Craig Ellsworth, WAPA

Smallmouth bass biological recommendation

Please review the following questions and provide responses to Matt by Thursday 12pm AZ time. The focus is the biological and environmental conditions. Please rate questions 1 and 2 on a scale of 1 (no risk) to 10 (certain to happen).

1) What is the risk of bass spawning in the upper stretch of the river if we off ramp bass flows before dam release temperature fall below 15.5C? This may result in an unknown period with temps in the Ferry exceeding 16C. For example, in 2023 the Ferry did not fall below 15.5C until Nov 20.
    a. Risk: 3
    b. Justification: Cantin 1994[1] found that smallmouth bass are capable, at least in a laboratory setting, of delaying spawning into the late fall if subjected to cool temperatures through the spring and summer. However, she makes it clear that in natural settings smallmouth bass spawn in the spring and early summer. The latest spawning Bestgen and Hill (2016)[2] found in the Yampa was August 19.

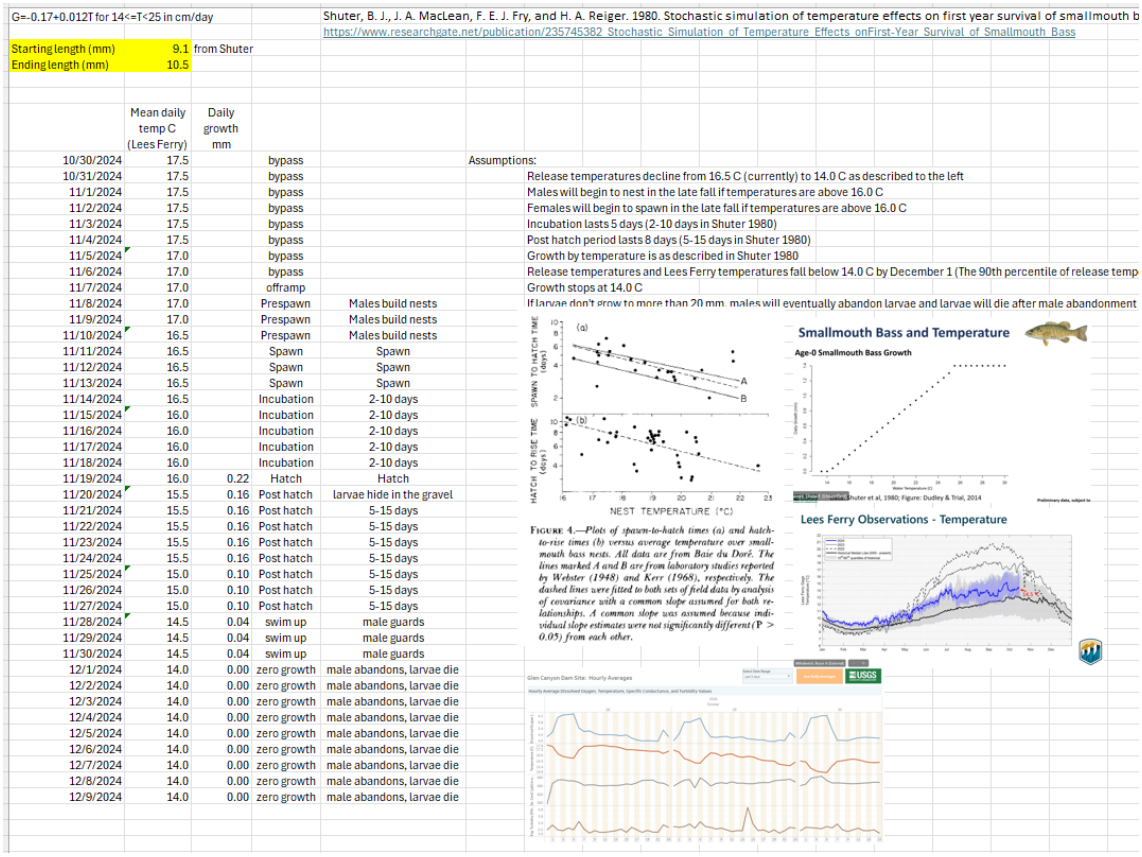
2) Given the conditions in question 2, what is the risk of offspring surviving into spring 2025?
    a. Risk: 1
    b. Justification: Creating a spreadsheet model of the process bass go through to successfully reproduce is helpful in visualizing the risk of bass successfully spawning and recruiting this fall. The process includes nest building, spawning, incubation, hatching, post-hatch larval development, swim-up and male guardianship. Comparing that process to a timeline of when an offramp for bypass might be initiated and when release temperatures are expected to fall below the minimum threshold for growth produces a picture of the low likelihood of overwinter survival for any offspring yet to be produced this fall. The attached model spreadsheet (Tab 1, screenshot below) indicates we have passed the window where overwinter survival for newly spawned bass is likely. The assumptions in the model include:
        - Release temperatures decline from 17.5 C (currently) to 14.0 C as described in the spreadsheet
        - Males will begin to nest immediately if temperatures rise above 16.0 C
        - Females will begin to spawn within 3 days if temperatures rise above 16.0 C
        - Incubation lasts 5 days (2-10 days in Shuter et al. 1980[3])

