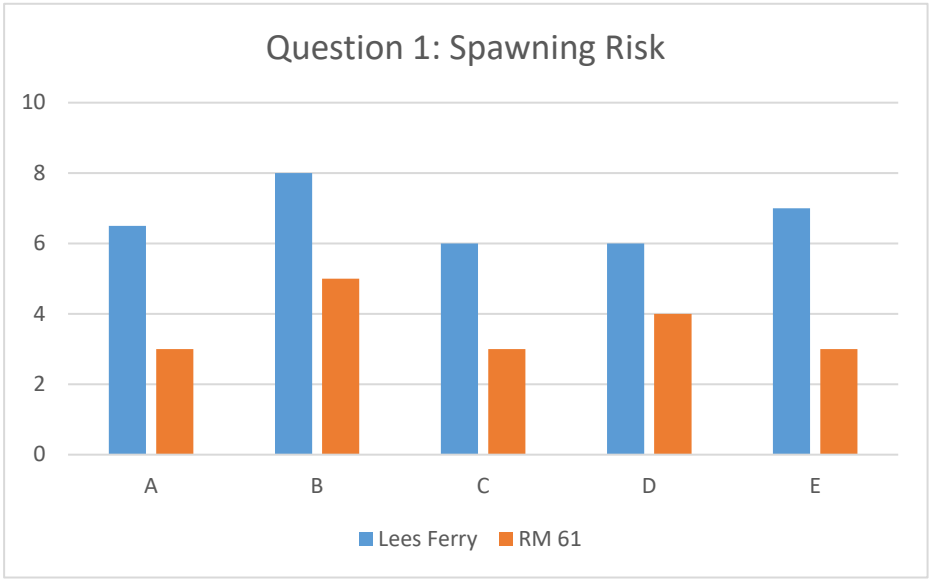
GCMRC Expert Responses	1. Spawning Risk Score for Lees Ferry	1. Spawning Risk Score for RM 61
A	6.5	3
B	8	5
C	6	3
D	6	4

E	7	3

Average Score	**6.7**	**3.6**



1. Explanation

Studies suggest that smallmouth bass will spawn at any time of year if temperatures are suitable, however if temperatures top out at only 17ish and given the slow rate of cooling it may not be as pronounced a signal as in the laboratory studies. If temps were going to increase to a warmer temperature (say 20) my risk score would increase

In at least one study (Cantin 1994), photoperiod was not found to influence spawning timing, and controlled temperatures could induce SMB spawning any time of the year.

I mostly put 5 because I am not sure (i.e., high uncertainty). Often water temperatures exhibit substantial influence on spawning and presumably SMB in the system have been waiting to spawn for many months (but have been deterred by the cold water temperatures up to this point). However, I am not sure how often SMB spawn in winter and whether photoperiod also affects spawning, because presumably SMB have to shift their physiology to store up energy to overwinter. I put 3 for the LCR because I would assume water temperatures would cool this time of year, so that 16C at the Ferry would be cooler at the RM61. That, and there are lots more SMB in Glen Canyon than near the LCR at this point.

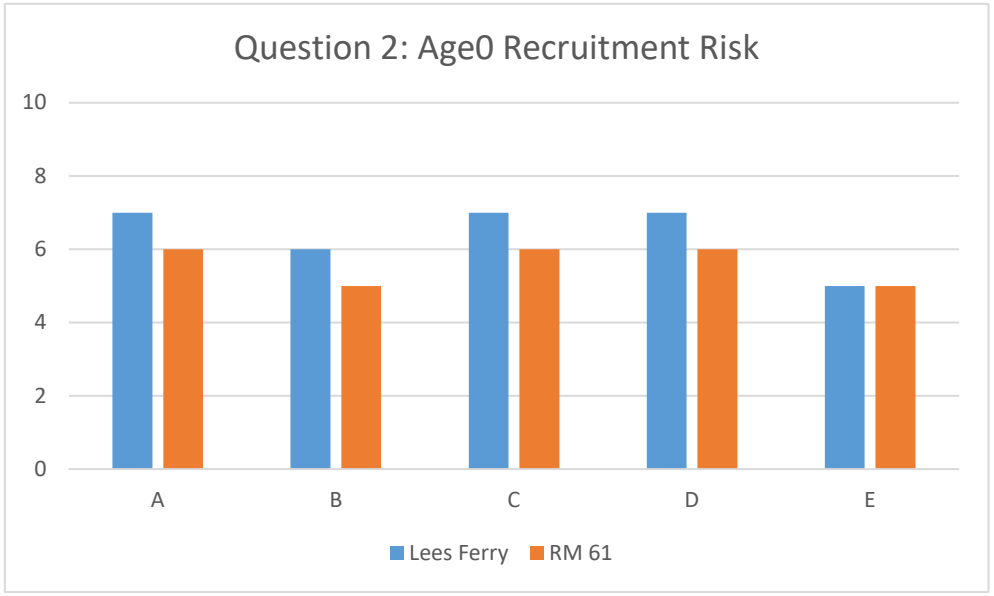
Models presented by Bryce Mihalevich on 10/29 during the TWG meeting, combined with the October 2024 Lake Powell profile at Wahweap indicate there is still a high likelihood temperatures will be above 15.5 degrees from the dam downstream to the LCR for at least 2-3 more weeks. Reproduction in smallmouth bass is driven more by water temperatures exceeding a thermal threshold, rather than being driven by photoperiod. In a system as hydrologically and thermally complex (and altered) as the Colorado River, it is my expert opinion that smallmouth bass still have a moderate risk (score 6) of spawning in Lees Ferry if temperatures exceed 15.5C (even in November), with a somewhat lower risk downstream at the LCR (score 4) due to that thermal cooling expected as the season moves into fall and winter.

