April 28, 2023

DRAFT Delta Coordination Group SDM Process Document

WY 2023

Contents

Introduction

This Structured Decision Making (SDM) Decision Process Document describes the decision scope, process, and outcomes for the water year 2023 decision facing the Delta Coordination Group (DCG) related to the Delta Smelt Summer Fall Habitat Action (SFHA). This is a living document that will be revised as the process evolves, as some considerations become less important and as others emerge.

This SDM Decision Process builds on existing work, and several documents have been produced that may provide background and context for this process. Documents are available upon request from Reclamation and/or DWR representatives on the DCG:

1. Reclamation strawman consequence table
2. Reclamation PM memo
3. SDM appendix
4. Reclamation DCG Guidance doc
5. DWR draft DCG process document
6. RMA report on habitat suitability
7. 2022 SFHA Action Plan

Decision Scope and Context

Given the continued decline of Delta Smelt (DS) and regulatory requirements, the DCG was formed to provide a collaborative forum among federal, state, and water agencies to develop a multi-year science and monitoring plan and on an annual basis to review existing information, evaluate proposed summer-fall habitat actions, and inform the development of the annual Summer Fall Action Plan. The DCG is required to use a structured decision making process with the intent of making transparent decisions informed by current scientific knowledge.

The regulatory documents establishing the membership and function of the DCG include United States Bureau of Reclamation (USBR)'s Final Biological Assessment (BA; October 2019), the United States Fish and Wildlife Service (USFWS) Biological Opinion (BiOp; October 2019), National Marine Fisheries Service (NMFS) BiOp (October 2019), and California Department of Water Resources (DWR)'s Incidental Take Permit (ITP; March 2020). Per these documents, DCG members consist of the California Department of Fish and Wildlife (CDFW), DWR, USBR, USFWS, NMFS, and state and federal water contractors (Public Water Agencies; PWAs).

For the purposes of this year's SDM process, the DCG has decided to focus on the following decision:

> What suite of actions should the DCG recommend for the next SFHA period (June to October), given the likely water year types? This includes not just broad categories of action, but how we implement them. We anticipate using between 90% and 10% as our definition of likely; we will cover as many WYTs as feasible given time and data.

Constraints:

The action options are currently constrained by regulatory requirements (e.g., ITP), lack of infrastructure (e.g., Sacramento Deep Water Ship Channel, SDWSC), and understanding of the system and the effects of possible actions.

The SFHA Plan for each year will need to adhere to the regulatory requirements. As understanding increases (we gain new knowledge), there may be reason to adjust management (i.e., adaptive management approach). Some adjustments may require permit amendments, which may come as soon as next year.

Linked decisions:

- The DCG may use this framework to explore SFHA options beyond what is currently included, as well as to target learning.
- The studies that DCG recommends as part of its annual planning will influence what options are available for inclusion in future years.
- Although amendment requests may be filed at any time, the Independent Reviews (ITP: 2024 and 2028; BiOps: 2024 - 2025, TBD) provide scheduled opportunities for higher-level re-evaluation.

Participants

DCG Steering Committee

DCG Working Groups

Jennie Hoffman, facilitator

Sally Rudd, facilitation support

Table 1 DCG members and support staff

TWG Status	Organization	Representative	Alternate
DCG Members	Reclamation	Kristi Arend	Brian Mahardja
DCG Members	FWS	Matt Nobriga	Jana Affonso
DCG Members	DFW	Brooke Jacobs	Kristal Davis
DCG Members	Federal Water Contractors	Scott Petersen	Deanna Sereno
DCG Members	State Water Contractors	Darcy Austin	Chandra Chilmakuri
DCG Members	DWR	Brittany Davis	Rosemary Hartman
DCG Members	NMFS	Garwin Yip	Barbara Byrne
DCG Technical Support	Reclamation	Kristi Arend	Brian Mahardja
DCG Technical Support	Science and Monitoring WG	Rosemary Hartman, DWR chair	—
DCG Technical Support	Hydrology and Operations WG	Ian Uecker, DWR chair	Tracy Hinojosa, DWR
DCG Technical Support	DFW	Mike Eakin	—
DCG Technical Support	CCWD supporting Federal Contractors	Deanna Sereno	Ching-Fu Chang (SMWG) Yuan Liu (HOWG)
DCG Technical Support	FWS	Will Smith	Leanna Zweig
DCG Technical Support	Metropolitan Water supporting SWC	Shawn Acuña	—
Facilitation Team	Lead SDM Facilitator, Contractor	Jennie Hoffman	—
Facilitation Team	SDM Facilitation Support, Compass Resource Management	Sally Rudd	—

Responsibilities and Decision Authorities

The DCG makes decisions relative to the SDM process. The DCG advises on what SFHA to carry out but may not have final say over what agencies do.

DCG members are responsible for attending meetings, reviewing information, providing input, and actively participating in deliberation.

DCG Working Groups provide technical input as appropriate.

Representation is important. The DCG facilitator will schedule all meetings for times when at least one Steering Committee representative or alternate from each agency indicates that they are available. If a member can't make a meeting, it is expected that they will designate an alternate and ensure the alternate is up to date on the process and issues under discussion.

Other than alternates, observers will only be allowed with prior agreement by the group.

SDM Facilitation

The SDM Facilitator is responsible for implementing a process that is responsive to input from DCG members while respecting overall process schedules and budgets and remaining focused on the agreed scope of the decision process. For the SDM process, the Facilitator will:

- Design the overall process
- Provide impartial facilitation of all meetings, workshops, and teleconferences
- Elicit and structure decision objectives, performance measures, and alternatives
- Utilize trade-off analysis tools to clarify key trade-offs and help the DCG in seeking consensus on preferred alternatives
- Produce a concise record of the process and outcomes.

Process Principles

The principles below are intended to guide how group members interact during this SDM process. The goal is to have ground rules that will set this SDM process up for success.

The DCG reviewed these principles during the August 11, 2021 DCG meeting and agreed with no changes. These principles may be revisited by the group as needed.

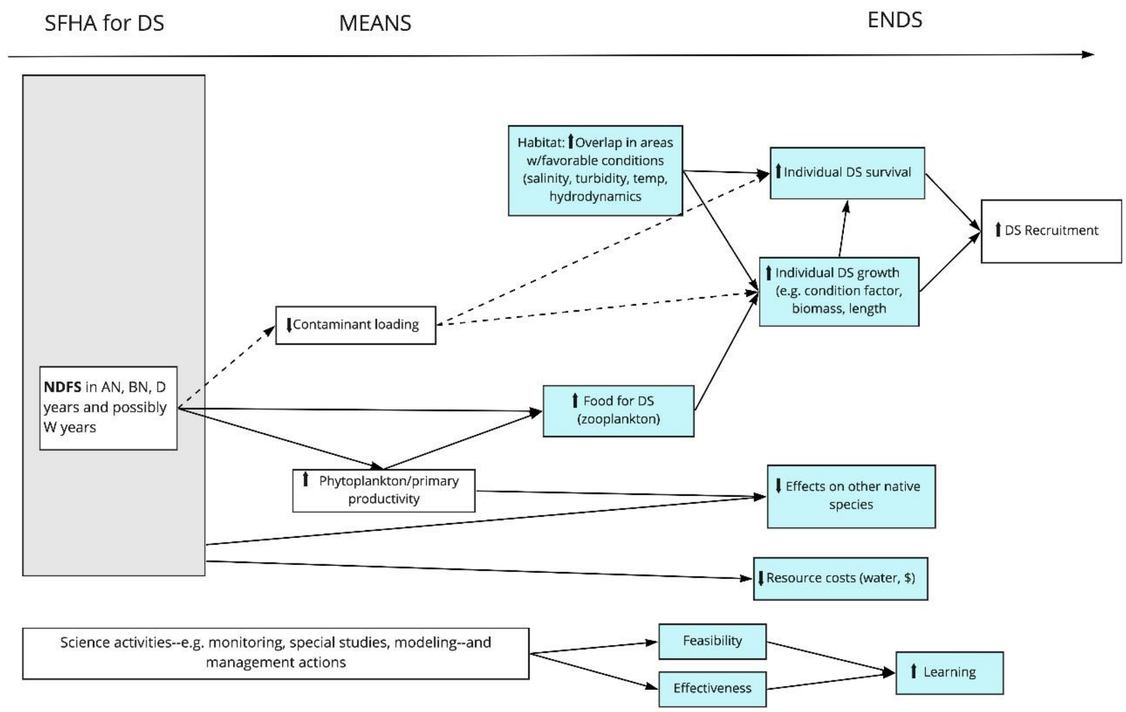
1. Strive for consensus
2. Strive to be inclusive
3. Stay present
4. Share relevant information
5. Explain reasoning and intent
6. State views and ask questions
7. Recognize that the BiOp and the ITP are different, and different DCG members are differentially bound by each.
8. This process doesn't alter existing legal rights and responsibilities of member agencies.
9. The facilitator is responsible for producing SDM process documents, although she will get input from the group. Documents will be finalized by consensus.
10. Acknowledge past SDM work, but focus on building a shared framing and prototype in a collaborative way

Decision Objectives

For the purposes of this decision process and this Decision Process Document in particular, the term "decision objectives" describes the factors important enough to the DCG to warrant consideration when choosing strategies for SFHA. A core feature of SDM processes is a focus on values – rather than on pre-established targets or agency mandates – to guide the development of these objectives. In SDM processes, decision objectives serve several important functions; they communicate what is important to consider when making decisions for a specific decision context, they help to guide the development of alternatives, and they provide the foundation for the analysis of consequences and trade-offs.

A means-ends diagram, shown in Figure 1, can be useful for understanding the relationships between objectives and management actions under consideration.

Figure 1 Influence diagram used for 2023 SDM



At the right-hand side of the diagram are fundamental objectives – the outcomes that DCG members care about and can be affected by the SFHA decision. At the left-hand side are the means or management levers available to influence the fundamental objectives. In between are the factors that describe the important connections between actions the DCG can recommend and the outcomes the DCG values. From a practical perspective, it is important to think about the means-ends continuum and use the diagram to determine which decision objectives will be most useful for discriminating among alternatives.

The grey box on the left-hand side of the diagram contains the main categories of management actions the DCG may include in the water year 2023 SDM process. The white box at the far right of the diagram (increased DS recruitment) is recognized as the broader objective supported by increased DS growth and survival. Because there are many efforts beyond those covered by the SFHA geared towards increasing DS recruitment, and the broader system is complex, DS recruitment is unlikely to be useful as a decision objective for this decision because of the statistical uncertainty that compounds as scientists “model up” from one response variable to a higher level one. Note that there is some duplication or overlap within the DS decision objectives (e.g., food is a means to increasing growth and transferring contaminants to Delta Smelt), and as the process proceeds, it may make sense to refine or combine some of these. It is an SDM best practice to be as concise as possible with decision objectives and avoid duplication.

During DCG SDM meetings in January and February 2022, the DCG reviewed and revised decision objectives and subobjectives from the 2021 SDM prototype. The WY 2022 objectives were reviewed in fall 2022/spring 2023 and revised for WY 2023. The new objectives and subobjectives are summarized in Table 2. DCG members acknowledged that there are other potential decision objectives (e.g., recreation) but do not feel they will be significantly affected by this decision. As with all aspects of this decision prototype, this decision may be revisited.

Notable changes between the 2022 and the 2023 objectives include:

- The DCG decided to operationalize the learning objective for WY 2023. See the learning PM Infosheet for full details.

Table 2 Summary of objectives, subobjectives, and why they matter

Objective	Subobjectives	Description, importance
DS Growth and Survival	Individual growth Individual survival	The primary goal and driver of the decision process is to improve individual Delta smelt growth and survival in the summer-fall period, which will contribute to overall DS recruitment and persistence. Increasing delta smelt survival is the ultimate aim of the SFHAs. Growth and survival are correlated at times, but growth is more readily estimable at present and is the sub-objective used in the 2023 SDM process.