[1] Cantin, Marie-Claude. 1994. "Influence of temperature and photoperiod on ovarian development and spawning of smallmouth bass (Micropterus dolomieui)." Dissertation, University of Stirling, https://storre.stir.ac.uk/handle/1893/29308

[2] Bestgen, K. R., and A. A. Hill. 2016. River regulation affects reproduction, early growth, and suppression strategies for invasive smallmouth bass in the upper Colorado River basin. Final report submitted to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 187.

[3] Shuter, B. J., J. A. MacLean, F. E. J. Fry, and H. A. Reiger. 1980. Stochastic simulation of temperature effects on first year survival of smallmouth bass. Transactions of the American Fisheries Society 109: 1–34. https://www.researchgate.net/publication/235745382_Stochastic_Simulation_of_Temperature_Effects_onFirst-Year_Survival_of_Smallmouth_Bass

- Post hatch period lasts 8 days (5-15 days in Shuter et al. 1980)
- Growth by temperature is as described in Shuter et al. 1980
- Release temperatures and Lees Ferry temperatures fall below 14.0 C by December 1 (the 90th percentile of release temperatures and temperatures at Lees Ferry fall below 14.0 C by the last week of November)
- Growth stops at 14.0 C
- If larvae don't grow to more than 20 mm, males will eventually abandon larvae and larvae will die after abandonment



G=-0.17+0.012T for 14<=T<25 in cm/day			Shuter, B. J., J. A. MacLean, F. E. J. Fry, and H. A. Reiger. 1980. Stochastic simulation of temperature effects on first year survival of smallmouth b	
			https://www.researchgate.net/publication/235745382_Stochastic_Simulation_of_Temperature_Effects_onFirst-Year_Survival_of_Smallmouth_Bass	
Starting length (mm)	9.1	from Shuter		
Ending length (mm)	10.5			
	Mean daily temp C (Lees Ferry)	Daily growth mm		
10/30/2024	17.5		bypass	
10/31/2024	17.5		bypass	
11/1/2024	17.5		bypass	
11/2/2024	17.5		bypass	
11/3/2024	17.5		bypass	
11/4/2024	17.5		bypass	
11/5/2024	17.0		bypass	
11/6/2024	17.0		bypass	
11/7/2024	17.0		offramp	
11/8/2024	17.0		Prespawn	Males build nests
11/9/2024	17.0		Prespawn	Males build nests
11/10/2024	16.5		Prespawn	Males build nests
11/11/2024	16.5		Spawn	Spawn
11/12/2024	16.5		Spawn	Spawn
11/13/2024	16.5		Spawn	Spawn
11/14/2024	16.5		Incubation	2-10 days
11/15/2024	16.0		Incubation	2-10 days
11/16/2024	16.0		Incubation	2-10 days
11/17/2024	16.0		Incubation	2-10 days
11/18/2024	16.0		Incubation	2-10 days
11/19/2024	16.0	0.22	Hatch	Hatch
11/20/2024	15.5	0.16	Post hatch	larvae hide in the gravel
11/21/2024	15.5	0.16	Post hatch	5-15 days
11/22/2024	15.5	0.16	Post hatch	5-15 days
11/23/2024	15.5	0.16	Post hatch	5-15 days
11/24/2024	15.5	0.16	Post hatch	5-15 days
11/25/2024	15.0	0.10	Post hatch	5-15 days
11/26/2024	15.0	0.10	Post hatch	5-15 days
11/27/2024	15.0	0.10	Post hatch	5-15 days
11/28/2024	14.5	0.04	swim up	male guards
11/29/2024	14.5	0.04	swim up	male guards
11/30/2024	14.5	0.04	swim up	male guards
12/1/2024	14.0	0.00	zero growth	male abandons, larvae die
12/2/2024	14.0	0.00	zero growth	male abandons, larvae die
12/3/2024	14.0	0.00	zero growth	male abandons, larvae die
12/4/2024	14.0	0.00	zero growth	male abandons, larvae die
12/5/2024	14.0	0.00	zero growth	male abandons, larvae die
12/6/2024	14.0	0.00	zero growth	male abandons, larvae die
12/7/2024	14.0	0.00	zero growth	male abandons, larvae die
12/8/2024	14.0	0.00	zero growth	male abandons, larvae die
12/9/2024	14.0	0.00	zero growth	male abandons, larvae die