SMB spawning is closely tied to temperature, and lab studies have shown they can spawn at any time of year that temperature becomes suitable. Therefore, I think there is a moderate risk of spawning in Lees Ferry. Projected temperatures without bypass are likely not going to warm dramatically, so that does reduce spawning risk. Adults have been and continue to be relatively rare in the system, so that also decreases the risk of spawning. The risk is lower for LCR reach compared to LF because of the much higher densities of SMB in LF and because temperatures will be cooler in the mainstem at the LCR during the winter.

2. Age0 Recruitment Risk Score for Lees Ferry	2. Age0 Recruitment Risk Score for RM 61
7	6
6	5
7	6
7	6

5 5

6.4 **5.6**


Question 2: Age0 Recruitment Risk
10
8
6
4
2
0
A
B
C
D
E
Lees Ferry
RM 61

2. Explanation

Studies suggests that fish size and the number of days under 10 C are factors that contribute to overwinter survival (the smaller the fish or the harsher the winter the lower survival). Unfortunately, our winters are much milder than any conditions they tested. These fish would likely also be much smaller than anything they tested. Therefore, we are forced to extrapolate outside their study. My guess would be that some would survive but not many and maybe not even enough to be detected. In other words, we think the probability that some survive is fairly high but the overall survival would be low- therefore the risk is low to moderate. Near the LCR, survival could be higher if spawning occurred right above the LCR inflow, winter flows are minimal out of the LCR and therefore water temperatures are ~13-14C at the mouth. Looking at overwinter survival of small fish might actually be a good idea for a laboratory study.

Lower score at LCR given cooling may be more rapid. However, diversity of temperature refugia near the confluence may benefit SMB

I am uncertain about this, and I think the success of offspring would be at least partly dependent on the water temperatures post-spawn. Like, if water temperatures warmed enough for SMB to spawn but then dropped to well below 16C shortly thereafter, I think offspring survival would be low. But, if post-spawn, water temperatures only drop slightly or warm from 16C, then the probability those larvae survive is higher.

The Colorado River downstream from Glen Canyon Dam is unlike other tailwaters across the west- the winters are much warmer and hover around 8-11 degrees in Lees Ferry from October-March and around 9-12 degrees near the LCR during the same time period, based on average conditions over the past 2 decades. While energetic demands would be high and smallmouth bass would need to forage, there is food available for small mouths and its likely at least a portion of fish spawned in fall 2024 would recruit and survive to the following spring.

Later spawned fish will be smaller, as they have a shorter growing period with cooler temperatures. This will decrease the the probability of overwinter survival and recruitment. However, compared to other river systems, the colorado river in Grand Canyon has mild winter conditions. So we would expect that mortality during winter would not be as strong a factor as other systems. This year, small SMB <50mm TL were captured that are assumed to be age1 fish that survived the winter. If spawning occurred, I think that a proportion (potentially a small proportion) of those offpsring would indeed recruit, but their numbers would likely be small enough that they wouldn't have meaningful influence on the larger population dynamics, so therefore the "risk" is only moderate

3. How many days above 15.5C for successful spawn?

If you look at Bestgen's work spawning sometimes begins just a few days after the 16 C threshold is reach, and sometimes takes a little longer. There are studies that suggest spawning can even occur at 15 C. Folks in the literature have speculated that the rate of warming may also be a factor. Taken together, my guess is that anywhere from less than a week to not at all during Nov.

7-10 days for spawning and hatch given summer temps were close to this temp (and seem to be warming recently).

I have no idea- I guess I would consult the literature to see if there's a published degree-day threshold for SMB.

Based on some of the work from Kevin Bestgen in the upper Colorado River basin that shows smallmouth bass spawn shortly after temperatures reach 16 degrees, and data from Glen Canyon where age-0 fish were captured in the slough within a few days after the mainstem reached 15-16 degrees in 2022 (with temps in the slough being higher than in the mainstem), it is my option that the river would need to be above 15.5 C for about 7-10 days for a spawn to occur.

Across the SMB published literature, spawning has been documented as low as 15C (note that in the upper basin the observed threshold is 16C). So it is certainly possible for SMB to spawn on day 1 of >15.5C. However, I think a 7 day period is more realistic but is highly uncertain, but that also depends on how warm the temperatures get (for example, steady 15.6C is much less concerning to me than temps that climb quickly to >17C).