Objective	**Subobjectives**	**Description, importance**
DS Food and Habitat	Food Habitat	The fundamental scientific hypothesis that underlies the SFHA is that targeted actions to increase feeding success of Delta smelt in key locations can replace more water-costly actions such as Delta outflow requirements. This is the rationale for separating “food” from “habitat” because habitat is shorthand here for physical habitat attributes like salinity, temperature, and turbidity, among others.
DS Contaminant effects	—	Some SFH actions have the potential to increase or decrease Delta Smelt’s exposure to contaminants, either through changing contaminant concentrations in areas where Delta smelt are expected to be and/or by affecting the overlap of suitable habitat for Delta smelt with areas of lower contaminant concentrations (e.g., Suisun Marsh and Suisun Bay have generally lower contaminant concentrations compared to other areas used by Delta smelt). Contaminant exposure could affect individual growth and survival as well as have potential multi-generational sublethal effects.
Resource costs (water, money)	Water costs Financial costs	As resources are limited, there is an interest in using resources efficiently and improving the cost-effectiveness of achieving Delta Smelt benefits. Water costs represent any CVP or SWP water that is used to support an action, e.g., reservoir releases or export reductions. Financial costs include any expenditures on capital and operating costs for implementing an action (e.g., costs related to operating the gates more frequently, monitoring, special studies, etc.)

Objective	Subobjectives	Description, importance
Effects on other native species	—	SFHA may have positive or negative effects on other native and nonnative species. Of particular concern are ESA- and CESA-listed species including winter- and spring-run Chinook Salmon, and steelhead, as well as fall-run Chinook Salmon, which are not ESA-listed. The primary concerns are related to extra reservoir releases to support SFHA actions and coaxing salmonids to stray off migration paths when water is re-routed.
—	Winter-run and spring-run salmon	Some alternatives may decrease reservoir storage and associated cold water pool availability which may result in warmer tailwater temperatures and, consequently, less suitable spawning conditions, increased salmonid egg mortality, and less suitable rearing conditions. Changes in reservoir operations to support SFHA could impact winter- and spring-run salmon in the Sacramento and Feather rivers, respectively. The conservation of winter-run salmon is acutely tied to water storage in Shasta Reservoir because egg incubation occurs over the summer when air temperatures are very high and must be mitigated using coldwater releases from the reservoir. Any action that increases demand on Shasta storage has the potential to impact the survival of winter-run eggs and fry. Some of these detrimental effects may occur in the water year of the SFHA action; others in the subsequent year depending on whether reservoirs are refilled.

Objective	Subobjectives	Description, importance
—	Steelhead	Some alternatives may decrease New Melones or Folsom storage and associated cold water pool availability which may result in warmer water temperatures (most likely during the summer) and, consequently, less suitable rearing conditions for steelhead in the Stanislaus River or American River. Some of these detrimental effects may occur in the water year of the SFHA action; others in the subsequent year depending on whether New Melones Reservoir or Folsom are refilled.
—	Fall-run salmon	Adult fall-run salmon migrating into the Delta cue on their natal rivers by smelling the source water. Re-routing Sacramento River water into the Yolo Bypass per some NDFS alternatives may increase straying of salmon into the bypass where they cannot spawn and may not find a path back into the river.
Learning	Feasibility Effectiveness	For actions that have never been implemented, simply learning whether or not they are feasible has value. There is significant uncertainty about the performance of NDFS alternatives on all objectives. Reducing this uncertainty could improve DCG members' ability to evaluate risks and make tradeoffs in future years, as well as to decide when to pivot to other possible SFHA actions.

Performance Measures

Table 3 summarizes candidate performance measures for each decision objective, which are the metrics that will be used to characterize the DCG's predictions of how an alternative performs relative to a decision objective. The DCG considered multiple options for predicting consequences (see Model Fact Sheets) For further information on PMs, how they were calculated, assumptions, uncertainties, and other information relevant to interpreting results, see the PM Infosheets, as well as the elicitation instructions for Effects on other species and Contaminants.

Table 3 Summary of Decision Objectives and Performance Measures as clarified at February 10 and 15, 2022 DCG meetings

Decision Objective	Sub-Objective	Candidate Performance Measures	Scorers	Units	PM brief Description, information source
DS Growth and survival	Individual growth	Delta Smelt growth rate potential	Lead: Will Smith	mm/summer	The PM was a metric to evaluate whether simulated actions increased the bioenergetics-based suitability of a region. The performance measure was the difference in potential growth predicted by the bioenergetics model between conditions representing no action and conditions representing the effects of a management action. Results were summed for the period June – October, with total growth relative to baseline calculated for four regions: Yolo, Lower Sacramento, Confluence, and Suisun Marsh.
—	Individual survival	Survival	Lead: Will Smith	0 - 1	Calculated from mean daily GRP values for 1000 simulated fish. Modeled for the period June – October with means calculated from regional, monthly means using the IBMR model and IBMR regions. **The DCG did not end up evaluating survival for the 2022 SDM process and does not plan to for the 2023 SDM process**

Decision Objective	Sub-Objective	Candidate Performance Measures	Scorers	Units	PM brief Description, information source
DS Food and habitat	Zooplankton	Food availability score	Lead: Rosie Hartman	Difference no action alternative, BPUE	The PM for zooplankton is the change in a food availability score between an action scenario and a no action scenario.
—	Overlap of suitable salinity, turbidity, food, temp, hydrodynamics	Habitat Suitability Index (HSI) w/temp	Lead: Brian Mahardja	Value between 0 and 1	The habitat suitability index (HSI) is based on four abiotic variables: salinity, temperature, turbidity, and current speed and was calculated using a methodology derived from Bever et al. (2016) and RMA (2021). The index represents spatially- and temporally-averaged suitability of habitats within the 12 delineated subregions in the Bay-Delta shown in the PM infosheet.
Contaminant Effects	Contaminant concentration in areas of good habitat	Contaminant risk	Lead: Shawn Acuña	Constructed scale, -2 to +2	Experts were asked to score alternatives relative to No Action Alternative for 5 PMs: DS survival, growth, and recruitment, and zooplankton abundance and quality. Experts were asked to focus only on direct effects of contaminants
Water supply cost	—	Additional outflow needed to offset action	Lead: Ian Uecker	TAF /yr	DSM2 was used to assess a case where no action is present and compared to a case where the SMSCG is operated; the PM is the additional outflow added to offset degradation from operating the gates to the control location.

Decision Objective	Sub-Objective	Candidate Performance Measures	Scorers	Units	PM brief Description, information source
Resource costs	Direct management costs (money for staff, operating gates, etc.)	$/yr	Lead: Brittany Davis	$/yr	Costs include direct management costs for staff, operations used to implement actions, and science and monitor including field and lab work, contracting costs, analysis and reporting.
Effects on other native species	Winter run	Effects on species	Mike Eakin	Constructed scale, -3 to 1	Experts were asked to provide judgements about effects at the individual and population level using the scale provided in the elicitation instructions.
—	Spring run	Effects on species	Mike Eakin	Constructed scale, -3 to 1	Experts were asked to provide judgements about effects at the individual and population level using the scale provided in the elicitation instructions.
—	Fall run	Effects on species	Mike Eakin	Constructed scale, -3 to 1	Experts were asked to provide judgements about effects at the individual and population level using the scale provided in the elicitation instructions.
—	Steelhead	Effects on species	Mike Eakin	Constructed scale, -3 to 1	Experts were asked to provide judgements about effects at the individual and population level using the scale provided in the elicitation instructions.
Learning	Feasibility	—	Brittany Davis	Constructed scale, 1 to 3	—

Decision Objective	Sub-Objective	Candidate Performance Measures	Scorers	Units	PM brief Description, information source
—	Effectiveness	Current knowledge	Brittany Davis	Constructed scale, 1 to 5	Based on the number of the times an action had been implemented or a similar flow pulse occurred through unmanaged flows since monitoring began in 2011. Lower scores indicate a greater amount of existing data (I.e. lower learning potential).
—	—	Possible learning increment	Brittany Davis	Constructed scale, 1 to 3	Regardless

Alternatives

For WY 2023 the alternatives will focus on management actions (those intended primarily to get a positive response for Delta Smelt); science and monitoring recommendations will be addressed separately by the Science and Monitoring Working Group. Some actions are required by the ITP or BiOp, while others are not.

Table 9a from the ITP (Table 4 in this document) outlines which actions are required for which water year types. Thus far, dry and critically dry hydrology have precluded any SFHA. FAs a result, no action would be required if WY2023 is a dry year; in a below normal year, the SMSCG would need to be operated for 60 days between June 1 and October 31. Operating the SMSCGs allows fresh water from the Sacramento River to enter the Marsh on the ebb tide while preventing brackish water from Grizzly Bay from entering on the flood tide. This increases low salinity habitat in the Marsh, which increases the likelihood Delta smelt will occupy the area. Suisun Marsh – or at least its larger sloughs - are hypothesized to provide better habitat than the Sacramento River due to higher turbidity, higher prey density, and lower contaminant availability. For WY 2023 the DCG decided against including any alternatives regarding SMSCG gate operations because the ITP requires salinity at Belden's Landing to be less than or equal to 4 ppt and the gates operation schedule that maximizes the number of compliance days was modeled sufficiently in 2022. Therefore, the DCG has left it up to DWR to determine the spacing of operations; the working concept for operating the gates is 15 days on, followed by 10 days off.

The DCG has been told that discussions about options for the additional 100 TAF Delta outflow will take place outside of the DCG, so the DCG will not consider alternatives related to this action regardless of WYT.

This means that for WY2023 the DCG is only evaluating alternatives related to the North Delta Food Subsidies Action. The NDFA uses existing infrastructure to redirect water (~20-30 TAF) down the Yolo Bypass in effort to restore net positive flow and improve plankton in downstream Delta Smelt habitat. The NDFA action relies on the coordination of water operations upstream of the Delta either to implement a Sacramento River action, an

Agricultural drainage action, or a combined action (see Figure 2 and Table 5).

- The Sacramento Action redirects Sacramento River water during summer through Glenn-Colusa Irrigation District and the Reclamation District 108 to pass the water into the Yolo Bypass and downstream to Cache Slough Complex.
- The Agricultural drainage action redirects agricultural return water mostly from rice fields in the Colusa Basin Drain through the Ridge Cut Slough and down the Yolo Bypass that would otherwise be drained into the mainstem Sacramento River. This action would occur during fall.
- A third type of action that has never been carried out is a summer Sacramento River action followed by a fall Agriculture action to generate a longer duration pulse (60 days) and time period with net positive flow.

In addition to differences in water source, NDFA actions can also be carried out to create a longer flow pulse with a lower magnitude, or a shorter pulse with a higher magnitude.

Table 4 Table 9a from the ITP

<table>
<tr><th rowspan="2">Month</th><th colspan="5">Water Year Type (SVI)</th></tr>
<tr><th>Wet</th><th>Above-normal</th><th>Below-normal</th><th>Dry</th><th>Critical</th></tr>
<tr><td>June</td><td rowspan="3">Additional 100 TAF Delta outflow, June through October**</td><td rowspan="3">Criteria: Operate SMSCG for 60 days*

Additional 100 TAF Delta outflow, June through October**</td><td rowspan="5">Criteria: Operate SMSCG for 60 days*</td><td rowspan="5">Criteria: In dry years following below-normal years operate SMSCG for 30 days*

Criteria: In dry years following wet or above-normal water years operate SMSCG for 60 days* ***</td><td rowspan="5">No action</td></tr>
<tr><td>July</td></tr>
<tr><td>August</td></tr>
<tr><td>September</td><td rowspan="2">Criteria: 30-day average X2 ≤ 80km</td><td rowspan="2">Criteria: 30-day average X2 ≤ 80km</td></tr>
<tr><td>October</td></tr>
</table>

* Water necessary to implement SMSCG operations may be provided through export curtailments supported by the SWP Contractors through a commitment pursuant to Voluntary Agreements or as early implementation of such agreements.

** If approved by CDFW the Additional 100 TAF may be deferred and redeployed to supplement Delta outflow the following water year during the March – October timeframe, unless the following water year is critical (see Condition of Approval 8.19). This use of the redeployed water is not intended to serve as a criteria.

