June 2023

Integrated Modeling Framework Workshop Summary

"One Delta, One Science, One Modeling Framework"

Delta Science Program

DELTA STEWARDSHIP COUNCIL

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Delta Integrated Modeling Framework Workshop

Background

The Delta modeling and decision-making community has long been trying to create a more unified, reliable, effective, and efficient working environment for using our vast amount of data and modeling tools to produce easy-to-understand and trustworthy results that serve as a foundation for decisions that affect a variety of California stakeholders. This vision includes creating a modeling framework that will help guide the processes and strategies we use for model creation and use, data selection and preparation, analysis, and producing reports and visualizations that are understandable, useful, and accessible to all. Also referred to as a "collaboratory," the modeling framework comprises shared infrastructure and human resources; standard practices for documenting, disseminating, reviewing, and updating models; and shared data resources, such as digital elevation models, downscaled climate inputs, and time-series boundary conditions.

To advance the vision, the Delta Science Program convened an Integrated Modeling Framework workshop in spring 2023 with a theme of "One Delta, One Science, One Modeling Framework." The workshop convened experienced modeling professionals, modeling group managers, and decision-makers from a wide variety of state, federal, academic, and private agencies/entities to coalesce details about the modeling framework purpose, structure, and specific components as well as

real-world use-cases for which the framework could provide benefits. Specific resources needed for implementation such as a suite of tools, collaboration forums, governance structures, and funding opportunities were also explored. Next steps are to detail the resulting vision and action-oriented recommendations in a forthcoming issue paper that will be presented to Delta Plan Interagency Implementation Committee DPIIC member agencies and other potential adopters.

Workshop Objectives

The Integrated Modeling Framework Workshop explored a variety of use-cases and case-studies to ascertain detailed suggestions for the creation of a modeling framework and virtual and collaborative modeling center.

The Integrated Modeling Framework meeting had three main objectives:

1. Work toward consensus on a common modeling framework,
2. Increase understanding of recent advancements in cyberinfrastructure to support open science modeling communities, and
3. Identify the potential benefits of an investment in a collaborative modeling framework by exploring case-studies of projects or use-cases of management needs that would benefit from these resources, and understanding perspectives and constraints faced by agencies and managers.

Purpose and Goals for this Summary

- Accurately capture the presentations, discussions, questions and answers, and interactions among workshop attendees
- Elaborate on key takeaways and suggestions for next steps in follow-up products (issue paper, etc.)
- Act as a catalyst for continuing these important conversations and knowledge sharing beyond the workshop, and to continue expanding on the ideas presented

Day 1 - Collaborative Modeling for the Delta's Grand Challenges

Recording available at:
https://www.youtube.com/watch?v=ledUyQ0oP4Q&list=PLqTHCliW1HhpXrGF1gI9jjC4lpHZNJWNM&index=3&t=12s

Plenary session

Delta Lead Scientist **Dr. Laurel Larsen** provided opening remarks to the workshop. Her presentation shared objectives for the workshop and provided background context for previous efforts that motivated this workshop, including several venues that call for development of a modeling collaboratory. Dr. Larsen emphasized that this is not a call for development of a single model but for a framework that could make it easier to integrate existing models to better address the Delta's Grand Challenges.

- Recording for Dr. Larsen's presentation.

Cisco Werner, the Director of Scientific Programs and Chief Science Advisor at the National Oceanic and Atmospheric Administration (NOAA), followed Dr. Larsen with a presentation about grand challenges in earth systems modeling. Dr. Werner emphasized that climate change effects on our environment require much faster response and progress in the future, and the explosion of data challenges require we rethink our approach to earth systems modeling.

- Recording for Dr. Werner's presentation.

Kristin White, Central Valley Project Operations Manager, US Bureau of Reclamation, then provided a presentation on "The Decision Making Puzzle" in which she described challenges to decision-making and how principles of best available science relate to best available tools for modeling.

- Recording for Kristin White's presentation.

Dr. Raleigh Hood, Professor at the Horn Point Laboratory, University of Maryland Center for Environmental Science and Program Coordinator of the Chesapeake Community Modeling Program, wrapped up the morning's session with a presentation about agency and academic partnerships using the Chesapeake Bay Program as an example of a success story. Dr. Hood highlighted the critical importance of communication and trust that developed between the managers and academics working together toward a common goal of restoring Chesapeake Bay.

- Recording for Dr. Hood's presentation.

Panel: Modeling Framework Case Studies and Use Cases and Lessons Learned

Dr. Steve Culberson, lead scientist for the Interagency Ecological Program, moderated a panel that focused on panelist's experiences with integrated modeling efforts in their work. This session began with Culberson giving an introduction of each panelist and allowing them to give a brief presentation of their use-case as it relates to the topics of the workshop. A panel discussion followed. The questions and topics discussed are included here, and a full transcript including the answers to these questions is provided in the appendix.

To see a transcript of the panel discussion, please see Appendix C.

- Panel recording

Panelists

Eric Danner, National Oceanic and Atmospheric Administration Fisheries
Lisa Lucas, United States Geological Survey
Andrew Schwarz, California Department of Water Resources
Derya Sumer, United States Bureau of Reclamation
Alison Whipple, San Francisco Estuary Institute

Panelists' presentations of their use-case:

Derya Sumer shared her thoughts and experience with collaborative efforts on the 2021 update to the Long-term Operations (LTO) of the CVP and SWP. She included topics such as the NEPA and ESA processes, effects analysis framework, and how modeling fits into the LTO decision-making process.

Alison Whipple shared her experience working with the Landscape Scenario Planning Tool and application/pilot at Staten Island. She discussed connecting models for landscape planning, using comparison tools to evaluate effects of

different landscape uses, challenges and uncertainties, and additional needs for enhancing this tool and approach.

Lisa Lucas presented on CASCaDE 2 (Computational Assessment of Scenarios of Change for the Delta Ecosystem). The CASCaDE project was motivated by the question, “Can we develop a system of linked models to evaluate ecosystem level impacts of regional and global scale forcings over this century?” She briefly explained the approach of CASCaDE and its components and provided an update on the status of some of the products. She concluded with some ways that CASCaDE could have benefited, or not benefited, from a Collaboratory.

Andrew Schwarz began by sharing examples of types of modeling that DWR does, and how climate change presents unique challenges for modeling. He then discussed the topic of risk-informed climate scenarios. Shwarz also talked about ways that that a Collaboratory could help with this modeling and unique challenges.

Eric Danner presented the Winter-run Chinook Life Cycle Model (WRLCM) as a case study for the Integrated Modeling Framework. He explained the life cycle of Chinook salmon and how the model works, including the model flow and specific components. Danner also talked about the model integration and how his team is working to improve sub-model integration aspects.

Moderator questions:
For Eric: Life cycle modeling seems to be a critical need for all conservation efforts directed at ESA-listed species. To what extent did you receive direction from an executive group or manager, and to what extent was the effort more of an exploratory, academic exercise? Were these two motivating factors in opposition, or were both necessary for sustained and creative approaches to the modeling and the community engagement?

For Andrew: DWR is a powerhouse for modeling. Given your internal expertise, what are your motivations for partnering with other agencies or academic scientists for modeling projects? What do you perceive as some of the biggest needs?

For Lisa: What is the "problem" CASCADE set out to solve, and has it become something more in the past decade? As an independent agency, it is important to note that the USGS protects its separation from policymaking. But do you see a direct pathway for CASCADE to supply information that would impact decision making, now or in the future? How have you engaged with regulatory agencies in its development?

For Alison: Is your use case extensible to others, or is this fairly unique? How did SFEI and associates arrive at this approach and application? What was your role in the use case you described? What other roles were necessary to the effort? How were your contracts supported?

For Derya: As you know, co-production of scenarios with extensive stakeholder engagement takes a tremendous amount of staff time and effort. What would you recommend as decision criteria or guidelines that make it worthwhile to agencies to embark on similar processes, as opposed to tackling the modeling in-house?

Note: Transcripts of the panel discussion, including responses from panelists, are provided in Appendix C.

Highlights and key takeaways:

- Current modeling work by agencies emphasizes scenario-driven approaches to planning and risk assessment and recognizes the importance of engaging diverse communities in the development of scenarios.
- Agency-academic partnerships can provide agencies with access to state-of-the-art computational resources, emerging methodologies, and scientists with time and willingness to engage in modeling, while ensuring that the science produced through the partnership is aligned with decision making needs.
- The ability to link different kinds of models (climate, operational, hydrologic, hydraulic, water quality, ecological) is essential for addressing questions about future costs and benefits associated with alternative operational and management strategies and promoting innovation in the development of strategies to address the challenges of climate change.

- Shared needs for model-based planning include quality assurance/quality-controlled boundary conditions (e.g., time series of flow and sea level inputs), tools and data to support calibration and validation, shared standards for input data cleaning, and clear documentation of model and data products that highlights any deviations from standard protocols. Due to severe time constraints on modelers, additional staff support to meet these needs is pivotal, and it would be counterproductive to mandate standards for inclusion of model or data products in a collaboratory.

Breakout Session: Discover Use Cases and Case Studies

In the afternoon of Day 1, in-person and virtual breakout sessions were held to provide opportunities for participants to share their own experiences with and ideas for future case studies and use cases. For more information on breakout discussions, please see Appendix D.

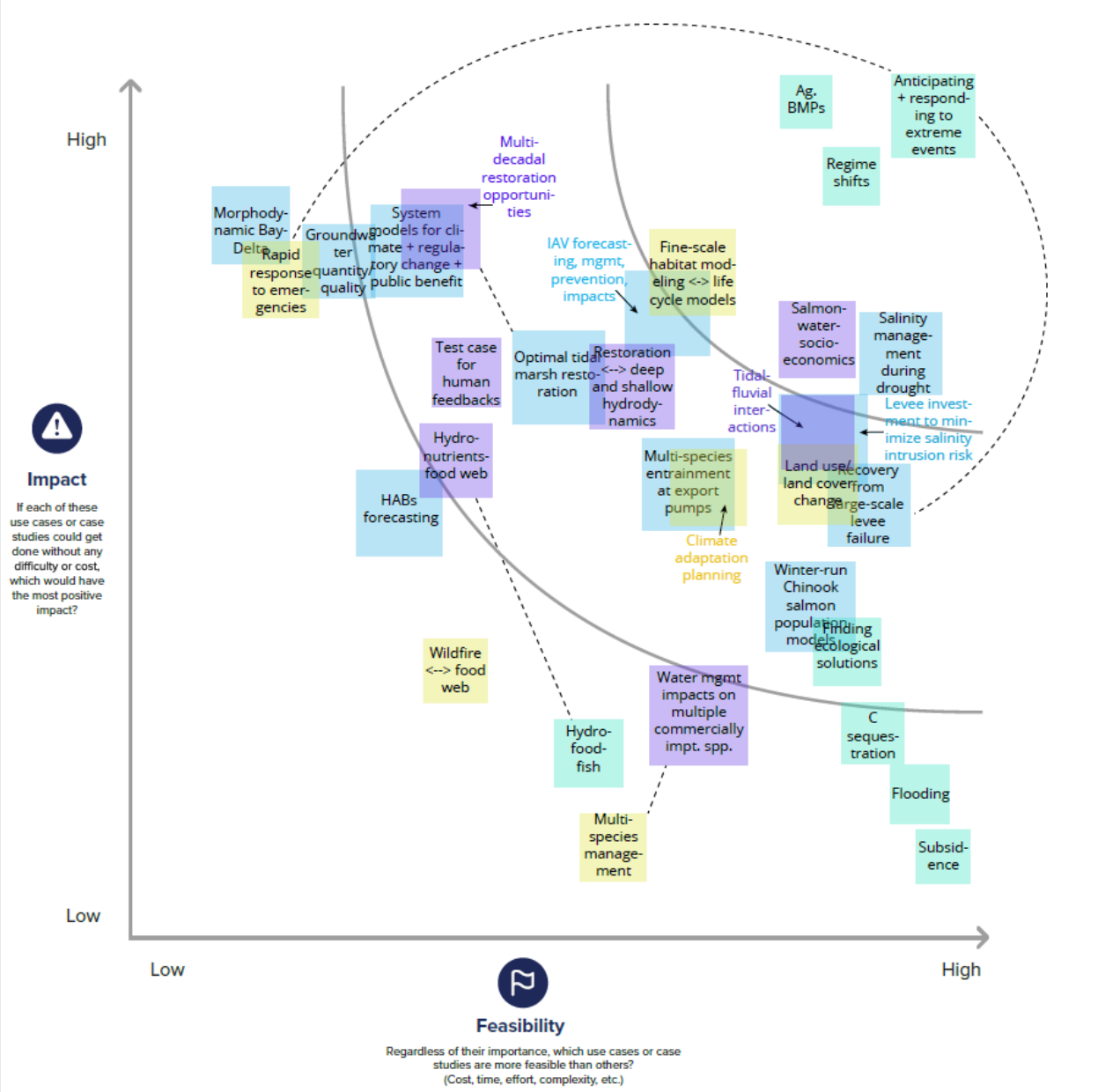
- Recording of Day 1 Breakout Report Outs

Day 1 Breakout Questions

link to example mural board at: https://app.mural.co/t/practice9612/m/practice9612/1677543702591/96a3565c649a5b0f2c2249edeae4c4ac303def1b?sender=1d0ce441-6273-4ae7-b919-e86aabd75d4b

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral)?

Participants were then asked to collaborate on an impact vs. feasibility ranking exercise in which ‘sticky notes’ with use cases or case studies were placed on a graph.



Synthesis of use-cases identified by breakout groups and their assessed feasibility and importance. Products of different breakout groups are shown in different colors. Similar use-cases identified by different breakout groups are connected with dashed lines, indicating high variability in how use-cases are ranked.