Assumptions:

Release temperatures decline from 16.5 C (currently) to 14.0 C as described to the left
Males will begin to nest in the late fall if temperatures are above 16.0 C
Females will begin to spawn in the late fall if temperatures are above 16.0 C
Incubation lasts 5 days (2-10 days in Shuter 1980)
Post hatch period lasts 8 days (5-15 days in Shuter 1980)
Growth by temperature is as described in Shuter 1980
Release temperatures and Lees Ferry temperatures fall below 14.0 C by December 1 (The 90th percentile of release temp
Growth stops at 14.0 C
If larvae don't grow to more than 20 mm, males will eventually abandon larvae and larvae will die after male abandonment

FIGURE 4.—*Plots of spawn-to-hatch times (a) and hatch-to-rise times (b) versus average temperature over smallmouth bass nests. All data are from Baie du Doré. The lines marked A and B are from laboratory studies reported by Webster (1948) and Kerr (1968), respectively. The dashed lines were fitted to both sets of field data by analysis of covariance with a common slope assumed for both relationships. A common slope was assumed because individual slope estimates were not significantly different ($P > 0.05$) from each other.*

3) In your expert opinion, how many days in the fall would the river need to be above 15.5C for a spawn to succeed?
    a. Opinion: The number of days in the fall above 15.5C needed for “successful” spawning (which includes recruitment/overwinter survival) is dependent on the water temperature where nesting and spawning might occur (i.e. sloughs, backwaters, slackwater in the mainstem, etc.). One can calculate when bypass can be stopped using water temperature, the date when smallmouth bass growth stops, and a minimum length needed for overwinter survival. Using the attached spreadsheet model (tab 2), a mean daily water temperature of 18.5 C for example, allows for an offramp date of October 24, or 37 days before December 1 when water temperatures typically become too cold for YOY bass to grow to a size greater than the minimum threshold needed for overwinter survival (see table below). The above example assumes a constant mean daily water temperature of 18.5 C from October 24 to December 1, when the mean daily water temperature falls below 14.0 C for the rest of the winter.

