Population Monitoring Work Group Meeting

June 2, 2020

Meeting Materials:

Agenda

Minutes

Draft Modeling Scenarios for the MRG [read-ahead, draft]

Revised MRGESCP PMWG 2020 Work Plan [read-ahead]

Draft Executive Summary: Age Composition of RGSM [read-ahead, draft]

Draft Executive Summary: Age-Specific Survival of RGSM [read-ahead, draft]

Draft Executive Summary: Consolidation of Mesohabitats for Monitoring RGSM [read-ahead, draft]

Draft Executive Summary: Effect of Environmental Cues on Spawning Onset and Activity of RGSM [read-ahead, draft]

Table 1. List of Potential Water Management Scenarios for Utah State University Modeling [read-ahead]

Executive Summary: Consolidation of Mesohabitats for Monitoring RGSM Trends [presentation]

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Population Monitoring Work Group (PMWG)
June 2, 2020
9:00 AM – 12:00 N

Zoom Information:
https://west-inc.zoom.us/j/8983593120
Call-In: +1-669-900-6833; Meeting ID: 898-359-3120

Meeting Agenda

9:00 – 9:15	**Welcome, Intros, Agenda, Meeting Notes, 2020 Work Plan** ➢ **Decision:** Approval of June 2, 2020 agenda ➢ **Decision:** Approval of April 28, 2020 minutes Read aheads: ☐ June 2, 2020 meeting agenda ☐ April 28, 2020 meeting minutes ☐ PMWG 2020 Work Plan (to EC)	*PMWG Chair*
9:15 – 9:30	**Executive Summaries Review by PMWG (due 7/1/2020)** Read aheads: ☐ Age-Specific Survival of RGSM ☐ Consolidation of Mesohabitats for Monitoring RGSM ☐ Age Composition of RGSM ☐ Spawning Onset and Activity of RGSM	*Rich Valdez* *Kevin McDonnell* *Catherine Murphy*
9:30 – 10:15	**Consolidation of Mesohabitats for Monitoring RGSM**	*Mike Marcus*
10:15– 10:25	**Break**	
10:25– 10:40	**1996 FLO Data**	*Shay Howlin*
10:40 – 11:30	**Modeling Scenarios** • Develop Model Scenarios Read aheads: ☐ Modeling Scenarios	*Rich Valdez* *Charles Yackulic*
11:30 – 12:00	**Wrap-Up** • Announcements (Hatch Paper, Coordinated Modeling) • Action Items • Next Meeting	*Rich Valdez* *Mick Porter*
12:00	**Adjourn**	

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Population Monitoring Work Group (PMWG)
Meeting Summary

June 2, 2020, 9:00 AM – 12:00 PM
Location: Zoom Meeting

Decisions:

- ✓ Approval of June 2, 2020 PMWG meeting agenda
- ✓ Approval of April 28, 2020 PMWG meeting minutes

Action Items:

WHO	WHAT	BY WHEN
Program Support Team (PST)	Send a doodle poll for June 2020 to schedule next meeting	June 4, 2020
PST	Distribute Hatch et al. (2020) paper	June 4 ,2020
Catherine Murphy	Create a tracking spreadsheet for the executive summary review process	June 4, 2020
PST	Distribute the writing guide for executive summaries	June 4, 2020
Shay Howlin	Ask Joel Lusk to review the FLO 1996 metadata description	June 7, 2020
PST	Upload the FLO 1996 data to Zotero	June 12, 2020
Rich Valdez	Distribute the one-page PMWG summary for the Executive Committee update	June 12, 2020
Program Support Team	Organize the Zotero library with separate folders for each executive summary topic	June 12, 2020
PMWG members	Provide comments on the draft executive summaries to the PST: • Age-specific Survival of Rio Grande Silvery Minnow (RGSM) • Consolidation of Mesohabitats for Monitoring RGSM • Age Composition of RGSM • Spawning Onset and Activity of RGSM	July 15, 2020
Mike Marcus & Catherine M.	Revise the Consolidation of Mesohabitats for Monitoring RGSM executive summary to incorporate the discussion points from the meeting	July 1, 2020
Rich V., Charles Yackulic, and PST	Develop an approach to look at modeling scenarios in the PMWG	By the next meeting

Meeting Summary

Welcome, Introduction, Meeting Notes, 2020 Work Plan

- Rich Valdez, SWCA Environmental Consultants, PMWG chair, opened the meeting, led introductions, and reviewed the meeting agenda. He then reviewed the action items from the April 28, 2020 PMWG meeting. The revised 2020 PMWG Work Plan has been approved by the PMWG and will be presented to the Executive Committee (EC) for approval at the June meeting.

✓ **Decision**: Approval of the PMWG June 2, 2020 meeting agenda
✓ **Decision**: Approval of the April 28, 2020 PMWG meeting minutes

➢ **Action Item**: Catherine M., PST, will distribute the executive summary writing guide to the PMWG
➢ **Action Item**: Rich V. will distribute a draft PMWG summary update to the PMWG

Executive Summaries Review by PMWG

- Four draft executive summaries were provided to the PMWG as read-aheads:
    - Age-specific Survival of RGSM
    - Consolidation of Mesohabitats for Monitoring RGSM
    - Age Composition of RGSM
    - Spawning Onset and Activity of RGSM
- PMWG members are invited to contribute to or review the executive summaries. There have been some comments on them. The comment period on the four draft summaries will be extended to July 15.
- The review process will be incredibly important in developing the summaries. The initial draft is a starting point, and it's expected that there will be counterpoints and additions from other interested individuals. To ensure that the review process stays organized, the group could use a tracking system.
    - Would that system include a track date on the document?
        - Track dates are a part of the document already. To further track the document, the PST will set up a table in the AM Database that will store who is providing comments and when. This will help comments get incorporated in an organized way. It's still early in the process, but it's expected that there will be a substantial number of comments as the process continues. The group should be encouraged to comment knowing that there will be documentation that all comments are being addressed.
    - The PMWG should be sure to get the full range of information with each summary. They should cover different ideas, thoughts, and hypotheses to best represent the group. The tracking tool can be displayed at each meeting to show progress on the summaries.
- When originally talking about the executive summaries, the group discussed the documents going to the EC. However, these documents are too time-consuming for EC review. The EC should get a summary document, preferably one page. Cutting down the document leaves out important detail for PMWG, so attention should be paid to the intended audience and content appropriate for each.
    - There are two audiences for the document: technical experts and the EC. The first step should be to create a version with all the information. Then, the PMWG can write condensed abstracts or fact sheets for the EC.

- The full document should be structured to focus on the key takeaways up front.
    - The executive summaries exercise should both inform the EC and contribute to the adaptive management (AM) process. From the executive summaries, one should be able to identify research questions or topics that need to be included in the Program's science plan.
- In order to help with the review process, the references for each of the executive summaries can be placed in the PMWG Zotero library.
- In the AM plan, will each uncertainty be listed and have an executive summary?
    - That hasn't been decided yet. If we get the process streamlined here, it can be used in other groups that are working to decide which uncertainties to move forward.
- When looking at the different executive summaries and reference lists, it's clear that some have had a lot of time spent on them and some have not. We could use a more neutral look, like simple stating the objectives of a study and its methods and results. A standardized approach helps to avoid incorporation of bias. This might resolve some conflict.
    - This comment should be included as part of a review, so it gets documented. It's a good idea to standardize the executive summaries.
    - This is a pilot effort. These comments help fix the process and streamline it.
    - When citing a paper in an executive summary, it's important to cite the results and not the discussion.

- **Action Item**: Catherine M. will create a tracking spreadsheet for the executive summary review process
- **Action Item**: The PST will organize the Zotero library with separate folders for each executive summary topic
- **Action Item**: PMWG members will provide comments on the draft executive summaries to the PST by July 15, 2020

Consolidation of Mesohabitats for Monitoring RGSM

- Mike M., Assessment Payers Association of the Middle Rio Grande Conservancy District, presented on the Consolidation of Mesohabitats for Monitoring RGSM executive summary (see presentation). These are the main points discussed following the presentation:
    - In looking at habitat studies, you could get two different results for habitat preference based on abundance that year. It's hard to draw preference on mesohabitat when you don't catch fish.
    - Mike M. discussed evaluating habitat studies, usefulness of seine hauls, schooling fish, representativeness of sampling, and goals of monitoring.
    - In the U.S. Army Corps of Engineers (USACE) project, the mapping and distribution of mesohabitat types analyzed isn't included in the report. If data are available, we may be able to look at them.

➢ **Action Item:** Mike M. will work with Catherine M. to revise the Consolidation of Mesohabitats for Monitoring RGSM executive summary to incorporate the discussion points from the meeting

1996 FLO Data

- Shay Howlin, PST, presented an update on the 1996 FLO data. FLO is the acronym of the consulting company that collected the data. The data have been entered and subjected to quality assurance/quality control. The data will be packaged as an Excel file and uploaded

to the Program Portal once the metadata are reviewed for accuracy. Shay H. will ask Joel Lusk, Reclamation, to review and can also send to any interested PMWG members.
    - The 1996 FLO data will be updated to the Program Portal.

- **Action Item**: Shay H. will ask Joel L. to review the FLO 1996 metadata description
- **Action Item**: The PST will upload the FLO 1996 data to the Program Portal

Modeling Scenarios

- Charles Yackulic, U.S. Geological Survey, has developed an integrated model and the PMWG is looking into modeling scenarios. Rich V. and Charles Y. put together a preliminary write-up of potential modeling scenarios, including a list of 7 items and are using the model as a forecast tool. The following are the main points of the discussion on modeling scenarios:
    - The 7 items are potentially relevant to management actions.
    - The list is reasonable but some items cannot be modeled outputs based on the data. So, we'll have to consider the scenarios and how much they matter.
        - Sensitivity analysis using salvage, for example: What will it look like if we assume all salvaged fish die, and all salvaged fish have the same survival rate? We need to take the worst and best cases and determine how much they affect model behavior. The critical uncertainties are the ones that significantly change model performance and/or outcomes.
    - There is sufficient information to separate augmented fish in the model.
    - To determine acres of floodplain habitat, a technical Ad Hoc group may need to be formed that models floodplain habitat availability over time. We may need to think about a way to estimate how discharge turns into floodplain habitat and how management actions tie in. This item requires work before putting it into the model.
    - What information is needed to translate these ideas into parameters that the model can use?
        - For numbers 1 and 7, Aubrey Harris, USACE, has been doing habitat modeling work for USACE and Reclamation. In a couple months, there should be pretty good data.
    - The integrated model is the skeleton to test hypotheses, but we still need people who know the fish and its biology to help come up with alternative competing hypotheses. That's where PMWG can be really useful.
    - Consider what we know about the species and ways to optimize the spring runoff hydrograph. A scenario analysis, using hypothesized conditions rather than empirical observations, may provide useful upper and lower bounds for some estimates. Following the scenario analysis, management approaches for working with less water can be explored.
    - How do you imagine running these within the model? What metrics do we expect to look at to compare between these scenarios?
        - The list of 7 items is almost a list of different management actions. For some of them, we're trying to quantify impact, including uncertainty. Down the line we'll consider the impacts of one action versus another and how to prioritize them.
    - How are we going to quantify what an impact is?
        - For short term, look at abundance. If we get to the point of comparing different strategies, it makes sense to look at probability of extirpation or extinction.

Exercise Looking at Spring Hydrograph

- The PMWG looked at the spring hydrograph. The following are the main points of the discussion:
  - What are two or three different hydrographs that may optimize RGSM habitat?
    - As a group the PMWG could also outline a couple different hypotheses that are obviously contrasting.
      - There hasn't been an attempt to design studies to determine hypotheses. There hasn't been enough flexibility to do so.
  - The group could do a sensitivity analysis and see what falls out as most important. This might direct what scenarios to look at.
    - Restrictions on water operations to modify the hydrograph may nullify a sensitivity analysis. Documenting these restrictions and their effect on the hydrograph is, therefore, a very useful preliminary step.
  - Something I'm not seeing is a different way to think about scenarios 1, 2, and 3. Will it be possible in some years to flip from one scenario prioritizing spawning to another year prioritizing adult survival? How many years can you go in one way or another before a total crash?
    - This is a state-dependent management decision and something we want to explore.
  - Joel L. gave us some hydrographs that U.S. Fish and Wildlife Service used to work on for the BO. Are those examples of hydrologic shifting useful for this exercise?
    - Those were good to figure out how to optimize, but it's just one approach and we have to figure out how to manage across 7 different hydrographs.
  - Is it possible to use a single hydrograph and manipulate the 7 elements independently and in combination?
    - 7 hydrographs might be overkill. Maybe the PMWG needs to decide it doesn't matter what you do in wet years and only focus on dry or medium years. Then consider how you would shape the hydrograph if you had full control or partial control.
  - Make sure the hydrographs are very distinct from each other so we can isolate why one hydrograph behaves differently from another in the model.
  - PMWG can come up with some blocky hydrographs (considering variations on magnitude, timing and duration of rise) just to get some concepts together. Everyone can come up with 1-3 hydrographs to see how common they are.
  - Some of the things coming out of this group's discussion are directly relatable to development of the Program's AM strategy and plan. The PST is very interested in using outputs of this group's model and tying it to pieces of the AM plan. All members are asked to think about how each of these questions relates to things like the conceptual ecological model.

➢ **Action Item**: Charles Y. and Rich V. will develop an approach to look at modeling scenarios in the PMWG

Wrap-Up

- Announcements:
  - There is a new Hatch paper and it will be presented at the next meeting.
    - The paper will be sent as follow-up and uploaded to Zotero.