*** CDFW anticipates deferring a portion of the 100 TAF received from an above normal or wet year when the following year is dry to facilitate SMSCG operation for 60 days in the absence of other available water.

The full suite of alternatives under consideration in the 2023 SDM process are outlined in Table 5. The DCG would like to do provisional analysis for all relevant water year types.

Table 5 Summary of Management Actions Under Consideration for the WY 2023 SDM Process

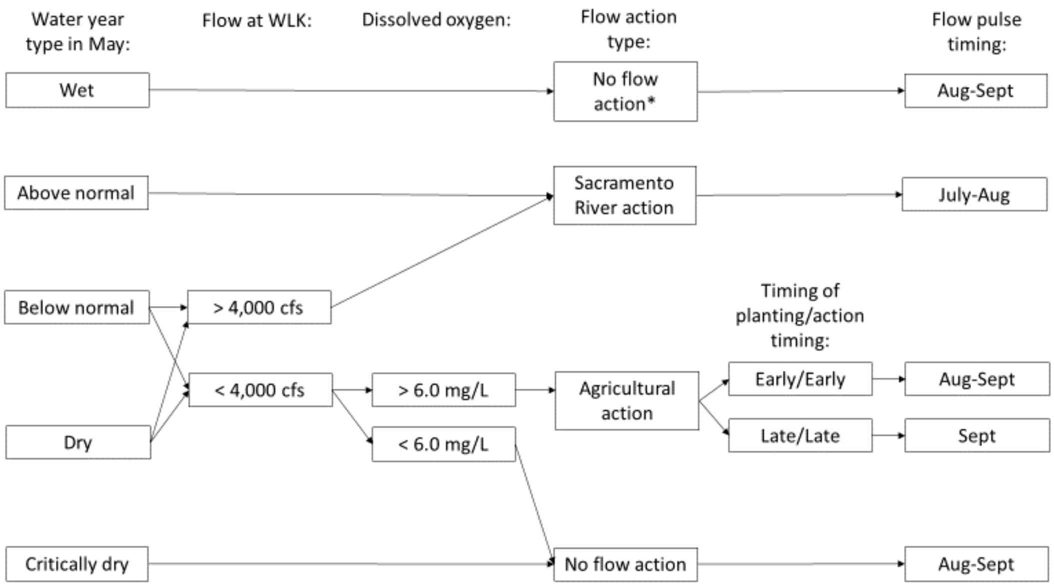
Type of action	Alternative name	Alternative description
North Delta Food Action	Sac long-low	Sacramento River water would be directed through Yolo Bypass for a longer duration (4 weeks) at a lower intensity (400 cfs)
North Delta Food Action	Sac short-high	Sacramento River water would be directed through Yolo Bypass for a shorter duration (2 weeks) at a higher intensity (800cfs)
North Delta Food Action	Ag long-low	Agricultural return water would be directed through Yolo Bypass for a longer duration (4 weeks) at a lower intensity (400 cfs)
North Delta Food Action	Ag short-high	Agricultural return water would be directed through Yolo Bypass for a shorter duration (2 weeks) at a higher intensity (800cfs)
North Delta Food Action	Sac-Ag	This alternative involves a Sac long-low summer action followed by an Ag long-low fall action to generate a longer duration pulse (60 rather than 30 days) and time period with net positive flow. While assumed to be operationally feasible, this approach has never been implemented.

The decision is not *which* of these to implement; based on previous analyses the order of preference will be as shown in Figure 2 with a long-low approach preferred to a short-high approach. The decision for the DCG is whether, if conditions permit, an action should be taken. Decisions would thus occur in the following sequence:

- If conditions allow a long-low Sac action, should this action be taken?
- If a long-low action is not possible but a short-high Sac action is, should that be taken?
- If conditions allow a long-low Ag action, should this action be taken?
- If a long-low action is not possible but a short-high Ag action is, should that be taken?
- The decision to do a Sac-Ag action would result from having implemented a Sac action and then deciding to implement an Ag action.

A new approach to Ag actions that has not been tried or evaluated but could be included in this year's alternatives: sending the initial flush of ag water, which is assumed to have lower DO levels, through the Knights Landing Outfall Gates, then continuing the action as usual. The idea would be to reduce the water quality risk while maintaining benefits.

Figure 2 Conceptual decision chart for conducting a Sacramento River (MA-SR) vs. agricultural (MA-Ag) flow action. Modified from Twardochleb et al. 2022, North Delta Food Subsidies Study 2021-2023 Operations and Monitoring Plan



Possible future management actions that the DCG decided to take off the table for this round of SDM:

- Roaring River Distribution System Food Production. There is not enough information to evaluate the proposed Roaring River action at this point or to consider its implementation in the next year. More studies would be beneficial to advancing this action to an implementation stage.
- SDWSC Food Transport and Production: We won't be able to do the full fertilization and export action until infrastructure is in place (which isn't expected before 2025). We could just do fertilization of the existing channel at this point but don't anticipate doing so (as the results from the previous fertilization experiment are still being synthesized).

Science actions

Science actions (those focused primarily on reducing uncertainty to improve future management decisions) may include modeling, monitoring, and experimental studies.

Monitoring and science programs are in place for the NDFS and SMSCG actions (see the 2021 NDFA operations plan and SMSCG monitoring plan as well as the 2023 SFHA Monitoring and Science Plan). In subsequent rounds of SDM the DCG may consider modifying monitoring programs to better inform tradeoffs, uncertainties, or other factors identified by the DCG as part of this SDM process.

The DCG may also suggest specific modeling or other special studies. Existing recommendations may be found in the 2022 SFHA Monitoring and Science Plan.

Consequences

This section presents the consequences of each alternative for each decision objective by predicting performance using methods agreed on by the DCG. For more detailed information on performance metrics, how they were calculated, assumptions, uncertainties, and other information relevant to interpreting results, see the PM Infosheets and the elicitation instructions and results for Effects on other species and Contaminants. Consequences and tradeoffs were explored using Compass Resource Management's online Altaviz tool. For each water year type, consequence tables were simplified as much as possible by removing uninformative objectives (those whose values did not differ significantly across objectives) and dominated alternatives. An image of the simplified table is shown in Figure 3.

Figure 3 Screenshot of Simplified Consequence Table for a Below Normal year including all objectives and subobjectives, from the Altaviz tool. Blue is the highlighted alternative for comparison, light blue indicates the other alternative scores better, orange does worse, and white the same.

Objective Expand All Collapse All	Performance Measure	Unit	BN No Action	BN NDFA Sac Long-Low	BN NDFA Sac Short-High	BN NDFA Ag Long-Low	BN NDFA Ag Short-High	BN NDFA Sac-Ag
Delta Smelt								
Delta Smelt Growth and Survival	Growth Increment	mm	0	.36	.25	.30	.24	.64
Zooplankton	Difference in BPUE	Biomass per unit effort	0	32.32	16	13.25	8.19	53.7
Contaminant Effects	Constructed scale	-2 to 2	0	0.18	-.23	-.58	-.81	-.26
Zoop quality effects	Constructed scale	-2 to 2	0	.38	-.25	-.88	-1.25	-.38
Zoop abundance (survival) effects	constructed scale	-2 to 2	0	.25	-.25	-.75	-.88	-.13
DS growth effects	constructed scale	-2 to 2	0	.13	-.25	-.63	-.75	-.25
DS survival effects	constructed scale	-2 to 2	0	0	-.25	-.13	-.63	-.29
DS recruitment effects	constructed scale	-2 to 2	0	.13	-.13	-.5	-.57	-.29
Resource Costs	Operating costs	$1000/year	0	250	250	100	100	500
Effects on other native species	Constructed scale	-3 to 1	0	-0.07	-0.07	-0.35	-0.35	
Spring Run	Constructed scale	-3 to 1	0	0	0	0	0	
Fall Run	Constructed scale	-3 to 1	0	-0.33	-0.33	-1.17	-1.17	
Steelhead	Constructed scale	-3 to 1	0	0	0	-0.6	-0.6	
Winter Run	Constructed scale	-3 to 1	0	0	0	0	0	
Green Sturgeon	Constructed scale	-3 to 1	0	0	0	0	0	
Learning	Constructed scale	1 - 11	3	7	6	5	6	8
Feasibility	Constructed scale	1-3	1	2	1	1	2	2
Effectiveness			2	5	5	4	4	6
Learning potential	Constructed scale	1-5	1	3	3	2	2	4
Learning increment	Constructed scale	1-3	1	2	2	2	2	2

For WY 2023 DCG used an optimization approach to tradeoffs rather that the direct negotiation approach used in WY 2022. The selected method, Simple Multi-Attribute Ranking Technique with Swings (SMARTS), worked as follows:

1. Prior to meeting to decide on SFHA recommendations, each DCG member used swing weighting to assign weights to fundamental objectives and sub-objectives in AltaViz. Weights are a subjective measure of the relative importance of each objective and sub-objective to a decision-maker's overall utility. Most sub-objective scores were rolled up assuming equal weights on all sub-objectives, but each DCG

member was asked to weight the growth, food, and contaminant sub-objectives in terms of their relative importance to the overall Delta Smelt objective (Figure 4), then weighted the four top-level objectives (Delta Smelt, Effects to Other Species, Costs, and Learning) in terms of their overall importance. Each DCG member also did direct ranking of alternatives, which can provide additional insight into the relative importance of different factors to that member's decision making. Weighting and ranking were performed first for a below normal water year type; DCG members were asked to repeat the process for an above normal water year type if their responses would differ.

2. Scores for each PM were normalized to a 0-1 scale.
3. Normalized, weighted scores were summed for each alternative to create a single gross utility score for each DCG member (Figure 5).

Figure 4 Swing weight percentages for (A) the four top-level decision objectives, and (B) weights for the contribution of the sub-objectives to the overall Delta Smelt utility, from the Altaviz tool. Each point represents a single DCG member and blue represents a single agency weight as an example.

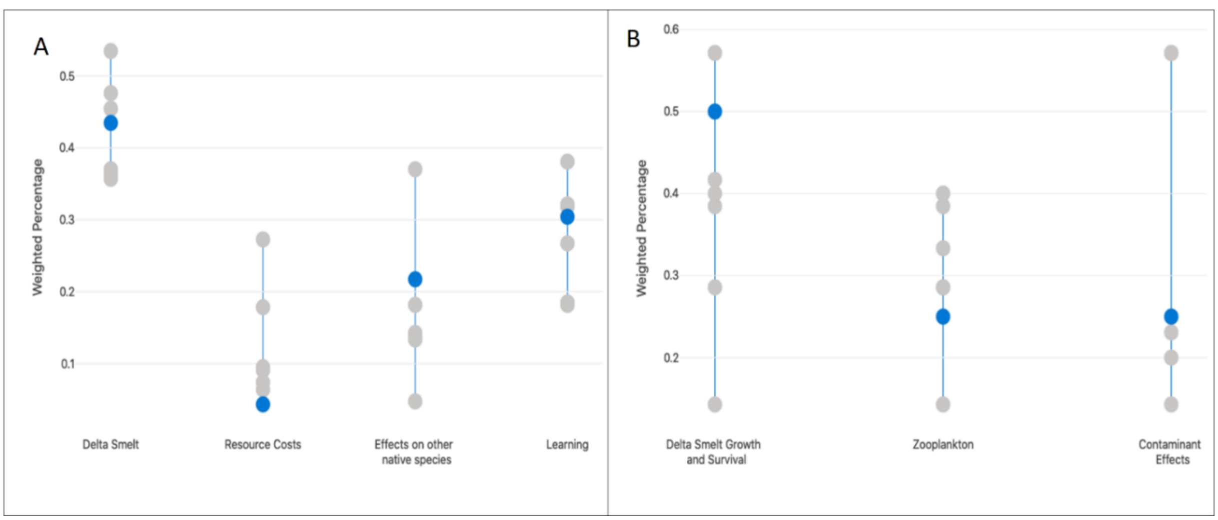
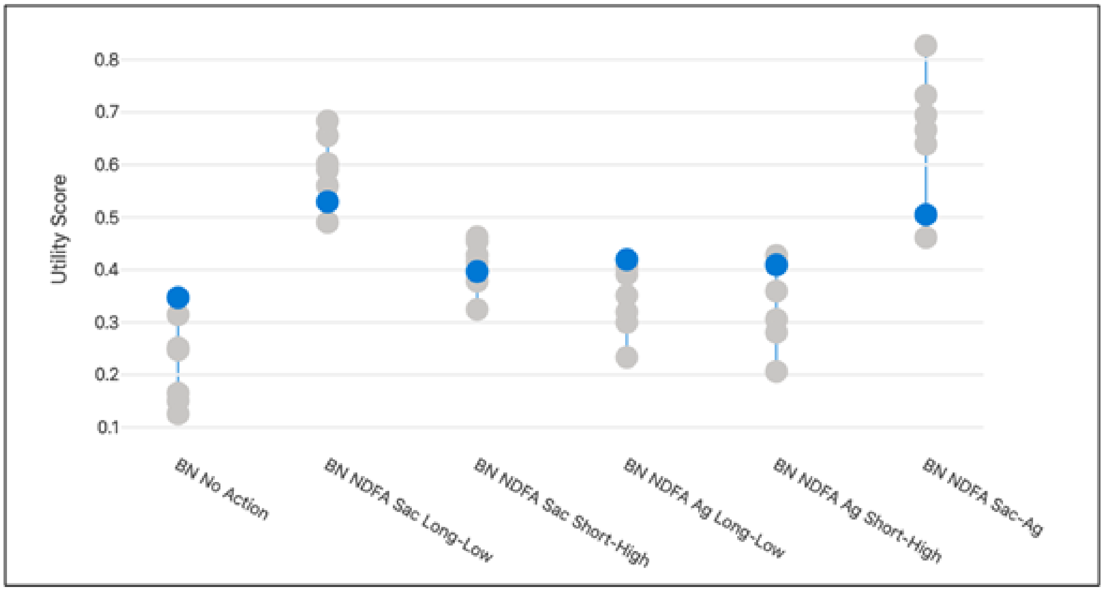


