PVA Biology Work Group Meeting

December 6-7, 2010;
AAO, U.S. Bureau of Reclamation
555 Broadway Blvd. NE, Albuquerque, NM 87102

MEETING SUMMARY

Action Items:

- David Gensler will attend the PHVA meeting on Wednesday, December 8th to help communicate the PVA data needs to PHVA.
- Phil Miller will review the URGWOM outputs already provided to attempt to determine how the results could be/will be used in a stochastic PVA model.
- Dan Goodman will post a copy of his model presentation from the December 6th PVA meeting to his website.
- Thomas Archdeacon will share the request for augmentation data with Jason Remshardt.
- Stacey Kopitsch will make the suggested changes to the 2010 PVA Accomplishments and the 2011 PVA work plan and will distribute the revised versions for review.
- Rich Valdez will review the salvage work report and will write up a first draft of suggested/requested modifications to the salvage protocol that might provide additional data useful to PVA modeling efforts.
- Rich Valdez will write a first draft project description/activity summary for the 3-level habitat inventory project.
- Peter Wilkinson, Mickey Porter, Rich Valdez, Rick Billings, and a Service representative will be involved in the development/review of the 3-level habitat inventory activity description for discussion at the January 2011 meeting.
- The December 14th Joint ScW/HR/MPT meeting agenda will be distributed to all Program work group and committee members.
- Dr. Goodman offered to post-process the approximate drying from the inflow for each subreach once the information has been provided to him (instead of the URGWOM tech team having to do the post-processing work). *Note: It is unknown if the PHVA/URGWOM The Team agreed to this offer.*
- David Gensler volunteered to draft a document to the PHVA with guidance from Dr. Miller and Dr. Goodman stating concerns about observed climate cycle data and URGWOM model run length.
- The next PVA meeting is planned for January 25th and 26th 2011. Terina Perez will verify that PHVA is able to attend the meeting.
- Dave Gensler, with assistance from Dr. Goodman and Dr. Miller, volunteered to draft a document expressing concerns regarding the PVA models relationship with adaptive management. *Note: Prior to going to the EC, this draft should be vetted through the PVA work group and the CC.*
- Jeanne Dye will be working with Dan Goodman to verify that all the Genetics raw data have been received.

Announcements:

- There is a Joint Work Group meeting comprised of Science, Habitat Restoration, and the Monitoring Plan Team work groups scheduled for December 14th. The agenda will include discussions on the high intensity monitoring portion of the 2-year habitat restoration Effectiveness Monitoring program.
- The Service calleda meeting in January to try to gather information on why the minnow population decreased by 10-fold this year (compared to last year) and to explore any possible linkages or reasons. People with any collected data, especially from this past year, that could be used to explore the issue are invited – mostly biologists and hydrologists. There is typically a drop in population sampled from July to August but nothing on this order of magnitude. There is concern on why the change this year.
- Section 7 training has been scheduled for December 15th.
- There is now a login required to access Dr. Goodman's website:
  - ID: msuesg
  - Password: occult

Decisions:
- The August 26th 2010 PVA work group notes were approved for finalization with no changes.

Recommendations:
- It was suggested that the URGWOM model run a "Middle Valley Run" with the purpose of getting predicted numbers at certain points in the valley for comparison purposes (ex. against CPUE plotted against flow) and to maybe provide calculated values to help address some of the outliers (ex. San Marcial). It might prove valuable for comparison of some of the "odd" results or outliers in the CPUE data.
- It was suggested the PVA work group revisit past work/studies/reports that have already been done on (1) the mesohabitat (~5 years ago) and (2) minnow food study (a few years ago) – to review what has been done and provide a potential start point for refinements instead of duplicating work.
- Increased communication and involvement between all the Program work groups was strongly encouraged. Especially considering the Program is in the development stage for several very important plans (Long-term Plan, Adaptive Management Plan, system monitoring plan, etc.) and the current consultation process, there is need for effective, open, integrated communications to inform all stages and levels.
- It was suggested that another PVA/Section 7 consultation team meeting be scheduled to help settle some of the uncertainty. PVA members were encouraged to attend the December 15th Section 7 training as a starting point before any additional meetings are arranged. There will be an analytical portion on the method and a lot of questions and good exchanges are expected.

Future Discussion/Needs:
- More specific augmentation data – the hatchery release data provided did not specify the origin of the fish released (first generation hatchery, second generation hatchery, wild eggs, etc)

Meeting Summary:

DAY 1: December 6; 8:30 – 4:40
- Dave Campbell brought the meeting to order and introductions were made. The agenda was reviewed and approved with a reordering in agenda items: (1) both model presentations will occur before lunch; (2) the PHVA discussions were delayed until after lunch; and (3) regular work group business will occur tomorrow. Attendees were reminded that there are 2 very different models with different data inputs and outputs and will likely provide different results. Part of today's purpose was to offer the opportunity to provide feedback on the baseline models to date.
- Phil Miller then presented on the baseline RAMAS model data input as of December 2010. Dr. Miller shared the thoughts and philosophies behind his approach. He reminded attendees that this is a highly uncertainty system especially with the lack of long-term data. Dr. Miller's intent is to use the types of information available to the best of his ability to look at overall population trends and to create a model with underlining demographic data that mimics the population trends from 1993 to 2010 (in terms of overall population abundance). The model will mimic the types of biological variability seen. In some cases, a known "end point" will have to be used to "back fill" areas of unknowns in order to create a simulated population that shows the same trends observed in monitoring.
    - Attendees were also reminded that a particular level of accuracy should not be ascribed to any PVA output but the value is in comparisons across outputs. Comparative statements about particular management options and predicted population response compared to the baseline model in the absence of that management.
    - As of the December 6th meeting, the baseline RAMAS model that is to serve as the baseline for all upcoming analysis includes 5 age classes instead of the original 2 age classes. The reason for the increase is age classes is based on the modal progression analysis that Rich Valdez has presented previously and the estimation that some much older individuals may exist than even seen in the collected data.
    - Dr. Miller then walked the group through the details of determining maternity, survivorship, and fecundity parameters for the age classes. The total abundance in the age class will be determined based on the

survivability. Fecundity is the aggregate of the maternity (M x S_0) and the survivorship from 0 to 12 months. Fecundity and survivorship values will be assigned for each of the 5 age classes.

- Using Rich Valdez's analysis, the monthly survivorship for Age 1 fish, and assuming constant survivorship from 12 to 24 months, the annual survivorship is about 3%. In the absence of other data, it is assumed this percentage will be the same for all age classes.
- Dr. Miller and attendees also discussed other parameters in the RAMAS modeling including the reach-specific carrying capacity (K), reach-specific population size, environmental variability, density dependence, spring flow, augmentation, and dispersal.
- At the conclusion of his model presentation, Dr. Miller discussed the data limitations and PVA model uncertainty and future discussions/guidance needed. There needs to be continued discussion and fine tuning of (1) the issues regarding K; (2) the types of density dependence at high/low populations, including whether Beverton-Holt is appropriate given potential for significant effect on modeling at low minnow densities; (3) floodplain inundation and spawning – which are not currently part of the model; (4) greater depth of information and realism for the habitat requirements – relates to the floodplain inundation, spawning, and habitat carrying capacity; (5) how to implement density dependence; (6) issues on downstream movement of individuals; (7) and the accuracy of reach-specific abundances and survivorship (or fecundity) values. There is a small window of opportunity in which the model can be refined before it has to be "set" in order to provide preliminary output by the March 2011 deadline.

- Dr. Goodman then began his presentation on the *Parameter Estimation Strategy for the PVA: 1. Deterministic Dynamics and Environmental Covariates.* He clarified that the discussion will be on parameter strategy and not the parameters themselves. The focus is currently on the "deterministic dynamics" how these variables affect the parameters in the PVA. There will probably be subsequent documents covering other pieces.
  - Dr. Goodman opened with a history on PVA models and explained their development with a very narrow subset of applications in mind. The original application was for long lived, slow reproducing, and late maturing species which is different than the extremely volatile dynamics of the silvery minnow.
  - Dr. Goodman cautioned that with only 20 years of data, different aspects will have to be examined and modeled in different ways in order to get appropriate answers for this species. The trend observed over the past 18 years is a "coincidence" of that year's situation and conditions - and doesn't tell us much about the long-term prospects of the species.
  - Dr. Goodman then began recruitment review and discussions and provided a quick background on ASIR's quarterly monitoring and CPUE information. Using graphs and regressions of ASIR's data "repackaged", Dr. Goodman illustrated how the various comparisons could be used to extrapolate many values including estimates of how many parents will be available for the next spawn, their production, and the survival of the young. With the exception of 1995 (which had an unusually long runoff period) and 2005, the remaining yearly data fit remarkably well into the regressions (ranging from 50% to 80+%). These relationships consistently hold for the entirety of the summer and fall of that year – indicating they can be used to estimate the spawning and survival rate for that particular year. It is also interesting to note that the "die" is cast early in the year for survival that year.
    - There is a threshold graphically observed between 1,000 and 2,000 cfs where the system appears to not be responding to the flow. One hypothesis shared was that at this low level of flow there isn't enough overbanking to create riparian spawning so there is only main stem spawning; above that threshold (2,000+ cfs) there is more overbanking resulting in spawning proportional to the flow.
    - All the metrics of the hydrograph are strongly correlated within a given year making it difficult to decouple which details are the most important. However, the May mean flow at the Albuquerque gage is strongly correlated to everything else in the system – including survivorship and recruitment and even drying. The early spring runoff is setting the stage for the rest of the year.
    - Breaking the correlation down by reach and using a graph of August interpolated recruits as function of May mean flow, indicates that there is still a linear response to flow – which if taken as the hypothetical measure of overbanking - is much more responsive in the San Acacia reach.
    - With the exception of the threshold effect in the spring, there is no systematic relationship between flow and the number of offspring per parent (per capita or number of recruits per spawner). One interpretation is that the density dependence is strong where flow creates spawning habitat independent of the number of parents that were there. This means there should always be enough

parents in any year with the ability to seek out the spawning habitat when accessible and can saturate (to the carrying capacity) the spawning habitat with enough young.

- Dr. Goodman then presented on survival. A given year's cohort (starting on August 1) can be used as a predictor for survival – if there is a small number of recruits in August, then survival is on the high end (up to 80+ or 90+% in years when density is vanishingly small). When crowding occurs, the survival declines and floors out at about 0.05.
  - The crowding effect is much stronger for Angostura and Isleta compared to San Acacia – San Acacia appears to a "garden of Eden" and looks like it has more spawning habitat for the given amount of flow and better summer/early fall rearing survival habitat. This suggests that the San Acacia reach is the place to be looking for the conditions to duplicate elsewhere to benefit the minnow.
- Dr. Goodman then began presenting mathematical support and formulas for his work. He modified the Beverton-Holt equation by replacing β with the reciprocal of saturation to make the saturation level stand out. He further manipulated the equation to highlight the role of flow and the flow relationships. These algebraic changes to the equation mean that all the coefficient values including flow can be taken right from the regression in the plots (which are quarterly monitoring data). The only parameter that then needs to be estimated is α. The ability to resolve alpha is not very good but it can be bound and will have a range.