➢ **Action Item**: The PST will distribute the Hatch et al. (2020) paper

➢ **Action Item**: The PST will send a doodle poll for June 2020 to schedule next meeting

Participants:

Anne Marken	Middle Rio Grande Conservancy District
Catherine Murphy	Program Support Team
Charles Yackulic	U.S. Geological Survey
Debbie Lee	Program Support Team
Eric Gonzales	U.S. Bureau of Reclamation
Grace Haggerty	New Mexico Interstate Stream Commission
Kevin McDonnell	Program Support Team
Lynette Giesen	U.S. Army Corps of Engineers
Melissa Mata	U.S. Fish and Wildlife Service
Mick Porter	U.S. Army Corps of Engineers
Mike Marcus	Assessment Payers Association of the Middle Rio Grande Conservancy District
Mo Hobbs	Albuquerque Bernalillo County Water Utility Authority
Rich Valdez	SWCA Environmental Consultants
Shay Howlin	Program Support Team
Thomas Archdeacon	U.S. Fish and Wildlife Service
Trevor Birt	New Mexico Interstate Stream Commission

Modeling Scenarios for the Middle Rio Grande

Population Monitoring Workgroup

May 21, 2020

Draft 1.1--Preliminary

Introduction

Three mathematical models are being developed to better understand the relationship of the endangered Rio Grande silvery minnow (RGSM) to environmental correlates, including river hydrology (Yackulic 2019; Walsworth and Budy 2020; Hatch et al. 2020). Scientific uncertainty and questions about ongoing management actions help to drive the design and utility of these models for addressing key hypotheses. A practical method of model interrogation is the development of experiments or management-oriented scenarios that produce expected species responses to a suite of options reflective of decisions faced by managers (e.g., Melis 2011). This document describes modeling scenarios designed to evaluate RGSM responses to associated environmental correlates of the Middle Rio Grande (MRG), including river discharge.

Rationale for Scenarios

The 2016 Biological Opinion for Water Operations of the MRG (USFWS 2016) contains the Hydrobiological Objectives (HBOs) as a practical framework for developing modeling scenarios. The HBOs are based on the fundamental relationship between river discharge and October CPUE, and offer two strategies for RGSM conservation:

- The production strategy fosters the production of young RGSM during spring, and
- The survival strategy provides guidelines to manage for RGSM survival when spring and summer flows are low.

These strategies describe the needs of the fish for two life history phases (spawning/larvae and juvenile/adults) during two hydrological periods (high spring flow and low summer base flow). These phases and periods are fundamental drivers of the RGSM population in the MRG, and the modeling scenarios developed herein reflect the need to understand mechanism within each period, as well as tradeoffs associated with water distribution across both periods.

Scenarios Under Development

The following modeling scenarios are under development as further described below:

1. Spring runoff hydrograph to inundate floodplains as RGSM nurseries
2. Summer base flow to minimize drying
3. Balance spring and summer hydrographs (tradeoff spring runoff and river drying)
4. Effect of RGSM augmentation on population (2.5 million from 2001 to 2019)
5. Effect of RGSM salvage on population
6. Effect of impediment/passage at three diversion dams on population
7. Acres of floodplain habitat needed to affect October CPUE

Scenario #1: Spring Runoff Hydrograph

- **Over-Riding Hypothesis:** The shape of the spring hydrograph determines reproductive success of RGSM.

- **Key Variables:** The following considerations are identified for each of the five key variables of spring runoff (Fig. 1):

  a. Timing
     1. Spring runoff may start as early as mid to late April, and as late as mid-May.
     2. Inundated floodplains provide habitat for newly-hatched RGSM larvae.
     3. Floodplains are available to more larvae if inundation begins between initial spawning (~700 ACDDs) and onset of majority of spawning (~1,000 ACDDs).

  b. Magnitude
     1. Floodplain inundations begins ~1,500 cfs at San Acacia reach; ~2,000 cfs at Isleta reach; ~2,500 cfs at Angostura reach.
     2. Relatively steady magnitude provides stable habitat for maturing larvae, and minimizes displacement and stranding.

  c. Duration
     1. Floodplain habitat needed for larvae to develop fins and fin rays in 14-22 days.
     2. Duration should include as much of the larval hatch as possible (Fig. A-1).

  d. Upramp
     1. Daily increase in flow not as critical as downramp.

  e. Downramp
     1. Rapid downramp can displace or strand larvae.

- **Conceptual Scenarios**: Conceptual modeling scenarios were developed with an Excel spreadsheet tool using the five hydrographic variables as inputs. Of 27 possible scenarios for three key variables, nine are identified in Table 1 and are illustrated in Figs. A-2-A-4.

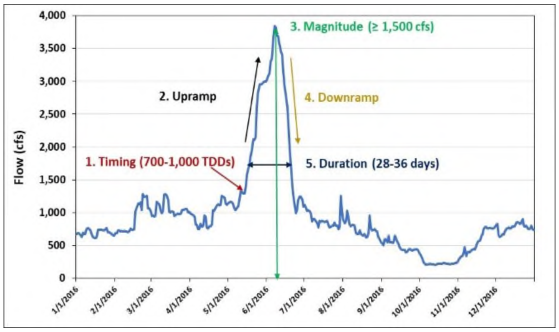

Figure 1. Five variables of spring runoff, with 2016 hydrograph for illustration.

Table 1. Scenarios for each of three runoff variables (see Figs. A-2-A-4 for illustrations).

Timing	Magnitude	Duration
1. Early (start April 15)	4. Low (<1,500 cfs)	7. Short (<15 days)
2. Mid (start May 1)	5. Moderate (1,500-3,000 cfs)	8. Medium (15-45 days)
3. Late (start May 15)	6. High (>3,000)	9. Long (>45 days)

Scenario #2: Summer Base Flow

- **Over-Riding Hypothesis:** Mortality from summer drying drives annual October CPUE.

- **Key Variables:** The following considerations are identified for each of the variables of summer base flow:

  a. <u>Timing of Drying</u>
     1. Early drying can strand post-larval RGSM with reduced swimming capability.
     2. Early drying can portend long drying duration.

  b. <u>Duration of Drying</u>
     1. Shorter duration drying allows quicker reinvasion.
     2. Longer duration reduces habitat availability.
     3. Longer duration affects food base longer and delays reset of food base (diatoms, algae, macroinverts).

  c. <u>Length (river miles) of Drying</u>
     1. Longer section(s) of drying results in more mortality and reduces habitat availability.
     2. Longer section(s) of drying affects more of food base.

  d. <u>Rate of Drying</u>
     1. Slower rate of drying may allow fish to move with water.
     2. Faster rate of drying traps fish in pools and pockets.

Scenario #3: Balance Spring and Summer Hydrographs

- **Over-Riding Hypothesis:** Possibly water volume used for spring runoff can be managed to minimize summer drying.

- **Key Variables:** The following considerations are identified for each of the variables of spring and summer hydrographs:

  a. Volume of water available
     1. Sufficient water volume is necessary to balance spring and summer hydrographs.
     2. Insufficient volume (low water year) limits management options.
     3. Moderate to high water volume can increase management options, depending on other management considerations (see #3 below).

  b. Series of low water years
     1. Second or third sequential low water year increases urgency to manage flows.
     2. Other management considerations may limit options in series of low water years.

  c. Other management considerations
     1. Status of Articles of Rio Grande Compact.
     2. Volume of water in reservoir storage.
     3. Others?

Scenario #4: Effect of RGSM Augmentation on Population

- **Over-Riding Hypothesis:** Augmentation of hatchery-reared RGSM helps to sustain the RGSM population in low water years or in years following poor production/recruitment.

- **Key Variables:** The following considerations are identified for each of the variables of augmentation:

    a. Number of RGSM stocked
        1. Number stocked can affect population size of RGSM.
        2. Greater number stocked can lead to more fish surviving.
        3. Large number stocked may affect genetics of RGSM population.

    b. Size and age of RGSM stocked
        1. Size and age of stocked RGSM can influence survival.
        2. Size and age of stocked RGSM can affect reproductive potential from size/age-specific fecundity.

    c. Number (CPUE index) in pre-existing brood stock by October
        1. Number of RGSM in pre-existing broodstock can influence effect of augmented fish on the population; augmented fish will have a larger influence on the population with a small pre-existing broodstock.
        2. Number of pre-existing broodstock of given size/age can vary effect of augmented RGSM on reproductive potential.

Scenario #5: Effect of RGSM Salvage on Population

- **Over-Riding Hypothesis:** Salvage of RGSM from isolated pools during drying and translocation to wetted areas helps to improve survival.

Scenario #6: Effect of Impediment/Passage at Three Diversion Dams on Population

- **Over-Riding Hypothesis:** Diversion dams at Angostura, Isleta, and San Acacia impede movement of RGSM among reaches and reduces population viability.

Scenario #7: Acres of Floodplain Habitat Needed to Affect October CPUE

- **Over-Riding Hypothesis:** Greater availability of floodplain habitat in spring enhances reproductive success and survival of larval RGSM that can result in higher October CPUE.

References

Hatch M.D., F. Abadi, W.J. Boeing, S. Lois, M.D. Porter, and D.E. Cowley. 2020. Sustainability management of short-lived freshwater fish in human-altered ecosystems should focus on adult survival. PLoS ONE 15(5): e0232872. https://doi.org/10.1371/journal.pone.0232872

Melis, T.S., ed., 2011, Effects of three high-flow experiments on the Colorado River ecosystem downstream from Glen Canyon Dam, Arizona: U.S. Geological Survey Circular 1366, 147 p.

U.S. Fish and Wildlife Service (USFWS). 2016. Final Biological and Conference Opinion for Bureau of Reclamation, Bureau of Indian Affairs, and non-federal water management and maintenance activities on the Middle Rio Grande, New Mexico. U.S. Fish and Wildlife Service, Albuquerque, NM.

Valdez, R.A., G.M. Haggerty, K. Richard, and D. Klobucar. 2019. Managed spring runoff to improve nursery floodplain habitat for endangered Rio Grande silvery minnow. Ecohydrology 12(7), https://doi.org/10.1002/eco.2134

Walsworth, T.E. and P. Budy. 2020. Rio Grande Silvery Minnow Hydrobiological Analysis: Annotated Draft Results. USGS Utah Cooperative Fish and Wildlife Research Unit, Power Point Presentation.

Yackulic, C.B. 2020. Rio Grande Silvery Minnow integrated population model. Power Point presentation to Population Monitoring Workgroup, February 26, 2020. U.S. Geological Survey, Flagstaff, AZ.

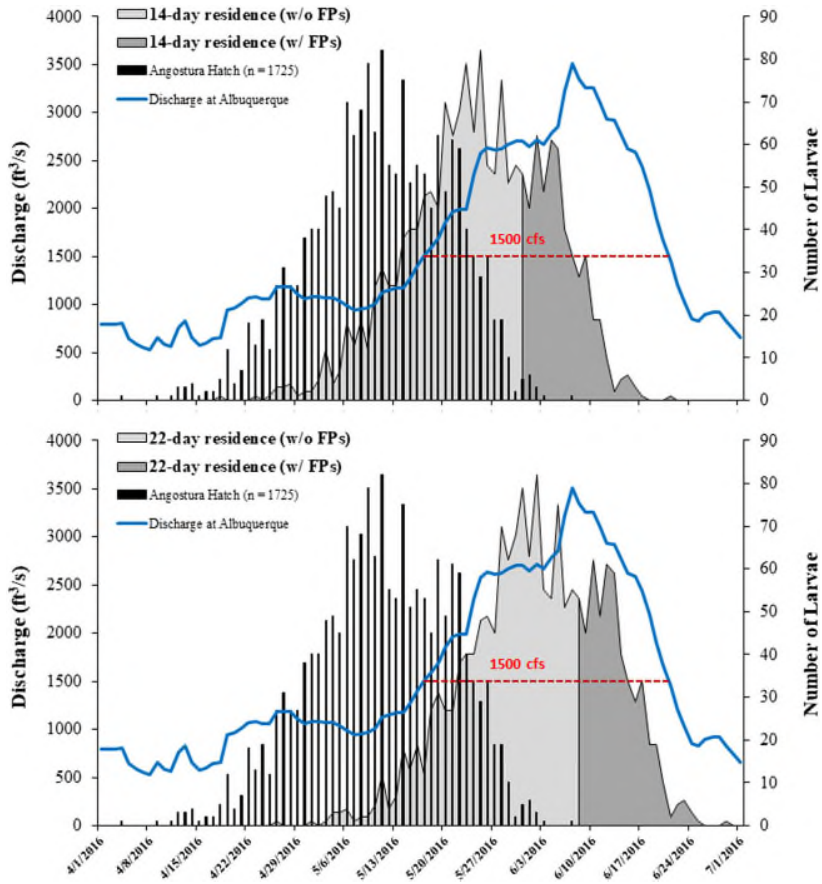

Figure A-1. Estimated hatch dates of Rio Grande silvery minnow and the projected end of floodplain residence by larvae for 14 and 22 days, divided as larvae hatched with and without floodplains (FPs). Discharge is for the Rio Grande at Albuquerque (U.S. Geological Survey #08330000). Horizontal dashed line shows discharge of 1,500 ft3/s where inundation of the six study sites began. Figure 10 from Valdez et al. (2019).