"We are drowning in information, while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely."
E.O. Wilson, 1978

Day 2 – Collaborative Resources and Modeling Frameworks

A recording of day two is available on the Delta Stewardship Council's YouTube channel at: https://www.youtube.com/watch?v=-BIoczqg_Sc&list=PLqTHCliW1HhpXrGF1gI9jjC4lpHZNJWNM&index=3&t=3s

Panel: Open Science and Collaboration Resources

Moderator: Dr. Peter Goodwin (University of Maryland Center for Environmental Science)

This session included an introduction of the topic and panel members led by Dr. Peter Goodwin, then proceeded into short presentations from each panel member, and concluded with questions to the panel from Goodwin and workshop attendees.

Goodwin included a quote in his opening statements that set the stage nicely for this topic and read; "We are drowning in information, while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely". (E.O. Wilson, 1978)

To see a transcript of the panel discussion, please see Appendix C.

- Panel recording

Panelist Presentations

Irina Overeem, Community Surface Dynamics Modeling System (CSDMS), University of Colorado-Boulder

Overeem kicked off this session with a presentation about the CSDMS community, which focuses on model earth surface processes like sediment transport, river dynamics, landscape evolution, and many others. CSDMS utilizes workbench technologies such as Basic Model Interface (BMI) Standards, Language Interoperability (Babelizer), Model Building Toolkit (Land Lab), Execution & Coupling Framework (PyMT), and Standard Variable Names (CSN). The community promotes F.A.I.R. (findable, accessible, interoperable, and reproducible) practices pervasively. Irina also discussed the level of effort this work demands, challenges the community faces, and lessons learned along the way.

Dave Bosworth, California Department of Water Resources
Bosworth presented on the topics DUWG (Data Utilization Work Group) within the IEP (Interagency Ecological Program). , The DUWG focuses on diverse datasets, including water quality, plankton, benthic, and fish data. They develop data standards, promote open science and best practices, and support IEP member agencies. He also talked about some challenges including lack of staff time and resources, insufficient knowledge, and fear of misuse of the data. Progress to date includes outreach and training workshops, data repository recommendations, publishing support, and other guidance.

Greg Gearheart, State Water Resources Control Board

Gearheart presented on open data synthesis and engagement activities at the State Water Resources Control Board and how the Board strives to increase capacity inside and outside the agency. Some of the topics discussed were the relationship between water conservation and energy savings, holding open data challenges, engaging with the public, and AB 1755: the Open and Transparent Water Data Platform for California. He also suggested that we embrace the iterative approach and expect to make mistakes. Open science includes data, methods, effective and impactful communication, as well as equity, inclusion, and a sense of belonging.

Erin Hestir, University of California – Merced

Hestir discussed remote sensing observations to support modeling, performance metrics and decision-making. Topics included the capability for remote sensing to provide trans-boundary systematic measurements at scale, multiagency funding for access to a variety of data types, use of both aircraft and satellites, and many more. Challenges include making the data interoperable, making data management plans available, data preservation, and using data effectively in decision-making. She also discussed the “internet of things” and its potential for contributing timely and complete information for decision-making.

Moderator questions:

1. Regarding A.B. 1755 and other open-source mandates, what would be helpful from your perspective with the responsibilities that you have been

given, that could enhance you and your staff with additional resources to tackle these complex issues?
2. What staff support and governance frameworks are needed to implement the tools and develop a collaboratory?.
3. What is the potential for adopting the tools you have described to a collaboratory type framework?

Highlights/key takeaways:

- Key components of collaborative open science are open data and methods, effective and impactful communication, as well as instilling principles of equity, inclusion, and belonging. With respect to these components, developing a diverse workforce and engagement of under-served communities that are often the most impacted by their environment and providing access to scientific data and modeling products is lagging.
- Social scientists have a critical role to play in understanding the consequences of a highly dynamic ecosystem and the feasibility of potential solutions and adaptation opportunities.
- Navigating different platforms for data and model sharing continues to be a challenge. For a collaboratory, it is important to identify mechanisms and people that could provide linkages to diverse data repositories and modeling platforms.
- There are many existing resources for development of standards, best practices, and a governance structure, such as the Bari Manifesto, which outlines 10 principles for data interoperability, and earthdata.nasa.gov, which serves as a data discovery portal.
- Intentional development of the human component of the collaboratory is critical—to create a culture that nurtures a safe space for innovation and ideas, to ensure connections to related efforts, to maintain sufficient human resources for data and model governance and integration.

Session: Deep Dive into Modeling Frameworks

The final session on the morning of Day 2 included an exploration of various topics related to modeling frameworks. Each panel member shared a brief “lightning talk” about a topic as summarized below, and then the group participated in a panel discussion moderated by Ben Geske.

Moderator: Ben Geske, P.E., Delta Science Program

Lightning Talks

Framework for Production Modeling – **John DeGeorge**, Resource Management Associates

DeGeorge shared his vision for a framework in the context of production modeling. He covered specific objectives for this method/approach, as well as listing out and explaining some important team roles. He also shared some visuals/diagrams and flow charts that explained the connections and relationships between multiple models in a framework, configurations, inputs, and outputs. He emphasized creating a framework that brings together the people and the tools to optimize the community's potential.

Frameworks Help Us Work Together – **Jay Lund**, University of California, Davis

Lund presented his vision and thoughts for how frameworks can help us work together. He led with a comic strip highlighting the notion that this type of work is a "struggle, eternal, and constantly changing". He covered topics/questions such as "why do this and pay for it", "who pays for it", "why do this together", governance and culture, funding for integration specifically, interfaces and interpretation, quality control, documentation, and the vision of continuous improvement. He concluded with an emphasis on the need for institutional cooperation that might take legislation.

Community Surface Dynamics Model System – **Irina Overeem**, Community Surface Dynamics Modeling System

Overeem presented and expanded on key tools that might be useful in a collaborative modeling center. These tools can be used for many different models and include an open catalog and repository for software and other tools, BMI, Babelizer, PyMT, LandLab, and a few others. She also mentioned resources and training focused on teaching and learning and lessons learned from the CSDMS experience.

COEQWAL: Equitable Stewardship of California's Water in a Changing Climate – **Ted Grantham**, University of California – Berkeley

Grantham's presentation focused on describing a "bottom-up" approach to decision-making using the proposed Collaboratory for Equity in Water Allocations (COEQWAL) project as an example. The bottom-up approach describes one in which scenarios are developed with extensive community engagement, here focused on risk assessment and water planning to aid in decision-making about water allocations. The project explores tradeoffs associated with three use-focused on drinking water for vulnerable communities, Chinook salmon recovery, and salinity management.

Modeling that Supports Decision-Making Under Deep Uncertainty – **Lisa Wainger**, Chesapeake Biological Lab/UMCES

Wainger is the chair of the Delta Independent Science Board, which promotes credibility of science in decision-making. She began the presentation with a slide explaining what deep uncertainty is, and highlighted some key decision-making under deep uncertainty (DMDU) tools such as scenario development, modeling, vulnerability assessment, and adaptive planning. Challenges include disagreement among stakeholders on consequences of certain decisions, so there is a need for stakeholder engagement and deliberative approaches. She concluded by identifying some collaboratory goals that would support the ability to conduct deep uncertainty analysis including 1) developing models that can be run relatively quickly to enable a wide range of parameters or model structures to be compared, 2) coupling models of human behavioral adaptations to promote realistic forecasts, and 3) creating models that can be adapted to stakeholder concerns.

Panel Discussion

Moderator questions:

1. What is the purpose of a modeling framework?
2. What are priority next steps to take us from general and abstract discussions into an implementation phase to start building the framework and modeling center?
3. Can you share your experience and/or ideas in working with people, specifically organizing "champions" to make meaningful progress in these early stages?
4. Share some ideas about key tools and specific skill sets needed to launch this effort, and what do think we are missing now?

Audience questions:

1. How can we use AI and machine learning to enhance this effort?
2. How can the modeling collaboratory help with the uncertainty of climate model projections?

Note: Transcripts of the panel discussion, including responses from panelists, are provided in Appendix C.

Highlights/key takeaways: (link transcripts)

- Operational use of models could benefit greatly from common resources provided by a collaboratory, including automation for time-dependent data processing to derive inputs and automated post-processing to enable model comparison at a consistent resolution or scale. Additional shared modeling needs include a library of boundary conditions representing the historical period, climate projections that could serve as inputs to different types of models, and tools for uncertainty analysis.
- Given the commonality of modeling needs across agencies, collective investment in a shared set of modeling resources can create efficiencies.
- One-third of the budget of a collaboratory should be devoted to integration. A consistent funding base is needed.
- A collaboratory can facilitate vulnerability assessments, adaptive planning (including the identification of triggers at which strategies should be adjusted), and uncertainty analysis.
- In addition to models used for planning and operations, exploratory model development should be an investment area for the collaboratory. Exploratory models can facilitate engagement of diverse stakeholders and students with complex problems and help communicate science.
- Students can fill an important niche in the collaboratory: they are able to take more risks in the modeling process, and they can contribute to workforce development.

Breakout Session: Resources for Promoting Open Science and Collaborative Modeling

On the afternoon of Day 2, breakout sessions were held to discuss resources that would be beneficial for open science and collaborative modeling in the Delta. In-

person groups focused on questions that related to cyberinfrastructure needs, modeling best practices, or governance. Virtual groups focused on a mix of questions from the cyberinfrastructure, best practices, and governance topics ("broad discussion" questions).

Day 2 Breakout Questions:

Cyberinfrastructure

- What is the ultimate vision for a modeling framework or modeling center?
- What components or resources are necessary to achieve this vision?
- How could we best organize and integrate these components and resources to make a cohesive framework/program?
- How does the idea of building a new working group in CSDMS resonate? What might be the costs and benefits?
- What has been your (or your agency's) experience with developing or using existing software to facilitate coupling models or integrating data? What lessons learned or important insights can you share?

Best Practices

- Why are protocols and best practices important to developing an integrated modeling framework and modeling center?
- How do you currently interact with modeling protocols and best practices in your work now? What do you reference (e.g., CWEMF Modeling Protocols Report)?
- How do we best educate and inform the modeling community about existing protocols and best practices?
- Should/how do we develop best practices around modeling and disseminating information about uncertainty?
- How might we make models more transparent to non-experts? How might we share information about embedded assumptions?

Governance

- What are the priority governance considerations for developing a modeling framework and establishing a modeling center?
- How could components and resources be organized to produce a cohesive framework and center?

- What specific people and/or skillsets should be engaged in this development process? Are there any specific agency leaders that we need to recruit as "champions" of this vision in order to maximize "buy-in" from the beginning?
- Who are the parties that would have an interest in the outcomes of modeling associated with these case-studies or use cases? Who are the parties who are already engaged in addressing these issues?
- What considerations are necessary for ensuring the modeling framework and center are accessible and transparent to participants? How do we encourage or facilitate collaborations that include participants from multiple institutions, disciplines, and interests?

"Broad discussion"

- What components or resources are necessary to achieve this vision?
- How does the idea of building a new working group in CSDMS resonate?
- How do you currently interact with modeling protocols and best practices in your work now?
- How might we make models more transparent to non-experts?
- What specific people and/or skillsets should be engaged in this development process?
- Are there any specific agency leaders that we need to recruit as "champions" of this vision in order to maximize "buy-in" from the beginning?

Highlights/key takeaways:

- Participants expressed widespread desire for consistent training in science communication, with a focus on best practices for effective communication of complex topics, together with training on open and reproducible science methods. Training resources that the collaboratory could draw upon include those provided by Software Carpentry, the National Center for Ecological Analysis and Synthesis, and OpenScapes.
- Desired human resources for a collaboratory include science communication experts; stakeholder engagement specialists and social scientists; scientific computing support; support for developing metadata and other documentation and for standardizing the format of data and model products; and community building among modelers that supports knowledge transfer (potentially facilitated through use of a forum and establishment of user groups).

- Best practices that a collaboratory should promote include the use of repositories for configurations and model environments (e.g., Github, Docker, Binder), detailed metadata and a culture of modelers reading metadata; long-term solutions for data and model archiving; standards to ensure cybersecurity; and engagement of students and underrepresented communities.
- Cyberinfrastructure resources desired within a collaboratory include a user interface through which models (such as those in the California Water and Environmental Modeling Forum inventory) can be accessed and manipulated; a wiki that provides high-level and detailed information about models; a help center; a makerspace for showcasing models, projects, and results; access to cloud storage and high-speed computing; tools for aggregating, lagging data and other types of data pre- and post-processing; and a rating system that can help users evaluate community uptake of models and their level of development.
- Developing a collaboratory and effective governance structure requires champions and a clear problem statement.

Closing Thoughts on the Workshop

Through the workshop, strong consensus emerged that the time is right for Delta agencies to invest in a collaboratory that advances shared needs. Currently, agencies are addressing shared challenges (e.g., updating models and modeling results when new climate forcing becomes available, linking different types of models, comparing results from different models, adapting to the rapidly changing landscape of open and reproducible science) independently and are struggling with staff time and computational resource limitations. A modeling collaboratory would create efficiencies and new partnerships that would allow agencies to integrate models into operational workflows more seamlessly, explore much broader ranges of possible futures and conduct more thorough risk and tradeoff assessments, and produce products that are more reproducible, understandable, and comparable across models and agencies, potentially engendering a greater degree of public trust.

Many “big problems” that are ripe for advancement with the resources of a collaboratory were identified in the figure on page 11. In addition to serving as justification for the need of a collaboratory, participants agreed that focused work on these applied problems could be a strategy for building the resources and best practices

associated with the collaboratory. Because specific projects may be more compelling to funding agencies than development of a multipurpose collection of tools, staff, and community, investing in the use-cases themselves may be the most tangible way to initiate the collaboratory. However, sustained funding investments are imperative to support long-term functionality and realization of the multi-agency efficiencies highlighted above. These investments can be maximized by building on existing resources for best-practices, cyberinfrastructure tools, and governance.

This workshop advanced upon the ideas for a collaboratory previously articulated in the Tetra Tech memos in several key ways. The consensus that emerged from this workshop places more emphasis on development of the human dimensions of the collaboratory, including resources to promote community engagement, communication and public education, and training. It also uniquely highlights the importance of agency-academic-community partnerships for producing products and analyses that are sufficiently broad and forward-looking, thorough, and equitable. Many of the items on the cyberinfrastructure and best-practices wish lists (see section summaries above) are also products of recent developments in the rapidly changing area of open and reproducible science.