- Members of the URGWOM tech team joined the PVA meeting after lunch to provide updates on the progress and current status of the URGWOM model. The PHVA work group is rerunning the pre-ESA management scenario which represents a "no tool" run to see what the river might look like with no species management actions in place. They are also running a 2003 BiOp run with tools included. The model updates are considered complete at this time. The current model runs will be reviewed at the PHVA meeting on Wednesday. It is assumed that the results will be available very soon. The tech team did receive the information request for model outputs converted into ASCII format and will be providing that information.
  - It was shared that the only way to achieve a 50-year sequence will be to string together 5 10-year sequences – the sequences can be shuffled randomly (10 year wet sequence followed by a 10 year dry sequence etc.) but the order of the years within those 10-year blocks cannot be changed. The probability associated with the sequencing would be lost. The ending conditions from one 10-year sequence block would be used to set the initial conditions for the next 10-year sequence block.
  - Attendees briefly discussed the issues of the literature indications from paleo-data that there is a 20-year oscillation and the problem associated with repeating 30 years of data (1975 to 2005) to generate a 50-year sequence.
- The work group then briefly revisited Dr. Goodman's equations before addressing the regular work group business portion of the agenda. All the August action items were completed as assigned. The work group approved the August PVA notes for finalization with no changes. Attendees then reviewed the PVA work group 2010 Accomplishments and the 2011 PVA work plan - minor suggested changes will be incorporated and redistributed.
  - Attendees also discussed how to begin addressing several of the identified PVA data needs and outstanding questions. Scopes of work would have to be written for any new projects and then elevated to the Science work group to put forth. It was suggested that maybe additional "tasks" could be added to existing projects/contracts that could help refine the information on the relationship between habitat and population. There may be additions that the PVA work group can request to the salvage protocol to capture data useful to PVA efforts. Also, a specific 3-level "habitat inventory" project was discussed. In this proposed work, the entirety of the river system would be looked at the (1) macro-habitat level - river channel configuration, side channels, floodplain habitat, etc; then the (2) meso-habitat level - runs, ripples, pools, backwaters, etc.; and then (3) the micro-habitat level (depth, velocity, temperature, etc.).
- The work group then discussed the Service's "talking points" shared at the November 18th EC meeting and the potential for changes to the PVA or URGWOM schedules. The official letters where sent to Reclamation and the Corps on November 30th. As far as is known, neither action agency has had time to "digest" the letters and hold the necessary internal conversations; and no decisions have been made in response. The Service still hopes to have the PVA's available for use in preparation of the BA/BO. Concerns were expressed with the preference for a front-loaded BA but until the PVA process is complete there won't be information on what management scenarios will offer the best for the species. Additionally, a concern was expressed that it appears a front-loaded BA would negate the value of the PVA and adaptive management to a large extent. The action agencies have to make decisions about what to analyze and what to include in the BA.

DAY 2: December 7; 8:30 – 12:00

- Dave Gensler brought the meeting order. No changes were made to the agenda.
- **Dan Goodman - Observations of climate cycle and potential effect on length of PVA scenarios**
  - Meeting attendees discussed observations of a 20-year climate cycle and the implications this may have on PHVA/PVA integration. It was said that the length of URGWOM model runs should be extended so that they are long enough to take "paleo" and observed climate cycle data from publications into consideration. It was pointed out that though PHVA will not be giving 50-year runs they will be giving "back-to-back" 10-year model runs. There was concern that "tacking" together 10-year URWGOM model runs to make a longer cycle may or may not recapitulate reality. The thought process of putting these strings of 10-year sequences together should include consideration of the longer term wet and dry cycles that have emerged from "paleo" data. One opinion was that not extending the URGWOM model runs would create vulnerability to litigation.
  - The question was posed of whether or not the need for the inclusion of observed climate cycle data in the PVA models warrants further discussions with the PHVA. Both Dr. Miller and Dr. Goodman were in agreement that it would be worthwhile to send a brief document to PHVA stating the concern and querying them on the degree to which they are taking observed climate cycle data into consideration and what it would take to include observed climate cycle data to the level that is satisfactory for the PVA models. David Gensler volunteered to draft a document to the PHVA with guidance from Dr. Miller and Dr. Goodman. *(NOTE: The CC has since clarified that all work group documents and anything for EC review has to first go through the CC).*
  - Attendees also discussed the possibility of looking at Jesse Roach's monthly time step model as a viable option to either add on to or replace the URGWOM modeling in order to extend the sequences. Though Jesse's model is faster and can produce larger sequences than URGWOM it can't predict daily drying and unlike URWGOM it does not have an operational decision tree built into it.
  - Meeting attendees discussed having a meeting with PHVA and Jesse Roach to further address issues with model run length and the inclusion of observed climate cycle data. The next PVA meeting is planned for January 25th and 26th 2011. Terina Perez will verify that PHVA is able to attend the meeting. The March "model debut" meeting was planned to coincide with the March 2011 EC meeting so that the models can be presented to the EC. PVA will meet March 17th with the possibility of the meeting extending to March 18th as well.
- **Discussion on new Adaptive Management Plan, and how it may or may not mesh with PVA models**
  - There were questions of what the adaptive management plan would be like and how it would utilize the PVAs. There was concern that ESSA (the adaptive management contractor) has not explained the kinds of decisions and actions that will be a part of the Adaptive Management Plan. The Service would hope that the Adaptive Management Plan would use concepts described in the Department of the Interior (DOI) Adaptive Management Handbook found on the DOI website. The view that several attendees had from the Kickoff Meeting and agency interview sessions with ESSA was that the PVAs might not be incorporated as a part of the Adaptive Management Plan. Some meeting attendees expressed a need for the PVA work group to develop a document to voice concerns of the relationship of the PVAs with adaptive management for the February 2011 EC meeting. Dave Gensler volunteered to draft a document with assistance from Dr. Goodman and Dr. Miller. Prior to going to the Executive Committee, this document should be vetted through the PVA work group and the Coordination Committee. Dr. Goodman shared that there is a Walters and Hilborn 1976 publication defining adaptive management. Several meeting attendees expressed interest in viewing this publication. Dr. Goodman volunteered to give a presentation on adaptive management as published by Walters and Hilborn.
- **Update on pending data needs, recommendations from Phil/Dan on any information still required to have functional PVA models prepared by March 2011.**
  - Dr. Goodman shared 2 data needs: (1) the updated Service data that Jason Remshardt is working on is needed for his model in preparation for the March 2011 PVA model debut, and (2) the Genetics raw data. Thomas Archdeacon has asked Jason for the data and it is expected that Jason will have it. Conclusions in the Genetics Report indicate that there may be more raw data than Reclamation has received. Jeanne Dye will be working with Dan Goodman to verify that all the Genetics raw data has been received.

Set date for next meeting, March 2011 PVA Model debut

- January 25th and 26th 2011 (tentative – pending coordination with PHVA work group)
    - Primary goal is to meet with PHVA to get a final understanding and possibly a decision on a process for how the PVA and URGWOM models can be integrated.
    - A presentation on Adaptive Management from Dan Goodman.
- March 17th 2011, possibly March 18th as well
    - PVA Models debut preliminary outputs

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DAY 1: December 6; 8:30 – 4:30

- **Introductions/Review agenda**: Dave Campbell brought the meeting to order and introductions were made. The agenda was reviewed and approved with a reordering in agenda items: (1) both model presentations will occur before lunch; and (2) the PHVA discussions were delayed until after lunch. Attendees were reminded that there are 2 very different models with different data inputs and outputs and will likely provide different results. Part of today's purpose is to offer the opportunity to provide feedback on the model parameters to date.
- **Phil Miller - Presentation of draft PVA model data parameters**:
  - Phil Miller presented on the baseline RAMAS model data input as of December 2010. Dr. Miller shared the thoughts and philosophies behind his approach. This presentation is an update on the current baseline model parameterization. The questions and discussions will be used to determine what needs to be done between now and March, when the final initial set of PVA models is due. Dr. Miller will explain the thoughts and philosophies behind the RAMAS parameterization approach.
  - *General Approach to Population Analysis*: Considerable uncertainty across the entire hydrological and biological system makes detailed interpretation of available data a risky proposition. We are working with a highly uncertain system. This species and the types of data collection make this system even more highly uncertain in terms of life history. The inherent instability in the biological system makes accurate determination of demographic parameters for PVA modeling difficult. The type of data collection methods employed for the minnow haven't been designed with that particular end point in mind – we have to try to make decisions about the Catch Per Unit Effort (CPUE) in order to make inferences about age specific rates. Dr. Miller explained that he is using the types of information available to explore long-term population trends and abundance. The intent is to use the overall population trends to create a model with underlining demographic data that mimics the trends observed from 1993 to 2010 and mimics the types of biological variability seen. There are areas that will have to be "back filled" using known end points in order to create a simulated population that shows the same trends observed in monitoring.
    - Dr. Miller emphasized the importance of the comparative framework within the modeling scenarios and with output interpretation. PVA members were reminded to not ascribe a particular level of accuracy to any particular PVA output – it is more robust to make comparative statements about managing system in a particular way to see the change in population compared to the baseline model in the absence of the management.
    - In deriving the demographic data for a baseline population model, Dr. Miller is working toward creating a demographic data set that when projected through time show results similar to the monitoring data set that is creating the CPUE data.
    - Due to the uncertainties, there is greater utility in the CPUE dataset as a mechanism for looking at overall population trends and abundance instead of trying to determine fecundity and survivorship.
  - *General Minnow Demographic Structure:* As of today, the baseline RAMAS model that is to serve as the baseline for all upcoming analysis will include 5 age classes based on the work that Rich Valdez has presented. There is analysis indicating there may exist some much older individuals than are even seen in the collected data. Place-holders for the multiple age classes have thus been added to the model platform even though there may only be a small number of older fish. The total abundance in the age class will be determined based on the survivability. There will be maternity, survivability, and fecundity values for all age classes. Fecundity is the aggregate of the maternity ($M \times S_0$) and the survivorship from 0 to 12 months.
  - *Maternity of the RGSM:* Modal progression analysis conducted by Rich Valdez using data from analyses by Platania and Altenbach that explored the linear relationship between length and age was use to derive anticipated maternity estimates for older fish. The age classes are defined on the length cut-offs. Remember there is an assumption that there is a linear relationship between size and age that extends beyond the first 2 age classes and holds for the older age classes. Attendees were reminded that the RAMAS model is female only.

- It was commented that the while Platania et. al. assume the relationship to be linear, it could actually be assumed to be asymptotic based on the range in this particular species. This assumption could be amended in the future depending on the consensus of this group.
- The RAMAS model is not a size-specific model but an age specific model, so the maternity (number of eggs produced per female) is based on age. An individual fish that survives through the age class structure to be age class 4 will have an assigned maternity based on that age class.

- *Fecundity:* In order to derive the fecundity, we need the survivorship of individuals within the first 12 months. Different data sources have to be combined to attain a reasonable estimate of survivorship – such as data from post-augmentation monitoring studies from 2004 and 2005, and other earlier data. In comparison, Dr. Goodman is looking at quarterly survivorship and CPUE between quarters to make inferences about survivorship. The modal progression analysis conducted by Rich Valdez is used for the older age classes. The calculated monthly survivorship values of about 66% can use to calculate an annual survivorship by projecting out through the year. Remember that there is a lack of information on survivorship for the first 45-day interval. Dr. Miller took the direct database extension of survivorship and multiplied by the survivorship of the 45 days rate discussed (and agreed to earlier) to provide a fecundity value that produces a demographic response similar to what has been observed. This is an example of the estimated values or "back fill" needed to provide the missing information.