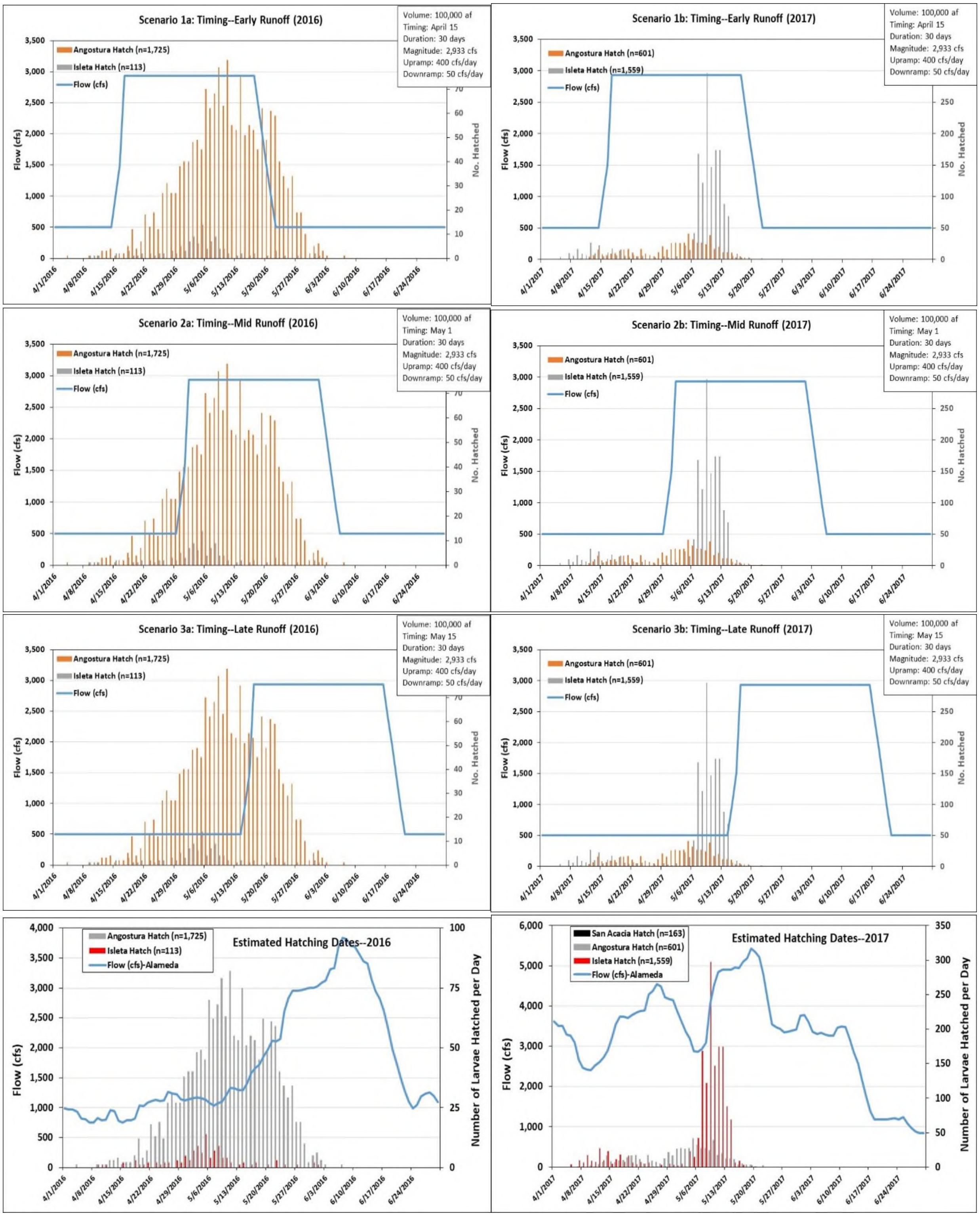

Figure A-2. Conceptual scenarios for **timing** of spring runoff as early (a. April 15), medium (b. May 1), and late (c. May 15), with estimated hatch dates of RGSM for 2016 (left column) and 2017 (right column). Actual hydrographs for April 1 to June 30 are shown for 2016 and 2017 on the bottom row.

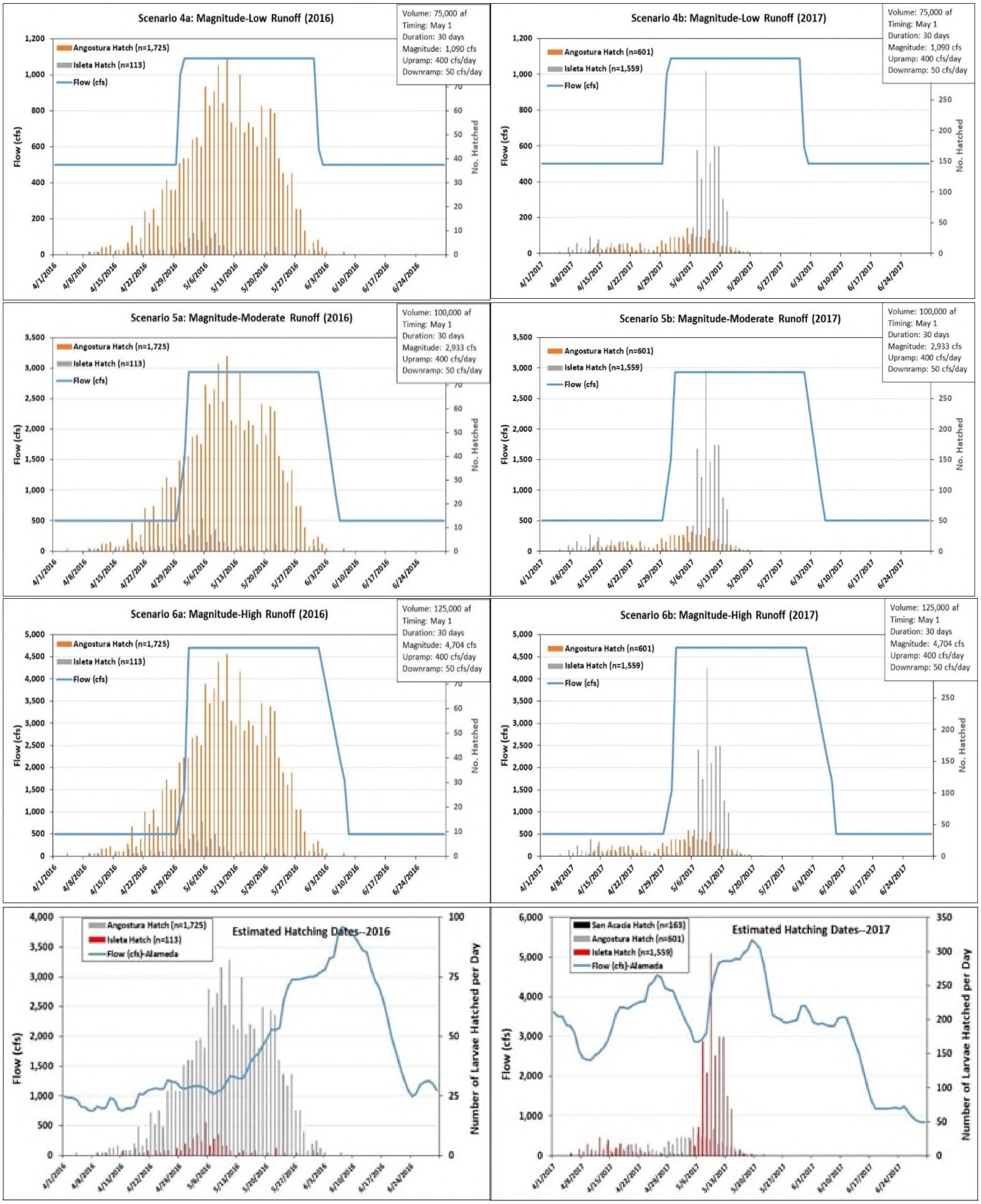

Figure A-3. Conceptual scenarios for **magnitude** of spring runoff as low (a. <1,500 cfs), moderate (b. 1,500-3,000 cfs), and high (c. >3,000 cfs), with estimated hatch dates of RGSM for 2016 (left column) and 2017 (right column). Actual hydrographs for April 1 to June 30 are shown for 2016 and 2017 on the bottom row.

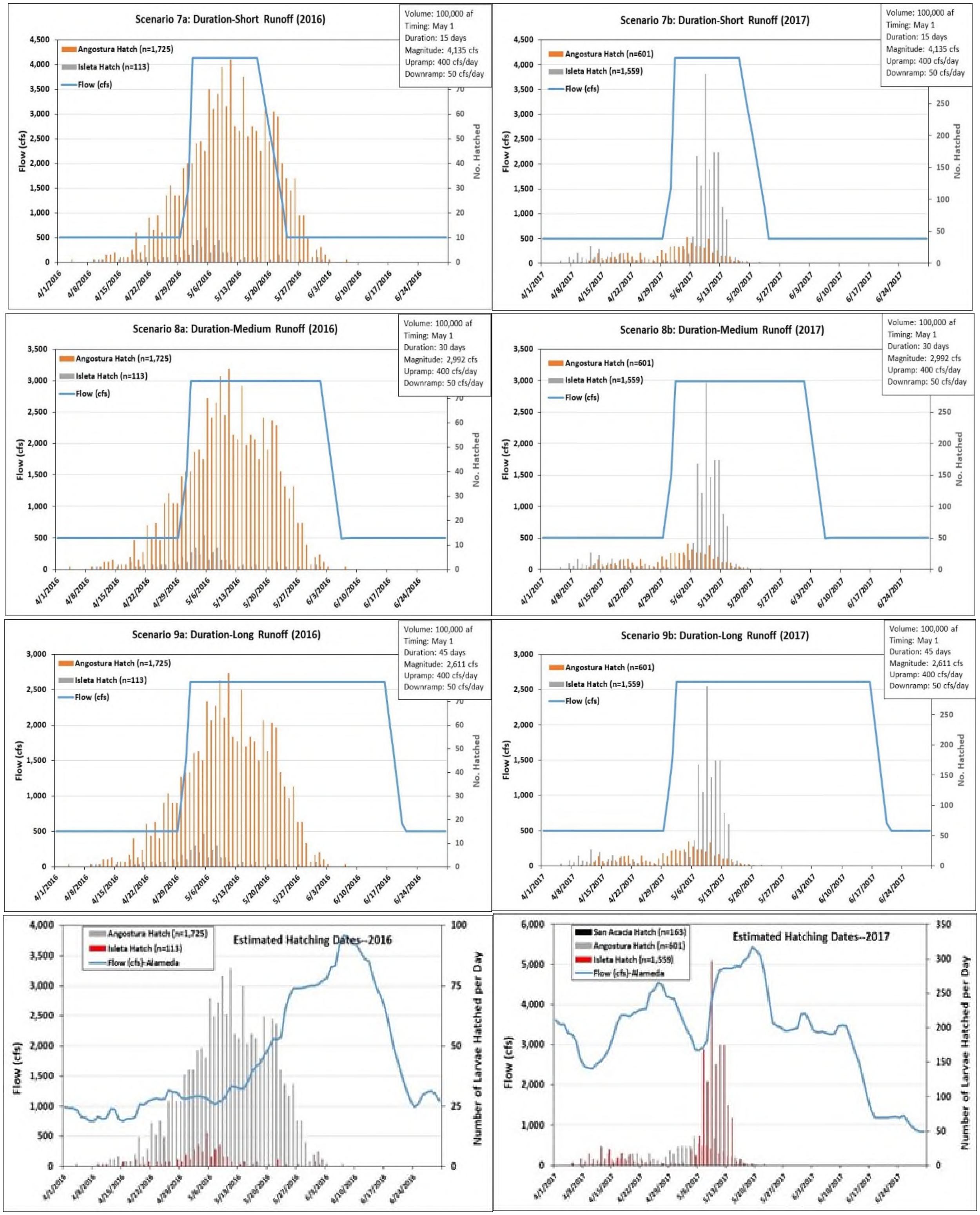

Figure A-4. Conceptual scenarios for **duration** of spring runoff as short (a. <15 days), medium (b. 15-45 days), and long (c. >45 days), with estimated hatch dates of RGSM for 2016 (left column) and 2017 (right column). Actual hydrographs for April 1 to June 30 are shown for 2016 and 2017 on the bottom row.

Middle Rio Grande Endangered Species Collaborative Program
Population Monitoring Work Group (PMWG)
2020 Work Plan

The Population Monitoring Workgroup (PMWG) is charged by the Executive Committee (EC) of the MRGESCP with evaluating the monitoring program and demographics for the Rio Grande Silvery Minnow (RGSM) in the Middle Rio Grande, in accordance with three tasks: (1) conduct a workshop on CPUE methodology, (2) review the fish population monitoring plan and demographics, and (3) update the monitoring plan. Task 1 was completed in 2016, and Task 2 is currently being executed by the PMWG.

The PMWG plans to conduct and complete the following elements under Task 2 in 2020:

Elements	Sub-Element	Target Completion Date
1. Integrate and prioritize consolidated recommendations from two science panels[1]	1a. Consolidate recommendations 1b. Complete Executive Summaries on six to eight recommendations to aid in the ranking and implementation processes 1c. Work with WEST to integrate recommendations into AM process	1a. February 18, 2020 1b. September 15, 2020 1c. Ongoing
2. Develop and review integrated RGSM model[2]	2a. Complete base model 2b. Review model parameters 2c. Conduct sensitivity analyses, and run scenarios 2d. Complete draft working model	2a. February 26, 2020 2b. July 15, 2020 2c. September 15, 2020 2d. December 20, 2020
3. Develop draft report of Integrated RGSM model and preliminary results	3a. Complete Preliminary Draft Report on Integrated RGSM Model	3a. December 20, 2020
4. Reports to EC	4a. Draft Progress Report to EC 4b. Present preliminary findings to EC 4c. End of Year Report to EC	4a. June 2020 4b. June EC Meeting 4c. Last 2020 EC Meeting

[1] Hubert Science Panel Report was completed in 2016; Noon Science Panel Report was completed in 2017.
[2] Dr. Charles Yackulic of the USGS has been retained through the NMISC to develop an integrated model.

Executive Summary

Topic Area Title: Age Composition of Rio Grande Silvery Minnow

Panel Recommendations (Noon et al. 2017):

- C: Clarify the detail of annular mark formation on otoliths and firmly establish the longevity of RGSM.
- E1: Establish the age composition of the RGSM population, including A.) application of distribution separation methods to estimate age composition, and B.) gear selection study.

Program Goal Relevance:

Provides an understanding of age composition for the current RGSM population, the effectiveness of sampling to characterize age structure, and possible changes in age composition over time that may be limiting population self-sustainability.

Brief Summary of Available Literature:

The age composition of the Rio Grande silvery minnow (RGSM) remains unresolved because: (a) various sample gears and locations reveal larger (and possibly older) fish than reported in standard monitoring, (b) modal separation and modal progression analyses indicate small numbers of older fish in the contemporary population not reported through monitoring, (c) numbers of older fish may be too small in some years for capture, (d) older, viable fish in captivity show the species is capable of living much longer than seen in the wild, and (e) examination of historical specimens shows older fish than reported from the contemporary population, indicating age truncation.

The RGSM in the Middle Rio Grande (MRG) is thought to comprise of principally three ages: age 0 (young-of-year less than one calendar year of age), age 1 (12-24 months old), and age 2 (24-36 months old). This determination was initially based on nominal assignment of age from visual inspection of fish length (e.g., Propst 1999; Dudley and Platania 2020). Histograms of wild RGSM lengths generally show one or two distinct modes and a blending or smearing of subsequent modes, reflecting slowed growth at maturity and overlapping lengths of older, same-age fish (Valdez 2018).

Cowley et al. (2006) determined length-at-age from scale growth rings of 13 preserved RGSM specimens collected in 1847 from San Ildefonso, NM, about 85 miles upstream Albuquerque. Scale annuli showed age classes 1 to 5 were present, indicating that individuals historically may have lived longer than fish of the contemporary population. The presence of multiple individuals of several ages suggests that annual survival rates of young fish were high historically, accounting for the presence of older fish. This analysis also showed that the species is iteroparous (i.e., undergoes multiple reproductive events in its lifetime), rather than being short-lived and semelparous (i.e., a single reproductive cycle before death). This means that RGSM spawn and survive multiple years, rather than all spawning at one time and dying.