Figure 5 Gross utility scores by NDFS action alternatives for normalized consequence scores in a BN year, from the Altaviz tool. Each point represents a DCG agency. Blue points highlight a single DCG member's score for example.



Following discussion, the DCG agreed on recommending against implementing an Ag Short-High action in any water year type, and for implementing other NDFA actions (Sac long low, Sac Short High, Ag Long-Low, and Sac Ag).

Key take-aways for the next round of SDM

1. The current "Effects to other species" PMs don't capture the full range of DCG member concerns. One DCG member stated that they were uncomfortable not explicitly including effects to species beyond those currently included. Other species of concern to CDFW include splittail and fall run chinook.
2. Contaminants continue to be a concern for some agencies, and it is not clear that the current contaminants PM or level of analysis captures these concerns. One DCG member expressed a desire to wait on NDFA ag actions until there had been a CEQA EIR analysis on contaminants; it was unclear why existing CEQA permits and documentation were not sufficient. It may be that some people are conflating general contaminant concerns with concerns specific to this action; ag

drainage happens regardless of whether or not there is a coordinated action. This interpretation is supported by differences between gross utility scores and direct ranking. It may also be that differences in risk tolerance are part of the challenge. At least one DCG member expressed concern over the potential for litigation.

3. There were some big differences among DCG members in weights given to different objectives.

In terms of WY 2024, it is unlikely that NDFA will be an option regardless of water year type because the structures needed for NDFA ag actions are being completely reconstructed in 2024. Thus there would be no need for a NDFA decision. That said, CDFW indicated that they may want to involve the DCG in the decision about the extra 100 TAF. This would involve evaluating multiple scenarios for how to use that block of water. CDFW would retain the ultimate decision authority on this.

APPENDICES

A. NDFS Action Specification Sheet
B. Performance Metric InfoSheets
C. Contaminant Expert Elicitation Summary
D. Swing weighting instruction

Appendices

Contents

Appendix A. North Delta Food Subsidies Action Specification Sheet

Action Specification Sheet: North Delta Food Subsidies

Preliminary draft 2-14-23

Information provided in this action sheet was compiled from Department of Water Resources' Science and Operations Plan for the North Delta Food Subsidies action (DWR 2023; Twardochleb et al. 2021a), project manager input, and previous literature.

Short Description

- The North Delta region of the San Francisco Estuary (SFE) (Figure A-4) is relatively rich in aquatic food resources compared to other regions, but low or negative flows from water diversions during summer and fall limit the distribution of these resources to downstream areas (Frantzich et al. 2018).
- The goal of the NDFS is to increase flows and distribute food resources downstream using managed flow pulses (i.e. above-average flows or "flow actions") directed through the Yolo Bypass, thereby restoring more natural flow patterns and enhancing the quantity and quality of food for Delta Smelt and other species in the North Delta.
- The NDFS may redirect Sacramento River water and/or agricultural drainage from Colusa Basin Drain into the Yolo Bypass region for up to 2-6 weeks during summer or fall to generate a flow pulse target of 25-30 mil m^3 (~20-25 TAF) with the goal of maintaining net positive flow (>300 cfs) at Lisbon weir in the Yolo Bypass Toe Drain. Flow actions, science monitoring, and assessments will occur annually in summer and/or fall depending on water availability and water year assessments. Through monitoring the effects of flow actions on water quality and the Delta food web, this project is managed adaptively to maximize food availability downstream.
- For WY2023 the DCG is considering the following options:

- Ag Long-Low: Agricultural return water would be directed through Yolo Bypass in August/September with low intensity, long duration (e.g., 400 cfs for 4-6 weeks, including 5 day ramping up and down periods).
- Ag Short-High: Agricultural return water would be directed through Yolo Bypass in August/September with high intensity, short duration (e.g., 800 cfs for 2-4 weeks)
- Sac Long-Low: Sacramento River water would be directed through Yolo Bypass in July/August for a longer duration (4 weeks) at a lower intensity (400 cfs)
- Sac Short-High: Sacramento River water would be directed through Yolo Bypass in July/August for a shorter duration (2 weeks) at a higher intensity (800cfs)
- Combined Sac-Ag. This alternative involves a Sac long-low summer action followed by an Ag long-low fall action to generate a longer duration pulse (60 rather than 30 days) and time period with net positive flow. While assumed to be operationally feasible, this approach has never been implemented.

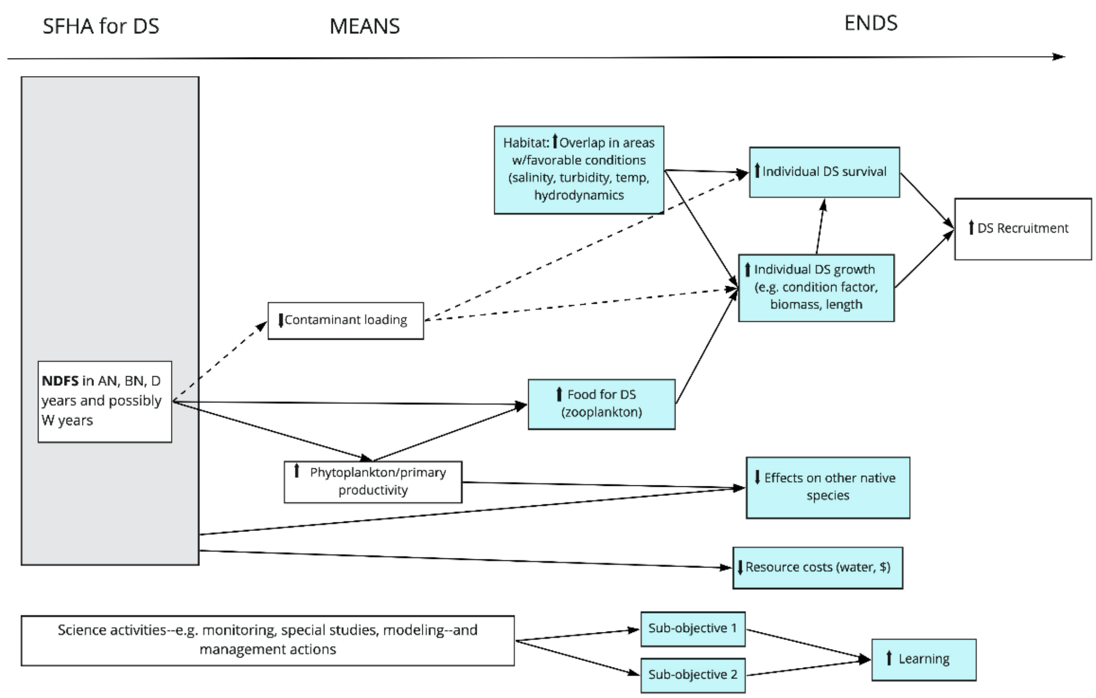
The decision is not *which* of these to implement; based on previous analyses the order of preference will be as shown in Figure A-5 with a long-low approach preferred to a short-high approach. The decision for the DCG is whether, if conditions permit, an action should be taken. Decisions would thus occur in the following sequence:

- If conditions allow a long-low Sac action, should this action be taken?
- If a long-low action is not possible but a short-high Sac action is, should that be taken?
- If conditions allow a long-low Ag action, should this action be taken?
- If a long-low action is not possible but a short-high Ag action is, should that be taken?
- The decision to do a Sac-Ag action would result from having implemented a Sac action and then deciding to implement an Ag action.
- Note that there has been discussion of a new approach to Ag actions that has not been tried or evaluated but could be included in this

year's alternatives: sending the initial flush of ag water, which is assumed to have lower DO levels, through the Knights Landing Outfall Gates, then continuing the action as usual. The idea would be to reduce the water quality risk while maintaining benefits, but there is uncertainty if benefits would be reduced if initial nutrients or chlorophyll in the upstream would also be lost.

Influence Diagram

Figure A-1 Means-end influence diagram for the North Delta Food Subsidy action developed by the Delta Coordination Group



Action Specification

- DWR is the lead implementing entity for this action with federal, state, and local partner coordination. Twardochleb et al. (2021a) provides their current operations and monitoring plan for this action.
- See below Figures A-2, A-3, and A-5 for more information.

Figure A-2 Conceptual hypothesis of the NDFS action; an augmented flow pulse will increase transport of water and food to downstream Delta Smelt habitat in the Cache Slough Complex.