- *Survivorship of RGSM (graphs):* Dr. Miller presented several graphs of CPUE plotted as function of quarters. It is assumed that the differences in CPUE among quarters are largely due to survivorship; the slope of the regression can be used to estimate the quarterly survivorship values. Survivorship of 3 of 4 quarters can be estimated with reasonable accuracy; but in the maximum flow and spawning period it is difficult to collect data with the same degree of robustness. Similar to the 45-day survivorship estimate, we have to estimate the survivorship that produces a demographic dataset consistent with observed data in order to calculate fecundity. Thus, it is then possible to calculate age-specific female-only fecundity for the identified age classes.
  - Survival values for the older age classes were derived from the Modal Progression Analysis of Valdez (2010) and assuming constant survivorship from 12 to 24 month fish, the annual survivorship is about 3%. In the absence of other data, it is assumed this will be the same for all age classes.

- *Environmental Variability in RGSM demography*: Dr. Miller is building a stochastic model where there is variability in the annual rates of fecundity and survivorship due to environmental variables (assuming the absence of specific human intervention). There needs to be a description of some type of statistical distribution to represent the biological variability in the system by both intrinsic and extrinsic changes. The distribution is described in log-normal - so instead of a bell-shaped symmetry, there will be an asymmetrical tail that will tapper off to the larger survivorship values. The environmental variability (EV) is the standard deviation divided by the mean. Given the uncertainty and measurement error (in catch rates, etc.), the ability to tease apart the variation is extremely difficult and possibly statistically indefensible. For the initial model runs, Dr. Miller developed annual variability that mimics what has been seen in the last 15 years of data collection. This is another example where the information cannot be responsibly derived from the data so it has to be "back filled" again. The coefficient of variation has waffled between 0.4 and 0.5 over the months. The 0.5 value is 50% of the mean of the stand deviation in the demographic rates for F and S. This is a lot of variation - which is fine since there is a lot of variation observed in the system and with management.

- *Reach-specific population size*: The minnow population has to be "seeded" with some population abundance; or a relative abundance index. The risk of extinction can be determined whether there is a true abundance or an abundance index. CPUE is most appropriately used to determine long-term trends instead of actual population quantity at any point in time. There is some question about the accuracy of the population estimates being developed. Using the reach-specific population estimate data from Rob Dudley in 2009, the reach-specific populations are:
  - Angostura: $N2009 = 1{,}048{,}598$; Isleta: $N2007 = 1{,}602{,}348$; and San Acacia: $N2007 = 923{,}352$

- *Reach-specific carrying capacity*: In this approach, a parameter that describes the carrying capacity (K) for the purpose of density dependence estimation should be included in the RAMAS model. K is difficult to estimate. In an initial "stab" at calculating a long-term K, assuming it remains constant over time (although maybe future management scenarios might have changes in K over time), the population estimators were combined with estimates of CPUE to arrive at estimates of how big the population is now and estimates of how big the

population could get based on past CPUE. Assuming a gross correlation between CPUE and an index of abundance, we observe that 2009 CPUE (15.51) is about 2.5 times less than the largest CPUE estimated in period of observation (2005 CPUE = 37.00). Therefore, we may hypothesize that an estimate of K for MRG is about 2.5 times 2009 population abundance index estimate:

- Angostura: *K* = 2,600,000; Isleta: *K* = 4,000,000; San Acacia: *K* = 2,300,000; **Total: *K* = 8,900,000**

- *Density Dependence*: Density dependence is difficult to quantify in the model but it is extremely important. In the past, a "ceiling" within the model was implemented from population size: small to population size: K (the model assumes the density rates are constant). When the population exceeds K, then at the end of the year, the population is reduced proportionally across all age classes to get back to K before the next spawning. K is a "hard" parameter in the model. Another mode in which density dependency can be implemented is to include some process for low populations. Typically, there is interest in low population density because that is when the risk is greatest for long-term population decline.
  - Remember, we are trying to create a simulated system that is true to observations and expectations for the low population density. There have been discussions and disagreements in the past within this group about inclusion of some type of mechanism that increases recruitment rate at low population density. This is based on the abundance of resources (habitat availability, food, etc.) at low populations so the individual will be able to increase recruitment. However, explicit data demonstrating positive density dependence (i.e., increased recruitment at low population densities) for the silvery minnow do not exist.
  - Dr. Miller expressed concern about applying Beverton-Holt because of the overall sensitivity of the population when at extreme lows if included; however, it is common and would be ok to include. Based on parameterization, then the recruitment rates are increased significantly at low population density. The question remains how to parameterize this type of process given the sensitivity of the model to such changes. It is unknown how to realistically and accurately include the Beverton-Holt using the available data.
    - It was commented that PVA outcomes are very sensitive to density dependence - so it is very important to have density dependence included for the results to be realistic. Dr. Miller agreed but cautioned work group members that we have to be extremely careful. He is not currently comfortable including that type of density dependence with the type of data that is available. Additional guidance on how to approach the issue and how to include density dependence is requested.

- *Spring flow and demography*: There is a need to evaluate different water management strategies so there needs to be a mechanism to tie particular flow to the subsequent population index: using predicted spring flow distribution to transform to abundances to track population response. There is relatively limited data that can be used to better understand the relationship of summer drying to surviving individuals in October. This parameter is not included in the model at this time since there is a small dataset and it is difficult to discern patterns.

- *Dispersal and RGSM metapopulation dynamics*: The model results look at the aggregate of the minnow population but there is also the desire to look at reach specific population responses. Movement of individuals between reaches may be an important factor that influences overall metapopulation dynamics in the long term. The movement study conducted in the San Acacia reach by Platania et al. in 2001-2002* suggests that silvery minnow can move significant distances – as much as 25km. While recapture rates in this study were very small, the data obtained in this study can serve as a basis for estimates of annual rates of downstream movement of minnows in a metapopulation analysis. The work group needs to reach agreement/conclusion on the reach-specific demographics and some quantification of downstream dispersal. The RAMAS model will provide a metapopulation analysis with reach-specific information with some description of dispersal downstream from one year to the next. Actual downstream dispersal data are few. If dispersal is included in a baseline or "foundational" model then reach-specific K and density dependence can be compared in subsequent water management scenarios.
  - Dispersal is "across the board" although it could be age-specific. There is no upstream return right now - specific mechanism by which that would occur would have to be identified and included.

- *Augmentation and RGSM dynamics*: Information on the number of individuals augmented is available from 2003 to 2007; this data can be use to get general "average" number of individuals added to river. The majority

Comment [CSA1]: Due to the possible conflicting statements highlighted in yellow, Dr. Miller will be asked for verification and/or clarification.

Comment [CSA2]: The reference for this study needs to be verified.

of augmentations appears to be in November. If we want these added individuals to spawn in appropriate quantities, we need to include an estimate of mortality before the next spring spawn. The RAMAS model uses an annual census so these individuals will be added immediately before the spawning event. All will be Age 1 fish or about 12 months old. It is assumed that they will have the same survivorship and fecundity as the native fish.

- *Initial Inspection of Baseline Model Dynamics:* With all these parameters discussed above (K, ceiling model of density dependence, etc.) Dr. Miller presented representative graphs of the baseline model dynamics. Each graph has the same initial population size and time horizon of about 50 years - 3.8 million individuals with a K of 9 million individuals. The initial graphs allow for comparing the types of inter annual variability and we can see levels of variability of the population abundance on the same order as measured by CPUE. The CPUE data from 2003 to 2005 give an overall CPUE change on magnitude order of 1,000 fold - if we try to infer some application to overall population abundance, maybe that type of change in abundance is realistic. Overall, the profiles of population abundance seem reasonable and realistic given the CPUE indices seen over the period of population monitoring data. There is about a 13% annual increase in population size – a pretty robust population growth rate with a λ of 1.13. There is opportunity for population growth but there is so much variability within the system. With 100 iterations, the long-term population growth (λ) is just over 1. Overall, in the period of simulation, the population is relatively stable but keep in mind there is great opportunity for variability.
  - Without K it is essentially an exponential growth model. The ceiling in place limits the population growth so we won't see an "infinite" increase.
- *Data limitations and PVA model uncertainty*: There are several outstanding issues or parameters that need additional discussion and fine tuning: (1) the issues regarding K; (2) the types of density dependence at high/low populations; (3) floodplain inundation and spawning – which are not currently part of the model; (4) greater depth of information and realism for the habitat requirements – relates to the floodplain inundation, spawning, and habitat carrying capacity; (5) how to implement density dependence; (6) issues on downstream movement of individuals; (7) and the accuracy of reach-specific abundances and survivorship (or fecundity) values. There is a small window of opportunity in which the model can be refined before it has to be "set" in order to meet the March 2011 deadline.

- **Dan Goodman - Presentation of draft PVA model data parameters:** Dr. Goodman then presented "*Parameter Estimation Strategy for the PVA: 1. Deterministic Dynamics and Environmental Covariates*." He clarified that today's discussion would be about parameter strategy and not the parameters themselves. He also explained the focus for now is on "deterministic dynamics" and how these variables affect the parameters in the PVA - which is only one piece of the picture and there will likely be subsequent documents covering other topics. A covariate is anything that is affecting a parameter value. Dr. Goodman explained that he will be providing a "PVA 101" background in order to explain the disconnects in philosophies between the models. He will be presenting many graphs to justify and explain how parameters are estimated from data. The 3rd section of the presentation is the mathematical presentation of formulas for attendees to take back with them to check.
  - *PVA Rationale*: Population viability analyses were invented ~25 years ago with a rather narrow subset of applications in mind; it was to be applied to listed species which were the "poster children" of the ESA. Most of the species had many traits in common – long-lived, slow-reproducing, and late maturing (ex. whales, sea turtles, elephants). However, these characteristics have nothing in common with the silvery minnow. The minnow has extraordinarily volatile dynamics. The mathematical tools developed for modeling long-life span, slow reproducing, and late maturing do not fit with the minnow. This might explain some differences in the overall framework between the 2 models. Focusing on the long-term trend over 10 or 20 years doesn't mean anything or tell us much about this kind of volatile dynamic species. Population growth rate and population size change so much from 1 year to next. The 18 censuses we have are a small sample from widely variably system. A PVA for this kind of population will have to focus on other aspects of the data besides whatever may appear as the long-term trend.
    - It was commented that since all changes with this species takes place in 1 or 2 years then the 10 to 20 years is just an accumulation of those. To get a meaningful average λ hundreds or thousands of years of data are needed – which is a luxury we don't have. With 20 years of data, we will have to look at different aspects and model in different ways to get appropriate answers for this species. The trend observed over the past 18 years is a "coincidence" of the conditions and situations of that particular

year and cannot be relied on to indicate the long-term prospects of the species. The confidence internals are very wide; increasing and decreasing trends are inconclusive and won't reveal a long-term carrying capacity (K).

- This does not negate the comparative results *between* the models. Comparing how the population changes with different management applications is still a legitimate application. Instead of constructing an average life table, Dr. Goodman recommends looking at the dynamics to see how they respond to an environmental covariant (flow in particular). Density dependence is a big deal since all volatile species would either be extinct by now or infinitely pervasive. Since the minnow does neither, there is strong, complicated density dependence that needs to be teased out to make sense.

- *Introduction:* For each year on a more or less monthly basis, ASIR has done surveys up and down the river. The entire river is sampled within a few days allowing the monitoring to be assigned a point in time. Their data does classify fish according to nominal age classes based on length. Using that classification, one cannot distinguish between 1 and 2 year old fish. Dr. Goodman is going to treat 3 categories within any given year beginning and ending in May since in May is the month for the reproductive pulse. A simple "repackaging" and graphing of the data indicates many interesting and useful regression trends.