Number of days needed for a newly hatched smallmouth bass to reach 20 mm with water temperatures ranging between 16.0 and 18.5 C.		
Mean Daily Water Temperature[4]	Number of days to reach 20 mm[5]	Date at which newly hatched bass are unlikely to successfully overwinter[6]
18.5 C	38	10/24/2024
18.0 C	43	10/19/2024
17.5 C	50	10/12/2024
17.0 C	58	10/4/2024
16.5 C	75	9/17/2024
16.0 C	90	9/2/2024

b. Justification: Shuter et al. 1980 shows how smallmouth bass growth is dependent on temperature and that overwinter survival is dependent size with smaller fish being less likely to survive the winter. They also identified that smallmouth bass stop growing with water temperatures below 14.0 C. GCMRC uses an overwinter survival threshold of 20 mm in their models. Release temperatures at Glen Canyon Dam typically fall below 14.0 C by the last week of November (the 90th percentile). Calculating the date by which bypass can be off ramped without bass spawned after the off-ramp being large enough to survive the winter can be back calculated using these metrics (see the table above, Tab 2 of the attached spreadsheet, and the screen grab below). Water temperature should be measured where bass are suspected of nesting and spawning. It should be noted that after the onset of downstream cooling in mid-October, there are no warmwater refugia in sloughs and backwaters for small warmwater fish since these areas are then cooler than the mainstem (figure below).

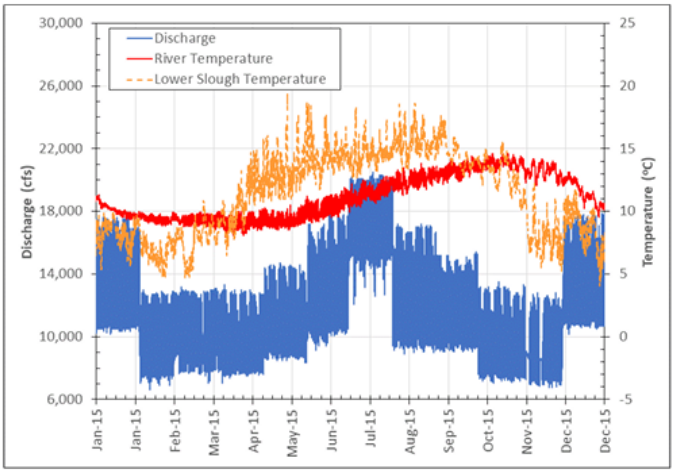


Figure 9.—Discharges through Glen Canyon Dam into the Colorado River and water temperature at Lees Ferry, AZ, and the lower slough during 2015.

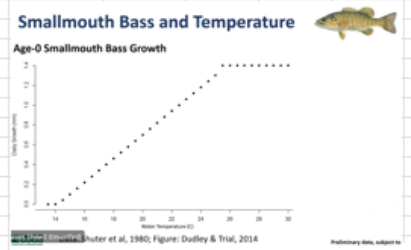
[4] This should be the temperature where spawning and nesting may occur, not necessarily release temperature.
[5] Assumption: larval smallmouth bass smaller than 20 mm will not successfully overwinter.
[6] This is the date after which a newly hatched smallmouth bass will not reach the 20 mm threshold by December 1 and successfully overwinter. December 1 is the date when release temperatures usually fall below 14 C and growth stops. These dates could be used as an offramp date for the temperatures listed in the table. The temperatures in this table could be used as proxies for release temperature after the onset of downstream cooling in mid-October since sloughs and backwaters will be cooler than mainstem temperatures.

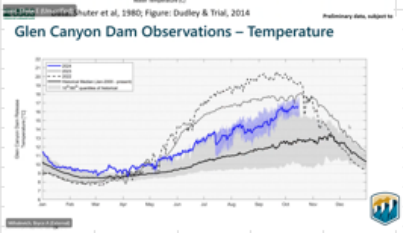
G=-0.17+0.012T for 14<=T<25 in cm/day

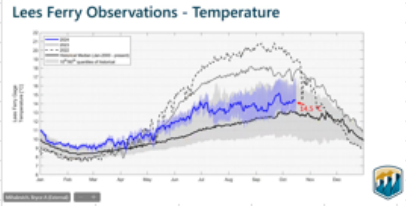
Shuter, B. J., J. A. MacLean, F. E. J. Fry, and H. A. Reiger. 1980. Stochastic simulatio
https://www.researchgate.net/publication/235745382_Stochastic_Simulation_of_