Next Steps

Through fall of 2023, Delta Science Program staff will work to consolidate recommendations from the Integrated Modeling Framework Workshop into a concise white paper that outlines a strategy for funding and launching a Delta collaboratory in the coming years. Staff anticipate further engagement with workshop participants and interviews with modelers and managers to support drafting of the white paper. The white paper will be presented to the Delta Independent Science Board (Delta ISB) for feedback, and support for collaboratory development will be solicited from Delta Plan Interagency Implementation Committee (DPIIC) member agencies and other partners.

The Delta Science Program will also continue to support agency and academic groups in proposal development for competitive funding opportunities that could support components of the collaboratory. Two groups that participated in workshop have already submitted proposals that are currently under review in federal and state venues. Additionally, the Delta Lead Scientist continues to explore the potential for cross-estuary coordination on collaboratory development with

workshop attendees from the University of Maryland Center for Environmental Sciences, who face similar challenges in the Chesapeake Bay watershed.

Contact Information

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Appendix A: Planning summary

Timeline

Planning committee

Co-Chairs:
Laurel Larsen, Delta Lead Scientist
Ben Geske, Delta Science Program

Members:
Michael Beakes, United States Bureau of Reclamation
Maggie Christman, Delta Science Program
Cory Copeland, Delta Stewardship Council
Steve Culberson, Interagency Ecological Program
Henry DeBey, Delta Science Program
John DeGeorge, Resource Management Associates
Pascale Goertler, Delta Science Program
Peter Goodwin, University of Maryland
Erin Hestir, University of California – Merced
Myfanwy Johnston, Cramer Fish Sciences
Steve Lindley, National Oceanic and Atmospheric Administration
Jay Lund, University of California – Davis
Russ Perry, United States Geological Survey
Sujoy Roy, Tetra Tech
Nicky Sandhu, California Department of Water Resources
Mark Stacey, University of California – Berkeley
Vanessa Tobias, United States Fish & Wildlife Service

In addition, the Planning Committee would like to thank the following people for providing input during the planning process:
Sarah Brown, California Department of Water Resources
Lauren Hastings, Delta Stewardship Council

Andrew Schwarz, California Department of Water Resources

Appendix B: Detailed Attendance Report

Summary

Day 1 In-Person Attendees

Name	Affiliation
Lois Colaprete	UMCES
Irina Overeem	Univ of Colorado
Henry DeBey	DSP
Maggie Christman	DSP
Laurel Larsen	DSP
Ben Geske	DSP
Edmund Yu	DSP
Pascale Goertler	DSP
Jereme Gaeta	CDFW
Jess Rudnick	CA Sea Grant/DSC
Cory Copeland	DSC
Erin Hestir	UC Merced
Michael Porter	US Army Corps of Eng
Scott Meyer	DWR

Raleigh Hood	UMCES
Victoria Coles	UMCES
Peter Goodwin	UMCES
Steve Culberson	IEP/DSC
Lisa Wainger	UMCES-CBL/ISB
John DeGeorge	RMA
Nimal Jayasuudara	DWR
Malinda Wimalaratne	DWR
Eric Danner	NOAA Fisheries
Paul Hutton	DWR
Pooja Balaji	DSP
Ben Bray	EBMUD
Darcy Austin	SWC
Derya Sumer	USBR

Day 2 In-Person Attendees

Name	Affiliation
Lisa Wainger	ISB/UMCES
David Bosworth	DWR
Jereme Gaeta	IEP @ CDFW
Greg Gearhardt	CalEPA/SWRCB

Eric Danner	NOAA Fisheries
Ted Grantham	UC Berkeley
John DeGeorge	RMA
Michael Porter	USACE
Scott Mexer	DWR
Lois Colaprete	UMCES
Victoria Coles	UMCES
Raleigh Hood	UMCES
Cory Copeland	DSC
Ben Bray	EBMUD
Morris Lim	DPAC RBOC
Henry DeBey	DSP
Maggie Christman	DSP
Laurel Larsen	DSP
Ben Geske	DSP
Edmund Yu	DSP
Pascale Goertler	DSP
Peter Goodwin	UMCES
Steve Culberson	IEP/DSC
John DeGeorge	RMA

Virtual Attendees – many folks attended virtually, but we don't have a list.

Appendix C: Panel Transcripts

Transcripts provided via YouTube application.

Note: The transcripts provided were taken directly from YouTube as provided to us. It is possible that the application did not capture everything correctly. These are intended to give the reader a good sense of the audio collected throughout the workshop. These should not be used for quoting any speakers. Please refer to the recording to confirm details.

Day 1: "Use cases and case studies" panel transcript

Steve:
Eric, lifecycle modeling seems to be a critical need for all conservation, ever directed at ESA listed species so what extent did you receive direction from an executive group or manager? And to what extent was the effort more of an exploratory academic exercise? We could get into were these 2 motivating factors in opposition, or were they both necessary for sustained creative approaches to modeling and community?

Eric:
Thanks, Steve. And yeah, and I forgot that you were. Gonna ask me that question I should have followed that with a clarification so let me start with the answer that it the life cycle model from NOAA Fisheries perspective, was actually demanded by a judge in in a in a federal lawsuit, because in Fisheries, Management and water management, and it's something like salmon. Have such a complex lifestyle, that lifcycle that, and have it so many different habitats. There's so many stressors involved here that you basically get different sides pointing at different things that are causing the decline or the lack of recovery. And so it was mandated that you needed a full lifecycle model to capture all of those stressors simultaneously and in better evaluate the overall impacts of individuals stressors on the whole system. So in that respect it was mandated from very high up on what we needed to do. What is actually, how the lifecycle models actually applied right now, so far, has been entirely limited to biological assessments and biological opinions associated with long-term operations of the Central Valley project. So we are given a series of zoom scenarios that we run through the lifecycle model, and then those are evaluated,

and in the process of and then those are evaluated, and in the process of those decisions, so again, that is sort of a top-down application. Unfortunately, we haven't had much chance to do our own analyses using lifecycle model where we applied in a bit more scientific exploratory format, and part of that is data limitation in that in order to do it you need to be able to run calcum and you need to be able to generate your own scenarios, to evaluate what those in water management operations are. Gonna look like we're starting to go down that road now is that?

Steve:
Yeah, thank, you. I bet there's about 3 days worth of problem. We could we could pursue. But let me move on to Andrew. For let's see. DWR. Is a powerhouse for modeling. Given your internal expertise. What are your motivations for partnering with other agencies or academic scientists for modeling projects and what do you perceive of some of the biggest needs right now?

Andrew:
Well, I mean on the agency side, I think the partnership between Dwr. And the Bureau is, is absolutely critical. We do so much join operation of the systems that we have very similar constraints. And and and we use the same model for all of our planning. And so making sure that we're aligned on what we're saying about climate change, what we're saying about, you know, the benchmark model where we are, what we're starting with is critical. And so you know, coordinating with Daria and her team is one of the big things that we're doing. And it is super important also with the, you know, with the fish agencies and the and the other environmental regulation agencies, and and the water board. That's a critical point. I'm less involved with that. So, maybe I'll focus on on kind of partnering with academic agencies has been or academic scientists has been, a huge benefit to us in the past, because I think climate change is really kind of at the frontier of this co-development of science for policy and management decision making and so we've had collaborations with. Of course, you see, Davis, and University of Massachusetts right now, we're working with Cornell on on on some weather generator, and some new techniques for better representations of stochastic hydrology that we can use with climate change. We've looked at different approaches for addressing climate change. We learned a ton from our collaboration with the University of Massachusetts on decision making under deep uncertainty and some bottom-up methods for looking at at how to how to study a system with a range of uncertain conditions, and so those collaborations have been super important for pushing our understanding of the system and for building ways that that we can do better management and that the scientists often don't have a great understanding of how

we use the information or how we're gonna make that into a decision. And so that that close collaboration and the code of this model of code development of science, I think, is one that has a ton of promise, and that we can really get to where we need to be, if we do that coupling more instead of just saying hey do this build this for us. We want this question answered. It really needs to be a partnership all the way.

Steve:
Thank you for your response. Let me make sure I'm near the microphone. Oh, I'm sensing an interesting tension here between directed investigation and collaborative. Round swell of interest. So I think this is a a fertile thing to think about. My next question would be for Lisa. Welcome back. What is the problem? Cascade set out to solve if I can put it? So crudely. I know you'll have issues with that. Is? Is it become something more in the past? Decade, and just a little bit of info for the background question as an independent agency. It's important to note that the Gs. Protects its for its agency. Separation from policy making. Do you see a direct pathway for cascade to supply information that would influence decision making now or into the future? And have you engaged with regulatory agencies about this? Or is that something that's not on the I don't think.

Lisa: (see video for Lisa's response)

Steve:
Yes, again, raising, potentially raising more questions than answers but that that is indeed why we're here and thank you for your response. Very thoughtful, and measured, appreciate it. We'll continue online with Lisa. I'm sorry with Allison. Is your use case extensible to others? Or is it a pretty unique one? How did Sfbi and associates arrive at your approach and application? And what was your role? What was your specific role in the case you described? And maybe some key. Other roles. If you might mention this. Maybe some say again. Some key, other roles. So I you mentioned the partnership. You know, they're obviously some very key players. In some of these things. So could you talk about yours and others role.

Alison:
Sure. Yeah. And thanks. Yeah. So as far as a question of whether this case is extensible to others, nice say, certainly the intention of the landscape scenario planning tool is that it's used by others. It's built to be flexible, modular, able to, you know, relatively. You know, be able to add in new metrics, as interests. Come along. You know the idea that entities stakeholders potentially can be able to see their

metrics reflected in the suite of metrics that are evaluated with the landscape scenario planning tool so you know, we're hopeful that it's becomes more widely adopted by others, and expanded on to provide again more links between various modeling and and other analysis efforts, and then for the multi model and multi metric assessment that I spoke of in terms of the application at staten island that's certainly an approach that can and is undertaken by others just reflecting on. I think Sfei is uniquely positioned in many ways. Given our past work and understanding kind of landscape scale benefits and and can ecosystem functions as they relate to landscapes, pattern and process? I think we are uniquely positioned to develop a tool like this. Also with our tool development expertise. But again, the idea that this can be used by others, and I should probably know, too, that even though this is built as to be, you know, it's an architgis toolkit, something that could be relatively straightforwardly adopted, by others it's there's still, a heavy lift right to, you know. Have one group develop a tool and have that be. Widely adopted by others, so that's where the partnerships development along the way communication along the way is really critical. I think, in terms of how we arrived at this approach, and the application I mean I've already spoken a bit in terms of the landscape scenario planning tool development that it really was a culmination of past work, but as kind of as we were moving from the Delta. Landscapes. There were a number of workshops, public workshops held in terms of how how that work might be applied, and so that's where a lot of the ideas for the Lspt came about. And also a number of one-on-one or more more detailed conversations with Delta, Stewardship Council, and that really brought the ideas forward. And so, and I think I mentioned, you know, space to brainstorm. So initial seed funding to be able to bring forward these ideas before going for a a larger project. We're really important along the way. And other other thoughts, I guess, in terms of the Statin Island application. Similarly came about through a number of you know, connections and conversations through workshops. I think specifically with the Staten Island example, that public land strategy process that the Delta Conservancy inspired, and and also do we sell at the Atnc, and that that all that really brought forward this idea of the Staten Island Visioning and scenario analysis process I think Hetera focus was also pretty involved early on in in bringing those 4. Those ideas forward in terms of the role in the work. So with the Lspt, as I mentioned the landscape scenario planning tool, I, personally wasn't involved in leading our Delta historical ecology work. Now over a decade ago. So a lot of the foundational understanding and thinking about landscape pattern and process, and and how we might think about that within our modified landscape today and going into the future and I've been involved in some of the updates to the tool recently but I'd say for an Sfi in my role with the Staten Island work was to, you know, adds with the Lspt. To be a kind

of a hub to bring these different modeling efforts together, and and kind of facilitate the process of bringing the partner's partners together. But really working again with teamc and conservation firms and on ranches to think through what would be some realistic scenarios to be to be considering. So I, and speaking to the other roles that you asked about. As I mentioned you know none of us could have done the Staten Island use that example. We couldn't have done that work independently. So it really came about. We needed to be able to hand things off to one another and work collaboratively. So again, the Hunter Focus team, Steve Devil and his team and his way, and he knowswater. So you know, both consultant and agents and and university expertise being able to bring that together. And it really came really was necessary for us to know what each other was. Doing, building on past collaborative efforts. So I'll leave it at that.

Steve:
Thank you for the thoughtful answer, Nelson, and I guess we've got time for the last one to bring this home. As we started. How are you? Some comments from you? If you wouldn't mind, and perhaps these could build on some of the things that Andrew was telling us as well as you know, co-production of scenarios with extensive stakeholder engagement takes a tremendous amount of staff time and effort. Would you recommend as decision, criteria, or guidelines that make it worthwhile to agencies to work on similar processes as opposed to tackling, modeling, souls in-house? Are there other use cases which we should probably stick with the person?

Derya:
Yes, it's definitely takes a lot of time. Didn't try really hard, though I wanna say all of our conversations, everything before all the models were publicly available. Everything was available. What was really different this time we really spent time and effort to develop a common understanding of our system and it's physical, hydrologic, regulatory limitations and like smoking. That is the key information that establishes the foundation part. Exchanging ideas, because otherwise we're in a different world. And we're speaking differently and kind of pass them through each other. That was a huge time consuming the Hmm! So can we send it back to the time that it takes? But I do believe that if we have it speaking tie to this, this workshop, if we have a if we miss in a community, if we have a community of people who are already in the know, if we have tools in our library, give it me, the 100 different tools something to select, from I think those things, are gonna help. expedite these processes in the future, and that's what we can do. People go, so you people come and take a while to everybody to come up to speak with the

system we can't escape those. It can be a standard practice. It would be nice. We can work towards it. It is gonna take time to establish that that whole community, though any other examples, what can we use this for? I think, for any other planning multiple studies, we could definitely use some in-person. We know we have a number of numbers sorry program programs. We're trying to figure out what we're gonna do on the climate change. Or it could mean facilities, or anything but the key is to really start somewhere and work on developing the community.