- *Recruitment Review and Discussion*
  - In an example of the 2007 cohort, the red dots are young-of-year or that year's cohorts. The green dots are the hold-over of 1+ year old fish from the previous year. The turquoise dots are the beginning of reproduction in the next year. This graph provides a glimpse of how many fish were born, the number of potential parents, when the fish spawned and how many survived. The left hand axis is the fish density in logarithmic scale. The graph is log-transformed because a strait line corresponds to exponential decay or the mathematical way to calculate survival rate for that year. The right axis is flow in daily values through the course of the year. The blue line is Albuquerque gage records. In 2007, reproduction had not taken place in May as expected but there is a huge pulse in June. About 6% of the new fish would have survived the first year. The pattern makes sense and there is a fairly consistent regression line that holds for the entirety of the summer and fall of that year – thus indicating how much spawning occurred and survival rate for that year.
    - In the next year, the originally red dots become green, and the originally turquoise dots will become red.
    - The slope is the strait exponential mortality - with a surprisingly good fit. It is convincing but very interesting and even odd that the "dice is cast" early in the year for survival that year.
    - By the time individuals "reach" green dots, the older fish are so sparse relative to the young-of-year that they don't show up properly in the data and ability to estimate them is poor. But we do have the ability to estimate the young-of year in terms of a relative sense (CPUE is relative). By extrapolating the cohort through to the next spring, we can achieve a good estimate of how many parents will be available next spring recognizing there are Age 2 and 2+ fish that are not being censused because they are less abundant. We can't say they aren't there, but numerically they only make up a small fraction of the reproduction.
    - It is possible to estimate how many adults are spawning, how many fish are produced, and how many survive to the next year. With the regression line, it is possible to interpolate to a common reference date that can be used to "adjust" for the years that the population monitoring was done in June/August but not in July and we can thus regularize the statistics. This is possible to do for almost all the years of data but there are a few years with too few censuses to do a regression. For 1997, the regression made no sense. In 1997 there was no reproduction – it is assumed that spawning didn't occur in the spring. All the rest of the years more or less fit this pattern and lend themselves to number of parents and number of recruits. May 1st is when the parents are censused; the recruits are censused on August 1st. Dr. Goodman then praised the developers of the monitoring protocol as it is proving to be very useful. He then strongly cautioned the Program to not skip any monitoring in the future.
  - Spring flows have a lot to do with the spring reproduction so we have to look at a summary of the spring flows. Dr. Goodman suggested this become a priority item for adaptive management. The height of yellow bars is the mean flow for May at the Albuquerque gage. The cohorts were analyzed by reach – red represents Angostura population monitoring fish density; green represents Isleta; and

blue represents San Acacia. Very roughly, we get the sense that there are years with "gang buster" reproduction corresponding to higher flows in May. This illustrates the volatility since there are years with estimates of reproduction that are significantly larger or a fraction of that - and those years can be back to back.

- A few years stand out as years that the work group may want to look at more closely – namely 1995 (where there was 3rd highest May flow on record and an enormous response in San Acacia) and 2005 (which was highest May mean flow on record and a good response from Albuquerque and San Acacia reaches and an explosive response in Isleta). Having seen this first association between flow and reproduction, we need to zero in on which aspect of flow is responsible for the population responses. Unfortunately, all metrics (that we choose to identify) of the hydrograph are strongly correlated within a given year. This will probably have to be joint work group discussion with the PHVA. For the PVA to be effective for adaptive management these efforts cannot be going on in isolation but there needs to be a really good, on-going "hand shake" to link them all. Otherwise, each piece will be building a back log of questions that will come out at the end in a struggle to write the BAs or BO. The questions need to be answered as quickly as possible.

▪ Dr. Goodman then presented a table to support his statements about strong positive correlations. All the rows are populated with different metrics (Albuquerque gage in June, July, mean, number of days above 3000 cfs, etc.). The May mean at Albuquerque predicts gages in other reaches and it predicts other aspects. Since the aspects of flow are "wrapped up" together, when it is time to design water management scenarios, we may not be able to say which details of the hydrograph are the important ones. It will probably require water management experiments to decouple the important aspects. Even the drying episodes are correlated with May's flow. The early spring runoff is setting the stage for the rest of the year. How much of this is natural or manipulated is not known.

- There is one exception with no current explanation – something reverses itself at low flow at the San Marcial gage. Is this a trustworthy gage? This could be another joint discussion with PHVA.
- 1995 was unique in the record since the spring runoff continued through July; in every other year, the spring runoff has a noticeable pulse that ended in May or June. In 1995 the flows stayed high. This is yet another question for PHVA – what was going on in 1995 to cause the flow to stay high?
- Dr. Goodman then presented several different regression graphs using the mean May flow to predict other things. The lowest correlation was around 50%.
  - The work group provided feedback on why the drying was "unique" in San Acacia and why even for a wet spring there are more drying days at the San Acacia gage. One compounding piece is that is it maintained by pumping at the boundary – flow will be maintained at 10 or 20 cfs even when large stretches of the reach are dry. But that maintenance didn't begin until a certain part in the record. The work group suggested labeling the years as possible way to make that clearer.
  - Another factor, the San Marcial gage is notoriously not useful for measuring flows. The amount of manipulation of water almost overwhelms the river at San Marcial but not at the other gages. With this in mind, we will need to see if stations of minnow monitoring around San Marcial are also taking on a "life of their own."

- Dr. Goodman then began discussing the response of the fish as reflected in population monitoring to flow. The October census is a reflection of both recruitment and a certain amount of summer survivorship; it shows a correlation of 0.79 with the May mean cfs. In an attempt to dissect out survival from reproduction in each year, Dr. Goodman showed graphs of the August 1st (recruitment of new, young fish) against the May mean flow and the regression is even better at 0.877. There is a "break point" between 1,000 and 2,000 cfs where the system is not responding to the flow. The obvious hypothesis is that at approximately 1,500 cfs there isn't enough overbanking to create riparian spawning so there is only main stem spawning. Above that threshold there is more overbanking resulting in spawning proportional to the flow. Dr. Goodman believes this is so convincing that it should be taken as fact.

- Next, Dr. Goodman presented correlations broken down by reach (page 15). In a graph of August interpolated recruits as function of May mean flow - red is Albuquerque, green is Isleta, and blue is San Acacia against the San Acacia gage, and magenta is San Acacia reach against the San Marcial gage. The linear response to flow (taken hypothetically as a measure of overbanking) is much more responsive in the San Acacia reach. Is that consistent with what we know about the habitat availability in San Acacia reach?
    - San Acacia overbanks at a much lower flow level. The data pulled from FLO2D and HECRAS should be able to put numbers on the amount of overbanking for each of these.
    - This knowledge has implications for management - to the extent possible, the morphology in the other reaches should be made more like the conditions in San Acacia to get more "bang for the buck" in terms of population response to the flow.
        - Attendees briefly discussed that while habitat has been created for lower flows, it hasn't been done at a scale large enough to incite such a population response. This type of information needs to be provided to the HR work group.
        - The mark-recapture data could be used to quantify the additive recruitment from the upper reaches that might be a confounding factor as well.
        - It might be theoretically possible with this data to narrow the May mean flows down to something more meaningful (compared to the hypothetical 3,000 cfs for 5 days as the break point) and to get at the aspect of flow that is the mechanism responsible for the response and what the Program should be focusing on in terms of adaptive management.

- As a point of departure between the RAMAS and FORTRAN, Dr. Goodman pointed out that he and Dr. Miller have shown the same relationship but their interpretations are different. Looking at the number of recruits per spawner (per capita) there is much less relationship to flow. There is still the 1,000 to 2,000 cfs threshold where there is very little per capita reproduction below that point. There is essentially no slope – the number of recruits (number of baby fish) per capita is how many baby fish per parent. With the exception of the threshold effect in spring, there is no systematic relationship between flow and the number of offspring per parent.
    - It was commented that there were some relationships that had roughly similar coefficients even with the outliers that were included in the overall mathematical interpretation but now, the outliers are not being included in this interpretation. The concern is that outliers were used to show more robust relationships in some examples, but are not being used now – selective usage.
        - Dr. Goodman responded that he is advocating not using the cluster of points below 1,000 to 2,000 cfs in the regression.
        - What kind of density dependence will give us this result (recruits per spawner as a function of flow)?
            - One interpretation is that the effect of flow and inundation on initial survival is a stronger correlation than just the number of eggs.
                - But survival isn't a factor at this point since the timing isn't with the summer drying. This indicates that the density dependence is strong where flow creates spawning habitat - independent of the number of parents that were there. This means there will always be enough parents to saturate the spawning habitat. In other words, the fish has enough adults in any year with the ability to seek out spawning habitat (when accessible) and they can produce enough babies to saturate to the carrying capacity that year. If they are not saturating, then we'd expect to see a doubling of parents then a doubling of recruits but we aren't seeing this "doubling" so we can be confident in saying there is a saturation.

- This regression, for ecological data is impressive (graph of predicted August 1 to May mean flow).
- If a smaller number of parents are capable of saturating habitat with fry – then there is a survival-based mechanism or maternity-based mechanism at play. Since the number of eggs per female is relatively consistent then it may be related to food availability or "hiding space" availability for protection from predators, etc. There is no direct evidence, but the trends lend support.
- It was commented that this is a "competition element" for prime places to spawn in years with relatively high population with good spring runoff - yet the per capita numbers come down. Maybe there is the situation where some fish are capable of producing offspring but they didn't.
    - It was responded that this is a question for the minnow biologists regarding behavior. Minnows don't defend territory, they are broadcast spawners. So it probably isn't competition for place to spawn but more likely severe competition for the eggs/fry - for food, habitat out of the high velocity, predator protection, the number of good egg retention sites limited, etc.
    - The distinction is that minnows are saturating the good rearing habitat but not necessarily saturating the overbanking habitat - which is consistent with monitoring data on sites.
    - Fry rearing habitat is probably a limited resource.
    - The suggestion is that there is a Beverton-Holt effect early on and very steep, but it flattens out rapidly – with a large alpha (ex. 1,000).

- Dr. Goodman was asked how a lack of a relationship suggests a strong density dependence at low flow. There was discussion whether or not the number of recruits per spawning is a constant or hyperbolic relationship.

- *Survival Review and Discussion*
    - If survival is taken as the regression line plotted against mean summer flow, there is not a positive effect of summer flow on survival but there is the appearance of summer flow actually being "bad" for survival. As the number of dry days (defined as flow below 400 cfs at the Albuquerque gage) increases, the survival increases – how is this explained? Using the density of that year's cohort (starting on August 1) as a predictor, then we can see that when we have a small number of recruits in August then survival is on the high end. This indicates that when the recruits are "crowded" survival tanks and floors out at 0.05.
        - Dr. Goodman then explained that he isolated the survival rate for the young-of-year cohort from the data. Survival can be as high as 80 to 90% even admitting single annual survival rates. Are these reasonable for this species? In a year with no crowding and all the fry are in habitat "sweet spots" then it may be reasonable. This only occurs in years when density is vanishingly small. In those years our ability to census also declines. This is thus convincing support for a strong density dependence affect. The crowding effect is much stronger for Angostura and Isleta compared to San Acacia. San Acacia appears to be a "garden of Eden." The San Acacia reach looks like may have more spawning habitat for the given amount of flow and better summer/early fall rearing survival habitat. It appears that survival "boils down" to habitat and suggests that the San Acacia reach is the place to be looking for the conditions to duplicate elsewhere to benefit the minnow.