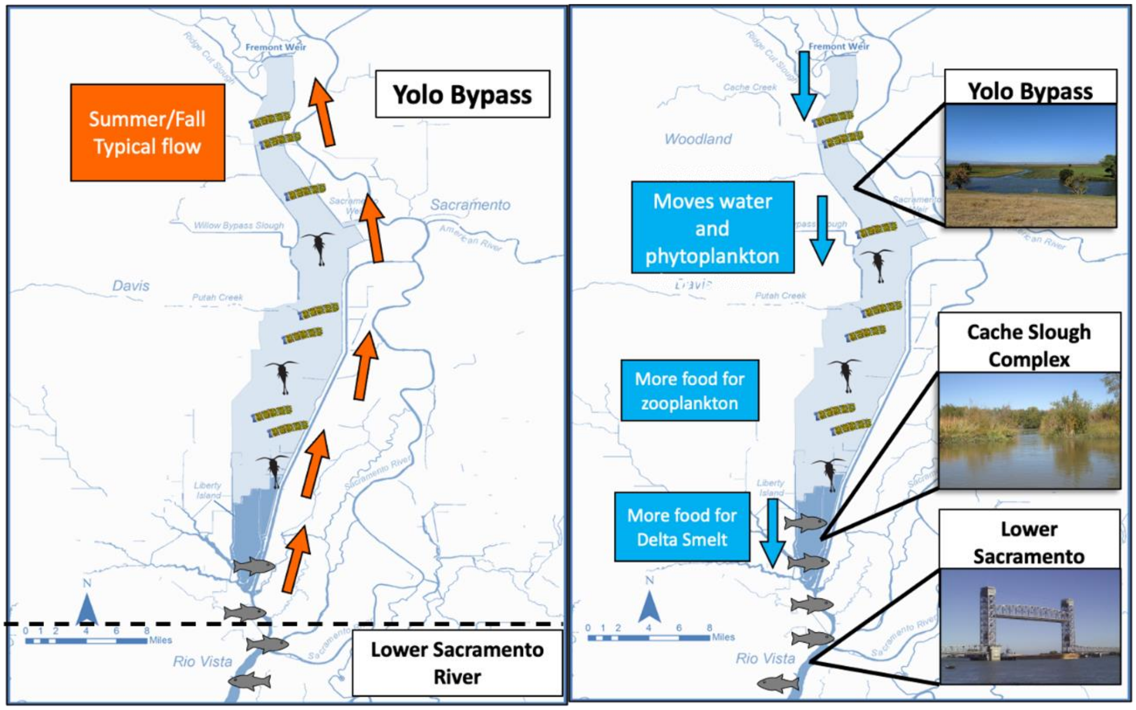
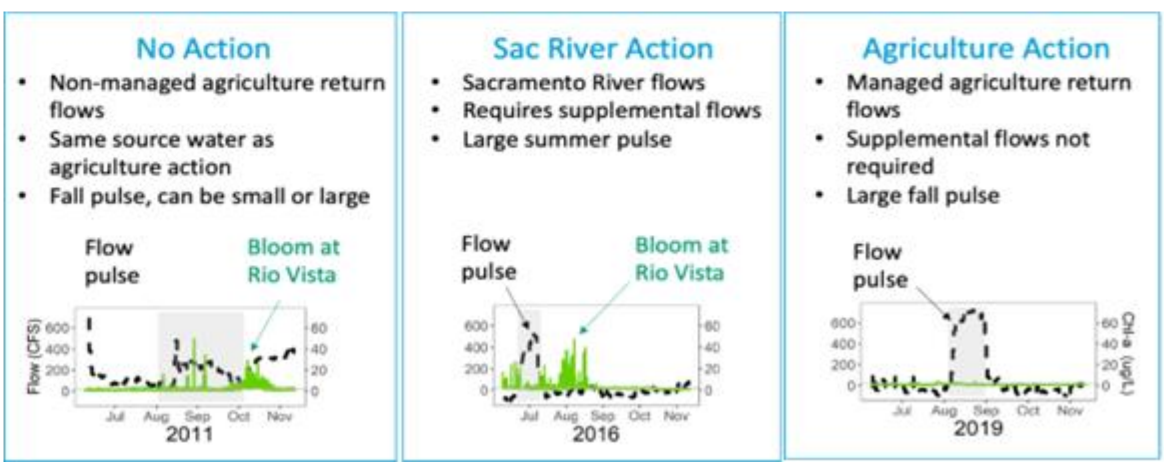


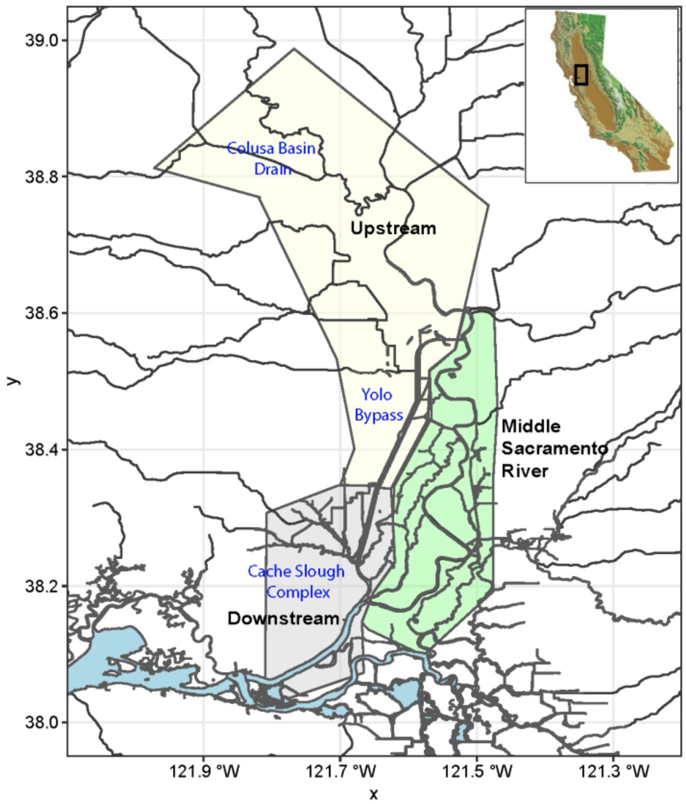
Figure A-3 NDFS action types, Sacramento River or Agricultural drainage action, compared to no action. Each panel provides an example hydrograph with flow (cfs) measured at Lisbon Weir in Yolo Bypass Toe Drain and correlated Chlorophyll florescence at Rio Vista in the Lower Sacramento River.



Location(s)

The North Delta Food Subsidy project area extends across North Delta regions including Colusa Basin Drain/Ridge Cut Slough, Yolo Bypass, Cache Slough and Lower Sacramento River (Figure A-4). The project also monitors a reference site at Sherwood Harbor on the Middle Sacramento River.

Figure A-4 Map of the San Francisco Estuary and North Delta Food Subsidy project area.



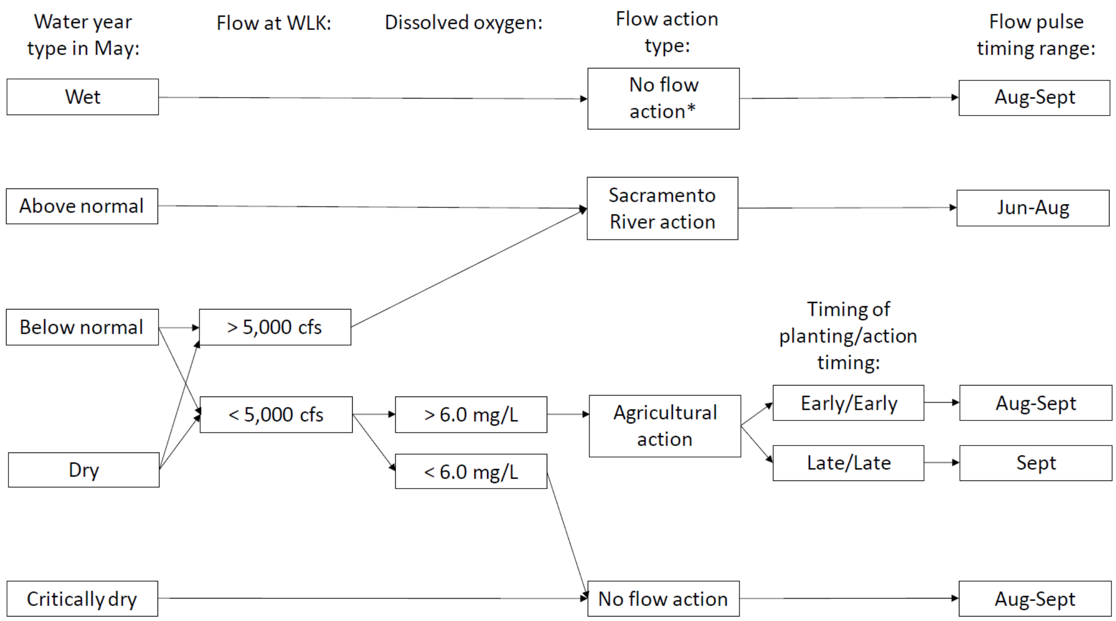
Timing / Lifestage / Triggering Conditions

- The action will be considered annually in summer and/or fall depending on water year conditions DCG SDM recommendations, and operational considerations. DWR and Reclamation will have the final decision to implement an action.
- In the absence of flow actions, low-to-moderate flow pulses still occur in the Yolo Bypass due to local agricultural activities, but changes in

net flow conditions are typically limited to the bypass and are unlikely to reach downstream regions.

- Managed flow pulses with Sacramento River water should be possible in Below Normal, Above Normal and Dry years with sufficient flow at Sacramento River below Wilkins Slough (>4000-5000 cfs).
- DWR may not pursue flow actions during the most extreme water years for both dry and wet conditions (wet or critically dry water year types, see Figure A-5).
    - Water availability may be insufficient to generate a flow action in critically dry years, and flow pulses during critically dry water years may exacerbate poor water quality conditions.
    - Flow actions in wet years may not provide enough additional benefits beyond those of non-managed flow pulses during wet years to justify the resources for conducting an action. This has not been formally assessed. During wet years, net flow from the Yolo Bypass is usually positive during summer without flow modifications. However, if a wet year is marked with an extended dry spring, a flow pulse may be considered.
- Modeling by DWR of operation scenarios showed water used in managed flow pulses is re-routed with minimal difference between the paths (down the Yolo Bypass Toe Drain or Sacramento River), therefore water costs are likely inconsequential to long-term operations, and electrical conductivity is not affected at key North Delta compliance stations during Dry water year types.
- Science and monitoring of project regions occurs annually for baseline contrasts.

Figure A-5 A conceptual decision chart for planning North Delta Food Subsidies actions developed from DWR given DCG and SDM input (DWR 2023).



Intensity Required

- Given past experimental actions and modeling, a larger than normal flow pulse in the bypass that creates net positive flow downstream requires ~20-25 TAF, lasting up to 2-6 weeks with greater than 300 cfs net flow in the Yolo Bypass.
- Intensity and duration of flow actions may vary given SDM alternatives and years conditions. In general, actions can be operated for low or high intensity (400 or 800 cfs) and short or long duration (2, 4, or 6 weeks).

Evidence

To date, DWR has led three experimental managed flow pulses (2016, 2018, and 2019). DWR has also analyzed data for non-managed flow pulses through the Yolo Bypass in years between 2011 and 2019 (Davis et al. 2022). This synthesis of nine years of flow pulses is currently under final formatting revisions and review and should be available in Spring 2023. Preliminary results from this synthesis have informed adaptive management of NDFS action planning. The table below is a summary of flow pulses through the Yolo Bypass from 2011-2022:

Table A-1 A summary of flow pulses in the Yolo Bypass from 2011-2022. Net positive flow pulse magnitude (Max Daily Ave Net Flow and Total Average Net Volume) and duration (Total Days Net Positive Flow and Date Range) were measured at Lisbon Weir in the Yolo Bypass Toe Drain. WY indicates water year type including wet (W), below normal (BN), dry (D), and critical (C). Flow pulse types include managed flow pulses using diversions of Sacramento River water (SAC) or agricultural return flows (AG), non-managed flow pulses during construction and/or infrastructure repairs (IR), or non-managed flow pulses (NM) from agricultural activities. Flow pulse magnitude is measured in cubic feet per second (cfs) and acre feet (AF). Similarity of each years flow conditions are described in relation to the 2023 NDFS action alternatives (e.g. Sac or Ag, long or short duration and low or high intensity).

Year	WY Type	Flow pulse type	Max Daily Ave Net Flow (cfs)	Total Average Net Volume (AF)	Total Days Net Positive Flow	Date Range (start/end of pulse)	Similarity to 2023 SDM alternatives
2011	W	NM	412	22,356	63	Aug 23 - Oct 24	No action (long/low)
2012	BN	IR	723	27,224	38	Aug 26 - Oct 2	Short-long/high
2013	D	NM	283	11,437	42	Aug 22 - Oct 2	No action (near long/low)
2014	C	NM	239	2,503	15	Sep 9 - Sep 23	No action
2015	C	NM	383	17,909	42	Aug 21 - Oct 1	No action (long/low)
2016	BN	SAC	546	12,752	19	Jul 14 - Aug 1	SAC-short/high
2017	W	IR	125	1,022	12	Aug 29 - Sep 18	No action
2018	BN	AG	548	19,821	30	Aug 28 - Sep 26	AG –long/high (not-alternative)
2019	W	AG	750	31,600	26	Aug 26 - Sep 21	AG-long/high (not alternative)
2020	D	NM	159	3,081	17	Sep 1 - Sep 16	No action

Year	WY Type	Flow pulse type	Max Daily Ave Net Flow (cfs)	Total Average Net Volume (AF)	Total Days Net Positive Flow	Date Range (start/end of pulse)	Similarity to 2023 SDM alternatives
2021	C	NM	31	183	4	Sep 11 - Sep 14	No action
2022	C	NM	31	113	2	Sep 21 – Sep 22	No action

At a Stakeholder meeting of the North Delta Food Subsidies Study in May 2020, DWR presented updates on the 2019 field season and plans for the 2020 season. Conclusions from the 2019 agricultural flow action included:

- The flow action had a localized effect on water quality, nutrients, and the lower trophic food web in the upstream and Yolo Bypass regions compared to the downstream region.
- Following flow pulse increases in chlorophyll-a, phytoplankton biomass, and zooplankton density were observed upstream.
- Nutrient inputs from upstream wastewater treatment plants may have contributed to the increase in chlorophyll-a concentrations during the flow pulse.
- While phytoplankton growth likely increased in upstream regions after the flow pulse, there was evidence of nutrient-limited growth by phytoplankton downstream.
- Total pesticide concentrations may increase during the flow pulse compared to before or after.