Steve:
Hmm nice to send. Please join me in thanking our panel and want to reset this morning.

Peter Goodwin panel transcripts:

Peter:
Okay, part of this questions. I think the first question I'd like to ask is just to rip off Greg's comment that, as we've heard from several of your presentations like him in California, we had the passage of a.B. 1755. There's also Federal directives out there about open source data. And there's many laudable efforts to make data and models more publicly available. But the proliferation of repositories can be overwhelming, for end users. And I just wonder, how could a collaborative like is being proposed here? Help address this deluge, and particularly, perhaps, for Greg and Dave. What would be helpful in the responsibilities that you have given, that we all know that you're really understaffed under resourced for the magnitude of issues. And so any insights that you have for this group, for the conclusions, for the report. And Greg is you hit that if you want to start, and then we'll just work our way along the table.

Greg:
So one of the statements that I was gonna say, but I'm saving it. Print right now is that we've actually failed at open data. I think it's government and the water topic, and you know it's a hypothesis. So let's test it, may or may not be true, but I say that because I think what we've done is we provided access to data sets we've created automation and workloads that are unsustainable. For circular group that does does already know how to get that data. They knew how to get it. Probably prior to the statute. We a lot of our data sets that department fish and wildlife and the Water Boards have been publicly available for years. Decades, maybe. And so I think we need to rethink that.And I one of the ways that we can rethink that within this collaboratory and the Delta is because of the scale. I mean, it's both big, but it's

also smaller than all of California. We could we test out different ways to make data accessible in multiple ways. I think one of the favor has been that there would be one sort of front door to the giant library of open data in California, and everyone would just come through there and find what they needed immediately warehouses in the back. And what have you? And then Api's would be sort of like easy. And that machine machine connections, both building them and maintain them would just be sort of like, touch a button. And everyone's data flows. Right? So a lot of things have been learned. I think that should reframe both how the State moves forward with open water data, but also in this delta environment, because we are talking about a lot more than water data and the value of that synthesis is is paramount. So I think it's an opportunity for us to think it, and I'll just throw out also that we haven't reached the people that open government was intending with open data. So the the most vulnerable and overburdened communities still struggle to get the data they need to advocate for their interests, and so providing an open data with a with the jargony metadata and a bunch of field names that are meaningless to most people isn't really solving that problem either. So we have not to mention other languages. So we have a lot of work to do to really make open data working.

Dave:
I guess when I saw this question I was a little bit like, Oh, wow! I think we're part of the fire hose effect. I just basically was saying how we have 38 different of data products on the EDI data repository. But I guess in our defense they're all in one place. They're not scattered throughout different places, but I do agree that it is overwhelming to have that. And I mean I think my I mean I kind of already touched on it before, but I think data integration is kind of something that I would love for the Doug. And just for in general, just for the greater community to start focusing their energy on more. And I mean so right now at at the current state, we do have some date, like some data integration, like projects that are going on. And it. But they're they feel very like like a kind of like a volunteer effort. So. And I'm like kind of volunteering for one of them like myself. And it's been a lot of fun, and I really like I mean, I see the value in it. But I think that there needs to be more priority and focus and and resources and upper management to value that and to get it. Staff, time and and the resources to do that. So awesome! Oh, thanks!

Irina:
Oh, second you a little bit on the technology, and sort of like making things more smooth on the technological side. But I think big parts in the people, and so in a collaboratory, I think one of the valuable things is to like, make sure that you have

represented of these other data portals or the other like data efforts, and to sort of like make sure that they know about you and the laboratory has like representatives and connections to those other data sources, and that I think it could be like as easy as like importing from like other data portals. And but I think the people are like your connection to those to this data portals. And so that's a lot of like communication and putting people together.

Erin:
I'm gonna take the advantage of my university title and step into my ivory tower and not be a little contrary here for as long as I've been involved in this intergovernmental group on Earth observations. There have been calls for, you know, one quarter to rule them all, to do so inhibits innovation at the fundamental level, and we want to make sure that there is space for that and that means that there is a necessary amount of duplication. But there's also that space for innovation, and to try something new and to incorporate new data products and streams that we hadn't previously anticipated. So there's a tension there, right? And that tension, I believe, will always exist if we want a healthy, advanced technologically in these information systems. And so I think that the role of a collaborator is really that human element of having a knowledge base of experts that understand that space and keep up with the changing technology and are able to advise and potentially connect data systems, whether that's that's cyber infrastructure or whether that's just knowledge based in order to help promote users, but also stay on the, you know, cutting edge of technology as we innovate.

Peter:
Thank you for that. And perhaps just to build on that theme a little bit. One of the things I took away from this that each of you have your agency, responsibility or program responsibility. And when you start getting requests from are the folks that want to access that data, it's really hard for you to allocate resources for the amount of time it takes to explain it. Here's where you go, so I just wonder. Maybe I will go back the other way this time. She touched on that. What sort of staff support and governance frameworks are needed to implement the tools and to make a collaboratory like this. Your work for the agencies, the researchers, all of the folks that could benefit from that this kind of setup.

Erin:
Well, I you know it'd be 1755 was mentioned previously. You know, that is largely unfortunately, an unfunded mandate for a lot of folks in this room, and so you know, I think that it comes down to funding and human support. NASA is actually

taking a stab at this. If anybody has been to the new or data, nasa.gov. It is a website that is a discovery portal that then pulls together all these different Dacs and Helps kind of point. You to the right direction, depending on what your question is, and that might be a model that we might want to look into in terms of what the stating looks like, and how that might be scalable to the question of interest here. But it absolutely is stuff. And there are people there who are constantly calling pis calling program. Managers, asking them, What are the tags that I put on on this data set? How do I make it more discoverable?

Peter:
Thanks, Erin. You touched on some of the things you put in place. Work with your advice for you,

Irina:
I mean, I talked about the software engineering and the data people that are in our group. But I think unique to this laboratory is that there's also a very large purpose of informing the public and like connecting to the agencies and making like decision-wardy modeling available. And so like. I think you might have to think about social sciences or people who like do that communication with stakeholders in a different way than like modelers per say we do. And so that's not CSDMS experience. We have a human dimensions working group, and they do use cases. But I think for this purpose of the Delta Collaboratory. That might be an additional person or a nation additional expertise to think about. Hmm!

Peter:
I say, Dr. Wayne, you're not in. Yeah, I mean,

Dave:
I think I kind of already touched on it with the last question. But I think really, it's just. It's it's money, you know. It's funding. And it's people. I really think that like we wanna make these this a priority, we have to prioritize it. And and actually give people the time and what they need to accomplish. This. I think it's about as simple as it really gets, and I think a lot of people are really busy at the at the State in my agency. I mean, I barely have time to do to do anything, so I mean to give people that the time, and to hire people and have it be in their duty, state or just that's like your it's part of what you do is you're part of your workflow is that you prioritize, they date it. Whatever data, integration or data open data or anything, whatever we're talking about prioritize that. So thanks,

Greg:
yeah, absolutely building off everyone. It's a people problem. At the end of the day, and I think the the water boards are making a bit of a difference with our water right system, because we got a big chunk of money. Those of you who know we got money to build a new data ecosystem. We stole some good staff from other agencies, and we are. We now have a group that's called the Data Governments Team. And they're they're their focus is on governing data within that water rights data, ecosystem and they're rock stars. You know they bring coding, communication, kindness. They bring all skills to the to the process because it really is a people problem at the end of the day, like solving these data problems is like always people issue or people opportunity. I should say so. Yeah, I think centering data. We heard a lot about the list of the principals. I love the 10 ra principles I also also speak sometimes about care and fair together, and and sort of like, if you're dealing with indigenous folks, for sure. Understand the importance of data, sovereignty and care principles. But you could stack a bunch of words in principles. But if you really center it in this organization, I think this Delta group has the opportunity to center the data and some of those principles and then empower people say, here's your data governance team isn't some group group of people that sits in the corner and does data work. They're actually you know, top and center to this governance model. So something like that.

Peter:
Thanks, Greg, and we're not the time for concluding remarks. And so based on the discussion on also your thoughts, perhaps things which we haven't touched on in this session, just on, based on your experience. What's the really big? Take-home messages that you would advise? Perhaps in the formulation of this type of collaboratory you're particularly around governance. You're crossing agency boundaries and frankly touched on that. Obviously this is sensitive data, that you can't be open to. But eventually starts with you at the top end. What would your wisdom lead? Pass on to the group?

Erin:
So I think that it's actually gonna come from the breakout sessions last last afternoon, which is that principle of creating a safe space in which innovation and ideas can flow. And that is an important part of a culture that is established within this collaboratory which you realize. Culture setting is probably one of the greatest challenges that we'll have in this space. But this is a great for start getting.

Irina:

Thank you. I think you can feel really optimistic in this sense that, like a lot of tools, are sort of at a maturity level. And those are. Our thinking is at a maturity level. To like, make this happen. But also the problem is gonna stay like, so there's like sustained need for something like a Delta collaboratory that could warrant like saying, like we do paint out and and like ambitions, ambitious vision of like data and models being combined or being like ingested into each other and that's our L-term goal, because even in the long term the Sacramento is gonna need that kind of information.

Dave:
So, yeah, I mean, I think that I mean for my experience at at the Doug. It's it's pretty amazing what a small group of people who are highly motivated and what we could actually accomplish, and that if you have like, really a really clear vision, I was. I mean, I've been really impressed by the work of the dug. I haven't been a part of the duck for the entire time, and I have to definitely acknowledge the work. Try a bunch of people that have worked in that group in the past and in present. But really I think it's it's if you get a group of people who are highly motivated and dedicated, I mean, and you have a clear vision. I think you can accomplish a lot, and so I think there's a lot of optimism there. And I was gonna say something else. And I totally just blank let's see, let's we come to Greg, and then we'll come back to you.

Greg:
So I think all I can add, after all, those quick remarks and suggestions is just reiterating the the role of kindness in this process. I think we work in adversarial workplaces whether it's internal issues and politics sometimes, but for sure, within the Delta itself there's a lot of adversarial positioning that happens. And so an interest-based approach, with sort of a kindness raised up to the level of even engageaging around the data and the modeling and the conversations that happen. So there's more trust, I think, is really going to be the one thing that I would add to all the other great thoughts.

Peter:
Thanks, and I just was, yeah,

Dave:
I did remember where I think something that the Doug has been really great at is is not reinventing, but just kind of but using existing tools and resources that are already out there. And I just would encourage that this group to do the same thing. There's all. Seems like there's a lot of work that's already been done, and so I think

you can start from a place of you have a lot. You have a lot of the works kind of are even almost done for. You.

Peter:
So, and you have the final one. I do. So.

Erin:
This is actually to echo some of the great work that Greg has done. You know. I think maybe we should challenge ourselves to think about who's not in this room right now, and who should be in the future of the governance of what this takes on particularly thinking about those that are impacted most by the decisions that are made you know from the information in the system.

Peter:
Hmm, thanks, everyone. And I just like to thank all of the panelists for your time today and coming and sharing your experiences and wisdom. And we certainly look forward to your input throughout the rest of the day so we could just thank the panelists for.

Day 2: "Deep Dive into Modeling Frameworks" panel transcript

Ben:
What are your thoughts, on what the purpose of a modeling framework is?
So I know, John, you kind of honed in a little bit on your presentation about kind of production modeling, and that's not everybody's perspective. Of what the purpose of a modeling framework would be. But so maybe I'll that question up to you first time to start it out as far as what I maybe you know that was your. It was a purpose of a modeling framework, but from your perspective, what is the purpose of a yeah.

John:
So in my talk I kinda said, what the purpose is that usually presented with which is facilitating this production modeling where you're trying to minimize errors and make sense smoother and just to kind of like carry this conversation. I think other people come from other perspectives. You might come from an academic perspective where you're exploring some. Alice's technique, or a new set of equations, or a new concept insert into a model. You might be coming from a long-term planning question where you're trying to answer a much wider question like, how would you if you could do anything you wanted? How would you come without current constraints as long as you avoid it being shot, you should maybe carry that

through. But that's definitely that's definitely a different perspective. And the things that I've been involved, and I think there are. There's certainly some commonality, but let me stop there and then hand that question. Really sure.

Ben:
Yeah, I think this is great cause. I mean, we just come to see the the usefulness of the of the framework from many different perspectives. So I don't know. Jay, are you still around? Did you want it? Did you want to jump in that? We don't wanna forget about you online. There!

Jay:
Yeah. So I think John has focused on a very important realm of of problems for this kind of an approach, it's a laboratory approach. Really, relative, very routine problems that every year, or almost every year, every drought, they're going to have to pull together a very diverse set of information for very difficult decision-making and explore a wide range of options. So I think that's an attractive approach, because a wide variety of agencies should see a financial. You know, investment worthy benefits from from this kind of an effort. And so, therefore, so hopefully, you willing to invest in maintaining it and improving it over time. The that's a fairly narrow scope. However, many of the larger planning and policy interests actually have a lot more entropy in the kind of modeling they would like to see done and it's a lot more difficult for them to to get together in the in adopting a common Framework. Even in the case that John cites it was basically one agency. The Bureau of Reclamation that took the lead on on developing the framework and financing it and supporting it. So far, so I think you know. Come back to the the fundamentals of if you're gonna have a collaboratory. That's gonna work on these practical problem. It's gonna take millions of bucks routinely. And you've gotta be able to convince people in authority that have that kind of resource, and they can confer that kind of legitimacy on the effort.