- Just having spawning by itself will not benefit the species much unless there is summer rearing/survival habitat as well. This is supported by the 2005 data for Isleta, which had good spawning but not good survivorship. This is strongly suggesting a habitat issue.
- Some attendees questioned the capture efficiency at low flow. Dr. Goodman suggested that the best way to predict survival is to "forget" about flow but rather look at the August density. In the August meeting when the cohort reconstructions were explained, 3 stations were "called out" - those right below the diversion dams because those stations showed bizarre outliers in the summer because the plunge pool collects fish during drying. To get rid of that erratic behavior, they were eliminated from the entire analysis.
- Some attendees then asked about the survival rate in 2006 following the boom of 2005. It was responded that the 2005 survival rates were poor because the dominate recruitment was at Isleta and the associated survival rate was low. How did that affect the total number of spawners in 2006? It was responded that 2006 spawners were modest and not in proportion to the recruitment of 2005. Using a graph of that year to predicted August, Dr. Goodman showed that there was very little carry over, implying poor survival between 2005 and 2006.

- ***Mathematical Support and Formulas***
  - The third section of Dr. Goodman's presentation covered the mathematical formulas used to model the recruitment. Dr. Goodman explained that he is using the Beverton-Holt formula where R is the number of recruits or young; s is the number of spawners or adults; and alpha is the number of recruits per spawner at vanishingly sparse quantities. Beta has been replaced with the reciprocal of saturation.
    - With the beta replacement there are no covariables visible but the 2 parameters are alpha and the alpha/R_{sat}. It is the same functional form and same shape as the original formula but both portions were divided in order to make the saturation level stand out.
    - We have been seeing that R_{sat} is a function of an environmental covariant. Substitute R_{sat} = f(F) into the Beverton-Holt equation in place of R_{sat} to get the flow explicitly playing a role; and to parameterize recruitment as function of the number of spawners with coefficients including flow. The coefficients come right off the regressions in the plots. Thus the only parameter we need to estimate is the alpha.
    - The ability to resolve alpha is not very good but it can be bounded with ranges. Data indicates alpha has to be at least X large or we wouldn't see the relationships observed. Tentatively, this is the flow/recruitment relationship. Gamma and omega are narrowly tied down by the regressions relationships of recruits to flow but alpha will have a range. The linear function of flow is defined in a previous graph (on page 14) of the presentation.

- **Discussion with PHVA Workgroup members regarding URGWOM capability and how to mesh output with PVA models**
  - Members of the URGWOM tech team joined the PVA meeting after lunch to provide updates on the progress and current status of the URGWOM model. The PHVA work group is rerunning the pre-ESA water management scenario, which represents a "no tool" run to see what the river might look like with no management actions in place. The tech team is also running a 2003 BiOp With All PHVA Flow Tools scenario which represents the "current" system. The initial conditions for the latest URGWOM runs are based on the projections of end of 2010 conditions. The model updates are considered complete at this time. The current model runs will be reviewed at the PHVA meeting this Wednesday and the group will determine next steps.
  - It is assumed that the results will be available for wider distribution very soon. The tech team did receive the information request for model outputs converted into ASCII format.
    - As the "details" are worth noting, Dr. Goodman requested *all* outputs (approximately 178) be provided in the requested ASCII, tab delineated format.
  - Attendees discussed the timing of the runs – 10-year sequences are still an issue. URGWOM tech team members explained that it is very laborious and difficult to get longer than 10-year sequences from the URGWOM model. URGWOM has to load data from an existing database; it would take a long time to set up the database that would be needed.
    - The URGWOM tech team had previously determined that the best way to reach longer sequences is to take 5 of the 10-year sequences, shuffle them (10 dry years, then 10 average, etc. in a random order), and then string them together to achieve the longer desired sequences of 50+ years. However, the order

of the years within those 10-year blocks cannot be changed. Also, this approach would probably result in the loss of the probability associated with the sequencing. To be as accurate as possible, the process really should go back to the paleo-sequences first. PHVA representatives expressed concern that action agencies might not want to even do 50-year sequences.

- The "end" conditions from the previous sequence would be used as the initial conditions for the start of next sequence.
- Concern was raised that literature indicates there is a 20-year climatic "oscillation." It was cautioned that there will need to be "explaining to do" if the current modeling does not stay true to the known time series properties of the long records. The tech team explained that the process is "staying true" within the 10-year sequences. The concern was again pointed out that the literature says "20-year sequences."
    - The tech team pointed out another problem with attempting to do 50-year runs – the only data we can select is from 1975 to 2005 (30 years). Stretching 30 years into 50 years will results in a lot of "repeats." The best that can be done is to string together 5 10-year sequences.
    - When asked what is the "definition of an environmental baseline", the tech team explained that there is no definition of an environmental baseline in URGWOM modeling. There are 2 scenarios: (1) the pre-ESA water management and (2) the 2003 BiOp with all proposed flow management scenarios/tools.
        - According to the tech team modelers, the 2003 BiOp cannot be a baseline since it is not physically sustainable. Not a single model run has ever indicated that the 2003 BiOp can be met – even in the wettest sequences. However, the pre-ESA water management scenario could be considered a "baseline" as it represents the basic system.
            - It was explained that the Cochiti deviation has been included in the pre-ESA water management run because it is approved until 2013 so it is an action that will potentially occur in the first 2 years of the results.
        - It was pointed out that in the ESA Section 7, the action agencies have to define the "baseline" in their BAs. For the Service, environmental baseline is current conditions - which are the 2003 BiOp. It is an accumulation of everything that has happened historically that contributes to the current condition of endangered species.
            - A participant expressed concern that that definition of the ESA doesn't sound right based on case law and everyone was encouraged to talk to their agency lawyers for clarification. It was pointed out that if there is no agreed-to baseline, then the PVA analysis can't be done.
- In response to the question "how will the RAMAS model fit the scenarios?", Dr. Miller explained that a 50-year sequence of flows is the ideal. There is a rationale to relate the flow to the measure of minnow reproductive performance. Ultimately, a statistical distribution of flows to sample from over a period of time or prediction window needs to be developed. This could be "random" if agreed upon, or some more complex set of rules that would describe some trend in water availability over time. This will be related to the type of management scenarios that comes out of the PHVA. Environmental variability in its truest form is described by a statistical distribution drawn from at random; there might be some type of non-random hydrologic trends (that could describe some type of non-random biological trend). But there would need to be some type of accumulation of results from which Dr. Miller could get an idea of the trend of water availability over time.
    - It was cautioned that we can't just have a bunch of numbers in a hat for flow to just randomly pull. This is unrealistic because: (1) the evidence from paleo-data is that weather itself is exhibiting a time series oscillation structure; and (2) the water management decisions involve storage and release which carries over from one year to the next - this means certain kinds of management that need to be modeled. All of this has to be on the table to get to meaningful model results.
    - Returning to the statement that the 2003 BiOp is not sustainable, it was clarified that this is from a water supply point of view. Since 2002 to today we have needed between 10,000 to 70,000 ac-ft with the average between 30,000 to 50,000 ac-ft to sustain the 2003 BiOp. It is known that this supply won't continue in future. The San Juan/Chama water will not be available for lease in the future. The water won't be available.

- It was commented that this situation needs to be communicated to the regulators. One modeler expressed that there was no point in modeling scenarios that won't happen in the long-run; it doesn't make sense to plan RPAs around something not feasible.

- Attendees discussed how the drying piece will be achieved through the post processing of data. It can be possible to extrapolate drying averages for a reach given flows. This information can also be used to tell Dr. Goodman how many miles dry for any given day.

Action: Dr. Goodman offered to post-process the approximate drying from the inflow for each subreach once the information has been provided to him (instead of the URGWOM tech team having to do the post-processing work).

- Dr. Goodman explained that he is interested in this information in terms of data assimilation and hind-casting. It is valuable to make a scenario out of the last 19 years and use that to get predicted numbers on how much drying occurred each year by reach. This will lead to a retrospective analysis - to see how well the model predicts the drying. The point is to back transform the gage data into a time series of drying.
  - It was cautioned as important to note that there are probably only 2 good gages in the middle valley (Albuquerque and Cochiti). It was also cautioned that a "back transform" will not provide the exact results because of the management operations that differ every year while URGWOM is "set." Even the values in the permanent record have improved since the 90s with improved technology and operations. It is not possible to get an exact replica.
  - Dr. Goodman was concerned that given the known management changes, there needs to be a hydrologic model structure that allows for those changes.
    - Dr. Goodman suggested that an URGWOM "light" was needed for the just the middle valley with how much water entered and how much water ended up at certain points.

Recommendation: It was suggested that the URGWOM model run a "Middle Valley Run" with the purpose of getting predicted numbers at certain points in the valley for comparison purposes (ex. against CPUE plotted against flow) and to maybe provide calculated values to help address some of the outliers (ex. San Marcial). It might prove valuable for comparison of some of the "odd" results or outliers in the CPUE data.

- The tech team then specifically addressed 2 of Dr. Goodman questions:
  - (1) The positive correlations (relationships to flow that Dr. Goodman demonstrated earlier in his presentation) consistently include the San Marcial gage except at very low flow when there is a reversal of what is expected. Is this a trustworthy gage? If so, what is different between San Marcial and the other gages that this causes unexpected results?
    - Drying was "unique" in San Acacia and there can be more drying days seen at the San Acacia gage even for a wet spring because it is maintained by pumping at the boundary – flow will be maintained at 10 or 20 cfs even when large stretches of the reach are dry. But that maintenance didn't begin until a certain part in the record. The work group suggested labeling the years as possible way to make that clearer.
    - Another factor, the San Marcial gage is notoriously not useful for measuring flows. The amount of manipulation of water almost overwhelms the river at San Marcial but not at the other gages. With this in mind, we will need to see if stations of minnow monitoring around San Marcial are also taking on a "life of their own."
  - (2) 1995 was a unique year in the record in that the spring runoff continued through July; in every other year, the spring runoff has a noticeable pulse that ended in May or June. In 1995 the flows stayed high – why?
    - It was explained that during that spring pulse in 1995, Elephant Butte was full so the water passed through the gage and then "backed up" to the gage again. With Elephant Butte full, floodwater captured that year was released down the river so through mid-July there were Cochiti releases of several thousand acre-feet. It was a huge runoff year and water was released from Cochiti. There was also a sediment plug at Tiffany reach so there may have been some management for that. But the reasons start with the enormous runoff.
  - Dr. Goodman cautioned the group to consider the "big picture" – none of these processes are happening by themselves. They have to fit together and be usable in the adaptive management analysis and RPA process. We need to be clear about what kind of "conditions" or "situations" are under the control of the action agencies and which aren't in order to focus the modeling on the understood amount of "wiggle room" that the action agencies (instead of modeling acts of God).

Action: David Gensler will attend the PHVA meeting on Wednesday, December 8th to help communicate the PVA data needs to PHVA.