References

Davis et al. 2022. North Delta Food Subsidy Synthesis: Evaluating Flow Pulses from 2011-2019. Department of Water Resources, Division of Integrated Science and Engineering. Draft.

[DWR] California Department of Water Resources (2023). North Delta Food Subsidies Action Operations and Monitoring Plan. Division of Integrated Science and Engineering. Jan 2023 update.

Frantzich, J., Sommer, T., and B. Schreier. 2018. Physical and biological responses to flow in a tidal freshwater slough complex. San Francisco Estuary and Watershed Science. 16(1).

RMA 2021. Numerical Modeling in Support of Reclamation Delta Smelt Summer/Fall Habitat Analysis. Technical Memorandum, May 14, 2021. Prepared for: United States Bureau of Reclamation. Prepared by: Resource Management Associates. RMA Shiny Demo (rmanet.app)

Twardochleb L., Martinez, J., Bedwell, M., Frantzich, J., Sommer, T., and B. Davis. 2021a. North Delta Food Subsidies 2021-2023 Operations and Monitoring Plan. Department of Water Resources, Division of Environmental Services.

Twardochleb L., Maguire A., Dixit L., Bedwell M., Orlando J., MacWilliams M., Bever A., and B. Davis. 2021b. North Delta Food Subsidies Study: Monitoring Food Web Responses to the North Delta Flow Action, 2019 Report. Department of Water Resources, Division of Environmental Services.

Appendix B. Performance Measure Info Sheets

1. Delta Smelt Growth Performance Measure Infosheet

Drafted by Kristi Arend, Brian Mahardja, Matt Nobriga, and William Smith

27 December 2022

Take Home Messages

1. Prey density, temperature, and turbidity all impact individual Delta Smelt growth, so any action that changes these parameters may impact smelt growth.
2. SMSCG operations at 4ppt provided more growth than 6ppt due to the better turbidity, temperature, and prey density conditions assumed for the marsh.
3. Long-low NDFS actions provided more growth potential than short-high actions, and Sacramento actions provided more growth potential than agricultural actions.
4. All the actions assessed here had relatively small impacts on Delta Smelt growth (less than 1mm difference between action and baseline), so it is unclear whether this suite of actions would generate a population-level impact. However, there may be benefits to individual fish.

Summary

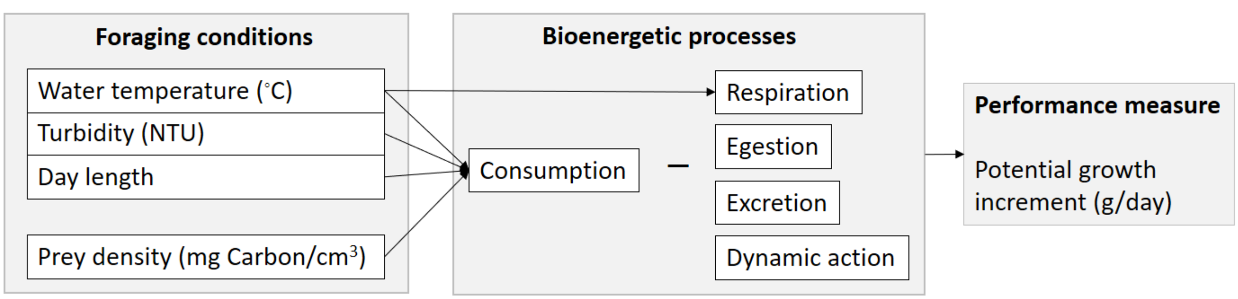
The Delta Coordination Group (DCG) chose to use predictions of delta smelt growth rate as one of several performance metrics in its structured decision-making process for summer-fall habitat actions (SFHA). The performance metric described below compares predictions of delta smelt growth rates to average growth rates observed during the summer-fall of 1999-2005. The tool used to predict growth is a modified version of the bioenergetics model (BEM) presented by Rose et al. (2013). For the DCG, the BEM was used to index the suitability of aquatic habitat to support successful delta smelt foraging (BEM-based HSI; Smith and Nobriga *in review*). The BEM-based HSI was used to predict the cumulative growth of delta smelt, assuming occupancy of a given region of the estuary and a set of physical habitat conditions and prey densities unique to each region.

Regional conditions driving the expected growth of delta smelt were water temperature, turbidity, and prey density. The growth predicted from the BEM-based HSI (growth potential) resulting from different SFHA were compared to an average rate of growth and the growth expected if no action were taken. The average growth was defined externally by fitting a von Bertalanffy growth model to size at age of wild delta smelt. If BEM-predicted growth was lower than average growth, regional conditions were considered insufficient to support robust delta smelt growth. The difference between BEM-based growth, given no change to water temperature, turbidity, and prey density (no action) and given SFHA effects, represented the expected benefit of the action.

The performance measure is a metric to evaluate whether simulated actions increased the predicted foraging success of delta smelt in a region of interest. Greater foraging success translates into faster growth in the model. The performance measure is the difference in potential growth predicted by the model, between conditions representing no action and conditions representing the expected effects of a management action.

Influence diagram

Figure B-1 Influence diagram for Delta Smelt Growth PM



Bioenergetics model

Growth reference points

Potential delta smelt growth, given a set of limitations on the foraging arena described below, was compared to the mean growth estimated for the wild delta smelt population from length-at-age data (Appendix). Mean growth rates of wild fish from throughout the Delta, were used as reference points to evaluate the suitability of foraging arena conditions to support delta smelt growth. The Fabens (1965) derivation of the von Bertalanffy growth model and parameters from a model fit to wild delta smelt length-at-age (Fig. B-8), was used to estimate the reference growth increment in fork length (FL)

(1) $$FL_t = FL_{t-1}(76.1 - FL_{t-1})\left(1 - e^{-2.98\left(\frac{1}{365}\right)}\right),$$

beginning with a July 1 (t = 1) starting size of 30 mm, and ending 152 days later on October 31. Length-at-age data were collected during 1999-2005 and represented average growth. The statistically fit von Bertalanffy growth model was associated with estimates of parameter and process error, which were propagated into uncertainty in predictions of average (reference) growth.

FL_t on day t were converted to weight W_t in grams using the length-weight equation provided by Kimmerer et al. (2005)

(2) $$W_t = 1.8 * 10^{-6} FL_t^{3.38}.$$

Growth

Specific foraging arena conditions (prey density, temperature, and turbidity) representing the expected effects of management actions in the Yolo Bypass, Lower Sacramento River, Confluence region, and Suisun strata (Fig. B-2), were used to simulate growth using the bioenergetics model, and the BEM-predicted growth was then compared to the growth reference point. The bioenergetics growth model described by Rose et al. (2013) was a system of equations estimating daily delta smelt growth in body mass as a function of rates of consumption C_{yt}, metabolism R_{yt}, egestion F_{yt}, excretion U_{yt}, and activity SDA_{yt} on day t of year y (Eqs. 3-7). For the DCG performance metric, measurements of estuarine habitat conditions (prey density, water temperature, and turbidity) were aggregated at the monthly scale (m), while the bioenergetics equations describing growth accumulated at the daily scale (t). A set of bioenergetics model coefficients, specific to each life-stage l to model each rate were listed in Rose et al. (2013) and reproduced here in Fig. B-4. In the notation below, these fixed coefficients are underlined to distinguish them from dynamic quantities that may vary by time period.

(3) $W_{y(t+1)} = W_{yt} * \left(1 + \frac{ep_{yt}}{4814} * \left(C_{yt} - R_{yt} - F_{yt} - U_{yt} - SDA_{yt}\right)\right)$, where

(4) $R_{yt} = \underline{ar_l} * W_{yt}^{\underline{br_l}} * e^{\underline{RQ_l} * Temp_{ym}}$,

(5) $F_{yt} = \underline{Fa_l} * C_{yt}$,

(6) $U_{yt} = \underline{Ua_l} * \left(C_{yt} - F_{yt}\right)$, and

(7) $SDA_{yt} = \underline{Sd_l} * \left(C_{yt} - F_{yt}\right)$.

The conversion of prey consumption to delta smelt biomass was expected to be less efficient for *Limnoithona* because of its lower energy density ed_p. The lower ed_p of *Limnoithona* was accounted by adjusting the efficiency at which simulated consumption was converted to delta smelt weight, represented by the ratio $ep_{yt}/4814$ (Eq. 1). ep_{yt} was the energy density of prey consumed, reduced by the fraction of consumed energy corresponding to *Limnoithona* (Eq. 8 and 9), and 4,814 J/g was the energy density assumed for delta smelt (Rose et al. 2013). The energy density of *Limnoithona* (1,813 J/g) was assumed to be 30% less than that of other prey items, which were all assumed to be 2,590 J/g per Rose et al. (2013).

(8) $ep_{yt} = 1813 * Limno_{yt} + 2590 * \left(1 - Limno_{yt}\right)$, where

(9) $$Limno_{yt} = \frac{1813 * Creal_{yt} * \left(\frac{\frac{PD_{ym(LImno)} * \underline{\underline{V_{(Limno)l}}}}{\underline{K_{(Limno)l}}}}{\sum_{r=1}^{12} \frac{PD_{ymr} * \underline{\underline{V_{rl}}}}{\underline{K_{rl}}}}\right)}{\sum_{q=1}^{12} \underline{ed_q} * Creal_{yt} * \left(\frac{\frac{PD_{ymq} * \underline{\underline{V_{ql}}}}{\underline{K_{ql}}}}{\sum_{r=1}^{12} \frac{PD_{ymr} * \underline{\underline{V_{rl}}}}{\underline{K_{rl}}}}\right)}$$

where PD_{ymp} was the prey density of prey type p.

The maximum possible daily ration $C_{max_{yt}}$ provided a benchmark of potential foraging rate, expressed as a proportion of body weight per day (Eqs. 10-12). $C_{max_{yt}}$ is typically estimated under optimal, controlled conditions, but in the wild, fish seldom, if ever, achieve a maximum daily ration, even under optimal conditions; thus, $C_{\text{max}_{\text{yt}}}$ was scaled by parameter P_{max} to generate growth rates observed in the wild. P_{max} of 0.688 maximized the fit of BEM predictions to lengths observed from 2016-2020 (Smith and Nobriga *in review*).