Ted:
The purpose of a modeling primer. Yeah, I mean from in the context, at least, that I'm you're kind of grappling with these questions. It's. I would say that the purpose of a modeling framework is to inform decisions, decision making in context of a characterized by uncertainty or deep uncertainty, and multi objective trade-offs. So I mean, this is California water management, right? This. This is the crux of what? What? What we're facing now in the face of climate climate change and other, you know, non-stationary forces. And so for me. It's that sort of sort of pragmatic and grounded need to have frameworks that allow us to make decisions that help

highlight. These sort of, you know, not just optimal decision optimal, you know solutions, but robust solutions also kind of leading off with Lisa, said. So solutions that are going perform well over a wide range of, you know, uncertain the plausible futures, and, I think models and modeling frameworks can really help.

Irina:
I think, in general I'm only exploratory side of modeling, but I think in the context of the Delta Collaboratory, the Timescale is like not too long out in the sense of like decision makers like think not to move out like not hundreds of years or very disruptive scenarios because it's just harder to funds and like motivate that like, yes, you're gonna 20 towards that. And so, whereas it's. Yeah. So predictions can only inform decisions if they have, like some reliability in the future, or if they. Make people aware of a very disruptive scenario.

Ben:
Okay. Alright, let's move into another question here that I've got written down. So the next question for the panel is, what would you focus on as a priority next? Steps needed for moving from a conceptual framework design and to actually taking action in integrating these concepts into a tangible program. So kind of a real step to, you know, over the last few years you know, we've been talking, you know, outside of these used cases, we've kind of been abstractly talking about what this collaboratory framework could be. And you know now that we've got through yesterday, and and though and the the breakout sessions yesterday, you know, we've got some real real world use cases and case studies to kind of apply this, you know the idea of the framework and collaboratory, so you know, from your experience, and your thoughts, you know, looking into this, what? What do you think are like the like priority next steps to be able to to move from the abstract? Conceptual conversations that we've been having into actually making this happen. Jay, I know you've had some thoughts on this. Did you want to jump in first, baby on this?

Jay:
Sure. I guess. My, there's several big gorillas in the room that are gonna bring all the resources and legitimacy that you'd need if you can get them aligned with the concept, and that will be the State Board and the Department of water resources, a third one might be the Bureau of Reclamation. The State Board could probably. Instead of this stuff happen all by itself, by requiring the State Department of water resources in the Bureau to to form the collaboratory as a way of meeting some regulatory processes that they have urgent needs for, and and John's example is a

really good example of that perhaps with a reclamation is trying to get out ahead of that kind of a regulatory situation. The other approach, which might also be necessary, would be to have State legislation that requires a joint modeling center among the major stay. Water agencies that has some involvement from the broader, stakeholder community, and perhaps the broader expertise community of academia. But I think it's it's gotta get down to brass tacks about that. It doesn't really matter what software you use. It doesn't really matter what database you use if you don't have that kind of political base and funding base for the enterprise.

Ben:
Yeah, thank you. Jay.

Irina:
I think I would plug for like involving students in the whole laboratory, because they have less at stake in the sense of exploratory modeling, because, you know, they will not have to do the decision making or communicate the decision making that you're also like growing them into these ranks of the like agencies, and into like the they will know people of the agencies or the like other stakeholders. And so I think there could be a real nice partnership with bringing early career people in that way.

Ben:
Yeah, that's a great idea.

Jay:
That's a very important point, because the other big thing that students bring is they don't know it can't be done.

Lisa:
I would just add, I think, you know, if if you really wanna get the decision makers for that Jay was talking about, I think it is important to find a compelling problem and try to show some progress on it. And I think that's what, how we've been able to get resources. We are. Gonna be able to help you solve problem X, yeah. Say, they want us, even though you won't really get there in any reasonable amount of time. They wanna know you care.

Ben:
Yeah, so that kind of that we can come back to this question.
But my next question actually is, is really relevant to what Jay brought up. And you know we've always talked about this being, you know, a people problem. And one

of the things that we that can really help is bringing in what we we can call like champions, right that are in a position at their agency to really to really lead this. And I think everybody's understands that. That's that's a necessity, you know, to move, to move further along our vision here with the collaborator in the in the modeling framework. But I guess maybe my question is, if anybody has had the experience with kind of the early stages of these kind of collaborative efforts, and you know how do we organize these? How do we do that part of it? Right? How do we organize these people and these champions to come together and advocate for this in search for funding and I don't know if the folks in the panel that are part of you know maybe smaller simpler you know, collaborative projects like this, that might be applicable to this, you know, to our vision. Here. But that's the how do you do? The people part is kind of my question.

Jay:
People have to have a reason to get together. It's gonna be either piles of money or laws, or or very firm director.You know directions from above.

Lisa:
Yeah, I think that's true. And then thinking about building networks of networks is also another way, like, Don't just say, Oh, we're starting from scratch we're rebuilding everything you know. Make it really clear that you're building. On what's already there. Find the common ground. That's gonna get people together. But some of the early steps I've seen of new initiatives in the Chesapeake Bay, not the stuff that really talked about, but is finding a shared goal. But then you wanna be. Most important things to get people in the room together on a regular basis. Make it a fun event. So they'll come. And honestly, that's what that's the social side of what moves it along.

All:
Feed them. Yeah. The pizza approach learning opportunities yeah,

Ted:

I was gonna add in in that process, make sure, in addition to shared goals, establishing expectations for like, what can can't be done, you know, or on within this the timeframe I think it's really important, you know, with a lot of these model, you know, particularly projects that involve complex models. There are some ways in model that which models can be, you know, adapted to to be various aims, but there, there's also a limit to how much that can be done before you have to build a

whole new model right? And so really communicating that clearly. So you don't set up, you know. So you don't over promise essentially, and let up with, you know, end up with very disappointed participants in the process.

Ben:
Yeah, that's good advice night. That reminds me of. I was super happy to see how conversations were moving. Yesterday in the breakout rooms and and Maggie put together a really good graph that we use as part of the breakouts where we will be kind of graphed on that on the X was the feasibility of some of these use cases that we were throwing out there on the y-axis was the was the impact. So I think that kinda talks a little bit about what you're talking about. Ted is bringing some of these, maybe lower hanging fruit, or that you know, that are, have a greater sense of of real feasibility and have a higher level of impact to kind of get this get this started and get the people in the room to be excited about stuff that doesn't feel, maybe excuse me, maybe so out of reach. I guess at the beginning, while we're sure why, we're but we're still kind of bringing this all together and figuring out how the tools can be used and getting the right people in the room. So, John, yeah, go ahead, John.

John:
I'm a little slow. Can I answer the previous question? Absolutely a few things that I think maybe could play across multiple purposes for a framework, including bringing, like onboarding students. It is one real challenge for detailed modeling of the Delta is consistent set of boundary conditions in Lisa. Lucas mentioned this in her presentation yesterday. Yeah, I think one strong contribution from a collaboratory would be to have a library of boundary conditions that represent a significant historical period that might actually fuel the search and understanding of these key scenarios that illustrate some of the tipping points. Kind of piling on to that. The maybe not the only, but at least a rational set of climate projections, or future scenarios building off of some of the stuff that Andrew was talking about yesterday, so that these were a resource to start from, and they were consistent, and they could feed models at different resolutions different spatial resolutions or temporal resolutions, and then, on the other side, some post-processing capabilities, where, if you run this models, particularly if you run them in an ensemble or microphone, you can process that stuff and get consistent results. I know there's many hydroeconomic models of the Delta. Many of them are very good at certain things, and not so great at other things. It's really, be lovely to put them all through sort of the standard set of output, and you line them up reasonably side by side. Say, you know, on a monthly basis, this model is doing a

great job. But if you're really looking at, you know, 5 min time scale things to answer this other question, you wanna look at these models that's a very rational use I think it's helpful to students to understand that as well. And then for the uncertainty part, and this is actually relevant to our curtain. Certain. Excuse me, this is relevant to our current activity with reclamation. They would like to know? Well what is the uncertainty in these production models you've created. How does that uncertainty impact your ability to do forecasting and make temperature management plans over the next 6 months? It's not just a sensitivity analysis. It's a deeper question. And you know we're struggling with that I bet you could help us figure that out. And if you already figured that out and put it in the laboratory, we could just go like, Look, we're talking to those staff that are familiar with so there's what's that for?

Lisa:
I just wanna elevate one of your points. I think you're not only saying that there would be some sort of standard way of, you know, outputting data, and verying data, but it's also you could have built-in good communication standards as well. So, especially if you're aiming for decision maker.

Ben:
Yeah, these are these are really good examples. Thanks for bringing those up, and reminds me of what Dave was talking about in the previous panel. You know these are. All. These are all activities that take time in people, you know, sitting down and figuring out how to do it. And then actually doing it. And besides, you know, Jay, you brought up, you know, piles of money can bring people, you know, towards this, but also I think that there's there's folks inside of these institutions that have the knowledge to be able to do that. Already, but you know one thing that we talked about as a as a group before is what Dave mentioned as well that I'd like to advocate for again, is is including this type of time and activity in in these folks that are already knowledgeable in the you know, have the ability to do this you know, including that in their duty, statement, and having managers on board to allow, you know, a certain percentage of their of their activity. Of time activities to engage in these, because, you know, you can. You can, you know, put out our Fos in contract and try to look for experts. But sometimes the you know, the best experts are the ones that you already have. You know, in the agencies in the system, but allowing for them to be able to to spend the time in communicating that to the you know, to upper management and executive, you know the importance of and the value that they can bring into the system, I think, is it's really good yeah, go ahead.

Irina:
I mean, I think you're right and, like you probably already have champions in the room or in your community, that you know are part of that network in different places. But I think there's also like a lot we learned in the last 5 years or so about like creating more diverse teams. And there's now better tools about like, why don't we put a call out within the agency of like who steps up and wants to do this? Or why don't we like put a general call out for like a specific use case where, like suddenly, like, someone pops up and has, like an invested interest. But we never knew about that in our little like network that we think we have so. And I think those tools are like way more developed than they were like, even like 10 years ago. And we're all more aware we all have within our statements. I think I think it will be a combination of the 2 things where? All British champions are here, where they they will step up like pretty easily, but they think it's also worth being like so it's open about it.

Jay:
I do want to point out at the end that we've made a lot of progress in all of this area over the last 30 years. From when I first came into the system, we still do a terrible job. But we have made progress in a lot of ways. Thanks for the. You you can. You can look at the piled up dead models that, and an early dead model versions of what we used to do and see that we have made progress, and and even had some collaboratory kind of an activities such as the early development of the calcum model by the bureau and Dwr. Which has an interesting institutional history. But John brought up a really a point that I think is really important, that all of these agencies, all of these modeling groups are gonna have to do 80% of the same work in order to solve these problems, they can do it inefficiently. Separately, or they could do it more efficiently, but more controversially, together. And in the end I think it produces a better product, even though it's more awkward to develop standards and develop processes. Different silos, to work together across different agencies, or sometimes within. I think different agency. It's the same agency, but in the end the product will be probably better technically, and be more understandable for folks and more useful overall. So I do think there's a lot of potential here. But we do need to find a institutional vehicle to make it work. And be sustainable, financially and politically.

Ben:
Yeah, thank you. Thank you. Jay, so this is, you know, this session is titled a deep dive into modeling frameworks, and and we don't have a whole bunch of time like Reena said to really take a deep dive. But we will have the rest of the day to do

some breakouts for folks that can stick around. But maybe for folks that can't, or maybe to kind of help, you know, spark some ideas moving into the breakout session what I'd like to do is maybe ask the panelists here about some ideas that they have as far as maybe some like very important you know, key tools, or maybe another way to say it would also be maybe some skill sets that folks can bring. I know that a lot of people talk about, you know, in our in a lot of these modeling meetings and workshops you know, it ends up being a lot of the same folks with the same types of skill sets.

And when you talk about data, you know, we don't have a lot of like the, you know, the computer science, you know, kind of folks that people that can organize the data. What are some of the things that maybe that that we're missing, that that can really help get us closer to our vision because kind of rounding out or filling the voids that you know in in maybe specific tools or skill sets that that folks need to bring to this table

Lisa:
So there's really really simple folks out there looking at ways to optimize models. I mean some of it is through the machine learning, and but they're you know, there's cutting edge stuff going on, and I keep wondering. If we were doing more of that. Would that give us more capacity to do the uncertainty, analysis to bring in social modeling? Because frankly, what happens is people want to build so much complexity into their biophysical models. That you can't at. You can't do either of those things. And so I wonder if we need to be just be thinking about hierarchical models or using some of these cutting edge tools.

John:
I'll second that if we in our group we use a wide variety of models from really heavy. 3D stratified flow models to machine learning techniques that can you run a zillion simulations and finding good surrogates where you can ask a lot of the questions very quickly. I think that's really important and having people who are really good at that and having them handy it in one place would be super.

Ben:
Yeah, maybe I'll throw an example, John, you and I worked on a on a modeling project where we were trying to assess the effects of let me failures and kind of many different modes. And and one of the one of the things that I always thought about would be a really good skill set or tools to bring to the collaboratory, or for people that weren't modelers like myself, but but rely on trying to digest the

modeling output to help me make better decisions in and educate folks on, on, what did that? What the model output really mean? And I think that the visualizations and the the ability to kind of translate that language from you know the kind of the technical help and explaining what the what the metrics are. Some people, you know, maybe. Don't you know, really understand really, even what the metric is that it's being produced as an output. And then coming up with creative ways, you know visually through all different kinds of different charts and different, you know, angles to look at the same output that way. People can really digest and understand what the you know. What the model is, you know, is actually helping us do.

Ted:
So let's say I'm a little skeptical of the idea that if we just, you know that if we just provide the information and better and more compelling ways, people will make better decisions, I think, or that you know our people know how to use the water, we've talked a little bit about the importance of narratives and sort of translation, but I guess that sort of junk, the Kool-aid, a little bit on these bottom-up approaches, and the importance of grounding are modeling, you know, endeavors in decision context and I realize there are certainly other academic settings. And lots of other reasons why we might use model, but I think they're sort of a because we have, you know, so much more computing power and the ability to use all these new tools to, you know, run bigger more computationally expensive models and generate more data, we do we create these cool visualization tools, and we do but it doesn't necessarily lead us to better decision making. And so I guess, for you to get your question about what sort of tools and resources are available. Direct folks to work being done by the Alliance for global water adaptation. In partnership with the World Bank, and others that are trying to use some of these. Yeah, I would say, decision making uncertainty or bottom up approaches things like decision, scaling. There's there's a whole kind of family of frameworks that are being used at adaptation pathways, particularly in the context of water. Adaptation, climate, adaptation, decision, making that could be because you've interested folks.