The first study to age RGSM from growth increments of scales and otoliths (Horwitz et al. 2018) determined from 158 specimens in 2009 and 2010 that the majority were ages 0, 1, and 2, with only three individuals age 3. Horwitz et al. (2018) disputed the ages determined by Cowley et al. (2006) for the preserved specimens of 1874, submitting that reexamination of scales showed the fish were age 0 to age 2.

Miller (2012) used four age classes in a population viability analysis (PVA) model for the RGSM, while acknowledging that the study of Horwitz et al. (2011) demonstrated the presence of three age classes in the population. Miller (2012) stated that model runs showed that "While the number of individuals in the oldest age class is quite small, we cannot statistically exclude the possibility of some individuals surviving to four years of age." Goodman (2010) also developed a PVA for RGSM and allowed the modeled population to self-extinguish at age 4 or 5.

As part of the data assimilation for the Miller (2012) PVA, Valdez and Medley (2010) conducted modal progression analysis using monthly standard-length data of 29,580 RGSM from the standardized population monitoring program. This analysis revealed that the population sampled during 1993-1997 and 1999 consisted of individuals up to 5 years of age with a predicted maximum length ($L\infty$) of 84 mm SL, which was slightly smaller than the largest fish observed in the samples at 87 mm SL. Proportions of fish from all samples with lengths equal to or less than predicted length-at-age were 77%, 21%, 2%, 0.17%, and 0.05%, respectively, whereas specimens examined by Cowley et al. (2006) were 8%, 23%, 31%, 31%, and 8% for ages 1-5, respectively.

Lengths at annulus formation 1-5 from modal progression were 41, 62, 73, 78, and 81 mm SL Valdez and Medley (2010), respectively, and were comparable to and not significantly different ($p < 0.05$) from lengths of 46, 61, 70, 76, and 81 mm SL, respectively, estimated from scale annuli from 13 preserved fish collected in 1874 (Cowley et al. 2006). This comparison indicates that growth of individuals in the contemporary population does not appear to differ from growth of individuals from historical collections. Lengths at age-1 (nominal 1st birthday) from modal progression analysis (41 mm SL) and from scale annuli (46 mm SL) were similar to lengths of 45-49 mm SL cited by Platania and Dudley (2003) for fish spawning at the end of their first year of life. Estimated length at ages 2-5 from this modal progression were slightly higher than those determined by Cowley et al. (2006), possibly because the historical collections were from San Ildefonso, an upstream reach of river with a shorter growing season than reaches of the MRG.

Valdez (2018) then used monthly length-frequency distributions and modal separation analyses to determine presumed age composition from standard lengths of 61,850 RGSM measured as part of the standardized population monitoring program for 1993-2016. He also used growth models and modal progression analysis to estimate length-at-age for the same samples. Length-frequency analysis using 2-mm bins of monthly data employed the Bhattacharya and NORMSEP methods (Sparre and Venema 1998) to distinguish lengths as most probable modes. This analysis determined that there were predominantly 1 to 3 length groups, with small proportions of a 4th length group and rarely a 5th group. These length groups presumably corresponded to ages, but actual age could not be determined from this analysis. A modal progression analysis using Shepard's Method of ELEFAN (Sparre and Venema 1998) also showed evidence of 4 and 5 length groups, but it was difficult to track length modes for more than 2-3 years. The data were then used to evaluate growth, using a first order von Bertalanffy growth function (VBGF) and a seasonalized von Bertalanffy growth function (SVBGF). These analyses showed that the RGSM sampled were comprised predominantly of 1 to 3 length groups, with small numbers of larger (and presumably older) fish that may or may not be present in some years. RGSM illustrate a seasonal growth rate (fast in spring-fall, slow in winter), with the best AICc score for the SVBGF. These samples represent post-larval fish that recruit into the gear type in June or July, at 1.5-2 months of age.

Hatch et al. (2020) used model simulations to evaluate two hypothetical "average fish" and five example fish species of age 1 or age 2 maturity, including RGSM. From a population equilibrium baseline representing a natural, unaltered environment, systematic reductions in adult survival were imposed to quantify how age truncation affected the causes of variation in population growth rate. Hatch et al. (2020) estimated the relative contributions to population growth rate arising from simulated temporal variation in age-specific vital rates and population structure. At equilibrium and irrespective of example species, population structure (first adult age class) and survival probability of the first two adult age classes were the most important determinants of population growth. As adult survival decreased, the first reproductive age class became increasingly important to variation in population growth. These results support the findings of Miller (2012) that the contemporary RGSM population was driven largely by the reproduction of age-1 fish. The conclusion of age truncation reached by Hatch et al. (2020) also lends credence to Cowley et al. (2006) that the historical population reflected older fish because of higher survival by younger fish. These findings indicate that older fish (age 3+) could be present in contemporary population, but in such low numbers as to be largely undetected in some years. This also supports the conclusion by Platania and Dudley (2003) and Miller (2012) that the majority of RGSM spawners are fish at the end of their first year of life (age-1), despite higher fecundity (number of eggs per females) in older fish.

Longevity of the RGSM is best determined from captive fish. Captive fish live longer than wild fish (Horwitz et al. 2011, 2018) and are still reproductively capable at 4+ years of age (City of Albuquerque BioPark 2018). Maximum documented longevity in the wild is about 30 months for wild fish inferred from length-frequency, but up to 36 months for hatchery-released fish. It is not uncommon for RGSM in captivity to live beyond 2 years and up to 6 years, especially at lower water temperatures. The U.S. Geological Survey's (USGS) Columbia Environmental Research Center in Yankton South Dakota had several silvery minnows in captivity with a maximum age of 11 years that range in size from 46 to 73 (± 8.1) mm SL (Buhl, pers. comm., cited in USFWS 2010).

Maximum longevity of wild RGSM was thought to be about 25-36 months, with most fish dying after their first reproductive cycle at 12-13 months, and few surviving past their second reproductive cycle at about 24-25 months (Platania and Dudley 2003). More recent analyses with model separation, modal progression, and growth models indicate that fish up to 4 or 5 years of age are likely present in the wild population. But because these older fish may not be represented every year, or because they may occupy habitat not commonly sampled, or outswim the gears in use, their presence may be missed and under-represented in the population.

Gear selection will be presented in a separate Executive Summary.

List the Uncertainties:

1. Does current fish monitoring account for all sizes (and presumably ages) of RGSM?
2. What proportion of the RGSM population is comprised of fish 3+ years of age?
3. How important are fish 3+ years of age in maintaining the population through years of low reproduction and recruitment?

List the Hypotheses Identified from Literature:

1. The contemporary RGSM population is age-truncated and reliant on age-1 reproduction.
2. Age-2 and age-3+ RGSM are important to carry over population reproduction in consecutive years of low flow.
3. Carry-over of reproductive potential was evidently present in the historical population, but may be limited in the contemporary population.

Management Implication(s) of Hypotheses (if any):

1. Enabling survival of older RGSM to age 3+ increases annual reproductive potential and minimizes population variability.

2. Survival of age-3+ fish could provide "carry-over" in the population so that large more fecund fish remain in years when reproduction and recruitment are otherwise limited by low river discharge.

Potential Approaches to Test Hypotheses:

1. Age fish sampled with a variety of gears and over time to determine if older fish in the population are being missed.
2. Determine through modeling the effect of various numbers of older fish on population production and viability.

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Executive Summary

Topic Area Title:

Age-specific survival of Rio Grande Silvery Minnow (RGSM)
Noon et al. (2017) recommendations A2 and A3.

Program Goal Relevance:

Provides an important demographic parameter to understand the numbers of fish surviving from one year to the next under different flow and environmental conditions.

Brief Summary of Available Literature:

Estimates of survival for RGSM were derived by Remshardt (2007) and Valdez (2010), and used by Miller (2012) to compute and infer age-specific survival in a RAMAS PVA (Table 1). Survival of RGSM by cohort was estimated by Goodman (2010) and used to resolve age-specific survival in a FORTRAN PVA. Yackulic (2020) preliminarily derived estimates of annual adult survival from an integrated population model. Estimated survival of RGSM has also been developed by Mike Hatch and David Cowley of New Mexico State University as part of an ongoing stock assessment model and PVA, but these estimates are not available at this time.

Remshardt (2007) estimated monthly survival of 0.662 for hatchery-reared fish released into the MRG in November 2004 and monitored through spring 2005. The fish were age-4 and were marked with VIE tags. Survival was estimated from the decline of marked fish in approximately monthly samples.

Valdez (2010) used the ASIR Population Monitoring dataset to compute mean monthly CPUE of all ages across reaches for years 1993–1997 and 1999-2010. He regressed these CPUEs over time in a “catch-curve” analysis that yielded an estimate monthly survival of 0.763 for wild fish, which was expanded to an annual survival rate of 0.039 (0.76312 = 0.039) for individuals 12 to 24 months of age. Valdez (2018) expanded the analysis to include mean monthly CPUE data for 1993-2017 (not 1998 and 2009) and derived monthly survival estimates for age-0 (mean = 0.736, range = 0.267-0.970), age-1 (mean = 0.740, range = 0.472-0.968), and age-2 (mean = 0.834, range = 0.583-0.976), which transform to mean annual survival of 0.03, 0.03, and 0.11, respectively. Annual adult survival (age 1+) was estimated at about 0.04.

Miller (2012) used the Remshardt (2007) and Valdez (2010) estimates of survival in his PVA model and reasoned that these monthly estimates represented some form of upper and lower bounds for the true value of this parameter. Miller (2012) noted that Remshardt (2007) did not see significant differences in survival among marked and unmarked fish in his 2005 augmentation study, and assumed that augmented fish (i.e., hatchery fish) were immediately subject to the same monthly rates of survival as the wild fish. Miller (2012) also assumed constant survivorship throughout the year, with the exception of an assumed lower survivorship of approximately 0.15 during the first month of life; he estimated survival of age-0 fish as (0.66211 = 0.007) x 0.15 = 0.0016 for fish up to 12 months of age. Miller (2012) then assumed a constant survival rate for age-1 (12-24 months of age) as 0.66212 = 0.007. Miller (2012) also assumed a constant annual survival for age-2 and age-3 individuals equal to 0.05, which was a value consistent with preliminary statistical analyses of survival (0.058) conducted by Goodman (2010) as part of PVA Workgroup activity.

Goodman (2009a) also used the 1993–1997 and 1999-2010 ASIR Population Monitoring dataset and estimated survival of RGSM by regressing inter-quarterly (Qn+1 vs Qn) CPUEs for all ages and reaches. Goodman (2010) determined a survival rate of 0.0580 for the 2007 cohort by plotting CPUE on a log scale and using the slope of the regression. Goodman (2009a) concluded that for years with a strong reproductive pulse, the survival rate to the pre-breeding census (early spring) ranges from about 0.03 to about 0.3; for years with reproductive failure, survival rate varies more widely, but the estimates may be less reliable for those years. On this basis, the Goodman concluded that PVA modeling should reasonably represent the cohort survival until the pre-breeding census as a random variable, with a mean around 0.1 and a mode around 0.05, and a longer right tail.

Table 1. Summary of Survival Estimates:

	Larvae	Age-0		Age-1		Age-2		Hatchery Age-?	
Citation	**Monthly**	**Monthly**	**Annual**	**Monthly**	**Annual**	**Monthly**	**Annual**	**Monthly**	**Annual**
Remshardt (2007)	--	--	--	--	--	--	--	0.662	0.01
Goodman (2009)	--	--	0.058	--	--	--	--	--	--
Hatch (2009)	--			0.09[b]				--	--
Valdez (2010)	--	0.763	0.04	--	--	--	--	--	--
Miller (2012)	0.15[a]	0.662	0.0016	0.662	0.007	--	0.05[a]	--	--
Valdez (2018)	0.502[c] (2016)	0.736	0.03	0.74	0.03	0.834	0.11	--	--
	0.472[c] (2017)	--	--	--	--	--	--	--	--
	0.301[d] (2017)	--	--	--	--	--	--	--	--
Yackulic (2020)	--	0.20 (0.15-0.25)[e]	--		0.04 (0.02-0.06)f			--	--

[a] estimated from model derivation.
b estimated from salvaged fish of all ages.
c estimated from floodplains.
d estimated from mainstem.
e approximate range derived from integrated model for June to October.
f approximate range of annual adult survival derived from integrated model.

Yackulic (2020), as part of the development of an integrated model for RGSM, derived estimates of annual adult survival (age-1+) each for the Angostura, Isleta, and San Acacia reaches. Altogether, estimates range from about 0.02 to 0.06 with a central distribution of about 0.04. Estimates of age-0 survival from June to October ranged from about 0.15 to 0.25 with a central distribution of about 0.20.

Mike Hatch (Personal communication, PVA Workgroup Meeting, 2009) provided an annual survival estimate of 0.09 for RGSM from salvaged fish, but no report was provided to detail the age of fish or method for deriving this estimate.

List the Uncertainties:

1. Is age-specific survival (larvae, ages 0, 1, 2+) different?
2. Is survival of older fish (age 2+) sufficiently high to enable “carry-over” from survival of older and presumably large and more fecund fish?

List the Hypotheses Identified from Literature:

1. Low spring-time survival of larval RGSM does not significantly increase population size, as measured by the October CPUE index.
2. Numbers of large and more fecund RGSM are not sufficiently large to significantly increase reproductive success.

Management Implication(s) of Hypotheses (if any):

1. Providing habitat and suitable conditions for survival of larvae can help to set cohort strength and the number of fish in the population.
2. Providing habitat and suitable conditions for survival of age-2+ fish could provide “carry-over” in the population so that large more fecund fish remain in years when reproduction and recruitment are otherwise low.

Potential Approaches to Test Hypotheses:

1. Estimate survival of larval RGSM from exponential function of density, or derived from modeling exercises.
2. Sample more intensively in spring to better determine the numbers of large RGSM present in the population in a given year.

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Executive Summary: Consolidation of Mesohabitats for Monitoring RGSM

Source Recommendation

Noon et al. (2017) E3: "Calculate revised CPUE values as mesohabitat-specific levels and do not combine across mesohabitat types. The mesohabitat specific CPUE calculated for the most abundant high density mesohabitat type should be used for assessment of trend in abundance of the RGSM population at the October sampling date."