4. Can we differentiate pre/during vs post coolmix flow spawned fish in 2025?
Probably not, unless we capture them on the nest or while Pops is guarding the nest.

No, I think it would be difficult to differentiate YOY as a results of spawning pre/post coolmix given that a) limited sampling is occuring and YOY fish would be difficult to capture during fall/winter, and b) it would probably also be difficult to identify daily growth rings in these fish, when growth might also be slow.

No. Previously, I thought yes because we could reconstruct the daily rings on the otoliths to get at hatch date. However, I learned that in 2022 Kevin Bestgen could not age SMB after water temperatures were below 16C because growth was too low to discern rings on ototliths, so based on this information I am going to say it is unlikely we could differentiate these fish. Also, to my knowledge, there is little sampling that occurs this time of year so it would be difficult to obtain small SMB necessary for this type of analysis (i.e., as fish grow larger, they are more difficult to age).

We can typically use otolith microstructural analysis to count daily rings and determine hatch dates, but given that water temperatures will be cool over the fall and winter months it will be very difficult to distinguish otolith rings because SMB will be growing so slowly. This will likely lead to difficulty distinguishing fish spawned pre and post-coolmix, particularly since coolmix flows have already decreased the growth rates of SMB already in the system. It may be possible to distinguish post-cool mix spawning with fish at the lower end of the 2024 length-frequency histogram, but the amount of sampling planned for Lees Ferry and downstream ceases in November, with NPS finishing their trips in the LF and PBR reach, and one trip planned in LF (the TRGD/AGFD trip). After that, we will have 1 trip in LF in January (TRGD/AGFD) and sampling by all agencies does not pick up again until late spring. Therefore, even if they do spawn after coolmix ends, we won't be sampling to detect the fish that do survive.

Assuming that we don't have age-0 entrainment, the answer is Yes, but only if the fish are captured quickly: Otolith analysis of hatch date will answer this question (assuming the fish is captured relatively close to spawn location), but the longer duration between hatch and capture results in greater difficulty in reading daily growth rings. The context here is that there are few if any monitoring trips scheduled for late Fall and Winter combined with lower capture rates from cooler temperatures- so catching fish quickly after hatch isn't going to happen.... There is an approximate zero% chance that fish spawned this fall that are then captured in spring 2025 would have readable otoliths. An alternative is to look at length frequency histograms to track cohorts, but this won't be able to give us a definitive answer.

5. What action is recommended until release temps are <15.5C?

It is not our place to recommend management. Letting temperature increase involves tradeoffs that managers must balance. There is a low to moderate change that increasing temperatures will allow spawning to occur and individuals will survive over winter. If water temperatures are cold next year (either naturally, or because of further cool mix use), this year's hypothetical yoy's are unlikely to contribute to long term trends in smallmouth bass in any appreciable way. If this year's experiment is a one off the outlook is different if spawning occurs.

Continue coolmix until temps decline and are maintained below 15.5.

USGS can't really make management recommendations. However, I will point out this is a question of risk versus reward. Keeping water temperatures cooler will decrease risk of SMB spawn but at the cost of hydropower. Also, there is the question of whether we will be able to learn about the effectiveness of SMB flows if there is warming towards the end of the experiment, or if the warming at the end compromises the entire experiment.

USGS is not a management agency, so we cannot make management recommendations. My scientific assessment is that extending coolmix flows into mid to late November (until the temperatures released from Glen Canyon Dam consistently reaches 15.5 degrees and the temperature profiles in Wahweap show consistently cool temperatures in the cone of influence) will reduce the risk of SMB spawning in the last few weeks of the year.

I am not a manager, but if the most important consideration is preventing SMB population growth, then continuing to keep temperatures below 15.5C yearround provides the most certainty of spawning prevention as well as the slowest growth of individuals (lowers age0 survival and delays reproductive viability of age1 and 2 fish). Continuing coolmix will also make it easier to identify whether or not the flows were successful in preventing spawning.

6. Additional questions, comments, concerns

If we think of cool mix as an experiment, it might be useful in the long term to keep water cold this year, but consider shortening the experiment incrementally in future years to lessen impacts to hydropower and other resources and through this process dial in whether cool mix can be applied for fewer months and still have its desired effect.

In answering these questions I assumed that the coolmix action is an experiment, thus, to assess whether it works or not, it should be continued through fall.

I do not know that much about SMB specifically and am basing my answers about knowledge of fishes in general.

Coolmix flows have been ongoing for almost 4 months. Extending these flows an additional 2-3 weeks to close out the 2024 season may provide us with more certainty in evaluating the effectiveness of this flow experiment without having to consider the confounding factor of several weeks of warm temperatures at the end of the season where SMB could spawn and recruit the following year.

SMB data from the Yampa/Green shows that after spawning commenced (~16C threshold), the lowest observed temperature at which spawning and hatch continued was 13.9C.