Ben:
Yeah. Thanks. Ted.

Jay:
That raises a really good point. One of the problems that we often see in our in our geeky wonderland of modeling it is that the decision makers. Are not really organized to digest more than about 5% of what we produce already. And and so I

think, in the long run, when and this is well beyond our pay grade or the topic here, we have to be able to help some of the decision makers that are serious in their in their much more difficult political realm. Help them. Rearrange some of their decision-making processes so that they can better digest technical information. It's not all on us to develop technical information that they can digest. They're also gonna have to change their digestive system. Yeah. So maybe I hope. And that's that's really tough. But I think that's reality. It's not all our problem.

Ben:
That's a good point, I mean, maybe thinking about, you know, how do we? How do we create a space where these decision makers can be a part of the of the framework and kind of get to know us better? I don't think it's gonna happen overnight, but you know, to share, to maybe start sharing a common language. And you know, having that, you know top of mind when when we're kinda creating the space for folks so I know we're getting a little close to lunch here, and I ran out of really clever questions to ask. But I've left some time on purpose to allow some folks in the room, and maybe even zoom. I don't know, Maggie, if there's been a any chat through the zoom, but maybe I'll open up first to for panel. If there's anybody in the room that has any questions of our panelists, we have a few minutes left.

Lisa:
Oh, my goodness! While we're waiting, I'll make one little point in response to Jay's thing. So when you do this with the kind of stuff that hits talking about this bottom of work where you really allowing the decision makers into your model, framing, you have to recognize that you're going to be asked to do things you didn't envision or want to do and so I just wanna just lay that out there that maybe this needs a certain kind of facilitation, or because it's hard for modelers to listen. Sometimes. And so it's, it's really have to be very receptive to the decision makers to make it worth their while. So 2 cents about those things.

Jay:
Very few of the decision makers will want to see our inner workings. That's it. They are. We think we're busy. They are 5 times 10 times busier than we are.

Ben:
But Derrick Orba, on on the chat, asked this to our panelists, to what degree our machine learning and deep learning models being utilized either as an adaptive

predictive tools or to guide further statistical expertise does anybody have any experience with the in that realm.

John:
We use the machine learning technique, in conjunction with a model that attempts to simulate the consequences of levy failures in the Delta was relate with regard to salinity. Management. So it's a fairly fast, simple one. Dimensional, timely average model that allows you to make reaches out of all over the Delta one at a time or many at a time. And then it simulates the objective flux of salt in from the same. It's drawn in to fill the boulders that are flooded, and then it simulates the flushing of our water as river inflows reservoir releases, push it out. So the question is, what would be the best strategy to recover as quickly as possible under a really large scale. Levy, reaching event that might be related to an earthquake near the Delta. 5 or 10 islands might fail, and there might be an assault that disrupts operations in the Delta for months, or even more than a year, it's a long time, so what can you do? You can turn off the exports, you can make more releases from the reservoirs. You can place temporary barriers. You could do some active pumping there's a whole variety of these things which would be the best approach given the scenario that just occurred when it occurred. What the state of the reservoirs. It's a fairly large solution. Space. So we did a clustering analysis to try to define the scenarios. That should be explored. We ran a bunch of simulations with many different recovery strategies, and then we used a tool to sort of search and choose the most likely best scenarios and I would say it was reasonably effective. We got reasonably consistent results, and it was very quick. Once it was running, so I thought that was an interesting thing. What that's given rise to is a notion that the next step in that it would be great to see if we could use reinforcement learning with that problem and have the model play. The solution game. So rather than guess what the best solution would be right at the beginning, it would actually play this salinity management game and say, Well, let's turn off the experts for a little while got a little fresher. Oh, no, maybe I needed pulse release now. Well, maybe I's a very temporary, varier, and do a timestamp by timestamp as opposed to doing it all in front. So those are. Those are my best shots. Right?

Ben:
Yeah, I kind of remember you bringing that up before,is that with the Delta emergency response tool.

John:

In normal use. That's kind of a forward simulation that it's a desktop tool. You can sit down and say, Well, I'm gonna break this and this, and this, and this and this and this, and it's, you know, a dry year. And next year is good also to be a dry year. You hit. Go! And a few seconds later it gives you a simulation forward in an estimate of the export disruption in terms of you know, days or weeks of export. Disruption, and the volume of water that couldn't be exported, and so is like you were talking about. Maybe still, never, maybe previously, the Delta emergency response tool. You were kind of making guesses at which islands would bail, or what what the scenario would be, and then you'd have. You'd kind of have those ready in case that happened. But are you saying like the machine? You can do that on the fly, and it only takes a few seconds to go an answer. But the question is, what should you do to recover from it? Right. Cause. There's a lot of choices, and if you've done this a lot, you have some experience. But if you're new to it, you know, you could be flown around looking for a good solution, and you might not find a really novel solution that really reduced the amount of time a disruption, a lot. It'd be nice to explore the larger solutions based fund. But I think that the part that I is really undone at this moment is, can we do something that you can take the results from a high dimensional model? And digest that into a machine learning technique to represent that. And this is part of the salinity management process that we're doing with laurel and her workshops. And with Eliz involved, and then and folks are involved to retrain the I think that's another really.

Ben:
Yeah, that's a great example. Okay? We still got just a couple more minutes, but we've got another one from the chat that I'll go ahead and read here. There has been a huge increase recently in the uncertainty of climate, model projections. I was wondering if you had any thoughts about how the collaboratory might help with thinking about how to incorporate that into. Everybody! Look at Lisa.

Lisa:
Right? Thanks for the question, Deirdre.The so that is one of certainly one aspect of the scenario development you'd wanna look at, and that you could do that. That data analysis, that really putting your models through their paces and saying Look, we were wrong in this way. We were biased in this way, and then use that in your scenario, planning to get at. You know. Of course, you can create more complex downscaling. You. You can put different drivers into the climate models. There's a lot of answers to this question, but fundamentally, what you're saying is, if I had noticed these shortcomings, let me build that into another scenario, maybe take it to an even greater extreme, so that I'm understanding what that forcing might do

to the system, so I you know it it scenarios are one way mechanistically, is the other way. I guess.

Ted:
Abroad a broad range of of climate projections, and understand how how system performance changes across the range of you know, even beyond the range of projected climate, variability and really focus on identifying, you know these thresholds at which system performance either you know, decline or or comes unacceptable and so again, we kind of Orient the analysis, not towards understanding like what the feature is going to be and what that means for your system. But what is the if I make a particular decision? Does the range of acceptable performance get bigger or smaller under the range of climate?You know, possible range of variability.

Ben:
Alright. We're just about at lunch. Great presentations. Thank you very much for your time. It was great to meet some of you for the very first time. This is great, well rounded, and been great panel discussion that we had as well. So, yeah, thanks again for the panelists.

Appendix D: Detailed Breakout Discussions & Takeaways

Day 1 Breakout Session

Questions

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)

4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?

Discussion points from each group

The following discussion points were taken directly from participant Mural board responses and may contain sentence fragments or incomplete ideas.

Group 1 (in-person)

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
    - Data issues...In the east, large scale climate data is archived in repositories, but when you get into smaller projects, it is hard to find.
    - It is huge challenge.
    - There are limited resources. If there was better data sharing, can focus on analysis rather than gathering data. Collaboratory can help focus on that.
    - Everyone says we should use EDI, but people do not know how it is done. There is a need for more resources.
    - To get people to become software engineers. Even with training, this is what holds people back. Short courses do not cut it.
    - Need resources for data and computational scientists.
    - A lot of speakers talk about upgrading models. You need to get your model up to date, but do not change the structure and ask for more funding. You need to let people upfront that things change.
    - SWC pays a lot of the modeling work and wants to make sure the work being done is the correct science to benefit species and managing water.
    - NCEAS work group produced a lot of synthesis papers, but there is a lot of "so what." You want to make sure the work is useful for decision-making.

- Need more resources to communicate with other Deltas. Did something like this for the Science Enterprise Workshop. People still talk about that conference.
- There is something call the Delta alliance where different Deltas come together to coordinate. DSC may consider joining.
- 1. Agree w/Q should make better use of limited/finite resources
- 2. Agree w/ Q… may help build trust
- 3. Yes, more documentation of what has been achieved
- 4. Resources need to be applied to construct integrated datasets. (Precursor to models?)
- 5. Focus on data use/compatibility and other collaborations will follow
- 6. Stakeholder/user buy-in by being in the formation + direction-setting
- 7. software people or scientist training in ????
- 8. Yes - resources + repositories
- 9. resources: - scientific computing, - data sharing, - stakeholder
- 10. updating models -people need to understand the output will change
- 11. NCEAS type model. How do we do this?
- 12. info exchange from alike Deltas
- 13. expertise in engaging stakeholder modeling
- 14. the more the merrier…seems more resources in data access/formatting
- 15. turnaround time

2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
    - Agriculture: best management practices
    - Can we respond to and anticipate extreme events. Problem: How do get policy makers involved. Solution: Modelers need to know what the policy makers need.
    - Regime shifts..can our models address outliers or black swans.
    - There is a big push for climate change mitigation and adaptation, and learning from what is working. We should not all be doing the same modeling, but learn from each other.

- Building with nature. Finding ecological solutions.
- linking fish, food and hydrodyamic models.
- Blue carbon
- Carbon sequestration
- Flooding
- Subsidence

Additional notes:

- People say California has a lot of data, but the data is not collected in a way that is useful for models. Need a systems approach.
- Optimal versus range.
- Alternative energy. Wind mills?
- reduction vs systems
- optimal vs range

3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)
    - Cisco Werner made a good point. Need to consider human dimensions
    - alternate power - solar & wind
4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?
    - Key points:

        1. Social science integration

        2. Problems are multi-disciplinary. This is a challenge for modeling, as you have to identify the different models. Collaboratory can help facilitate multi-discilpinary efforts on a issue.

        3. Need a safe space for sharing ideas.

        4. Collaboratory can provide local and global optimization.

            a. Economy of scale. Doing things that benefit everyone from data sharing...

    - You do a war games approach of high impact scenarios and work on issues that are outside of your comfort zone. This can help galvanize the community to work on certain issues...
    - Human resources....We need dedicated staff that will be helping people to work on interoperability.

- Collaboratory can help facilitate multi-disciplinary efforts.

Group 2 (in-person)

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
    - Yes, I think human resources are especially key
    - Indeed, human resources are crucial: - data science, - modeling, - stakeholder engagement
    - Yes, they could benefit from additional resources! Especially related to model "integration"
    - Improvement in the accessibility of CalSIM model results from USBR and DWR including inputs
    - All projects could benefit from additional computing power + cloud computing options. Also data integration resources.
    - Yes, and in particular I heard that human resources are needed to reduce burdens on modelers and facilitate broad participation. I liked Derya's idea about open-science resources to help share information about model limitations and constraints
    - Boundary condition cleaning especially CDEC data in tidal areas
    - Agree with Lisa Lucas comment that well QC'ed and documented data would be very helpful. - model boundary conditions observed for validation
    - Andrew -- would like good baseline estimates of climate change to drive new model studies
    - Yes
    - Is model integration a specialty or skill?
    - API
2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
    - 1. Winter-run chinook salmon population models
    - 2. salinity management during drough
    - 3. HABs forecasting

- 4. IAV forecasting, management, prevention, impacts (e.g., ET, food)
- 5. blue crab recruitment in Chesapeake Bay
- 6. System models for climate change w/ regulatory change + public benefit metrics
- 7. groundwater levels/quality under future scenarios
- 8. parallel endangered species entrainment risk due to water exports + affiliated suites on management triggers
- 9. levee investment to minimize risk of Delta disruption due to severe salinity intrusion
- 10. Delta recovery strategy after large scale levee failure event
- 11. "Optimum" investment in tidal marsh restoration in the face of sea level rise and climate change
- 12. Dynamic bathymetry/geomorphic changes to Delta as influenced by climate change & wetland restoration (considers changing tidal prism, sediment dynamics)
- 13. Striped bass habitat suitability in Chesapeake Bay (operational)
- 14. voluntary actions???

3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)
    - Socioeconomic (demographic) vulnerability to climate change & whether management practices/actions disproportionately impact/benefit certain demographics
    - dead zone forecasting (Gulf of MX)
4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?
    - A lot of case studies -> modeling need are high
    - Need for resources + pro development + physical resources
    - Collaboratory independent w/ experts + physical space
    - Stakeholders support/sci comm/ best practices
    - Integration!

Group 3 (in-person)

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources

such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.