Program Goal Relevance

Revising the distribution and intensity of sampling across mesohabitat types at the sampling sites, along with other potential modifications, used during the Population Monitoring Program (PMP) may improve the relationship associating computed catch-per-unit-effort (CPUE) index estimates of RGSM population trends from the PMP to needed estimates of the RGSM abundance and status in the MRG. Such a revision also may enhance the cost-effectiveness of the PMP.

Literature Summary

Assessing the potential importance for and differences among in-channel habitat characteristics influencing RGSM presence during sampling began with the recognition that RGSM occurrence in samples occurred along the continuous physical-habitat variables of flow and depth. Subsequently, due largely to the impossibility of measuring flow and depths prior to sampling without causing fish to scatter, the PMP focused on sampling within qualitative mesohabitat categories as flow-depth "surrogates." The following summarizes a sampling of the literature and PMWG analyses intended to aid in evaluating this peer recommendation and provide next step recommendations toward potential modification of PMP sampling procedures. (Additional PMWG documents overview and summarize additional literature and analysis assessing relationships of flow, depth, and habitat quality to RGSM in the MRG.)

Platania (1993a, b) provided the earliest extensive assessments of fish population distributions and RGSM habitat usage along the MRG. Focusing on winter habitat, **Dudley and Platania (1996)** reported that the majority (72.3%) of RGSM were caught in mesohabitats containing instream debris and consistently occurred over small substrata, at moderate depths, and in low velocity water. Subsequently, **Dudley and Platania (1997)** collected RGSM and other fish species during monthly sampling from July 1994 to June 1996 at two MRG sites, one each near Rio Rancho and Socorro. Habitat availability was determined at both sites monthly October 1995 to June 1996. They reported that RGSM exhibited differences in habitats use by size-class, with velocity being the strongest predictor of habitat use by size-class closely followed by depth; however, the correlation between these two physical variables clouded clear definition of the relative importance of each. Most RGSM (91.3%) were collected over silt substrata. RGSM tended to be most abundant in low-velocity mesohabitats (debris piles, backwaters, and pools) and rarest in high velocity habitats (runs and riffles). Greater proportions of RGSM occurred in higher velocity mesohabitats (main and side channel runs) in summer than winter, with the population shifting from pool and backwater habitats in summer to habitats with instream debris piles in winter.

Summarizing available information, the **USFWS (2010)** RGSM Recovery Plan states that the species only uses a small portion of the available aquatic habitat, occurring most often mesohabitats having low or moderate water velocity (e.g., eddies formed by debris piles, pools, backwaters, and embayments) and is rarely found in habitats with high water velocities, such as main channel runs, which are often deep and swift (citing **Platania 1993a, 1993b, Dudley and Platania 1997; Watts et al. 2002; Remshardt 2007, 2008**). Both marked (hatchery) and unmarked (wild) RGSM collections are positively associated with habitats having low velocity, most commonly shorelines, debris, eddies, and submerged vegetation.

Implementation of mesohabitat sampling during the RGSM PMP has varied somewhat over time. Its purpose is to estimate “population trends over time using a density index (i.e., CPUE)” (**Dudley et al. 2020: 48).**The most recent approach is described in the 2019 PMP draft completion report (**Dudley et al. 2020**). This includes collection fish using a two-person 3.1 m x 1.8 m small-mesh seine (ca. 4.8 mm [0.2 in]) through 18 discrete mesohabitats (< 1.5 m long [5 ft]). Runs were sampled four times at each site, as were shoreline pools (when available); backwaters, pools, and riffles were sampled two times (when available); any remaining samples (to obtain a total of 18 to 20) were taken in shoreline runs. Also, a 1.2 m x 1.2 m [2 ft x 2 ft] fine-mesh seine (ca. 1.6 mm [0.6 in]) was used to selectively sample shallow low-velocity mesohabitats for larval fish (two samples/site) from April to October. Mesohabitats with similar conditions, which did not exceed reasonable depths or velocities for efficient seining, were sampled regardless of flow conditions.

Dudley et al. (2020) also described results from their qualitative examination of mesohabitats occupied by RGSM, noting that the physical locations of mesohabitats in the MRG shift around considerably over time. They reported that RGSM occupancy trends were quite similar throughout 2002–2019 for five different mesohabitats, backwaters, pools, runs, shoreline pools, shoreline runs, despite notable differences in the estimated densities of RGSM among mesohabitats. Densities were typically highest in lower velocity mesohabitats and lowest in higher velocity mesohabitats.

Technical staff from the U.S. Geological Survey, collaborating with USACE and USFWS personnel, evaluated the physical habitat characteristics and fish assemblage compositions of available mesohabitats over a range of streamflows at 15 MRG sites during winter 2011–12 and summer 2012 (**Braun et al. 2015**). They reported that in the winter of 2011–12, RGSM were weakly associated with sand substrates, relatively moderate velocities, and relatively shallow depths; during summer 2012 they were associated with run mesohabitats, relatively high velocities, sand substrates, and relatively moderate depths. Of the four minnow species assessed, RGSM were collected from the narrowest range of depths (0.30–2.1 ft) during summer 2012 and the narrowest range of velocities in both winter 2011–12 (0.0–3.18 ft/s) and summer 2012 (0.02–1.51 ft/s). As time allowed, they also measured the physical characteristics of mesohabitats with the number of each mesohabitat type assessed done in proportion their abundance, with 20 mesohabitats assessed at each site. Measured depths and velocities varied greatly by mesohabitat type, site, and sampling period for both assessment periods. Applying area-weighting factors to the depths and velocities for assessed sites, they reported that shallower mean depths and slower mean velocities during summer 2012, when discharges tended to be lower, relative to same sites in winter 2011–12. Visual inspection of the box and whisker plots presented in their Figure 10 for measured depths and velocities for each of the eight type of mesohabitat assessed during each season at each assessed sampling site reveals considerable overlapping distributions for both physical parameters across all mesohabitat types within each site by season. [The data produced by this studyare currently undergoing additional assessment by the USACE to evaluate approaches to (1) integrate its mesohabitat mapping with LiDAR, HEC-RAS, orthophotography, and other data sources to produce a geospatial model of in-channel habit; (2) investigate geospatial and temporal analyses for describing and presenting in-channel habitat information; and (3) develop techniques for integrating riparian floodplain and riverine habitat into single mapspace for the MRG (M. Porter, personal communication, email 4/9/2020).]

For the PMWG, **Marcus (2019)** primarily used histogram bins to group categories of collected data to characterize and summarize PMP data collect using RGSM using “regular gear” from February 1993 to October 2017. Summing the total RGSM collected by mesohabitat type only for the period March 2002 to 2017 and for the decade 2008 to 2017 showed that total numbers of RGSM collected varied by more than four orders of magnitude across the sampled mesohabitat types. He suggested that limiting the numbers of mesohabitat types sampled to those in the top three classifications having the greatest numbers of RGSM collected (mid-channel shoreline runs and pools plus backwaters, with the possible additions of the next four types with abundant RGSM recorded) might be done without meaningful loss of information, but cautioned that more advanced analyses of these results are needed to refine this conclusion. This summary indicated that hauls with >50 RGSM collected occurred most frequently in mid-channel shoreline pools followed by backwater mesohabitats, with markedly and progressively lower collection numbers occurring for the other mesohabitat types. In contrast, the two mesohabitats having the greatest frequency of hauls lacking RGSM were mid-channel runs and mid-channel shoreline runs.

For the PMWG, **Valdez (2013)** assessed the attributes and uses of the CPUE estimates produced by the PMP under several objectives. He reported that the high level of heterogeneity in the collection data indicated a mismatch between the spatial distribution of sampling units (i.e., seine hauls) and the distribution of RGSM, nothing that RGSM usually occur as large concentrations (i.e., schools) in preferred habitats that are disconnected and uncommon. He stated that the placement of seine hauls proportional to mesohabitat areas misses many of the small, uncommon, but important habitats occupied by RGSM, producing a disproportionately large number of zero catches for sampled mesohabitats, with considerably higher CPUE estimates in certain mesohabitat types. He concluded that there was not sufficient information at that time to develop a reliable, precise, and unbiased monitoring program for the RGSM. Nevertheless, his assessment indicated that the spacing and location of sampling units (i.e., seine hauls) should be congruous with the spatial distribution of the RGSM, which is strongly allied to specific mesohabitat types, especially during September through November when there is least variability abundance. He suggested two alternative PMP designs that would improve monitoring results.

To repeat, Recommendation E3 from **Noon et al. (2017)** suggested evaluating individual mesohabitat types and not combining types for computing mean annual CPUE estimates. Working with the PMWG to specifically address this recommendation, **Valdez (2018)** assessed CPUE estimates calculated for each of the most abundant mesohabitat types with highest fish density to determine whether the trend in abundance of RGSM could be assessed using only one or a few of the mesohabitat types. Only one mesohabitat type, mid-channel pools, yielded a distribution and magnitude of CPUEs not significantly different from that computed using all mesohabitats types, but the sample size was limited, including only 283 seine hauls. By using subsets of the 22 mesohabitat types sampled during 2002-2016, he found sample sizes could be increased while maintaining computed CPUE estimates not significantly different from those currently reported by the PMP using RGSM collections from only the main channel pools and backwaters, but the total numbers of samples (seine hauls) from both of these mesohabitats were less that an order of magnitude fewer than the total in the PMP during the same period. Next, combining the six mesohabitat types with highest CPUEs (five pool types plus backwaters) would produce larger sample sizes, again producing CPUEs not significantly different from those reported by the PMP using all mesohabitat types. Thus, either of these combinations could produce the same CPUEs patterns with 73% and 65% fewer samples, respectively. He noted that unequal samples of backwaters over time or space could inflate CPUEs. Of note, the reduced numbers of samples using only the available pools plus backwaters reduced the precision (i.e., coefficient of variation) of CPUE by about 27% and 19%, respectively for the two estimators of pools only and of pools plus backwaters. However, simulating an equal number of 400 samples per year showed an improved precision of 29% and 34%, respectively, over the simulated CPUEs drawn from all mesohabitats. Additional discussion was presented to address issues related to potential limited occurrence for the six mesohabitat types by sampling site and over years, also an approach was suggested to potentially reduce the numbers seine hauls needed for RGSM at differing densities.

List the Uncertainties:

1. Is the ongoing use of multiple diverse mesohabitat-based sampling for the PMP the most appropriate basis for assessing RGSM population trends in along the MRG? The PMP sampling has used mesohabitat types as a surrogate for depth and velocity where RGSM most commonly are collected. Yet, physical conditions measured for mesohabitats presented by Braun et al. (2015) clearly show considerable overlap in flow and depth measurements among all of the mesohabitat types they assessed. From this, questions may be raised on whether multiple diverse mesohabitat-based sampling as currently employed by the PMP are appropriate or, indeed, are reasonable surrogates for habitat flows and depths apparently favored by RGSM. If the current PMP based on multiple diverse mesohabitat-based sampling do not reasonably, consistently, or agreeably characterize depth and flow (i.e., habitat suitability) most favored by RGSM, what is an appropriate alternative?

2. Is it appropriate, as apparently is the current practice of the PMP, to weight sampling of mesohabitats more toward those frequently characterized as having flow and depth characteristics less suitable for, less favoring RGSM presence, which then would produce biased low CPUE index values for RGSM occurrences?
3. What more assessment is needed for recommendation E3 posed by Noon et al. (2017)? Marcus (2019) and Valdez (2013, 2018) have summarized and assessed the PMP RGSM collection data associated with mesohabitats sampled. Valdez (2018) specifically assessed these data in the manner specified under the E2 recommendation from Noon et al. (2017) and has made recommendation on next steps.
4. Will next step recommendations present in Valdez (2018) be followed? The combination of mesohabitat types (PO/BA/ED; RU/RI/FL) recommended by Valdez (2018) are being implemented by Yackulic (2020) in a RGSM Integrated Model.
5. Can the PMP be modified in a manor to produce potentially more reliable CPUE index values for RGSM population trends, which may also be more cost effective for the MRGESCP?

List the Hypotheses Identified from Literature:

1. Based on the PMP as currently implemented (e.g., Dudley et al. 2020): All mesohabitat types currently sampled and in the proportioned sampled during the PMP are necessary and appropriate for the calculation of CPUE index values to characterize the trends of RGSM population in the MRG.
2. The PMP can be modified to emphasize a subset of the currently defined mesohabitat types to compute CPUE index values to track RGSM trends, while continuing to provide a meaningful relationship and continuity to the long history of data from the RGSM PMP.
3. There is no reasonable method to routinely assess the status (actual population abundance) of RGSM in the MRG.

Management Implication(s) of Hypotheses (if any):

The MRGESCP and its collaborating member will potentially obtain improved data quality on RGSM trends in the MRG and potentially at less cost.

Potential Approaches to Test Hypotheses:

Follow recommendations provided in Valdez (2013, 2018) and then assess results relative to historical RGSM PMP collections.

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Executive Summary

Topic Area Title: Effect of Environmental Cues on Spawning Onset and Activity of Rio Grande Silvery Minnow

Panel Recommendations (Noon et al. 2017):

- B2: Improved assessments of relations between possible environmental cues that trigger spawning activity.
- D2: Establish the proximate trigger(s) for spawning by evaluating the effects of flow velocity, temperature, rate of increase in flow velocity, or some combination of these factors.

Program Goal Relevance:

Understanding the cues that trigger RGSM spawning can lead to possible management actions that can maximize reproductive success and recruitment and eventually lead to population self-sustainability.

Brief Summary of Available Literature:

The Rio Grande silvery minnow (RGSM) is a schooling fish that spawns principally in spring during snow-melt runoff, with altricial larvae hatching in 2−4 days at ~4 mm long (Platania and Altenbach 1998; Dudley and Platania 2007). The species belongs to a reproductive guild of small, broadcast-spawning minnows that evolved in hydrologically variable rivers of western North America, characterized by high spring snow-melt runoff, low summer flow, and periodic high spikes from monsoonal rainstorm events (Krabbenhoft et al. 2014). These minnows maximize their reproductive success by releasing and fertilizing their eggs in the water column in response to rapidly increasing sediment-laden spring flow and water temperature (Cowley et al. 2009). The cues that trigger spawning by RGSM are not well understood, but identifying those cues can lead to possible management actions that maximize reproductive success and recruitment, and eventually to population self-sustainability.