- ***Return to Dr. Goodman's Mathematical Support and Formulas (Beverton-Holt Recruitment w/ Flow Dependent Saturation)***
  - This morning, before lunch, Dr. Goodman presented on the recruit/spawner relationship (see section 8.1 of the presentation). He explained that he would now like to explore the spawner-to-spawner relationship – recruits need to survive to reach the next spawning cycle.
    - The number of recruits multiplied by the survival rate from August to May of the next year allows for calculation of the spawners available in May of the next year. This survival, from August until next May, relates to the survival rate calculated from the log regressions. The log regressions were on an annual basis (9 month is ¾ of a year) so by raising to power of ¾ we can get the rescaling of time. If we compute spawners in the next generation to spawners in this generation, we get a generational lambda (pg 23 of presentation). Thus, that year's λ can be predicted deterministically from that year's number of parents and the flow. That year's survival rate is needed to now develop the density dependent expression for the survival rate. Density dependence will need to include a crowding term. Putting the density dependence into the equation we can now get an equation that is time-varying for the λ that responds in a saturation manner to the number of spawners that year and responds to the flow in terms of an expression in both numerator and denominator.
  - This allows for the deducing of the deterministic properties that allow recovery from very, very low numbers – by using 0. The λ at low densities, (flow cancels out due to no crowding), is simply the low density survival rate (based on regression analysis of 0.7) times the α from the Beverton-Holt. There is reason to believe α is a big number - since we've seen the capacity of the population to exhibit very high growth rates. If λ is the recovery from low density potential, all that is needed for a resilient population is for λ to be greater than 1. This is a condition that is going to be easily met with this population. We have a formula for the λ that indicates the population has every ability to bounce back in every way.
    - If flow is held constant from 1 year to the next, the population density would equilibrate at whatever λ equation equals 1. This provides us the ability to create a model for population dynamics that will provide insight even before we address the stochastic simulation. The system has properties - as its tendency under its own driving forces - to (1) bounce back and (2) if the environment is held constant, to equilibrate to a certain number of spawners.
    - It was asked that since the Beverton-Holt α plays a huge role since it is a multiplier, how is that realistically determined here? Dr. Goodman explained that in fact, the curve fitting will do a poor job resolving α but will allow us to find a range. In terms of the biological constraints using as Bayesian Prior, α can't be bigger than number of eggs per female; α couldn't be smaller than a particular number and still let us see the recruits to flow relationship. The relationship between recruits and flow sets the lower bound. It becomes a probability of α that gets propagated through the analysis.
      - The upper bound can't be much bigger than 1,000 since that is the number of females per female. α scales up depending on how quickly Beverton-Holt goes to saturation - which has to happen quickly in order to get to the observed relationships.
    - Dr. Goodman was asked to explain when factors are input into the λ calculation. Basically, there is a relationship of recruits per spawner as a function of flow (which sets the saturation level). If we take the recruits per spawner and multiple by survivorship we calculate next year's spawners. We can make the ratio of spawner to spawner in successive generations.
    - It was asked if λ could be calculated by year once the hydrographs are available. Yes, this is feasible. We should be able to reproduce with some fidelity in the time trajectory. The time trajectory of recruits could turn into a time trajectory of λs.
      - Eventually, once there is enough good monitoring data, we can start looking at reproducibility of monitoring measurements for measurement error.
      - In response to a question on how to partition out the biological variability from monitoring variability, it was explained that the true population size should be treated as an unknown parameter that is connected by state equation.
      - The PHVA will develop some set of sequences with trajectories of flows. That will be deterministically developed flow from URGWOM. Under management scenario X, a 50-year

sequence is deterministically developed that has to be dealt with in the stochastic model. So there is relatively little stochasticity in the system.
    - The stochasticity in the system is the weather – there needs to be a probabilistic weather future to flesh out the models; this will involve going beyond the URGWOM outputs.
- Dr. Goodman was asked how flow cancelled out of the density dependent equation. He replied that it only cancelled for $\lambda = 0$ since flow affects the carrying capacity. But if there is no crowding, then it disappears for this singular case.
    - Discomfort was expressed with the fact that deterministic causal relationships in this model are mostly coming down to spring peak flow in May and that is in the category of the "hand that nature dealt" – it is not the agency actions in most years. This is the reason the PVA needs to have a definition of what is feasible and within the ability of management to "tweak." Adaptive management is an integral part with all the other pieces (PVA, LTP, PHVA, etc.).
    - Concern was raised about the situation of needed flow while in Article VII – we need to layer the water management constraints on top of the science in order to arrive at what really can be done. The PVA should be used to figure out the potential viable options but there might also be an element of trial and error. There should also be on-the-ground experiments - with fail-safes and monitoring to be able to abort if/when necessary.
    - It was asked if there is a framework using λ to test if recruitment results turned out better than predicted. The response was that it may be possible, once we have a system with regression prediction to see if the residuals correlate with anything we've done.
    - Dr. Goodman was also asked if he is considering λ on an annual basis - for a single, isolated year. By 2013, 1 or 2 more Cochiti deviations may have been done, so there needs to be analysis to determine if it is worth doing. So yes, λ can be considered on an annual basis but only as a single point.
    - In Dr. Miller's presentation, the population bumps against a ceiling but the actual population doesn't really do that. In Dr. Goodman's model, each year's ceiling is determined by its flow. Thus it isn't necessary in the FORTRAN model to set a ceiling for K.
    - Regarding the λ calculation (pg 24 of the presentation) and the recovery of the minnow population from low numbers, at a basic level to calculate λ we need the flow for the year and some starting point on the number of spawners. A possible tool for the water managers could be a matrix of starting spawning numbers and flow intervals.
        - However, bear in mind that the uncertainty about α will be considerable. It can be bracketed in reasonable range but there will be a lot uncertainty within that range.
- In terms of settling doubts, there are some easy things that could be done first – such as a simple multiple regression of recruitment as function of flow and number of adults.
- The uncertainty and variability around α has been acknowledged. The evidence from monitoring data indicates that the population hasn't been low enough to have α clearly expressed. In terms of incorporating that variability into the stochastic model, it will be sampled on every time step.
    - In a stochastic PVA with parameter uncertainty, certain things get sampled once a year but other things can be sampled once per trajectory – such as these uncertainty parameters or nested loops. Each trajectory pulls a random α to explore the consequences of that α.
    - Basically, it is an evaluation of different α levels to see how those fit the observed data/populations. That will be done first to establish the confidence intervals on α. For diagnostic purposes, we can pick trial values of α to see what difference it makes.

- **Work group business**
    - *Review action items from August PVA meeting:*

- ✓ Jeanne Dye will email the 2009 - present Population Monitoring data to the PVA workgroup. – *complete;*
  - This information should be posted as of today. Concern was expressed that what was posted is not the actual raw genetics data – what is included in the reports is not enough to analyze. The reports are the *synthesis* of the raw data – the conclusions can't be reproduced and the calculations can't be verified.
- ✓ Jeanne Dye will check when the report for the Age Determination study is due. – *complete;*
  - The Age Determination Study report is over due. The contractor is behind schedule but no new schedule has been provided yet. It is expected that the delay will be short. Access to the data (at least in draft form) was originally due in October.
- ✓ Phil Miller and Dan Goodman were tasked with looking at the Recovery Plan and translating critical habitat standards and recovery standards into PVA language. – *complete;*
  - This was attempted but no progress was made. The Program will have to try to translate the recovery and critical habitat into terms that can be plugged into the PVA for testing. The purpose is to keep them related to the flow measures.
- ✓ David Gensler will formally request ASCII output from the URGWOM models. – *complete;*
  - The tech team just today indicated they will provide all the outputs in ASCII.

- *Review/Finalize August meeting minutes:* The August PVA work group notes were complimented as "quite thorough" and approved with no changes.
- *Review/Approve 2010 Work Group Accomplishments/2011 Work Plan:* Attendees reviewed the documents and provided feedback and suggested changes/additions.
  - It was suggested that the PVA meetings be added to the 2010 accomplishments for a complete picture.
  - For the "incorporating spatial structure", the deadline should be "on-going."
    - The work entails going beyond a spatially non-explicit population module by overlaying a spatial grid system on top of the somewhat amorphous description of a reach to get to x,y coordinates of habitat attributes and then portraying a particular set of population characteristics. There is interest in considering this work, but it is not really "close on the horizon." Realistically, RAMAS might not be able to include that spatially explicit demographic characterization. There could be significant value in knowing the different habitat types in the river and using that information to determine how extensive certain habitat has to be in order to make an X% difference.
    - The "inclusion of spatial structure" will be carried over to the 2011 work plan. Attendees agreed that an interim step could be reach specific analysis.

Action: Stacey Kopitsch will make the suggested changes to the 2010 PVA Accomplishments and the 2011 PVA work plan and will distribute the revised versions for review.

  - Attendees discussed possible ways that habitat information could be refined.
    - It was discussed that there needs to be more interaction between all the work groups. The groups need to know what each other is doing in order to help reinforce that work. This could be accomplished through scheduled joint meetings to achieve better cross-communication.
      - It was pointed out that most of the work groups have representation (including several co-chairs) at today's meeting.
      - The science work group has stated at least twice before that they would like to see the PVA put forth a study and are willing to assist.
      - A joint meeting between ScW, HR, and MPT has been scheduled for December 14th. Part of the agenda is to look at the 2-year monitoring program for habitat restoration and to work with ScW to determine what kind of monitoring is needed for this year.
      - Also, the Service has initiated a meeting in early January 2011 to bring biologists and hydrologists (anyone who has collected information/data from 2010) together in an attempt to determine why (links or reasons) the population monitoring (CPUE) data is really low this year. There was a decrease of 10-fold in the population compared to last year. The largest drop occurred in the July to August samples. Retrospectively, there is usually a drop from July to August but it is not on this order of magnitude. The concern is why such a significant change this year?

- Open to biologists and hydrologists that have data for this year that might be informative. There is no reason this meeting couldn't be open to and advertised through the Program.
  - If we think next year will be a dry year and there is opportunity to collect needed drying information then scopes need to be developed, solicitations issued, contracts awarded, etc.
- It might be possible to look at the monitoring or salvage scopes of work to either find existing descriptions of habitat at those sites that could be used to refine the relationship between habitat and population. Or to recommend ways that the monitoring or salvage scopes could be "tweaked" provide answers to some of the additional questions/data needs instead of having to issue and fund a completely new project.
  - It was cautioned that salvage was not set up as a "scientific experiment" as that is not the intended purpose.
  - Disappointment in the salvage data was expressed in terms of its utility for PVA modeling, understanding the salvage protocol was not designed to obtain data for PVA model use. Rich Valdez referenced a study that was done as part of the salvage work and related to the condition/health of the fish at different times using the fish collected from isolated pools in intervals while the pool was reducing in size.

Action: Rich Valdez will review the salvage work report and will write up a first draft of suggested/requested modifications to the salvage protocol that might provide additional data useful to PVA modeling efforts.

- It was commented that one of Dr. Goodman's slides indicated reach differences in the minnow population and densities that were attributed to habitat; suggesting that habitat in the San Acacia reach was better than the other reaches. This is significant. There has been ongoing discussion on what specific habitat is needed for the species. It appears that San Acacia offers a better suite or mosaic of habitats. It was then shared that Tom Hardy (Utah State University) has an approach to these kind of habitat questions that has proven to be very successful. He uses macroperspective first with aerial photography and spectral videography and then he develops algorithms based on ground-truthing. This might be one approach that could inform the habitat restoration portion of this program. We can make sure the spatiality of those habitats is related to flow in order to help unite these efforts.
  - With the drop in the minnow population this past summer, it might be worthwhile to look at habitat and its ability to support fish in each of the reaches. The K is one testable hypothesis. The approach could be to look at fish growth rates in a sufficiently large sample and compare to museum specimens.
  - Attendees then discussed inventorying 3 different levels of habitat from the large scale to the micro scale. For example, the macro level forms would include river channel configuration, side channels, floodplain habitat, etc. The meso level forms would include runs, ripples, pools, backwaters, etc. The third or micro level would include depth, velocity, etc. This is a different approach to habitat inventory than what has been explored before.
    - The results presented by Dr. Goodman this morning give motivation to start "tackling" the habitat relationships and needs. It was acknowledged that the results of such a 3-phased habitat approach might not be available for this (PVA, BA/BO) process, but it would be valuable for the longer-term.
    - Reinventing the entire habitat assessment process is not being suggested, but rather to explore what the river channel looks like in a broader perspective especially in San Acacia compared to the other reaches to see if some aspects can be better managed in the other areas. It is a very complex and important issue that ties in with the adaptive management that the Program is currently working on.
    - It was suggested a small sub-set of the PVA assist with this effort

Action: Rich Valdez will write a first draft project description/activity summary for the 3-level habitat inventory project.