- Link models by ID common parameters to understand the linkages/opportunities
- Code models as standalone components/functions/scripts
- Salmon model - would potentially benefit from ability to model species & human interactions. What else? Could see expanding usefulness from modular models that could be linked
- Could see building on Cisco's idea that we can project human use & charges (mechanistically) of the ecosystem to improve ecological forecasts
- All case studies could probably benefit from shared data resources. Lowering the bar to data use & analysis is key. Do we have the repeated measures we need to conduct natural experiments?
- To get at economic analyses I'd need to know more about the capacity to output management relevant outputs
- successful management culture
- hurting stalemate

2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
    - better sharing + searching
    - greater sharing of data + models
    - which models can be expressed using Graph Theory to understand processes
    - User group for major models
    - Reducing sludge of multi-obj. modeling
    - modeling human behavior as a function of environmental market and policy drivers
    - workforce development + succession planning
    - collaboration on representing changing conditions
    - e.g., climate scenarios (model inputs)
    - Governance model USEPA in Chesapeake
    - Investing in RSRCs up front (DPIIC?)
    - Find policy entrepren. who see benefits

- Extra resources could accelerate the delivery of model results, communication of model uncertainty
- Enhancing CWEMF community with resources could have a big impact
- - Learn from experiences (governance) of Chesapeake Bay; - Did not reference earlier work on Integ Models; - Case studies could benefit from funding, but I don't see that as path forward; - Community-model user groups
- Cost of inaction at system level
- Considering coequal goals
- We are in a dynamic system. It is difficult to anticipate some questions. Making data + models accessible will make response to questions faster, easier, defensible
- – Tools; - Governance; - Community; - Staff experience (interface of expertise areas)
- Improve on simple cost/benefit analysis
- Cost of doing nothing on flooding & levee stability -> effects of mgmt. alternatives on land use outcomes, ecological outcomes (riparian areas)

3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)
    - Team science approach to Delta smelt modeling
    - Multiple models to reveal epistemic (=missing knowledge) uncertainty
    - Policy support
    - Gap-filling experts e.g., delta smelt
    - user groups for major models
    - Tradeoff curves for trust resources
    - Need modeling framework for this
4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?
    - Resources (up front)
    - Governance (e.g., Chesapeake)
    - Facilitate modeling
    - Better sharing + searching

- User Groups
- Workforce development + succession planning
- Modeling human behavior

Group 4 (virtual)

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
    - Challenges/ current efforts for coupling existing models? (Bob)
        - transitioning is challenging
        - Thought about model coupling diagrams- the arrows between models can mean a lot of different things/methods for coupling. It's interesting to think about how to communicate what coupling means in terms of coding logistics
        - needs to be sufficient documentation; CDMS system for creating a model framework (Sujoy)
        - DSC-funded - modeling inventory; CA Environmental Modeling Forum (voluntary org)
    - Transparency
        - Open code/science/data takes time, so it costs money. Funding support or staff time could be helpful
        - Sharing model code would be really useful - Group 4
        - easiest way to share something would be better documentation (commenting in code)
        - models with established users and data
    - Communication
        - One model documentation format (unified procedures for documentation of models)
        - ability to translate coding/technical information to others (funders)
        - adding enough details
        - improving vocabulary/description and communication around models

        - Putting the effort to making connections is hard. it takes staff time. - Group 4
    - resources already available - Github, etc. requires understanding the language and assumptions
        - https://cwemf.org/wp/resources-3/model-inventory/
    - Documentation
    - DWR Div Flood Management - CalSim, etc. "library of models with certain rules for changing/ documenting
    - A challenge to understand where the limitations are (Jeff)
    - Documentation as a form of transparency and communication that can help with coupling models
    - Nature of the model output - description
2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
    - Fine scale habitat modeling lifecycle models
    - understanding societal/ community concerns
        - not sure how feasible?
    - Land Use/Land Cover Change (incl. Delta infrastructure)
    - Climate adaptation planning (Delta)
    - rapid response to emergencies modeling
        - HABs, water spikes, temperature anomalies (Peter)
        - To streamline this & be able to toggle between different versions would be great! (Ann-Marie)
        - Similar to winter-run salmon; lifecycle-->Shasta-->water temperature modeling
    - Effects of wildfires on estuary food web
    - multi-species management
    - DWR "library of models"
        - Areas not modeled by the state as well as other local entities (Jeff)
        - somewhat proprietary, security concerns (Jeff)
        - platform issues
    - CA Data Exchange (Jeff)
3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)

    - Need multi-disciplinary approach to model development (Bob)
4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?
    - fine scale habitat lifecycle modeling
        - high feasibility high impact
    - Transparency, communication, documentation
    - What levels of scale are we trying to couple?
        - Difficulty with coupling social science models and biophysical models
    - Recommendations
        - Resources for training how to apply models after they're developed
        - identify standard ways/ time steps that may be used
        - Matching funds should be available to produce multiple model resolutions (Peter)
        - Matching funds for interoperability in new model development
        - thinking about questions to answer in the documentation

Group 5 (virtual)

1. Do you agree that the use cases and case studies we heard about could be significantly advanced with improved resources? Consider resources such as sharing and documenting code, linking models, and developing collaborative practices around the use of models.
    - collaborative center is great, but the question being asked may have specific needs; generic models may be important
    - importance of input data: needs to be available, regularly updated
    - communcation between all modelers so everyone knows all the ones being applied in the SFE
    - we've made some progress, but we need momentum; questions keep growing
    - tools need to be developed in ways that allow them to be reused
    - space to brainstorm
    - Established scenarios (e.g., climate change, land use) that modelers can use

2. What additional use cases or case studies could be significantly advanced with better resources for accessing and linking models and using them in a collaborative process?
    - The salmon-water case needs to be expanded to include socioeconomic endpoints-- what are the costs and benefits, and who pays and gains?
    - Tidal-fluvial interactions (how hydrology & climate change affects fluvial dynamics and how that interacts with the tidal system incl SLR scenarios)
    - Cant find a star but agree with Steve about deep and shallow-no-one looks at primary productivity at depth or models it specifically-even in the deep channels- may be more happening than surface info tells us
    - Connecting deep and shallow hydrodynamics to represent impacts of restoration (and other land use change) - are we representing tidal marsh and sediment dynamics well?
    - Ability to consider landscape scenarios over time (multiple decades) - allow for opportunities becoming available (or being foreclosed upon) over time
    - Identification of efficiency frontiers in trade-off analyses, rather than evaluation of a small set of pre-defined alternatives. To be practical, we need to be able to run thousands of scenarios in a feasible time span.
    - Use of AI and machine learning - new forms of modeling that may help us move faster
    - test case to build human feedbacks in (e.g., water supply, levee failure, agriculture). Thinking of Dr Werner's point that adding human decisions could actually help constrain alternatives
    - Building economic tradeoffs into considerations of scenarios (drawing on on-the-ground knowledge)
    - Develop a universal hydrologic-nutrient-productivity model to use for pelagic food web - bloom prediction-combine all positive parts of whatever models are out there
    - Many commercially-significant fish and invertebrate species besides salmon are dependent upon estuaries. How does water management affect them?

- Underlying anthropogenic changes in nutrients in system as well as due to climate and weather - eg. Regional San plans to recycle all their discharge to agriculture which would reduce the major- probably all nutrients feeding northern SFE.. Small WWTPs are making upgrades that will also impact pelagic food web - consolidating all the changes to nutrient inputs would be essential want to ensure a functioning pelagic foodweb or predict cyanoHABs
- Projects to develop the linkages between existing work/teams (e.g., compare possible future scenarios using existing tools to evaluate a range of functions and benefits)
- Develop linkages between (invasive) species distribution models and physical changes to the landscape + climate models to better understand future scenarios (especially for possible new species that are likely to be brought into the system)
- Improved learning/exchange between Bay and Delta modelers (build in feedbacks where needed)

3. Are there use cases of an entirely different sort we are omitting (e.g., social, economic, anthropogenic, behavioral?)
    - Is this collaborative going to consider coastal oceanographic models, or be just limited to estuary-may be use cases from there that have socioeconomic impacts in Bay community- closure of crabs due to HABS Also atmospheric models being developed for green house gases. How broad to extend the collaborative
    - Adding risk benefit models to more typical ecological/fish/conservation etc type model outcomes
4. Impact vs. feasibility ranking exercise
5. Key takeaways: Which use cases are most feasible? Which have the biggest impact? What else can we share about these ideas?
    - Bay-Delta information & communication gap
    - question of scale - how big/broad is this vision, or how much more feasible are these ideas if we addressed them in a more manageable way
    - considering endpoints: how human decisions can constrain alternatives, and how socioeconomic endpoints should be included

- making use of new and emerging technologies and methods

Day 2 Breakout Session

Questions and responses

Cyberinfrastructure (in-person)

1. What's the ultimate vision for a modeling framework or modeling center?
    - Confused on what is cyberinfrastructure. There is agreement that it involves people. There are people who understand data, QC/QC, there are an array of expertise.
    - We need interfaces that can create queries to generate the datasets.
    - These ideas have been kicked around in Chesapeake Bay. Need to have interoperable, and something that is flexible. Need Integration of science and management problem.
    - Need a vision on who needs to be part of the infrastructure.
    - Data accessibility...Access multiple datasets. Need help with QAing data; data are in different time zones, etc.
    - AI is a computational method. AI still involves people. This is no longer a specific issue.
    - The abilities to pull down processed data. We need multiple databases.
    - Rank and file....There are limited resources. Do not have the right hardware. Need computational resources.
    - We need someone who knows cost and performance tradeoffs.
    - What is the vision for stakeholder engagement?
    - We need distributed resources/storage that can help with scalability.
    - Need to develop a culture.
    - We should be able to run multiple models at the same time in a collaborate.
    - Ability to do things without making it public.

2. What components or resources are necessary to achieve this vision?
    - Collaboration tools. A physical space and virtual space for collaboration.

- Some models are not comfortable with outputting their model runs at a different scale since it may not be as accurate.
- Report template: Have a tool that can generate multiple reports with a similar style and template.
- Needs an independent location of any agency. It can have a unique name and can be a good way to find a donor (e.g., it can be named after you)
- There are tools that compile tools like SacPAS, but need a resource for compiling codes. IEP also has tools as well.
- We need best practices and the practices with technology.
- Need disaggregation tools. We need to quickly change the time scale or rescale.

3. How could we best organize and integrate these components and resources to make a cohesive framework/program?
    - BMI or something like that. Need data interfaces
    - Modeling linking and coupling.
    - Need a venn diagram of what everyone is doing. Need a comparison of what overlaps and what does not. Need linkages with overlap.
    - Database+ access
    - Launch computations over cloud.
    - Library of models
    - Need a variety of people and expertise.
    - Versioning
    - To organize and integrate, we need a true working workshop. We need someone who has experience with the tools.
    - Metadata
    - Need structural design. Need a receptionist, IT. There is a need for organizational structure. Need someone who knows data management.

4. How does the idea of building a new working group in CSDMS resonate? What might be the costs and benefits?
    - Not meant for decision support. It provides mid-low level support to link models. May be a framework.

- There are other codes that exist for earth system models. People don't use BMI that is used for CSDMS. Some organizations have adopted, but not everyone uses it.
- If there are existing groups, why do we need a new group.
- It provides a good foundation or to implement one of the existing. Need a scalable resources.
- What is the current infrastructure? How can we build off what we have.
- CSDMS might get pulled by NSF.
- This is not sustainable. Use their tools

5. What has been your (or your agency's) experience with developing or using existing software to facilitate coupling models or integrating data? What lessons learned or important insights can you share?
    - Agencies need computing power. It cannot be understated.
    - Need data managers, computer scientists in house.
    - Need to be clear on the motivation. Need to show this can lead to efficiency.
    - Need to upload your computations.
    - Not up to the collaborative to keep your system alive.
    - May not get NSF funding, but agencies can fund.
    - There are policies within the State of computers they can buy. There needs to be an infrastructure
    - Need better science communication.
    - If there is computational power, projects can be done quickly.
    - Some of these repositories can be very active, but then goes away. This is a big challenge.
    - Need functionality for the computer
    - This could be giant help center or maker-space.

Best Practices

1. Why are protocols and best practices important to developing an integrated modeling framework and modeling center?
    - For transparency & reproducibility
    - Best practices enhance intercompatibility & can help achieve transparency goals
    - They eliminate guesswork in assessing model/data quality

- Common criteria inter-agency disciplines
- Thinking space w/ agreed upon boundaries
- Facilitate model interpretation
- reduce common errors
- They can facilitate comparisons between models and baseline development (i.e., apples-to-apples comparisons)
- Achieve agreement/baseline
- Ways to ensure that all stakeholders are involved from the start
- Collaboration
- engagement
- Helps provide structure for education/training
- Culture/communication relationships
- Comms (external)
- ID stakeholders early
- ID critical problems/partnerships
- Shared understanding (internal)
- mission creep
- define scope

2. How do you currently interact with modeling protocols and best practices in your work now? What do you reference (e.g., CWEMF Modeling Protocols Report)?
    - CWEMF modeling protocols
    - replicable science
    - model + data sharing
    - Training staff & outside training
    - GitHub R markdown
    - content ID
    - version control
    - multi-level data products
    - Stakeholder communication
    - Open source principles
    - NCEAS
    - Berkeley Institute for Data Science Resources
    - Delta Science Plan
    - Personal network
    - I have familiarity with gnmm standard for model documentation

- Tools for reproducible pipelines
- Gitlab, Docker, Binder, Jupyter Notebooks

3. How do we best educate and inform the modeling community about existing protocols and best practices?
    - Agency model reviews
    - Look for gaps & resources to overcome the gaps
    - Reward system
    - Workshops (bootcamp)
    - free training
    - External support
    - ranking system for models/outcomes
        - which tiers of best practices models achieve e.g., tier 1, tier 2, tier 3
    - co-production min
        - e.g., minimum level of documentation to get models into collaboratories
    - pubs
    - identify web repositories
    - mentoring
        - CWEMF to promote mentorship opportunities
    - time
    - peer reviews
    - seminars
    - Workshops, making time to learn & get experience
        - virtual resources too (e.g., recorded workshops)
    - get buy-in through various venues, develop/share protocols via community documents (like Delta Science Plan)
4. Should/how do we develop best practices around modeling and disseminating information about uncertainty?
    - examples
    - partners with experts for/on workshops
    - training that includes technical staff and decision makers
    - no 'best' way
    - be open to disagreement
    - case studies
    - context - valige? impacts

- compare similar models
- develop common pre-/post- processors (e.g., John DeGeorge) to facilitate ensemble-generated uncertainty envelopes
- keep broad
- from Greg Gearhart: (key for communicating uncertainty)...open data, open science, equity inclusion, belonging, effective & impactful communications
- provide funding/staff support for implementation

5. How might we make models more transparent to non-experts? How might we share information about embedded assumptions?
    - narrative/viz descriptions
    - simple applications
    - relevant applications
        - make co-production a common practice
    - documents & metadata
    - community outreach/STEM education
        - frontiers for kids
    - visualization toolbox for common models
    - clear visualizations and interactive interfaces
    - involve them @ the development phase
    - through documentation available w/minimal barriers
    - engage social scientists
    - translation
    - produce simple 'toy model' versions that people can play/game with
        - with disclaimers?
        - seems like model documentation/metdata should include section on caveats/assumptions
    - if not open source at least open algorithm
    - metadata format

Governance

1. What are the priority governance considerations for developing a modeling framework and establishing a modeling center?
    - How will it operate short term/long term? Will the same team stay forever? Will the same agencies be involved forever?
    - clarified mission statement

- decision-making process
- decision-making structure
- $
- management and accounting - oversight
- structure of who is at the table/where the money is coming from
- leadership
- assume paranoia & self-interest. so over-share and over-transparent - keep shared efficiency at forefront to benefit participants
    - include stakeholders in governance structures (naive? given issues?)
- does there need to be a directive that has representation from all participants, or should the highest level of organization be small and serve limited priority objectives
- who allocates resources/staff time for participating institutions
- a mission that aims at questions, products that are currently out of reach
- How get buy-in from directors, secretaries down to heads of modeling teams in each participating agency/institution
- who sets priorities
- who decides what projects to adopt? will there be a "steering committee" or other filtering body?