The RGSM has been described as a “pelagic-spawning species” whose non-adhesive semi-buoyant eggs and newly-hatched larvae drift long distances downstream, with a subsequent return of young to upstream natal areas (Dudley and Platania 2007). These presumed upstream migrations remained undocumented, and more recently, the RGSM has otherwise been characterized as “demersal spawning” in low velocity main channel and floodplain habitats (Medley and Shirey 2013), like those of the historical Middle Rio Grande (MRG). Medley and Shirey (2013) examined the characteristics of RGSM eggs and proposed that the species is primarily a demersal floodplain spawner with evolved eggs that are secondarily buoyant in high sediment environments rather than a main channel pelagic, broadcast spawning species with an evolved long-distance downstream drift phase. The evidence that the species is a floodplain spawner is further supported by studies in an outdoor aquaculture facility in which RGSM adults left the stream during hydrological manipulation and entered off-channel, low-velocity habitats where they spawned exclusively (Hutson et al. 2018). This strategy is consistent with the reproductive ecology of other *Hybognathus* species and broadcast-spawning minnows (e.g., Page and Burr 1991; Jenkins and Burkhead 1994; Department of Fisheries and Oceans 2016).

In the contemporary MRG, floodplains have become delinked from the main channel (Molles et al. 1998), and the reproductive phenology of spring broadcast spawners, including the RGSM and two extinct species (i.e., phantom shiner, *Notropis orca*; and Rio Grande bluntnose shiner, *Notropis simus simus*), has been disrupted by the reduced frequency and magnitude of spring floodplain inundation (Turner et al. 2010; Krabbenhoft et al. 2014). The onset of RGSM spawning in the contemporary MRG is not well understood but appears to be driven by a set of complex factors that include season and photoperiod, water temperature, and river discharge (USFWS, 2010). The synergistic effect of increased photoperiod and temperature in spring typically induces oocyte development in temperate fishes (de Vlaming 1975), and appears to lead to gonadal maturation of female RGSM in the wild, but the actual onset of spawning appears to be cued by a hydrological event. Platania and Dudley (2008) reported that spawning by RGSM appeared to be strongly associated with changes in flow and water temperature, where an appearance of eggs occurred shortly after a 200-300 cfs daily increase in river discharge. Moreover, Hutson et al. (2018) determined from an outdoor aquaculture facility that the most important spawning cue for RGSM appeared to be an increase in flow stage. The change in stage may be the increased discharge that leads to floodplain inundation or a flow spike prior to or absent of inundation.

As part of annual egg collection in the MRG, Dudley et al. (2019) used logistic regression modeling of RGSM egg presence-absence data to reveal strong associations with the percentage change in mean daily discharge just prior to egg collection. The probability of collecting eggs (i.e., occurrence), as opposed to egg passage rate, was highest when river flows increased substantially across days. The probability of collecting eggs during a 100% daily increase in flow was 0.80, whereas the probability was 0.97 during a 200% increase in flow. RGSM egg presence-absence data also revealed associations with water temperatures, though not as robust as the discharge relationships. The probability of collecting eggs ranged from 0.51 (temperature = 14°C) to 0.26 (temperature = 26°C). The probability of collecting eggs showed a steady decrease as a function of elevated water temperatures. These findings seem to support the hypothesis that photoperiod and temperature lead to gonadal development, but the act of spawning is cued by increase in river discharge.

The hypothesis that increased river discharge cues the fish to spawn was used during the low water year of 2018 (Lusk and Lang 2018; SWCA 2018) when four temporary increases in discharge were implemented at the Angostura and Isleta diversion dams. Eggs were collected with MECs for transfer to hatcheries and subsequent augmentation of the population. Each 24-hour flow increase (i.e., “jiggle”) was created by holding water behind a dam and releasing it as a spike to cue RGSM to spawn. Local rainstorm-related increases in flow (i.e., “riggle”) also took place. Releases took place at the Isleta Dam on May 8 (increased discharge from 95 to 200 cfs, jiggle) and May 22 (50 to 700 cfs, jiggle + riggle), and at the Angostura Dam on May 15 (500 to 650 cfs, jiggle) and May 29 (400 to 550 cfs, jiggle). In addition, riggles occurred in the Angostura Reach May 21 (500 to 1,200 cfs) and June 3-4 (450 to 900 cfs). The largest numbers of RGSM eggs were collected within 1-2 days after each spike flow, and very few or no eggs were collected before a jiggle or a riggle. The jiggles produced between 201 and 41,750 eggs one day after the release. The largest number of eggs (96,802) were collected two days after the Isleta jiggle + riggle of May 22, which followed the second largest flow change of about 650 cfs. The second largest number of eggs were collected one day (41,750) and two days (16,000) after the Isleta jiggle of June 4. All of the jiggles and riggles produced eggs except for the May 8 Isleta jiggle.

Egg collection studies show the presence or absence of eggs within the 2-4 day incubation period of RGSM. In an attempt to better determine spawning and hatching times, larval RGSM were collected from floodplains of the MRG and the hatching dates of these fish were determined from a temperature growth model (Valdez et al. 2019, In Review) and from daily growth increments of otoliths (Zipper unpublished manuscript; Zipper et al. unpublished manuscript). The normal distribution of estimated hatching dates over a period of about a month indicates that female readiness and spawning are not simultaneous across the population and that different females are at different stages of gonadal maturation and possibly cued by different sequential hydrological events (Valdez et al. 2019). Individual RGSM in laboratory trials have been observed in multiple spawning events of 3–18, with 15–30 min intervals between events (Platania & Altenbach, 1996), but this does not account for the spatial distribution in spawning and hatching dates observed for 2016 (Valdez et al. 2019) and for 2017 (Valdez In review).

The earliest persistent spawning for RGSM in 2017 was April 5 in the Angostura and Isleta reaches; whereas earliest persistent spawning in 2016 was April 16 and April 17, respectively (Valdez et al. 2019). River temperatures at the Alameda Bridge at first spawning for 2016 and 2017 were 12.5°C and 10.6°C, respectively; however, the cumulative temperature degree-days (ACDD above 5ºC) were similar at 692 and 694, respectively. This indicates that river temperature at the time of spawning may vary, but the total thermal regime experienced by the fish continues to accumulate. For the two years of study, ACDD for RGSM for first persistent spawning was about 700, and the bulk of spawning started at about 1,000.

A predictor of spawning time for RGSM is needed to explore hydrological opportunities that will enhance spawning, egg incubation, and larval nursery habitat. As a first approximation of a temperature index, Valdez et al. (2019) computed annual cumulative mean daily river temperature (ACDD) at the Alameda Bridge of 717 and 692 for the start of spawning in the Angostura and Isleta reaches, respectively. No other estimates of ACDDs are available for RGSM spawning, which are among the earliest of spawning cyprinids in the MRG (Krabbenhoft et al. 2014). Comparable estimates of growing season degree-days (synonymous with ACDDs) for the start of spawning by the congeneric brassy minnow (*Hybognathus hankinsoni*) was 671 (April 25) and 741 (April 30) for the fathead minnow (*Pimephales promelas*; Falke et al. 2010). Computed ACDD was 758 (June 1) for the red shiner (Cyprinella lutrensis) and 727 (May 30) for the fathead minnow in the Yampa River, Colorado, based on 1981 spawning dates by Muth and Nesler (1993). These studies show that while dates for onset of spawning vary, ACDDs tend to be about 700 for small-bodied western cyprinids.

The ACDDs derived for RGSM probably reflect photoperiod and temperature accumulation, as well as a hydrological spawning cue; daily increases in discharge of 200–300 cfs occurred in early and middle April, correspondent with the onset of spawning. A more resolute predictor will allow managers to know when the fish are ready to spawn so as to synchronize discharge with spawning and larval hatch, as hydrological conditions allow. A measure of annual cumulative water temperature may be a reliable predictor of spawning onset and peak, but this index will need to be more thoroughly investigated in a laboratory setting with additional data collection in the wild.

List the Uncertainties:

1. Is ACDD a reliable index for onset and peak of RGSM spawning?
2. Are there management options that can be implemented if annual spawning dates can be predicted?

List the Hypotheses Identified from Literature:

1. Female RGSM gonadal maturation is complete with spawning readiness at about 700 ACDDs.
2. Onset of RGSM spawning is cued by increases in river discharge of 200-300 cfs.

3. Female readiness and spawning are not simultaneous across the population and different females are at different stages of gonadal maturation and possibly cued by different sequential hydrological events.

Management Implication(s) of Hypotheses (if any):

1. Management options (flow management and habitat restoration) may be available to enhance spawning, egg incubation, and larval survival if timing of spawning readiness is known in advance.
2. Floodplain habitat can be enhanced to correspond with available annual water volume and river discharge.

Potential Approaches to Test Hypotheses:

1. Conduct laboratory studies to determine ACDD for RGSM.
2. Continue to evaluate relationship of discharge to onset of spawning.
3. Determine is spawning onset differs by reach of the MRG.

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Table 1. List of potential water management scenarios for Utah State University to consider for their RGSM CPUE prediction model. Note: Bureau of Reclamation goals for potential water management scenarios (that are within its discretionary authority) are to seek to maximize sustainable economic development, to seek to avoid the unwise or impactful use of floodplains, and to protect and restore the functions of natural systems. Legal authorities, the Rio Grande Compact, contractual relationships, tribal trust responsibilities and agreements, availability, timing, or other water governance policies may affect the implementation of these potential water management scenarios. [Additional information on some of these or other potential water management scenarios was described by U.S. Army Corps of Engineers et al. 2007, U.S. Army Corps of Engineers 2009; U.S. Bureau of Reclamation 2016; or Audubon 2016)]

Scenario	Water Management Scenario Name	Volume of Water/year	Description of scenario with some constraints listed (cfs = mean daily flow in cubic feet per second)	Guesstimate of costs - this is a rough conjecture of estimated costs
1	Cochiti Lake Deviation	up to 40,000 acre-feet	With approvals, when Rio Grande flows exceed downstream demands during early spring runoff (~April), Corps could temporarily store 5,000 to 40,000 acre-feet of water in Cochiti Lake. That water would likely be released on the descending limb of the runoff hydrograph to create spawning flow or overbanking habitat. All stored water must released by June 15th.	Water temporarily stored at Cochiti Lake would also evaporate or be lost. Some entity would likely have to account for those water losses. Best guess is $100/acre foot. If losses were 1,000 to 3,000 acre feet, then costs could range from $60K to $300K. There would likely be additional staff time costs.
2	Supplemental Water in a DRY year	up to 35,000 acre-feet	Reclamation often leases San Juan-Chama water to support water needs of listed species. Water for lease is based on availability. Reclamation generally uses this acquired water to reduce rate/extent of river drying, but it could also be used to augment spring runoff. In general, about 10,000 to 15,000 ac-ft is available in a single year. In extraordinarily dry years Reclamation has sometimes been able to acquire additional water that could only be used to prevent or reduce river drying.	Only when it is available, San Juan-Chama water can be leased at costs ranging from $60 to $100/acre feet (or more). Leased SJC water can have associated terms, such as its release only during low flow conditions and not during spring runoff, to maintain other water operational needs of the lessor. (Therefore, costs could range from $900K to $3.5M)
3	Supplemental Water in an AVG year	up to 25,000 acre-feet	Reclamation often leases San Juan-Chama water to support water needs of listed species. Water for lease is based on availability. Reclamation generally uses this acquired water to reduce rate/extent of river drying, but it could also be used to augment spring runoff. If this volume of water is available it generally means water has been carried over from the previous year.	Only when it is available, San Juan-Chama water can be leased at costs ranging from $60 to $100/acre feet (or more). Leased SJC water can have associated terms, such as its release only during low flow conditions and not during spring runoff, to maintain other water operational needs of the lessor. (Therefore, costs could range from $900K to $2.5M)
4	Supplemental Water in a WET year	up to 15,000 acre-feet	Reclamation generally uses this acquired water to reduce rate/extent of river drying, but it could also be used to augment spring runoff. Water for lease is based on availability. While more water could be available, less water is necessary. Reclamation often uses this acquired water to reduce rate/extent of river drying or they can augment spring runoff.	Only when it is available, San Juan-Chama water can be leased at costs ranging from $60 to $100/acre feet (or more). Leased SJC water can have associated terms, such as its release only during low flow conditions and not during spring runoff, to maintain other water operational needs of the lessor. (Therefore, costs could range from $900K to $1.5M)
5	El Vado Modification	up to 32,000 acre-feet	In 2016, the RGCC approved El Vado Modification that allowed 32,000 acre-feet held during April & May for release in late May to early June. Releases of temporarily stored water plus other flows cannot exceed channel capacity (< 1,800 cfs) downstream of Abiquiu. RGC Article VII constrains this scenario.	There was a low cost associated with this 2016 scenario. This scenario requires Rio Grande Compact Commission and stakeholder approvals. In 2016, New Mexico addressed these depletions using the Strategic Water Reserve. Some entity would need to account for lost or evaporated water, which was estimated at ~1,000 acre feet. Direct costs could be up to $100K. There would be additional staff costs.
6	Water Pumping Program	up to 10,000 acre-feet	A single pump station can pump as much as 40 cfs (usually from the Low Flow Conveyance Channel to the Rio Grande). Total pumping is capped at 150 cfs per day. Note that in a DRY year, flows in the LFCC tend to allow pumping only from one location.	If the costs of pumping are $60 to $100/acre feet, then costs to pump 5,000 to 10,000 acre feet would range from $300K to $1M.
7	End of Year Water Exchange	up to 20,000 acre-feet	Certain types of water that are not beneficially used during the irrigation season may be released at the end of irrigation season (in November and December). It may be possible to release water at other times, but such water would be subject to diversion, costs, and evaporative loss.	For this type of exchange, there would also be evaporative and conveyance losses (or depletions). If Strategic Water Reserve was not available, then some entity might have to account for such losses. If the losses ranged from 1,000 to 3,000 acre feet, then direct costs would range from $100K to $300K. There would be additional costs for staff. Depending on when this water was released the following year, there could be losses as high as ~1/3 of the water volume due to evaporation, seepage, or possible diversion.
8	Water Banking or Leasing Programs	up to 5,000 acre-feet	To date, no private/cooperative purchase and release of water has exceeded 5,000 acre-feet in a year.	Leased water would range from $60 to $100/acre feet (or more). The costs for permanent purchases of water range from $12K to $15K (and possibly more). But beyond costs, there aren't enough water rights available, transactions and permitting takes years, and run-of-the-river rights do not have a storage component, so they are not available for upstream release. Leased water could cost up to $500K, purchased water could cost up to $75M or more.
9	Abiquiu Reservoir Native Water Storage	likely to range from 20,000 to 75,000 acre-feet	Abiquiu Reservoir is operated as a flood control facility by the Corps. Provided there are storage easements, the reservoir can be used to store San Juan-Chama Project water. This reservoir is also authorized to store Rio Grande water, when storage space is not needed and numerous conditions are met. Corps has additional requirements for holding and releasing Rio Grande water, would need a NM Office of the State Engineer permit, Corps deviation from normal operations, and unanimous concurrence of the Rio Grande Compact Commission.	Costs for this potential water management scenario were estimated as high (~$95M in 1987 dollars - now estimated at ~$216M in 2020 dollars). Ownership of the water stored was unresolved. Circumstances allowing storage of Rio Grande water at Abiquiu Reservoir were considered limiting. Purchase of additional flowage easements in Abiquiu Reservoir was found to not be cost-effective for any potential local sponsors (see USACE et al. 2007 for additional information).

