level impacts in different years

The size/age and sex of fish in harvest (e.g., reg) matters

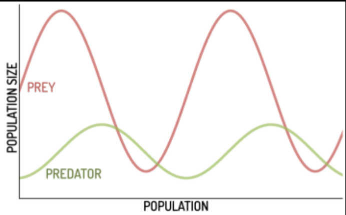
Setting target impacts (rather than target harvests) creates an incentive to fish in ways that maximize harvest while minimizing impacts

Plan and agree on harvest policy in advance

To that end…[see slide]

Recommendations for management

2) Keep target impacts and harvest low (perhaps permanently)



If Mille Lacs can no longer support as many walleye as it once did, then Mille Lacs walleye can no longer support as much harvest as they once did

Predation by adults can lead to cyclic population dynamics, which is encouraging (perhaps we're in the valley)

Prudent management given that we don't know what the 'new normal' looks like in terms of available harvest (which may or may not cycle)

Agreeing on policy ahead of time is important. If Mille Lacs can no longer support as many walleye as it once did, then Mille Lacs walleye can no longer support as much harvest as they once did. Population regulation through predation on young is an interesting phenomenon that is present in some fish species and can lead to cycles in fish populations, especially when fishing rates are low. These cycles occur because predation on young limits recruitment and ultimately erodes adult abundance; however, fewer adults leads to less predation, higher recruitment, and an eventual increase in adult abundance. Cycling is encouraging because it suggests that things might be better on their own. But we should manage prudently because the lake is continuing to change (i.e., zebra mussels and spiny water flea). We don't know what the 'new normal' is going to be in terms of available harvest (which may or may not cycle).

Recommendations for management

3) Manage other species to the benefit of walleye and stakeholders

Encourage harvest of pike and bass (good for walleye)

But also manage pike and bass as a new opportunity for recreation and harvest so that Mille Lacs remains a destination (good for stakeholders)

Consider whether cormorant management is warranted

The future character of walleye fisheries (and fisheries in general) may also depend on how other species are managed. To this end, we recommend managing other species to the benefit of both walleye and stakeholders. Regulations should encourage the harvest of pike and bass (which is good for walleye in terms of competition, predation, and reduced harvest), but also manage pike and bass so that they provide new opportunities for recreation and harvest. It could very well be that Mille Lacs can support less walleye but more pike and bass. Walleye may benefit from cormorant management, but only if cormorants are an important source of walleye mortality.

Recommendations for management

4) Avoid stocking

Stocking is a tool for supplementing natural reproduction (e.g., Red Lakes)

Natural reproduction in Mille Lacs is already high; the problem is low survival from the first to third fall of life

Wasted effort. Stocked fish will suffer the same fate (and could make the predation problem worse)

Stocking older fish is infeasible and hasn't worked in other walleye lakes (e.g., Oneida in NY)

We do not recommend walleye stocking in Mille Lacs. Stocking supplements natural reproduction and can therefore be an important part of a walleye recovery effort (e.g., Red Lakes walleye). However, natural reproduction in Mille Lacs is already very high. The problem appears to be lower survival from the first to third fall. Stocked fish will suffer the same fate and, assuming that low survival is due to predation, could exacerbate the problem by sustaining predator populations. Stocking older (i.e., age-3) fish is infeasible for such a large lake, and is most likely to result in a large-scale, put-grow-and-take fishery. Stocking 100,000 age-1 spring walleye did not help in Oneida Lake.

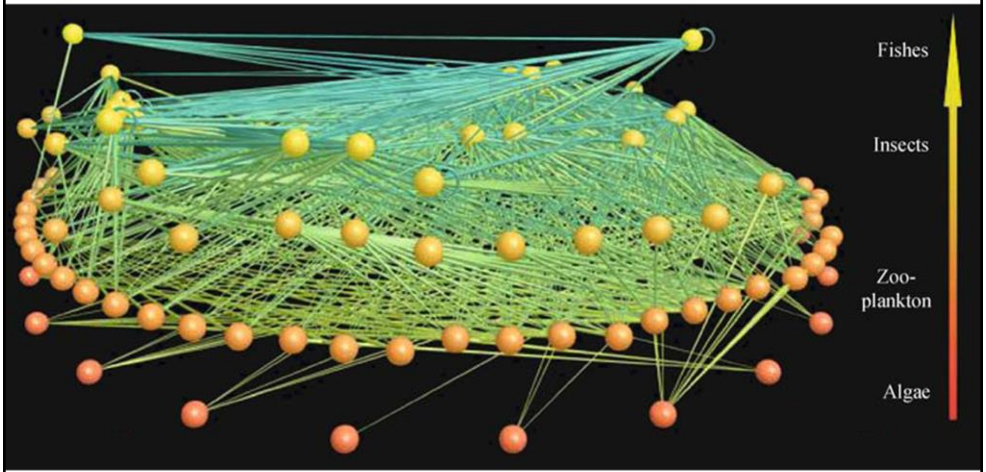
Thank you

Download the report: z.umn.edu/millelacswalleyepanel

Request a copy of this presentation: pventure@umn.edu

Food web in Little Rock Lake, WI

(182 species, 997 connections)



18 ha (44 acres)

Neo Martinez

EXTRA SLIDE. This is a diagram showing the food web of a small WI lake. It contains over 180 species (including 6 fish) and almost 1000 connections. This figure doesn't include other important factors like water temperature and chemistry. As you can imagine, attributing a change in the abundance of the top predator (in this case largemouth bass) to any other species is a challenge.