Number of days (and date) to offramp before December 1 to keep YOY smallmouth ba

	Mean daily temp C	Daily growth mm	Mean daily temp C	Number of days to reach 20mm	Mean daily temp C	Offramp date	# days before 12/1
9/1/2024	18.5	0.52			18.5	10/24/2024	38
9/2/2024	18.5	0.52	16.0	90	18.0	10/19/2024	43
9/3/2024	18.5	0.52			17.5	10/12/2024	50
9/4/2024	18.5	0.52			17.0	10/4/2024	58
9/5/2024	18.5	0.52			16.5	9/17/2024	75
9/6/2024	18.5	0.52			16.0	9/2/2024	90
9/7/2024	18.5	0.52					
9/8/2024	18.5	0.52					
9/9/2024	18.5	0.52			Assumptions:		
9/10/2024	18.5	0.52				Growth is as described in Shuter 1980,	
9/11/2024	18.5	0.52				Release temperatures and Lees Ferry temperatures fall below 14.0 C t	
9/12/2024	18.5	0.52				If larvae don't grow to more than 20 mm, males will eventually abando	
9/13/2024	18.5	0.52					
9/14/2024	18.5	0.52					
9/15/2024	18.5	0.52					
9/16/2024	18.5	0.52					
9/17/2024	18.5	0.52	16.5	75			
9/18/2024	18.5	0.52					
9/19/2024	18.5	0.52					
9/20/2024	18.5	0.52					
9/21/2024	18.5	0.52					
9/22/2024	18.5	0.52					
9/23/2024	18.5	0.52					
9/24/2024	18.5	0.52					
9/25/2024	18.5	0.52					
9/26/2024	18.5	0.52					
9/27/2024	18.5	0.52					
9/28/2024	18.5	0.52					
9/29/2024	18.5	0.52					
9/30/2024	18.5	0.52					
10/1/2024	18.5	0.52					
10/2/2024	18.5	0.52					
10/3/2024	18.5	0.52					
10/4/2024	18.5	0.52	17.0	58			
10/5/2024	18.5	0.52					
10/6/2024	18.5	0.52					
10/7/2024	18.5	0.52					
10/8/2024	18.5	0.52					
10/9/2024	18.5	0.52					
10/10/2024	18.5	0.52					
10/11/2024	18.5	0.52					
10/12/2024	18.5	0.52	17.5	50			
10/13/2024	18.5	0.52					
10/14/2024	18.5	0.52					
10/15/2024	18.5	0.52					
10/16/2024	18.5	0.52					
10/17/2024	18.5	0.52					
10/18/2024	18.5	0.52					
10/19/2024	18.5	0.52	18.0	43			
10/20/2024	18.5	0.52					
10/21/2024	18.5	0.52					
10/22/2024	18.5	0.52					
10/23/2024	18.5	0.52					
10/24/2024	18.5	0.52	18.5	38			







4) If fish do recruit into 2025, will we be able to identify post-flow spawned fish as having spawned after flows stopped?
    a. Ability: 10
    b. Justification: If smallmouth bass were to spawn after the offramp, they would only grow to be about 10.5 mm before the onset of winter. Length at hatch is typically 9.1 mm (Shuter et al. 1980). Overwinter survival for such a small and underdeveloped smallmouth bass is extremely unlikely. GCMRC uses a minimum overwinter survival length of 20 mm in their models. If a fall-spawned smallmouth bass were to somehow survive the winter and it was collected in the spring, it would be of such a size one would easily be able to decern it from a bass that was spawned or entrained over the summer of 2024. It would also be discernable from a bass spawned or entrained in 2025 by the lack of daily growth rings in its otolith.

5) What action does the panel recommend until we see temps come out of the dam at 15.5C?
    a. Recommendation: Offramp as soon as practicable because the likelihood of a successful spawn and overwinter survival is extremely unlikely.

6) Please list any additional questions, comments and concerns.
    a. Could you please make available each of the recommendations this group produces available to each of us so we can discuss positions and understand where others are coming from? Can you also make these recommendations available to the P&I team, with whatever recommendation this group come to on Friday, so the P&I team can see and understand each of our positions?