1. U.S. Army Corps of Engineers, Bureau of Reclamation, New Mexico Interstate Stream Commission. 2007. Upper Rio Grande Basin Water Operations Review. Final Environmental Impact Statement. U.S. Army Corps of Engineers, Albuquerque, New Mexico
2. U.S. Army Corps of Engineers. 2009. Final Environmental Assessment for a Temporary Deviation in the Operation of Cochiti Lake and Jemez Canyon Dam, Sandoval County, New Mexico. U.S. Army Corps of Engineers, Albuquerque District, Albuquerque, New Mexico
3. U.S. Bureau of Reclamation. 2016. 2016-2021 Supplement to the Rio Grande Supplemental Water Programmatic Final Environmental Assessment and Finding of No Significant Impact. U.S. Bureau of Reclamation, Albuquerque Area Office, Albuquerque, New Mexico
4. Audubon. 2016. Audubon Announces Historic Water Release to the Middle Rio Grande. National Audubon Society September 07, 2016, Press Release. Accessed online at https://www.audubon.org/news/audubon-announces-historic-water-release-middle-rio-grande

Executive Summary: Consolidation of Mesohabitats for Monitoring RGSM Trends

Noon et al. (2017:25) E3:

- "Calculate revised CPUE values as mesohabitat-specific levels and do not combine across mesohabitat types.
- "The mesohabitat specific CPUE calculated for the most abundant high density mesohabitat type should be used for assessment of trend in abundance of the RGSM population at the October sampling date."

"We propose that the current aggregated (across mesohabitat types) CPUE metric be replaced with a mesohabitat-specific metric calculated for a "high density" mesohabitat type that has substantial availability in all primary sampling reaches. The time-series of this metric should provide a more reliable indicator of trends in October abundance of RGSMs because it assumes only that catchability within this mesohabitat type are constant across years at the time of October sampling. As flows during October are probably low and have relatively little variation across years (relative to other months), we believe that this assumption is a reasonable one."

Program Goal Relevance

Revising the distribution and intensity of sampling across mesohabitat types at the sampling sites used during the Population Monitoring Program (PMP) may

1. Improve the relationship associating computed catch-per-unit-effort (CPUE) index estimates of RGSM population trends
2. Better contribute to estimating RGSM TRENDS in abundance and status in the MRG
3. Enhance the cost-effectiveness of the PMP

How did mesohabitat-based sampling come to be used for the MRG PMP?

1. Recognition that RGSM occurrence in samples occurred along the continuous physical-habitat variables weighted toward slower flows and shallower depths.
2. Due largely to the impossibility of measuring flow and depths prior to sampling without causing fish to scatter, the PMP focused on sampling within discrete mesohabitat categories as flow-depth “surrogates.”

Literature Summary

1. Platania (1993a, b) - early assessments of fish population distributions and RGSM habitat usage along the MRG
2. Dudley and Platania (1996) - in winter the majority (72.3%) of RGSM captured in mesohabitats having instream debris, over small substrata, moderate depths, and low velocity water
3. Dudley and Platania (1997) - monthly sampling July 1994 to June 1996 at two sites (Rio Rancho and Socorro)
    1. RGSM differed in habitat use by size-class based on velocity and depth
    2. **RGSM tended to be most abundant in low-velocity mesohabitats (debris piles, backwaters, and pools) and rarest in high velocity habitats (runs and riffles**)
    3. Greater proportions of RGSM occurred in higher velocity mesohabitats (main and side channel runs) in summer than winter, with the population shifting from pool and backwater habitats in summer to habitats with instream debris piles in winter

Literature Summary

4. USFWS (2010) – Summarized available information in RGSM Recovery Plan: RGSM uses only a small portion of the available habitat
    1. Most often in mesohabitats having low or moderate water velocity (e.g., eddies formed by debris piles, pools, backwaters, and embayments)
    2. Rarely in habitats with high water velocities (e.g., main channel runs, which are often deep and swift)
5. Dudley et al. 2020 - RGSM PMP purpose is to estimate "population trends over time using a density index (i.e., CPUE)." Mesohabitat sampling the has varied over time. The most recent approach is to seine 18-20 discrete mesohabitats (< 1.5 m long [5 ft]).
    1. Runs and shoreline pools (when available) each sampled 4 times at each site
    2. Backwaters, pools, and riffles each sampled 2 times (when available)
    3. Any remaining samples were taken in shoreline runs (to obtain a total of 18 to 20 samples)
    4. Mesohabitats with similar conditions, which did not exceed reasonable depths or velocities for efficient seining, were sampled regardless of flow conditions
    5. [Slower flow habitats sampled ≤ 8x; faster flow habitats sampled ≥ 10-12x]

Literature Summary

6. Braun et al. 2015 - USGS, USACE, and USFWS evaluated the physical habitat characteristics and fish assemblage compositions of available mesohabitats over a range of streamflows at 15 MRG sites during winter 2011–12 and summer 2012
   1. RGSM were weakly associated with sand substrates, relatively moderate velocities, and relatively shallow depths in the winter of 2011–12
   2. RGSM were associated with run mesohabitats, relatively high velocities, sand substrates, and relatively moderate depths in summer 2012
   3. Measured the physical characteristics of mesohabitats in proportion their abundance, with 20 mesohabitats assessed at each site
   4. Measured depths and velocities varied greatly by mesohabitat type, site, and sampling period; based on area-weighting for depths and velocities reported shallower mean depths and slower mean velocities for RGSM during summer when discharges were lower relative winter discharges
   5. Measured depths and velocities for each of the 8 mesohabitat types assessed during each season at each assessed sampling site show considerable overlapping distributions for both flows and depths across all mesohabitat types within each site by season and in total

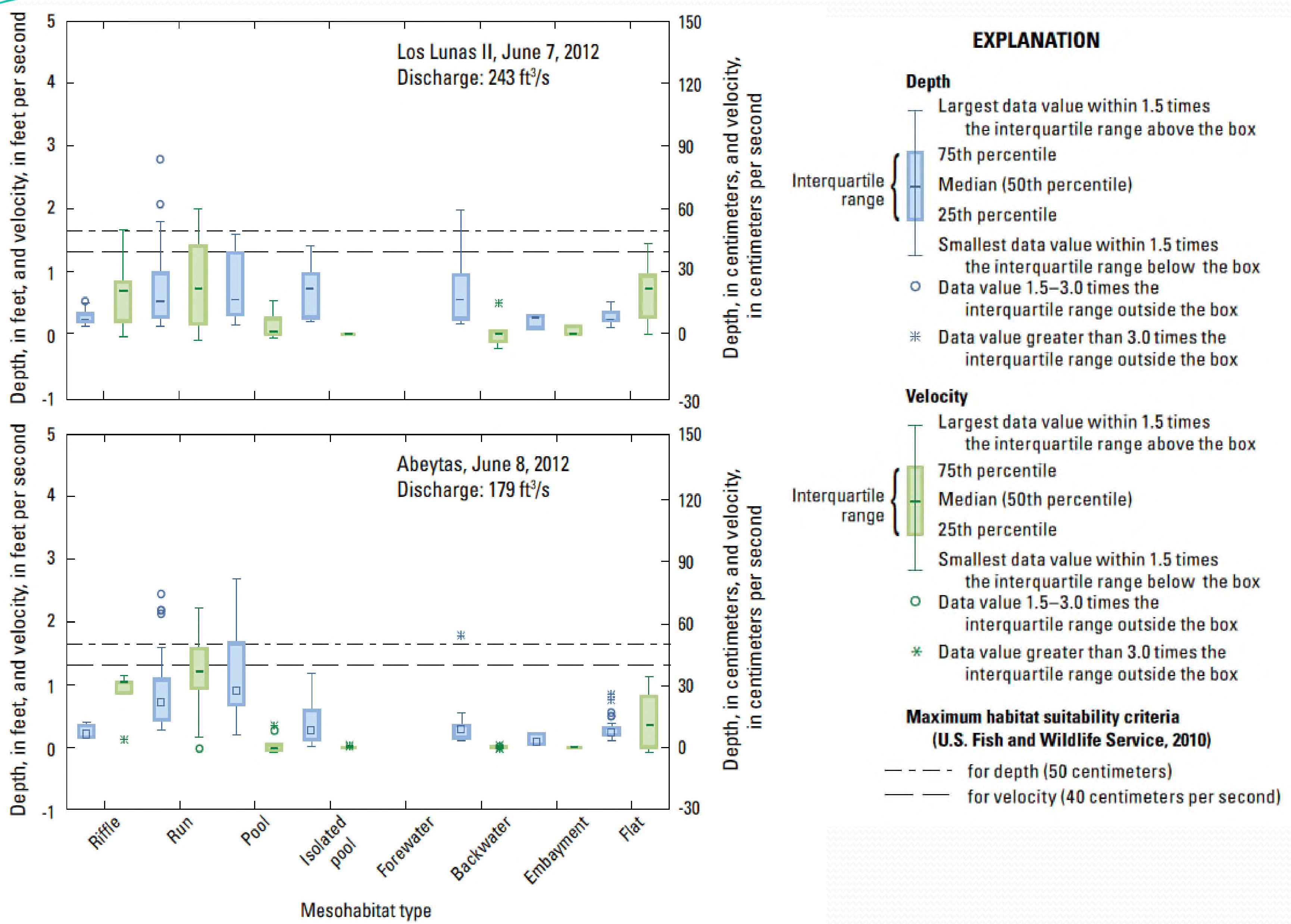
From Braun et al. 2015

Table 2. Description of mesohabitat types (modified from Platania, 1993) and channel features that were mapped on the Middle Rio Grande, New Mexico, 2011–12.

[ft/s, feet per second; ft, feet; NA, not applicable]

Mesohabitat type	Description	Velocity minimum to maximum (ft/s)	Depth minimum to maximum (ft)
Riffle	Relatively shallow and low to moderate velocity feature characterized by moderately turbulent water	-0.05–4.80	0.01–2.58
Run	Relatively high-velocity feature with laminar flow and a nonturbulent surface	-1.05–5.39	0.02–4.31
Pool	Feature with little or no velocity that may be deep in places	-2.14–1.70	0.04–4.40
(a) Channel	Type of pool where current moves in the same flow direction as the channel		
(b) Eddy	Type of pool where current moves in the opposite direction relative to flow		
Isolated pool	Type of pool that is separate from the main channel; frequently a portion of a former backwater or forewater that has become disconnected from a secondary channel	-0.06–0.21	0.01–2.40
Forewater	Slackwater feature oriented into the principal direction of flow	-0.10–0.08	0.01–1.00
Backwater	Slackwater feature oriented in an opposing direction to the principal flow direction	-0.23–2.25	0.01–2.87
Embayment	Slackwater feature located adjacent to the channel and oriented perpendicular to flow	-0.27–1.02	0.03–1.26
Flat	Very shallow, low-velocity feature typically located on the periphery of an existing point or channel bar; caused by a slight rise in stage	-0.62–3.13	0.01–2.4