Action: Peter Wilkinson, Mickey Porter, Rich Valdez, Rick Billings, and a Service representation will be involved in the development/review of the 3-level habitat inventory activity description for discussion at the January 2011 meeting.

- The Habitat Restoration work group (with ScW and MPT) is looking for ideas on how the monitoring can be used to solve more of the actual scientific questions; but this requires clearly defined questions.
  - There is a Habitat Restoration Plan that provides the guiding principles under which restoration has been completed. In the last few years however, we have new information but no new, sound hypothesis testing studies to confirm.
  - The current focus in on targeting flow – ex. of bank lowering to create habitat but what constitutes acceptable habitat? How do we approach this? From a habitat standpoint, we might be able to incorporate some questions into the monitoring that is currently being done and not go into another expensive project.
  - Attendees briefly discussed the lack of agreement on study results and the lack of continued studies to dissect the "spawning on the floodplain" or "sufficient food in river during residential periods during low flows." There are a lot of missing pieces. Even though there is a lot of gathered information that has guided restoration in the past, there are still gaps and missing pieces.

Recommendation: It was suggested the PVA work group revisit past work/studies/reports that have already been done on (1) the mesohabitat (~5 years ago) and (2) minnow food study (a few years ago) – to review what has been done and provide a potential start point for refinements instead of duplicating work.

Action: Rick Billings will distribute the December 14th Joint ScW/HR/MPT meeting agenda to PVA members.

- **Discussion of possible changes to PVA use and URGWOM resulting from FWS Talking Points presented at 11/18/10 EC Meeting**
  - At the November EC meeting, the Service handed out a draft "talking points" document outlining their position on several points of the consultation. That draft document was molded into official letters that were mailed to Reclamation and the Corps on November 30th. The action agencies just received those letters and are still in the process of assessing the impact and how to proceed in the future. In the draft talking points, the Service described intent to prepare a single BiOp and provided strong recommendations on the process. The concern is that this new information could affect PVA use but maybe not the PVA process itself.
  - The Corps has adjusted their timeline to submit in February 2011; neither the Corps nor Reclamation have officially responded at this time.
  - The Service still hopes to have the PVAs for use in preparation of a BiOp.
    - It was cautioned that everything in the process has to "really fit together" and if the PHVA is working on the wrong scenarios, then there might realistically be delays and challenges.
      - A non-front loaded BA depended on the pre-ESA water management model runs to set the stage; now, we have to figure out what goes next to be able to submit a front-loaded BA first. The schedule and timing of things will have to be discussed. The question remains whether or not the PVA will be used in the development of the BA.
    - Concern was raised that in seeking a front loaded BA is "pre-deterministic" especially considering the PVAs aren't completed enough yet. Without the PVA process complete, we don't know what management scenarios will offer the best for the species. It appears to some attendees that pursuing a front-loaded BA is negating the value of the PVA and adaptive management to a large extent. This approach is like putting ourselves in a box by limiting the ability of the PVA to tell us what the "boundaries" might be. It is like asking what the scenarios are going to be before we know from the PVA process what might work best; especially considering the perspective that the 2003 BiOp shouldn't be considered a baseline.
      - It was explained that there is a sequencing issue. The Program is developing the LTP, Adaptive Management Plan, and the PVAs concurrently with the BA development. The Service's preference is that the BA not be submitted until those other components are built. Either a lot of time can be spent upfront on the BA and a short time on the BO or vice versa. The Service's preference is that the LTP, adaptive management plan, annual operation plan, PVAs, etc. come together to inform a really good BA. But the action agencies have to make decisions about what analysis to include in the BA.

- Concern was expressed that it would be nice to "firm up" what the Service will or won't accept.

Recommendation: It was suggested that another PVA/Section 7 consultation team meeting be scheduled to help settle some of the uncertainty. PVA members were encouraged to attend the December 15th Section 7 training as a starting point before any additional meetings are arranged. There will be an analytical method portion and a lot of questions and good exchanges are expected.

PVA Biology Work Group Meeting
December 6-7, 2010;
AAO, U.S. Bureau of Reclamation
555 Broadway Blvd. NE, Albuquerque, NM 87102

DAY 2: December 7; 8:30 – 12:00

Agenda Approval

- Dave Gensler brought the meeting order. There were no changes to the agenda.

Dan Goodman - Observations of climate cycle and potential effect on length of PVA scenarios

- Meeting attendees discussed observations of a 20-year climate cycle and the implications this may have on PHVA/PVA hydrologic integration.
    - There is evidence from literature that a 20 year climate cycle is detectable in southwest tree rings. It will be difficult to use tree ring reconstruction that URWGOM/PHVA has used while dismissing that claim of a 20 year climate cycle. If there is agreement that there is a climate cycle then URGWOM cycles need to represent the climate cycle for the PVA. There was concern that "tacking" together 10-year URWGOM model runs to make a longer cycle may not recapitulate reality.
    - The PHVA has had these discussions and it is believed that a decision was made by Reclamation that a 10-year scenario would be used because that's the length of the current BO.
    - An observation was made from a figure from the Woodhouse paper that the 20 year cycles appear to be within a longer cycle of 75 years. Given that there are these cycles that have the tendency for the system to be either wetter or drier, at this point in time the water situation on the Rio Grande is going to either stay the same or get worse in the next few years. Given the longevity of this species which might be up to 4-5 years and given the generation time of 1.5 years, it doesn't seem tenable that these cycles would have influence on the species because those fall outside of the cycles.
        - If there were not cycles then good and bad years would have an equal probability of following one another. If there are cycles then there will be a string of bad or good years and this will create volatility in the species.
        - The cycle is not precisely 20 years, it shifts, lengthens, and compresses but there is a constant up and down. This can be seen in the "paleo" records.
    - Would two 10-year sequences put "back-to-back" mimic a 20-year cycle?
        - Selectively choosing the 10-year sequences may destroy the average pattern.
        - There will need to be a comparison of the selected sequences relative to the full time series and determine if it is the full time cycle.
    - Concern was expressed that not doing this is creating a vulnerability to more litigation. It would be good to fix as many loose ends as possible.
    - The question was posed of whether or not the need for the inclusion of observed climate cycle data in the PVA models warrants further discussions with the PHVA workgroup. Both Dr. Miller and Dr. Goodman were in agreement that it would be worthwhile to send a brief document to PHVA workgroup stating the concern and querying them on the degree to which they are taking observed climate cycle data into consideration and what it would take to include observed climate cycle data to the level that is satisfactory for the PHVA and PVA.
        - Dave Gensler volunteered to put together the document to the PHVA workgroup with guidance from Dr. Goodman and Dr. Miller.
- It was pointed out that PHVA will not be giving 50-year runs, instead they will be giving "back-to-back" 10-year model runs. Attendees discussed whether "back-to-back" 10-year sequences would be biased as a full run.
    - The stringing of 10-year sequences should include consideration of the longer-term wet and dry cycles that have emerged from "paleo" data.
    - We will also need to look at multiple 50-year cycles that are a fair sample of what we think will occur. There was concern that "tacking" together 10-year URWGOM model runs to make a longer cycle may or may not recapitulate reality.
    - Attendees discussed the possibility of looking at Jesse Roach's monthly time step model as a viable option to either add on to or replace the URGWOM modeling in order to extend the sequences. It was not

understood if there is a relationship between what Jesse and Nabil (URGWOM) are doing and it was not known if the two models could be compatible.

- One opinion is that Jesse's model would be a viable option to look at spring flow projections based on URGWOM type inputs and internal mechanisms.
- Though Jesse's model is faster and can produce larger sequences than URGWOM, it can't predict drying data and unlike URWGOM it does not have an operational decision tree built into it. The URGWOM modeling has daily decision tools that will hopefully be built into the BO. Perhaps pieces of Jesse's model could be tagged on to the URGWOM model to extend to 100 years.
- One of the issues with Jesse's model is that it doesn't include switches that happen on a day to day basis. It's useful for RPMs to a limited extent.
    - Concern was expressed that the PVA doesn't understand how complicatedly managed the river system is. URGWOM is the only model that has an operational decision tree built into it.
    - When the time comes to explore potential RPAs, these same issues of flexibility in the model will arise. Every candidate RPA that emerges will have a different rule set and a model framework to test those rule sets will be needed.

- It was remembered that there were previous conversations about the use of URGWOM in the PVA. The earlier models always had the capability to string sequences but ran very slowly. Now the process has been streamlined and stringing can be achieved for a few runs. Stringing the models together will be subjective. There should be a method that reflects what we know of the cycles seen in the last several hundred years.
- One opinion was that to hedge against the possibility that the hydrologic issues with URGWOM are not resolved that sample coding for the rule sets be requested so that modelers can have enough information to be working on alternatives.

- Meeting attendees briefly discussed that stringing together a series of certain kinds of years, intentionally in order to stress the system, for example a series of dry years, could be done to see what the prospect or probability of the population is under strain. For example what would be the impact on the population for 3 years below "x" or "y" cfs, or every third year under "z" cfs. In more stochastic projections we would allow those years of strings of strain to occur randomly, but this is not random so we could impose that sequence. The more you impose a sequence on the environment the less stochastic it becomes. But we could explore and evaluate the impact of any sequence of hydrologic variables deemed to be possible under the conditions we describe including strings of good years.
    - From a sensitivity aspect if a large number of factors are set to the "worst case" then a combination of circumstances that is impossible may have been created. There needs to be a way of assessing whether scenarios have a probability of 1 in 100 or 1 in 1 million. When only a couple of factors are "tweaked" this is done easily but "tweaking" a lot of factors could create a scenario that will not happen.
    - Have to build verbs to see how likely a scenario is and use that as a basis for responsible inquiry for RPAs.
        - Overall reductions in water are a realistic situation to talk about. What will the future look like from a water availability standpoint?
- Meeting attendees discussed having a meeting with PHVA and Jesse Roach to further address issues with model run length and the inclusion of observed climate cycle data.
    - The queries are set and it's not known if any changes could be made to the URGWOM models by the PVA deadline for the "model debut" in March 2011.
    - It was said that there will just be interim outputs presented in March without any pretense that those inputs are what will be included in BO development. Any time spent after March in solving the water sequence issue will be time well spent.
    - The final BO has a deadline to be completed by December 2012.
    - It was thought that the letter to the PHVA could initiate joint discussion on agenda development for the joint meeting and ensure that the appropriate people attend.
- The next PVA meeting is planned for January 25th and 26th 2011.

Action: Terina Perez will verify that PHVA is able to attend the meeting.

- The March "model debut" meeting was planned to coincide with the March 2011 EC meeting so that the models can be presented to the EC. PVA will meet March 17th with the possibility of the meeting extending to March 18th as well.