2. How could components and resources be organized to produce a cohesive framework and center?
    - interagency? JPA?
    - easy data accessibility
    - already have some # of experts. Is there a way to tap them as needed and protect their time as they help?
    - around key questions/issues
    - independent center. academic? institute?
    - workforce development anglecore staff post docs or science fellows (agencies can hire if good fit)
    - core funding that serves outward. outside agency e.g. national academies
    - independent seed $ with annual operational funds from participating agencies?
    - allocate budgets to reflect need for core staff, key priority projects, and emerging needs

3. What specific people and/or skillsets should be engaged in this development process? Are there any specific agency leaders that we need to recruit as "champions" of this vision in order to maximize "buy-in" from the beginning?
    - interdisciplinary experts
    - base budget for core staff- director- data scientistsprogrammers visualization translators communicators
    - a regular convening forum of the heads of modeling groups in agencies & NGOs
    - social scientists
    - heads of existing modeling offices
    - agency directors AND managers
    - computer/IT experts
    - big picture thinkers
    - early adopters
    - how to bring in DEI
    - human dimensions specialty
    - database management experts, software programmers, data visualizations experts, communication conduits
    - internal skills:ML/AIcomp sciHPCdataexternal skills:models/domain expertise
    - CNRA secretary, interior secretary, modeling group leads

4. Who are the parties that would have an interest in the outcomes of modeling associated with these case-studies or use cases? Who are the parties who are already engaged in addressing these issues?
        - GSAs-groundwater dynamics
        - water supply agencies + F/SWC -> system model
        - front page of Washington Post todayFinding a path forward or alternative for tunnels
        - agency modeling chiefs regulatory + review bodies water operations units species recovery efforts
        - environmental groups -> eav. models (lead models?)
        - flood control agencies - flood models
        - PWAs NGOs state and fed agencies
        - academic researchers

- restoration planning units land use planning units 30/30 team

5. What considerations are necessary for ensuring the modeling framework and center are accessible and transparent to participants?
    - bylaws
    - routine open meetings
    - clear mission statement
    - Mural etc.
    - clearly identify end users at the start
    - identify stakeholders hybrid delivery + participation opportunities
    - guidelines for engagement/participation
    - publish & distribute expectations + requirements for participation open source software requirement
    - make participants inclusive & real needs rather than postulated needs

6. How do we encourage or facilitate collaborations that include participants from multiple institutions, disciplines, and interests?
        - consider projects or test cases in terms of how/why do they uniquely require collaboratory
        - $$$
        - think about barriers to participation and work to eliminate or mitigate them

“Broad discussion” (Group 4)

1. What components or resources are necessary to achieve this vision?
    - That could happen through a GitHub Organization
    - Something like github that allows collaboration and version control
    - Input from someone experienced with software engineering to design the system to be scalable
    - Clear definition of how models interoperate. Structure to enforce standards.
    - I'm still not clear what the vision is.
    - Archiving / Version Publishing
        - A set of webpages with guides to the modeling that are not changed / revised removed regularly

- We need a framework for categorizing all constituent models across numerous dimensions with an eye towards identifying how the models can be coupled and integrated
- Need overarching impetus to work together (e.g. CBP had EPA)
- computer facilities with each different SFE models running
- As Jay Lund says lots of money and dedicated personnel
- Cloud computing and/or high powered servers for modelers to use would be awesome.
- Dedicated support staff
- co-production
- Goal of co-production of knowledge with stakeholders, esp. ones that are often not in the room
- Principle of transparency of code and calibration / validation datasets
    - Value open source code and data
- Share with everyone any specific use cases that seem to be important to drive development of such a platform/collaboratory
- Clear benefit to the model developers for models to be integrated.

2. How does the idea of building a new working group in CSDMS resonate?
    - NOt re-inventing the wheel would be great
    - potential to learn from their experiences to get a better start on this for our system/needs
    - Long-standing delta models (e.g. DMS2/CalSim) don't have much incentive to change - needs to be a clear value added for them
    - Long-standing issues with model development / validation / working w/ all stakeholders. Most of the recommendations of the CALSIM II independent review panel were never implemented, similarly with 2009 Bay-Delta modeling community letter.
    - Recommendations of 2012-2015 Climate Change Technical Advisory Group (CCTAG) re: education, addressing knowledge gaps, downscaling, etc. have not been implemented. Critically important w/ accelerating climate change impacts.
    - Have we talked to NCEAS about how they set up their support frameworks? Would that model be better for us than CSDMS? (Honest question.)

- If we could have a group that worked to incorporate all the present working models -ie DMS2,etc but that could be maintained by their personnel and made available all those python links and tools that could be used to couple and integrate and smooth our models

3. How do you currently interact with modeling protocols and best practices in your work now?
    - Reviewing modeling results and validation / calibration and handling of uncertainty due to climate change
    - DOI/FWS just implemented some new protocols for using GitHub. They're still developing, but they could be a helpful model in some ways.
    - Sometimes I think I should pay more attention to coding best practices, then I forget to do it.
    - So far, minimally, would appreciate centrailsed training/s standards to be clearly published
    - Documentation

4. How might we make models more transparent to non-experts?
    - Online GUI's would be helpful
    - Need to establish closer relationships between decision makers and modelers
    - Clear conceptual models and better output graphics
    - There need to be resources for training of NGO / CBO folks
    - Funded summer training for college students
    - It kind of depends on what we mean by "non-experts" and what our goals are. General public is different than decision-makers or managers.
    - Retrain/ designate specific people with modeling backgrounds as communicators
        - provide science communication trainings to modelers :-)
    - Managers like two-page summaries
    - also, how to make them transparent/accessible to other modelers/users
    - Make model code and data fully available. With clear documentation on how to run/use the model.

5. What specific people and/or skillsets should be engaged in this development process?
    - Need more input from climate scientists re: scenarios and climate change impacts
    - Better integration with ICARP / Climate Change Assessment efforts
    - We need a breadth of expertise beyond just the technical. The science should come first and policy folks should be involved to help us understand what questions would be most impactful for them.
    - Senior Software Engineer to help architect a system
    - Communication Skills
        - especially with decision makers to convince them to give the required funding/ manpower
    - social scientists/need to make sure the human dimensions of issues/processes/questions are included
    - Facilitators to help with scientists, coders, and managers all getting on the same page
    - need buy-in/engagement with people currently working on integrated modeling efforts

6. Are there any specific agency leaders that we need to recruit as “champions” of this vision in order to maximize “buy-in” from the beginning?
    - Definitely need buy-in from DWR's Delta modeling group - Aaron Miller, Eli Ateljavich
    - IEP Synthesis teams - would be good examples/champions
    - Many groups rely on funding from DWR and/or USBR so getting them on board would be critical
    - Legislative Analyst's Office
    - We need people with an in depth understanding of the model while also having the communication skills to convey the key elements of the model to non-experts. This can be achieved with training.

“Broad discussion” (Group 4)

1. What's the ultimate vision for a modeling framework or modeling center?
    - A virtual or physical entity that accelerates progress on the development and application of coupled phsyical-ecological-social-

etc models by providing computer science support (human, data and computational resources) to the local modeling community.
- A tool that can represent and match the CA Water Plan

2. What components or resources are necessary to achieve this vision?
    - Regular workshop to educate and train new models for interested modelers
    - For a center, dedicated resources, both money and personnel
    - State and Federal Buy-in
    - $$$
    - Data! We don't always collect data that modelers need
    - Educate the IT people about what the modelers' resources needs and time sensitivity so they can be more helpful. Let them know IT and modeling are not the same.
    - A cadre of computer scientists to help other scientists take advantage of a the modeling framework and write adequate code
    - A repository for models and their documentation
    - Cloud-based compute and data storage and help on how to use it.
    - A system to make needed data readily available to modelers. Maybe use erddap. https://tinyurl.com/2p8bcp3u

3. How does the idea of building a new working group in CSDMS resonate?
    - Data sharing and not repeat the same work
    - One cost would be lost investments in alternate modeling frameworks that aren't closely related to CSDMS (not sure these are very large yet).
    - I have seen a number of these initiatives be undertaken. Unfortunately, they seemingly ignore what has been achieved and not be carry i.e., existing versus new data)
    - Not necessarily a cost, but a potential concern - who determines what the group works on (who makes the list of ideas and prioritizes)?
    - My impression from presentations on CSDMS is that it would take a significant and prolonged investment by a government agency to get the Delta modeling community to settle on that.

- The benefit would be a clearer path for development of new integrated modeling projects, with higher likelihood of success and a side benefit of potential reuse of some or all of the products in other projects.

4. How do you currently interact with modeling protocols and best practices in your work now?
    - I hired someone from Google to help us better integrate our models.
    - Currently work with disparate resources that are engaged in modeling activities for watershed vulnerability and groundwater Decision Support Tools at various HUC levels.
    - Teamwork, cross reference, not to hide from others

5. How might we make models more transparent to non-experts?
    - Language that is used during the process could be a faactor
    - Keep it simples (KIS) at the highest level.
    - A wiki that provides high-level and detailed information on models.
    - Tech/science communication documents at a layperson level
    - Engage managers, decision-makers, non-modelers, etc. directly at conferences, workshops, etc
    - Documentation explaining what the model is doing and what data is being used

6. What specific people and/or skillsets should be engaged in this development process?
    - It is my understanding that the two major systems impacting the Delta are: Central Valley Project (CVP) and the State Water Project (SWP). Resources should be enlisted. Curious as to any role CALSIM 3.x plays.
    - There are models being developed at UC Merced's Sierra Nevada Research Institute (SNRI) that could contribute
    - There are Decision Support Tools (DST) being developed at Lawrence Livermore Labs focused on surface/groundwater hydrology.

- Broad knowledge and skillset of the field you are working on and good communication to share experience with the other modelers who are working in the same field/model

7. Are there any specific agency leaders that we need to recruit as "champions" of this vision in order to maximize "buy-in" from the beginning?
    - Kamyar Guivechti at DWR Kamyar.Guivetchi@water.ca.gov
    - Governor
    - Agency Directors - e.g., Karla Nemeth, Yana Garcia

Key takeaways from each group

Group 1: Cyberinfrastructure (in-person)

- Talked about different components of infrastructure but noted that need to have the people infrastructure.
- Need experts in modeling and having people help people who need help or link models together. There is a need for IT to move things in and out of cloud.
- Some of the people can be part time or cyberinfrastructure people need to be on hand all the time.
- Many agencies do not have support on computer scientists.
- Some folks do not have the computing resources. This is a benefit of collaboratory.
- Collaboratory is help center or maker-space. You go this place and there is people to help you. You have access to tools that you do not have. Some groups will rely on it, while others will not need it.

Group 2: Best Practices (in-person)

- Flexible nested minimum and documented standards of BP that are being met
- Need synthesis, lots already available (might be role for DSP)
- Templates/examples
- Community outreach

- More support/reward for individuals + as a community
- Best practices essential for multi-model & model-data integration, model intercomparison, baseline development, and ensemble solutions
- To get uptake, need multi-pronged approach (e.g., seminars, training, online interfaces, etc.)
- Update by modelers + stakeholders

Group 3: Governance (in-person)

- Identify leader(s)
- Identify a problem statement
- Connect to funders
- Build in flexibility
- DEI + Transparency

Group 4: Broad Discussion (virtual)

- Resources: dedicated staff, computing resources, funding
- also need to consider training/education/communication opportunities for resources (e.g., GitHub)
- what is motivation to participate? (requires effort/resources/change and so you need to consider the "why")
- need to consider longevity of products/how to archive, maintain availability
- not reinventing the wheel would be great!
- not much out there, but would be helpful, especially when initiating efforts
- CSDMS might be really helpful for this, but also may not have applicable protocols for the Delta's models
- documentation recommendations would be very helpful
- We need people with an in depth understanding of the model while also having the communication skills to convey the key elements of the model to non-experts. This can be achieved with training.
- what is motivation to participate? need buy-in/engagement with people currently working on integrated modeling efforts
- also consider buy-in from agencies/programs (e.g., DWR, SWRCB)....without them, a collaboratory probably wouldn't be used
- need to involve academics (not just agencies)
- communication: need to support training/skill development to improve transparency

- translations: what is interesting to modelers might not be the same as for managers/decision-makers; need to facilitate conversations across these groups & have facilitators that do this communication effectively

Group 5: Broad Discussion (virtual)

- Funding, dedicated personnel and education, and infrastructure are key components/resources necessary to achieve the vision
- Regarding building a new working group in CSDMS, it's important to consider:
    - Overcoming skepticism of community
    - Problems not straightforward or simple - who decides priorities if only one framework
    - Synchronization can save time and improve efficiency
- To make models more transparent to non-experts,
    - Keep it simples (KIS) at the highest level.
    - Engage managers, decision-makers, non-modelers, etc. directly at conferences, workshops, etc.
    - Need a wiki that provides high-level and detailed information on models.