From Braun et al. 2015

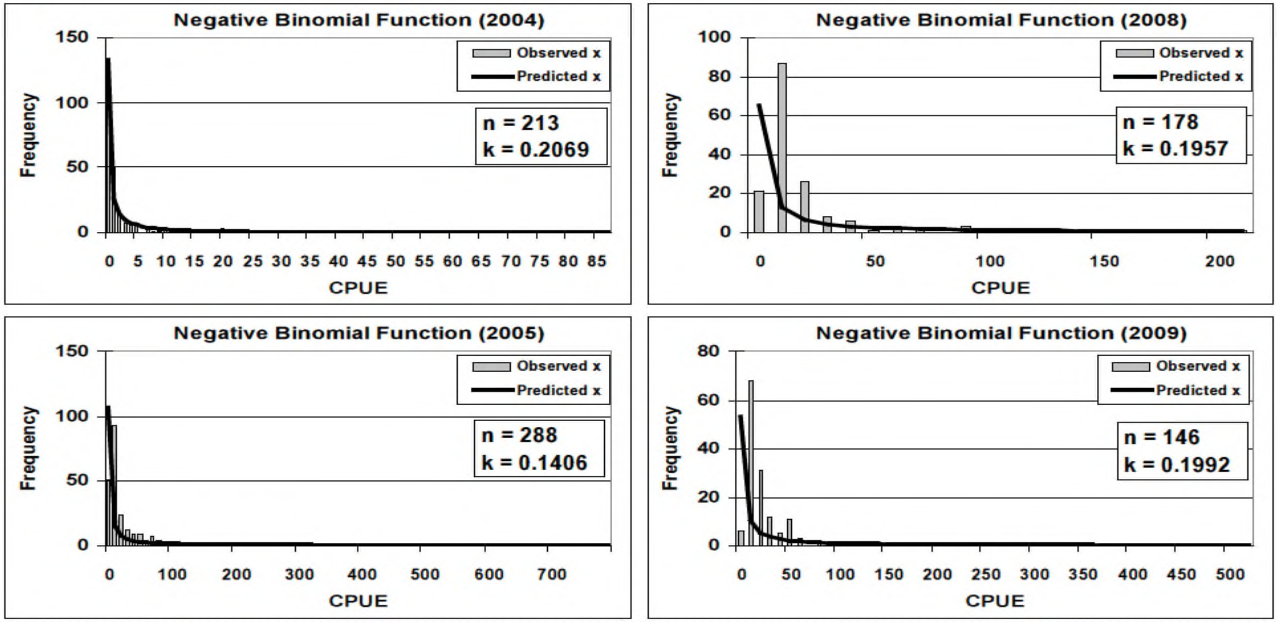


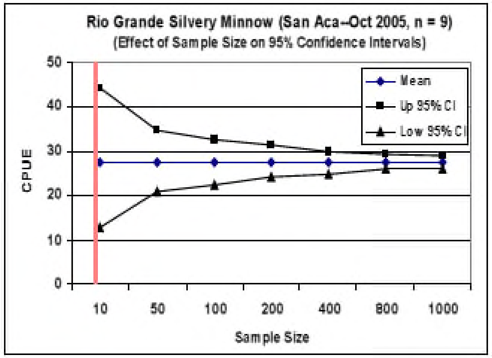
Literature Summary

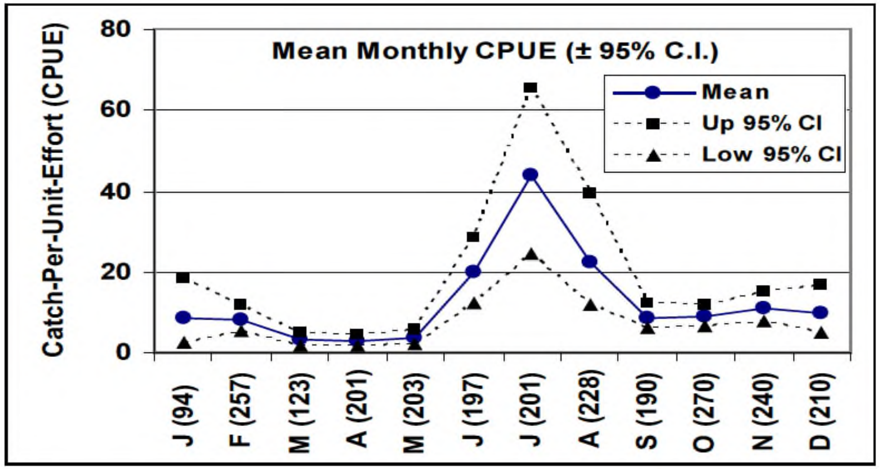
7. Valdez (2013) for the PMWG - Assessed the attributes and uses of the CPUE estimates
   1. High level of heterogeneity in the collection data indicated a mismatch between the spatial distribution of sampling units (i.e., seine hauls) and the distribution of RGSM, which usually occur as large concentrations (i.e., schools) in preferred habitats that are disconnected and uncommon
   2. Placing seine hauls proportional to mesohabitat areas misses many of the small, uncommon, important habitats occupied by RGSM, producing a disproportionately large number of zero catches for sampled mesohabitats, with considerably higher CPUE estimates in certain mesohabitat types (negative binomial distribution, see next slide)
   3. Of 2,414 raw CPUE data points (pooled CPUE from 20 seine hauls per site for 1993-2010), 679 (28%) were 0 (i.e., no RGSM were caught in the sample) and 543 (22%) were 0.1-1.0; hence, 50% of all CPUEs were 1.0 or less.
   4. Samples taken at different times of year can yield dramatically different CPUEs (see next slide).
   5. Precision and variability can be improved by increasing sample size, e.g., increasing sample size from 10 to 50 can improve change detection from about 120% to 50% but the cost of sampling is tripled (see next slide).

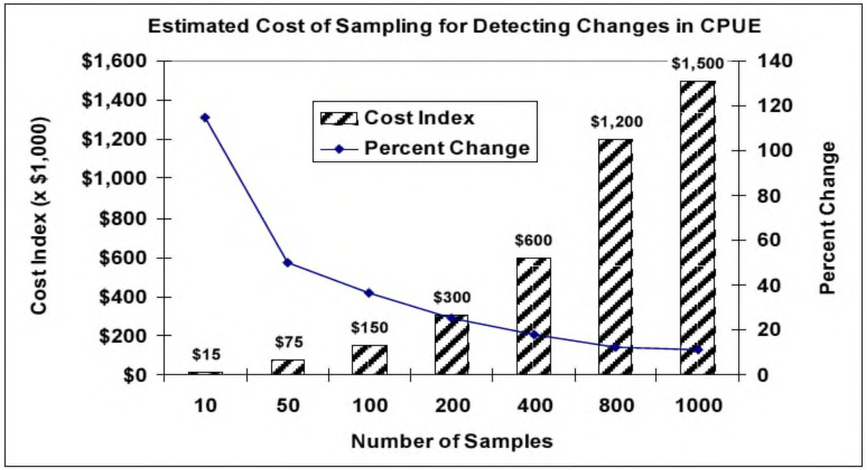
From Valdez (2013)

Figure 24. Negative binomial fit to frequency of pooled CPUE data by year, 1993-2003. Sample size (n) and over-dispersion coefficient (k) are displayed on each graph. CPUE bin sizes may differ by graph.



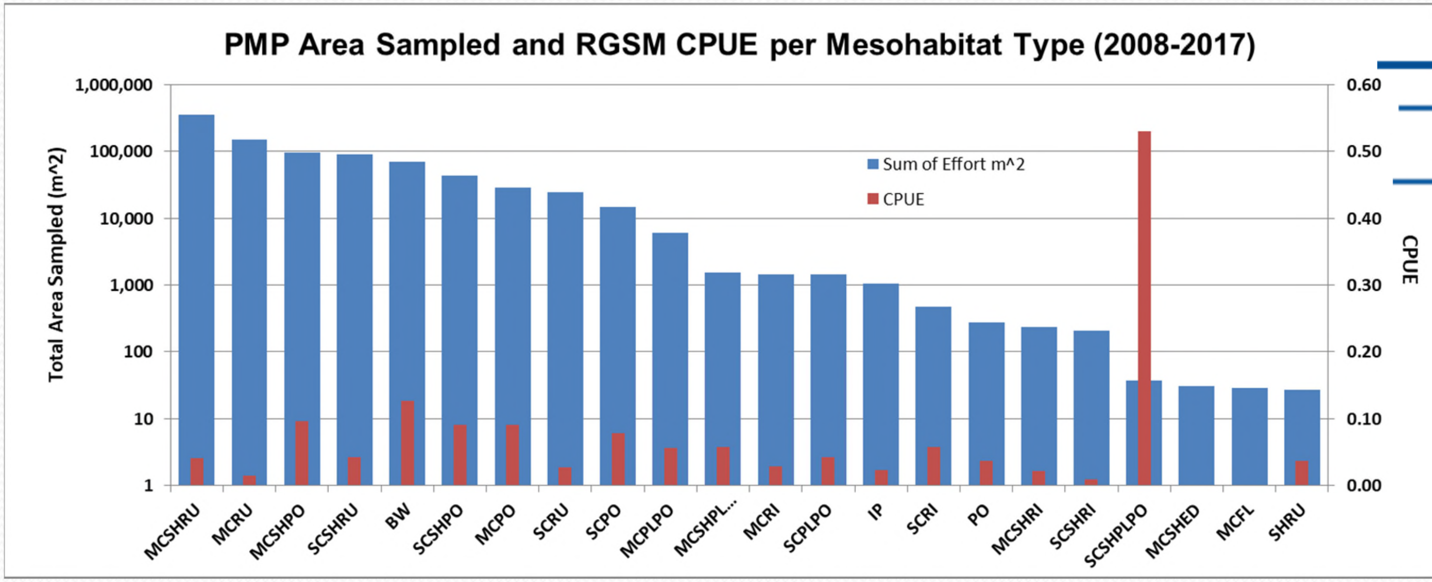


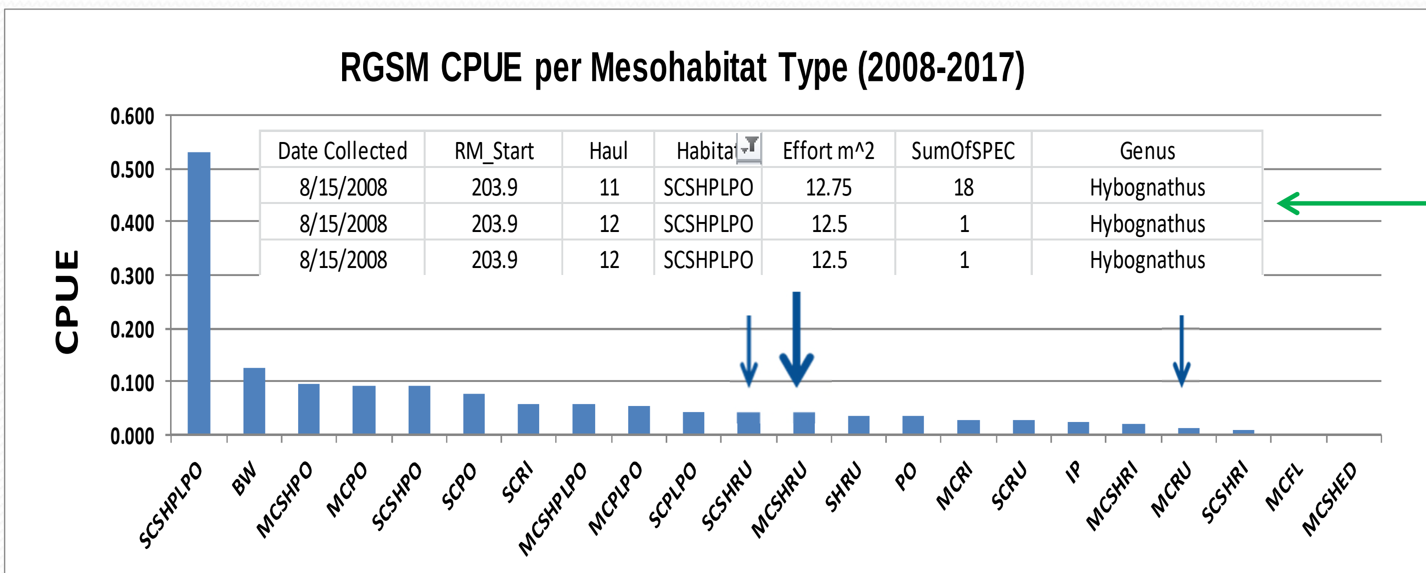




Literature Summary

7. Marcus (2019) for the PMWG - During 2008 to 2017 total numbers of RGSM collected varied by more than four orders of magnitude across the sampled mesohabitat types (data histogram plots, no CPUE calcs)
   1. Suggested that limiting the numbers of mesohabitat types sampled to those in the top three classifications having the greatest numbers of RGSM collected (~~**mid-channel shoreline runs**~~ ~~and~~ pools plus backwaters) might be done without meaningful loss of information
   2. Hauls with >50 RGSM collected occurred most frequently in mid-channel shoreline pools followed by backwater mesohabitats
   3. Two mesohabitats having the greatest frequency of hauls lacking RGSM were mid-channel runs and **mid-channel shoreline runs [?????? See next slide]**





2008-2017

Mesohabitat	Total m^2	%
MCSHRU	352,885	40.0%
MCRU	148,867	16.9%
MCSHPO	97,253	11.0%
SCSHRU	89,421	10.1%
BW	70,046	7.9%
SCSHPO	42,843	4.9%
MCPO	29,096	3.3%
SCRU	24,581	2.8%
SCPO	14,791	1.7%
MCPLPO	6,139	0.7%
MCSHPLPO	1,561	0.2%
MCRI	1,462	0.2%
SCPLPO	1,443	0.2%
IP	1,043	0.1%
SCRI	468	0.1%
PO	276	0.0%
MCSHRI	235	0.0%
SCSHRI	208	0.0%
SCSHPLPO	38	0.0%
MCSHED	31	0.0%
MCFL	29	0.0%
SHRU	27	0.0%
	882,741	

The 3 run habitats comprised 67% of area sampled.

Literature Summary

9. Valdez (2018) for the PMWG - specifically addressed Noon et al. (2017) E3, assessed CPUE estimates calculated for each of the most abundant mesohabitat types with highest fish density to determine whether the trend in abundance of RGSM could be assessed using only one or a few of the mesohabitat types
    1. Using one mesohabitat type only, mid-channel pools, yields a distribution and magnitude of CPUEs not significantly different from that computed using all mesohabitats types using a limited sample size (283 seine hauls)
    2. Sample sizes could be increased while maintaining computed CPUE estimates not significantly different from those reported by the PMP using only the main channel pools and backwaters; the total numbers of samples were less that an order of magnitude fewer than the total in the PMP
    3. Combining the six mesohabitat types with highest CPUEs (five pool types plus backwaters) produced larger sample sizes, again with CPUEs not significantly different from those reported by the PMP for all mesohabitat types, using 65% fewer samples
    4. Recommendation were suggested to potentially reduce the numbers seine hauls needed for RGSM at differing densities.

Hypotheses from Peer Review

What more does the PMWG need to do to address Noon et al. 's E3 on page 17:

"E3. Currently Calculated Catch-Per-Unit-Effort Values Cannot Provide a Valid Index of Rio Grande Silvery Minnow Population **Abundance**

1. "We show that the currently calculated CPUE metric can provide a valid index of abundance only under the untenable assumption that **catchability** (proportion of fish captured compared to fish subjected to sampling gear) is identical across all mesohabitat types.
2. "Also, the **fraction mesohabitat area** within primary sampling units (reaches) that are sampled is not constant across sampling units, further complicating aggregation of CPUE (see Hubert et al. 2016).
3. "Mesohabitat-specific CPUE values, however, appear to have similar temporal trends across mesohabitat types (at least on a log scale: see Figure 11 in Dudley et al. 2016b), implying that CPUE for a specific **[one] mesohabitat type** (e.g., one with generally high density) should provide a reasonably valid index of total population size."

Other Sections-Does the outline work?

[Facts Agreed to (“Settled Science” or What do we know?)]

[“Alternative Facts”]

List the Uncertainties (“Unsettled Science”)

List the Hypotheses Identified from Literature (versus from the Peer Review)

Management Implication(s) [of Hypotheses—Needed?]

Potential Approaches to Test Hypotheses (TMI for EC?)