Discussion on new Adaptive Management Plan, and how it may or may not mesh with PVA models

- The Program is currently working on Adaptive Management Plan development through hired contractors (ESSA). Dr. Goodman attended an interview session with the contractors and he expressed concern that no one has indicated how the adaptive management plan is expected to mesh with the PVA or how it will mesh with what the other work groups are doing. It is also unclear how it will be used in the BO process especially in the "search for RPAs."
  - It was explained that these concerns should be directed to Reclamation.
  - Several members who attended the Adaptive Management Plan development kickoff meeting expressed concern that there are still many questions remaining about the process. However, other attendees felt the adaptive management contractor did a good job defining their version of adaptive management (what it is and isn't) and in that context, relaying what their planned outcome and product is.
  - As previously mentioned, the Service would like to see all these components, including the adaptive management, come into the BA instead of the BO.
  - Concern was expressed that the tentative adaptive management plan appears to be more about how to "manage people." The Service was asked to describe what, in their opinion, an adaptive management plan should look like.
    - It was explained that this question could not be answered directly as it would depend on what was driving it. The base parameters are not known yet but the adaptive management plan should be comprehensive and focused. Similarly, until the adaptive management plan is farther along, it will be difficult to say how it could fit into the BA/BO process.
    - Concern was expressed that there seems to be several "definitions" of adaptive management. For some attendees, adaptive management is a series of actions that can be taken and are basically if/then statements.
      - The opinion was shared that the Platte River example shared by the ESSA doesn't really apply to us since we do not have a law that sets aside a certain portion of water for use.
    - The Service was asked to provide an example of what they would accept.
      - The Service's representative shared that his understanding of adaptive management is how the river will be operated over time in a flexible manner.
      - Concern was expressed that based on the kickoff meeting and the interviews, ESSA is looking at a different type of management regime instead of flexible, if/then, on-the-ground management.
      - It was suggested that the Program look at adaptive management in litigation or mitigation on the Columbia River. Apparently ESSA developed a management plan that wasn't used.
  - It was shared that the revised adaptive management schedule should be available for tomorrow's CC meeting but will definitely be available for the January 20th EC meeting. Included in future steps is the alignment of the BO process, planned working adaptive management sessions and workshops. It is being called "Version 1" of the adaptive management plan and when available it could be incorporated with the BO stuff.
    - Attendees are still concerned that this doesn't indicate what the plan will look like. What are the constraints of the contract? It is difficult to "picture" what this plan is going to be. What kind of decisions and actions are going to be included?
    - The Department of the Interior has an adaptive management hand book and it describes how the Department views adaptive management. The hand book is available on the internet.
    - The Service would hope that the Program's adaptive management plan uses those same concepts.
      - ESSA did present a flow chart indicating where things would start and end.
      - It was expressed that the content in the flow chart was mostly about people and not really about on-the-ground actions.
      - Concern was expressed that the questions from the interview were not "geared" toward developing a more specific "action oriented" outline.

- Program participants would like to have a clearer idea of what the adaptive management is really going to be and will it be utilized? How will it utilize the PVA? LTP?
  - The LTP has to be a "working document" – it can't be "set in stone" and still have adaptive management. With adaptive management, there cannot be a lot of boundaries. There has to be flexibilities and the ability to change as needed, when needed.
  - The Program has to be able to shuffle the priorities within the LTP. It has to be able to "interact" and "react" to the PVAs, the adaptive management, etc. But how will all these pieces come together?
  - Right now, the PVA has cost the Program more. But the adaptive management development could end up costing the most in the long run.
  - ESSA clearly indicated at the kickoff meeting that they didn't foresee using the PVA very much.
    - It was pointed out that the contractor was hired to write a plan and the PVA is not done yet.
    - There is a sequencing issue. How can they use the PVA when both processes are happening concurrently? Even with the delay until September, there is no inclusion of the PVA within the adaptive management schedule. Shouldn't all the available tools be considered?
    - Part of the issue is that there is almost an "amorphous infrastructure" that is used with the fundamental principle of "learning as you do" and "making adjustments as you go." It is difficult to grasp because all adaptive management plans are different and each one is tailored to a specific program and the specific problems they are facing.

- A question was posed that if there is concern by some PVA members that ESSA will not be using the PVA, is it appropriate for this work group to make some mention of the utility of PVA in Adaptive Management?
  - The Program could probably request the addition of the models to the "problem assessment" section of the adaptive management development outline.
  - Some attendees had the impression that ESSA was going to not use the existing PVA models but rather something else that they create.
  - It was suggested that the PVA work group should provide some documentation to the EC with recommendations on how the PVA should be utilized in the adaptive management.
    - Several attendees agreed. A key publication by Walters and Hilborn published in 1976 that defines adaptive management was referenced. Adaptive management can be considered a "scientific discipline" that is as old as the PVA and there is a tradition of "how to do it right." It was cautioned against ignoring this defining literature.
    - There is no formal adaptive management work group at this time.
    - It was shared that the PVA charter describes being engaged in the adaptive management process – this was discussed at the kickoff meeting as well.
    - It was expressed that the EC has already committed to the completing of the adaptive management process as ESSA is already contracted. The role of PVA (work group and the model) needs to be clarified.
    - Any written information for the EC will need to have an executive summary.
    - This situation seems to mirror what the courts are dealing with – everyone is trying to determine what adaptive management is.
      - Is adaptive management included in the BO as a decision tree or is it hypotheses and scientific inquiry for later in the process?
      - When setting up adaptive management for Glenwood, they brought in Carl Walters, the originator of the adaptive management concept, to help focus what needed to be done.

- The write up should address the concerns of the PVA work group about the relationship between the PVA and adaptive management.
- Attendees were reminded that there is no standard format for PVAs; there is no standard format for adaptive management plans. Each is done on a case-by-case basis for specific situations. There are "guide books" and "handbooks" out there for reference.
- It was shared that the more certainty that is included in the Section 7 process, the easier it goes and more likely judges won't "throw out" the adaptive management plan; it makes it hard proofing up that you are avoiding jeopardy. The consequence of throwing out an adaptive management plan results in reinitiation. The action agencies would have to revert back to the prior action(s) that was in consultation.
  - The PHVA tech team has expressed the opinion that would not be a good place to be (2003 BiOp).
  - The write up for the February EC meeting should include technical expectations of what an adaptive management plan should include, how we recommend it be accomplished, and how we recommend the PVA fits into that framework. The work group is concerned that the Program may end up with "mush" for a plan; and that the plan tries to operate in isolation from other key components.
  - It was shared that the HR work group is also concerned about their role/interaction in the adaptive management plan.
  - ESSA put together a draft adaptive management outline of what the plan might look like based on information that was provided at the kickoff meeting. Tentative components include: problem identification and assessment, implication and monitoring, etc.

- Dr. Goodman offered to walk the PVA work group through the classical mathematical adaptive management concept as published by Carl Walters and Ray Hilborn. In their version of adaptive management, PVA would obviously be part of it. This may or may not relate to what ESSA is doing. He explained that when he teaches adaptive management, he uses an analogy of a chess game.
  - It has been the understanding that the Program wanted adaptive management as part of the consultation process.
  - This means that the adaptive management plan would have to be completed by the time the BAs are finalized. It is the Service's preference that it be included with BAs as well.
  - It is still a concern that adaptive management exists as more of a "buzzword" in people's heads without everyone understanding the "nuts and bolts."
  - If the PVA work group decides to have Dr. Goodman on the agenda to present on adaptive management, then the work group should consider more widely distributed advertisement (instead of just PVA) as a lot of people might benefit (such as technical people in various agencies.)
  - Stochastic optimal control in engineering – that is what this is.
  - Dr. Goodman was concerned if the math would be difficult to follow, but attendees understood the mathematics presented yesterday.

- In terms of logistics, the PMT liaison asked if the work group wanted the CC to be made aware of this conversation (and the tentative write up to the EC in February) at their meeting tomorrow.
  - It was instead suggested that the information be provided as part of the work group update to the EC.
  - It was suggested that the PHVA members be encouraged to attend the adaptive management presentation by Dr. Goodman in January, since PHVA is closely interacting with the PVA. It was agreed that the January PVA meeting will be scheduled as a joint meeting.

- *NOTE: the CC has since clarified that all work group documents and anything for EC review has to first be vetted through the CC.*

Update on pending data needs, recommendations from Phil/Dan on any information still required to have functional PVA models prepared by March 2011.

- Dr. Goodman needs the updated Service data that Jason Remshardt is working on and the genetics raw data.
  - It was shared that Jason will not be available until January 2011 but that Thomas Archdeacon has asked Jason for the updated data and it is expected that Jason will have it.
  - The Genetics raw data is posted to the Program website, as corresponding to the reports for genetics monitoring. Dr. Goodman stated this data incomplete as the reports cite data that is not included with the posted data. Before finalizing the BO, sense needs to be made out of the genetics claims that are being made, mainly regarding census size and variance effective size relationship.
    - It was cautioned that the reports may cite other data that is not a part of the work that was done for Reclamation; that raw data may not be available.

Action: Jeanne Dye will be working with Dr. Goodman to verify that all the Genetics raw data has been received.

- **Set date for next meeting, March 2011 PVA Model debut**
  - January 25th and 26th 2011
    - The primary goal is to meet with PHVA to get a final understanding and possibly a decision on a process for how the PVA and URGWOM models can be integrated; and Dr. Goodman's presentation on Adaptive Management
  - March 17th 2011, possibly March 18th as well
    - PVA Models debut

PVA Meeting Attendees
December 6th and 7th, 2010

NAME	AFFILIATION	Date		PHONE NUMBER	EMAIL ADDRESS
		12/06	12/07		
Lori Robertson	FWS	✓	✓	505-761-4710	lori_robertson@fws.gov
David Gensler	MRGCD	✓	✓	505-247-0234	dgensler@mrgcd.com
Jeanne Dye	Reclamation	✓	✓	505-462-3564	jdye@usbr.gov
Dr. Daniel Goodman	Specialist – MRGCD rep; PVA Modeler	✓	✓	406-994-3231	goodman@rapid.msu.montana.edu
Phil Miller	CBSG – PVA Modeler	✓	✓	952-997-9802	pmiller@cbsg.org
Rich Valdez	SWCA/ISC	✓	✓	435-752-9606	valdezra@aol.com
Mick Porter	COE	✓	✓	505-342-3264	michael.d.porter@usace.army.mil
David Campbell	FWS - NMESFO	✓		505-761-4745	david_campbell@fws.gov
Terina Perez	Reclamation	✓	✓	505-848-7174	tlperez@cabq.gov
Stacey Kopitsch	FWS	✓	✓	505-761-4737	stacey_kopitsch@fws.gov
Jennifer Bachus	FWS	✓	✓	505-761-4714	jennifer_bachus@fws.gov
Tanya Scott	MRGCD-LRPA	✓	✓	505-346-0998	tls@lrpa-usa.com
Yvette Paroz	Reclamation	✓	✓	505-462-3581	yparoz@usbr.gov
Grace Haggerty	NMISC	✓		505-383-4042	grace.haggerty@state.nm.us
Wally Murphy	FWS	✓	✓	505-761-4781	wally.murphy@fws.gov
Rick Billings	ABCWUA	✓	✓	505-796-2527	rbillings@abcwua.org
Warren Sharp	Reclamation	✓		505-462-3637	wsharp@usbr.gov
Janet Jarratt	APA	✓	✓	505-865-1430	jj@jjwater.info
Nabil Shafike	ISC	✓		505-383-4053	nabil.shafike@state.nm.us
Craig Boroughs	BH&H/Reclamation Contractor/URGWOM Tech Team	✓		970-513-4459	boroughs@bhandh.com
Lisa Croft	Reclamation	✓		505-462-3541	lcroft@usbr.gov
Peter Wilkinson	NMISC	✓	✓	505-827-5801	peter.wilkinson@state.nm.us
Andrew Monie	NMDGF	✓	✓	505-476-8105	andrew.monie@state.nm.us
Alison Hutson	NMISC	✓	✓	505-841-5201	alison.hutson@state.nm.us
Thomas Archdeacon	USFWS	✓	✓	505-342-9900	thomas_archdeacon@fws.gov
Christine Sanchez	Tetra Tech		✓	881-3188 xt 139	christine.sanchez@tetratech.com
Marta Wood	Tetra Tech	✓		505-259-6098	marta.wood@tetratech.com