Foraging arena theory suggests that fish reduce their time spent foraging to mitigate perceived risk of mortality, at the expense of forgone foraging and growth. Three environmental constraints on delta smelt foraging were considered: temperature $Temp_{\text{ym}}$ ($KA_{\text{ym}} * KB_{\text{ym}}$), turbidity $Turb_{\text{ym}}$ (KT_{ym}), and day length (KL_{t}). Relationships between *Temp*, *C*, and *R* are shown in Fig. B-3.

$$(10)\quad C_{\text{yt}} = C_{\text{real}_{\text{yt}}} * \sum_{q=1}^{12}\left(\frac{\frac{PD_{\text{ymp}} * \underline{\underline{V_{\text{pl}}}}}{\underline{K_{\text{ql}}}}}{\sum_{r=1}^{12}\frac{PD_{\text{ymp}} * \underline{\underline{V_{\text{pl}}}}}{\underline{K_{\text{rl}}}}}\right), \text{ where}$$

$$(11)\quad C_{\text{real}_{\text{yt}}} = \underline{P_{\text{max}}} * C_{\text{max}_{\text{yt}}}, \text{ and}$$

$$(12)\quad C_{\text{max}_{\text{yt}}} = \underline{ac_{\text{l}}} * W_{\text{yt}}^{\underline{bc_{\text{l}}}} * KA_{\text{ym}} * KB_{\text{ym}} * KT_{\text{ym}} * KL_{\text{t}}.$$

Rose et al. (2013) assumed a *Temp*-*C*max model for delta smelt (KA_{m} and KB_{m}; Eq. 13 and 14) that reduced foraging time as water temperatures increased above 22°C (Fig. B-3).

$$(13)\quad KA_{\text{ym}} = \frac{\underline{CK1_{\text{l}}} * e^{\frac{1}{\underline{T0_{\text{l}}} - \underline{CQ_{\text{l}}}} * ln\left(\frac{0.98*\left(1-\underline{CK1_{\text{l}}}\right)}{0.02*\underline{CK1_{\text{l}}}}\right) * \left(Temp_{\text{ym}} - \underline{CQ_{\text{l}}}\right)}}{1 + \underline{CK1_{\text{l}}} * \left(\left(e^{\frac{1}{\underline{T0_{\text{l}}} - \underline{CQ_{\text{l}}}} * ln\left(\frac{0.98*\left(1-\underline{CK1_{\text{l}}}\right)}{0.02*\underline{CK1_{\text{l}}}}\right) * \left(Temp_{\text{ym}} - \underline{CQ_{\text{l}}}\right)}\right) - 1\right)}$$

$$(14)\quad KB_{\text{ym}} = \frac{\underline{CK4_{\text{l}}} * e^{\frac{1}{\underline{TL_{\text{l}}} - \underline{TM_{\text{l}}}} * ln\left(\frac{0.98*\left(1-\underline{CK4_{\text{l}}}\right)}{0.02*\underline{CK4_{\text{l}}}}\right) * \left(\underline{TL_{\text{l}}} - Temp_{\text{ym}}\right)}}{1 + \underline{CK4_{\text{l}}} * \left(\left(e^{\frac{1}{\underline{TL_{\text{l}}} - \underline{TM_{\text{l}}}} * ln\left(\frac{0.98*\left(1-\underline{CK4_{\text{l}}}\right)}{0.02*\underline{CK4_{\text{l}}}}\right) * \left(\underline{TL_{\text{l}}} - Temp_{\text{ym}}\right)}\right) - 1\right)}$$

Forage fish, such as delta smelt, typically show a decrease in foraging rates as turbidity declines and the perceived risk of being detected by a predator increases (Pangle et al. 2012). The risk of predation and changes in delta smelt behavior in clear water were documented by Ferrari et al. (2014), though rates of predation may have been biased high because smelt could not effectively evade predators in laboratory conditions. The relationship between delta smelt foraging rate and turbidity reported by Hasenbein et al. (2016) was approximated using a logistic model (Fig. B-3), that increased from the lowest turbidities evaluated (5 NTU) to the turbidities associated with maximum foraging rate (25-80 NTU). Since turbidities greater than 80 NTU were rarely observed during the time period explored, foraging limitation at high turbidity was not modeled, i.e., using a dome-shaped double-logistic model. As turbidity declined, the effect of turbidity (KT_{ym}; Eq. 15) was assumed to reach some asymptotic minimum α_{FL}, and α_{FL} was assumed to increase linearly from 0.68 to 0.85 as fish grew from 20 to 45 mm FL, simulating a reduction in the turbidity effect on foraging as fish grew during the summer, which is historically a season of declining inflow and turbidity.

(15) $$KT_{\mathrm{ym}} = \alpha_{FL} + (1 - \alpha_{FL}) / \left(1 + e^{0.1 * \left(Turb_{\mathrm{ym}} - 56.2\right)}\right)$$

Delta smelt only feed during daylight (Baskerville-Bridges 2004; Hobbs et al. 2006), so day length was considered as a third scalar of consumption (KL_{t}; Eq.16). The rationale for a daylight constraint was that the time available to acquire a daily ration, begins decreasing after the summer solstice in late June. From July 1 through October 31, daylight at San Francisco, CA ranges from a maximum of 884 min to a minimum of 758 min (https://www.esrl.noaa.gov/gmd/grad/solcalc/). As with temperature and turbidity effects, the effect of day length was represented by a scalar, ranging from zero to one. The effect of day length equaled the daily fractional daylight hours divided by the maximum fractional daylight hours (887 minutes on the summer solstice). This approach ignored the potential effects of cloud cover on visibility, sensu Hansen and Beauchamp (2015), because summers in California’s Central Valley tend to be sunny and dry.

(16) $$KL_{\mathrm{t}} = \frac{day.length_{\mathrm{t}}}{887 \text{ minutes}}$$

Assumptions and Uncertainties

In this application, delta smelt are assumed to reside within a single stratum for the entire time period, and growth potential is cumulative within the July-October time frame modeled.

Uncertainty in inputs leads to uncertainty in outputs. BEMs depend upon externally-generated estimates of *Temp*, *Turb*, and *PD* that represent the expected effect of management actions on specific regions. Each of these predictions of environmental conditions is uncertain and magnitudes and directions of change are largely based on the opinions of the DCG and its technical working group members.

While the models used to simulate delta smelt bioenergetic dynamics are supported to varying degrees by experimental results, no experiment has directly quantified the parameters of a delta smelt bioenergetics model (i.e., from data collected during directed bioenergetics studies). Furthermore, the delta smelt model has not and cannot be validated empirically using data collected from wild delta smelt, because delta smelt catches and abundance are currently too low to support the types of studies that would be required. Experiments using caged hatchery-origin delta smelt might be a means to validate some model parameters, but caging experiments could be associated with foraging biases, given the limited mobility of caged fish relative to free-roaming shoals of wild delta smelt.

The temperature function that describes delta smelt's metabolic response to temperature (equations 11-12) is very uncertain. Though the model used here results in declining consumption at temperatures greater than 22°C, decreased delta smelt foraging rates were documented in laboratory conditions at temperatures as low as 20°C (Eder et al. 2014). If the Eder et al. study generated more accurate results than the parameterization of equations 11-12 chosen by Rose et al. (2013), then the predictions made here under-represent the effects of temperature and BEM-based growth estimates are positively biased.

Reproducibility

The model was implemented in the R statistical environment. Code to run the model is available on request or to reproduce modeling efforts in future years.

Results

Median predicted reference length by the end of October was 58.9 mm FL (95% CI: 49.7, 68.9), and starting with a July 1 assumed length of 30 mm, the BEM predicted that most combinations of foraging habitat conditions explored (region x year type x scenario) would produce slightly less than average (reference) growth by the end of October (Table 1). Conditions in Suisun Marsh appeared to support slightly above average growth. With no simulated action, the difference between the most energetically favorable region (Suisun Marsh) and the least energetically favorable region (Lower Sacramento River) was 3.01 mm of potential growth in a dry year and 3.15 mm of potential growth in a below normal year. The incremental benefit of each scenario (action – no action) was much smaller than the regional differences, ranging from zero to 0.58 mm (Table 2). Predicted terminal length was highest in Suisun Marsh under the SMSCG 4ppt action (+ 0.41 mm FL) versus 0.31 mm under the SMSCG 6ppt action. Predicted incremental growth due to a Yolo Bypass flow action was highest under the SacAg action (+ 0.58 mm).

Relative to the uncertainty in the reference growth, all BEM-predicted lengths, except in Suisun Marsh in Below Normal years, were between the first and second quartiles (0.25-0.50) of the reference distribution (Figs. B-6 and B-7; Table B-3). This suggests that current growth opportunities throughout the upper estuary and poor relative to 1999-2005.

Decomposition of the predicted foraging limitations into the three component effects due to temperature, turbidity, and day length demonstrated that the greatest predicted limitation resulted from low turbidity (Fig. B-5). Though turbidity declined over the time period analyzed, its effect was less in the fall than the summer because the model assumed that fish became less sensitive to turbidity during the same time period (as they grew from 30 to 45 mm FL; Fig. B-3).

Future directions

The present iteration of BEM-based HSI developed a ‘baseline’ set of prey, temperature, and turbidity conditions from water-year type averages over 1995-2015. Prey was predicted from a model fit to zooplankton observations in zooplankton and fish surveys; temperatures were DSM2-simulated, and turbidity was measured during multiple fish surveys in the Delta. Many compromises were made to address data deficiencies early in the 1995-2015 time series that have since been resolved. A superior method to develop a baseline set of prey, temperature, and turbidity conditions would begin with recent observations and direct measurements of conditions, rather than model predictions of historical conditions. Zooplankton observations in all regions and July-October (SFHA) months are available, and temperature, turbidity, and salinity have been continuously logged at a series of fixed monitoring stations from Suisun Bay to the Deep Water Shipping Channel since at least 2016 (Smith and Nobriga *in review*). These recent, more resolved observations could be a superior representation of near-future habitat conditions for delta smelt, compared to the historical 1995-2015 time series.

A desirable outcome for the DCG was to represent uncertainty in results. This can be decomposed into uncertainty BEM predicted growth and uncertainty in the reference growth; however, only the reference growth model was statistically fit (Appendix), making it possible to quantify uncertainty. The BEM represented a series of assumptions about delta smelt foraging, and the model was only *calibrated* to observed seasonal lengths. It is therefore not a statistical model, and uncertainties in the BEM parameters and processes are unknown. It may be possible, however, to represent uncertainty in abiotic conditions. In future iterations of the model, using subdaily (15-minute) temperature and turbidity monitoring data from recent years, environmental uncertainty could be quantified by developing estimates of the daily variance in conditions. A measure of daily variance (uncertainty) would permit a stochastic simulation of temperature and turbidity.

References

Baskerville-Bridges, B., Lindberg, J. C., and Doroshov, S. L. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. *In* American Fisheries Society Symposium 39: 219–227.

Eder, K. J., R. C. Kaufman, D. E. Cocherell, J. C. Lindberg, N. A. Fangue, and F. J. Loge. 2014. Longfin and delta smelt food consumption and bioenergetics assessments. Final Report to U.S. Bureau of Reclamation Project # R10AC20107.

Fabens, A. J. 1965. Properties and fitting of the von Bertalanffy growth model. Growth 29: 265–289.

Ferrari, M. C. O., L. Ranaker, K. L. Weinersmith, M. J. Young, A. Sih, and J. L. Conrad. 2014. Effects of turbidity and an invasive waterweed on predation by introduced largemouth bass. Environmental Biology of Fishes 97:79–90.

Hansen, A. G., and D. A. Beauchamp. 2015. Latitudinal and photic effects on diel foraging and predation risk in freshwater pelagic ecosystems. Journal of Animal Ecology 84:532–544.

Hasenbein, M., N. A. Fangue, J. Geist, L. M. Komoroske, J. Truong, R. McPherson, and R. E. Connon. 2016. Assessments at multiple levels of biological organization allow for an integrative determination of physiological tolerances to turbidity in an endangered fish species. Conservation Physiology 4(1). https://doi.org/10.1093/conphys/cow004

Hobbs, J. A., W. A. Bennett, and J. E. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco estuary. Journal of Fish Biology 69: 907–922.

Kimmerer, W. J., S. R. Avent, S. M. Bollens, F. Feyrer, L. F. Grimaldo, P. B. Moyle, M. Nobriga, and T. Visintainer. 2005. Variability in length-weight relationships used to estimate biomass of estuarine fish from survey data. Transactions of the American Fisheries Society 134:481–495.

Pangle, K. L., T. D. Malinich, D. B. Bunnell, D. R. DeVries, and S. A. Ludsin. 2012. Context-dependent planktivory: interacting effects of turbidity and predation risk on adaptive foraging. Ecosphere 3(12): 1–18.

Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett. 2013a. Individual-based modeling of delta smelt population dynamics in the upper San Francisco Estuary: I. model description and baseline results. Transactions of the American Fisheries Society 142:1238–1259.

Smith, W. E. and M. L. Nobriga. *In review*. A bioenergetics-based index of habitat suitability: spatial dynamics of foraging constraints and food limitation for a rare estuarine fish.

Table B-1a **Bioenergetics model (BEM)-predicted and reference (external von Bertalanffy growth model) lengths at the end of October, assuming a July 1 length of 30 mm FL. Below normal year.**

Region	BEM-based (No action)	Reference
Yolo	56.42	58.91
Lower Sac	56.05	58.91
Confluence	56.73	58.91
Marsh	59.20	58.91

Table B-1b **Bioenergetics model (BEM)-predicted and reference (external von Bertalanffy growth model) lengths at the end of October, assuming a July 1 length of 30 mm FL. Dry year.**

Region	BEM-based (No action)	Reference
Yolo	56.16	58.91
Lower Sac	55.80	58.91
Confluence	56.41	58.91
Marsh	58.81	58.91

Table B-2a **Growth increment (performance measure) for each region-year type-scenario combination. Growth increment was the difference between BEM-predicted growth with simulated action minus predicted growth with no action (Table 1). Below normal year.**

Region	AgLong-Low	AgShort-High	SacAg	SacLong-Low	SacShort-High	SMSCG-4ppt	SMSCG-6ppt
Yolo	0.26	0.20	0.58	0.32	0.21	0	0
Lower Sac	0.04	0.04	0.06	0.04	0.04	0	0
Confluence	0	0	0	0	0	0	0
Marsh	0	0	0	0	0	0.41	0.31

Table B-2b Growth increment (performance measure) for each region-year type-scenario combination. Growth increment was the difference between BEM-predicted growth with simulated action minus predicted growth with no action (Table 1). Dry year.

Region	AgLong-Low	AgShort-High	SacAg	SacLong-Low	SacShort-High	SMSCG-4ppt	SMSCG-6ppt
Yolo	0.37	0.30	—	—	—	—	—
Lower Sac	0.06	0.06	—	—	—	—	—
Confluence	0	0	—	—	—	—	—
Marsh	0	0	—	—	—	—	—

Table B-3a Quantiles of bioenergetics model predicted lengths, within the distribution of the growth reference point, for each region-year type-scenario combination. Below normal year.

Region (base quantile)	AgLong-Low	AgShort-High	SacAg	SacLong-Low	SacShort-High	SMSCG-4ppt	SMSCG-6ppt
Yolo (0.29)	0.31	0.31	0.33	0.32	0.31	0.29	0.29
Lower Sac (0.27)	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Confluence (0.31)	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Marsh (0.52)	0.52	0.52	0.52	0.52	0.52	0.55	0.55

Table B-3b Quantiles of bioenergetics model predicted lengths, within the distribution of the growth reference point, for each region-year type-scenario combination. Dry year.

Region (base quantile)	AgLong-Low	AgShort-High	SacAg	SacLong-Low	SacShort-High	SMSCG-4ppt	SMSCG-6ppt
Yolo (0.27)	0.30	0.30	--	--	--	--	--
Lower Sac (0.25)	0.25	0.25	--	--	--	--	--
Confluence (0.29)	0.29	0.29	--	--	--	--	--
Marsh (0.48)	0.48	0.48	--	--	--	--	--

Figure B-2 Map of the Sacramento-San Joaquin Delta, showing the spatial strata used to partition delta smelt habitat. This map was reproduced from Rose et al. (2013a) and Peterson et al. (2019).

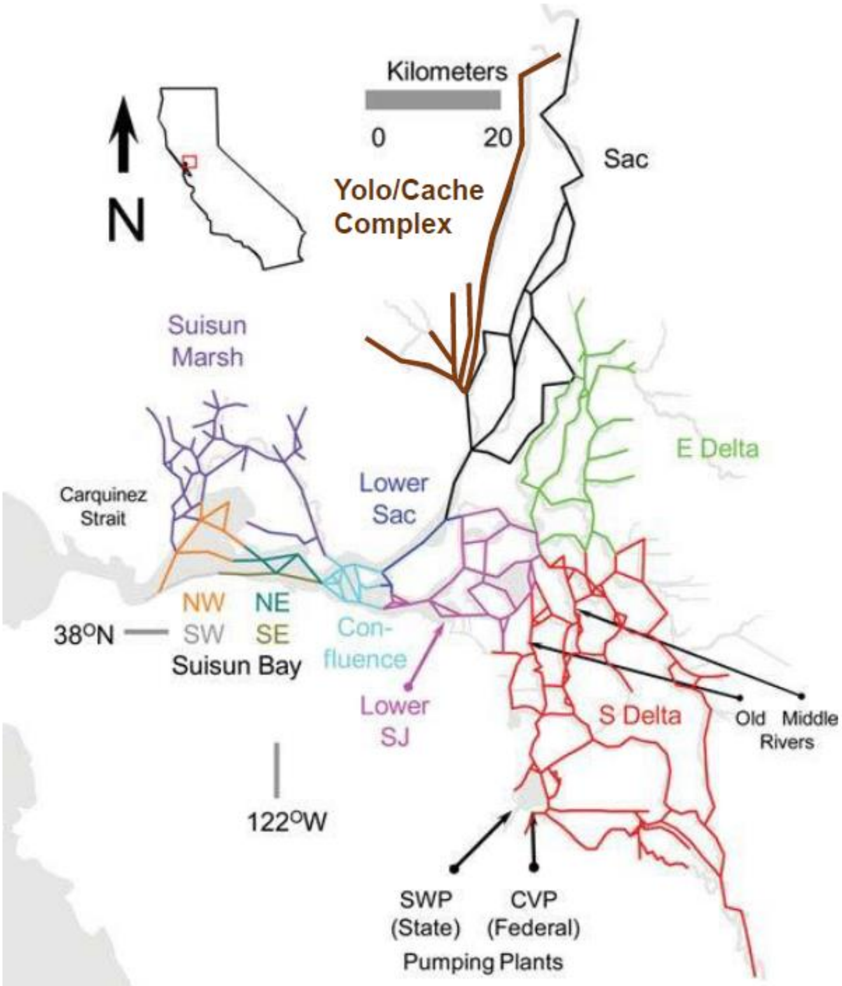


Figure B-3 Models of maximum consumption (C_{max}) and respiration assumed by Rose et al. (2013a) (top row). In the bottom row are shown the model of temperature effects on C_{max} used in this application (the Rose et al. 2013a model) versus an alternate model based on sparse empirical data, and the model of the effect of turbidity on C_{max}, suggested by data published by Hasenbein et al (2016).

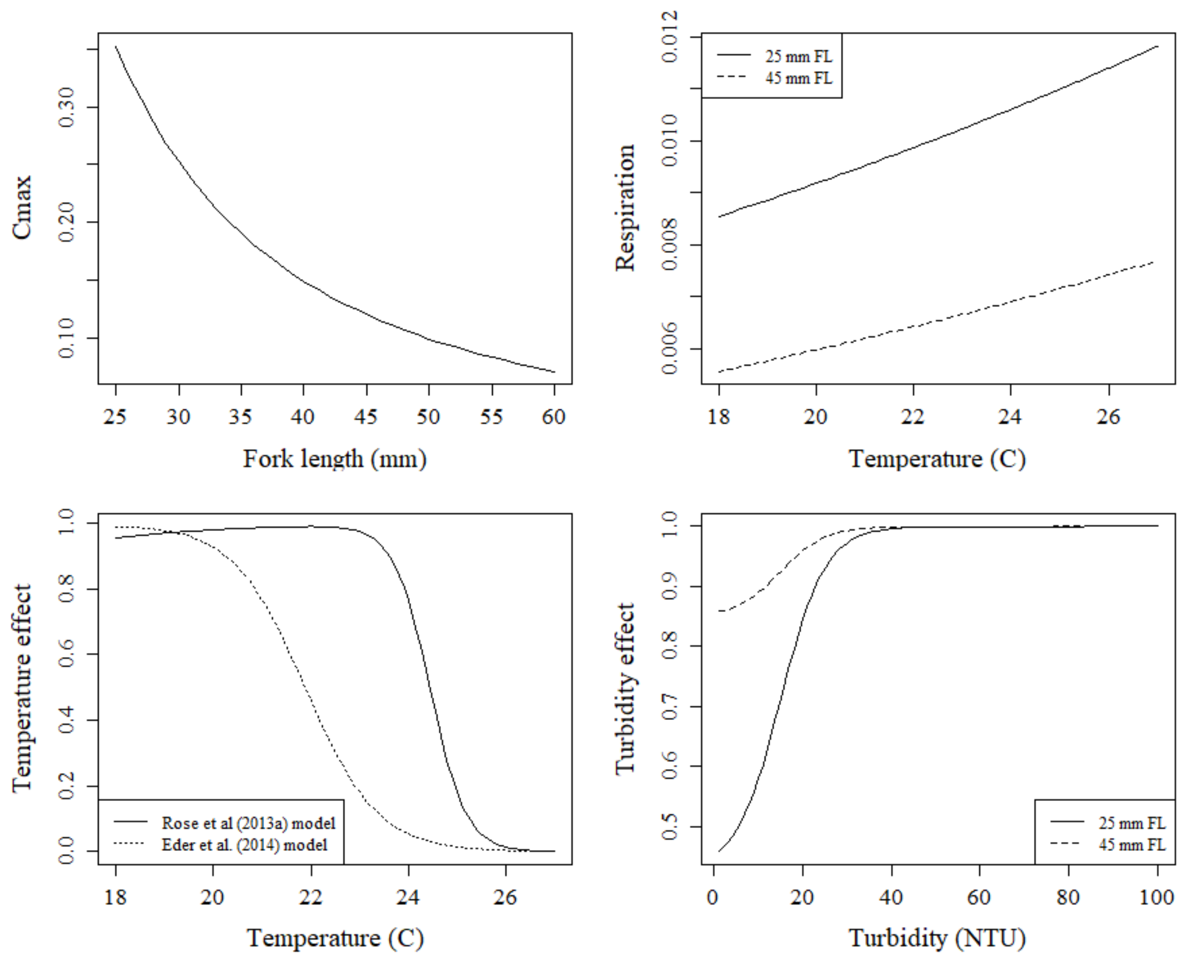


Figure B-4 Original image of a table from Rose et al. (2013a) showing fixed parameter values used to simulate Delta Smelt feeding and growth. For this application, fish were assumed to be of the juvenile (>25 mm FL) life stage.

TABLE 1. Parameter values for each Delta Smelt life stage in the bioenergetics model.

Parameter	Description	Larvae	Postlarvae	Juveniles and adults
	Maximum consumption (C_{max})			
a_c	Weight multiplier	0.18	0.18	0.1
b_c	Weight exponent	−0.275	−0.275	−0.54
CQ (°C)	Temperature at CK_1 of maximum	7	10	10
T_O (°C)	Temperature at 0.98 of maximum	17	20	20
T_M (°C)	Temperature at 0.98 of maximum	20	23	23
T_L (°C)	Temperature at CK_4 of maximum	28	27	27
CK_1	Effect at temperature CQ	0.4	0.4	0.4
CK_4	Effect at temperature T_L	0.01	0.01	0.01
	Metabolism (R)			
a_r	Weight multiplier	0.0027	0.0027	0.0027
b_r	Weight exponent	−0.216	−0.216	−0.216
R_Q	Exponent for temperature effect	0.036	0.036	0.036
S_d	Fraction of assimilated food lost to *SDA*	0.175	0.175	0.175
	Egestion (F) and excretion (U)			
F_a	Fraction of consumed food lost to egestion	0.16	0.16	0.16
U_a	Fraction of assimilated food lost to excretion	0.1	0.1	0.1

Figure B-5 Time series of temperature and turbidity used to predict delta smelt foraging limitations (red lines) and time series of predicted effects of each physical limitation on delta smelt foraging (black lines).

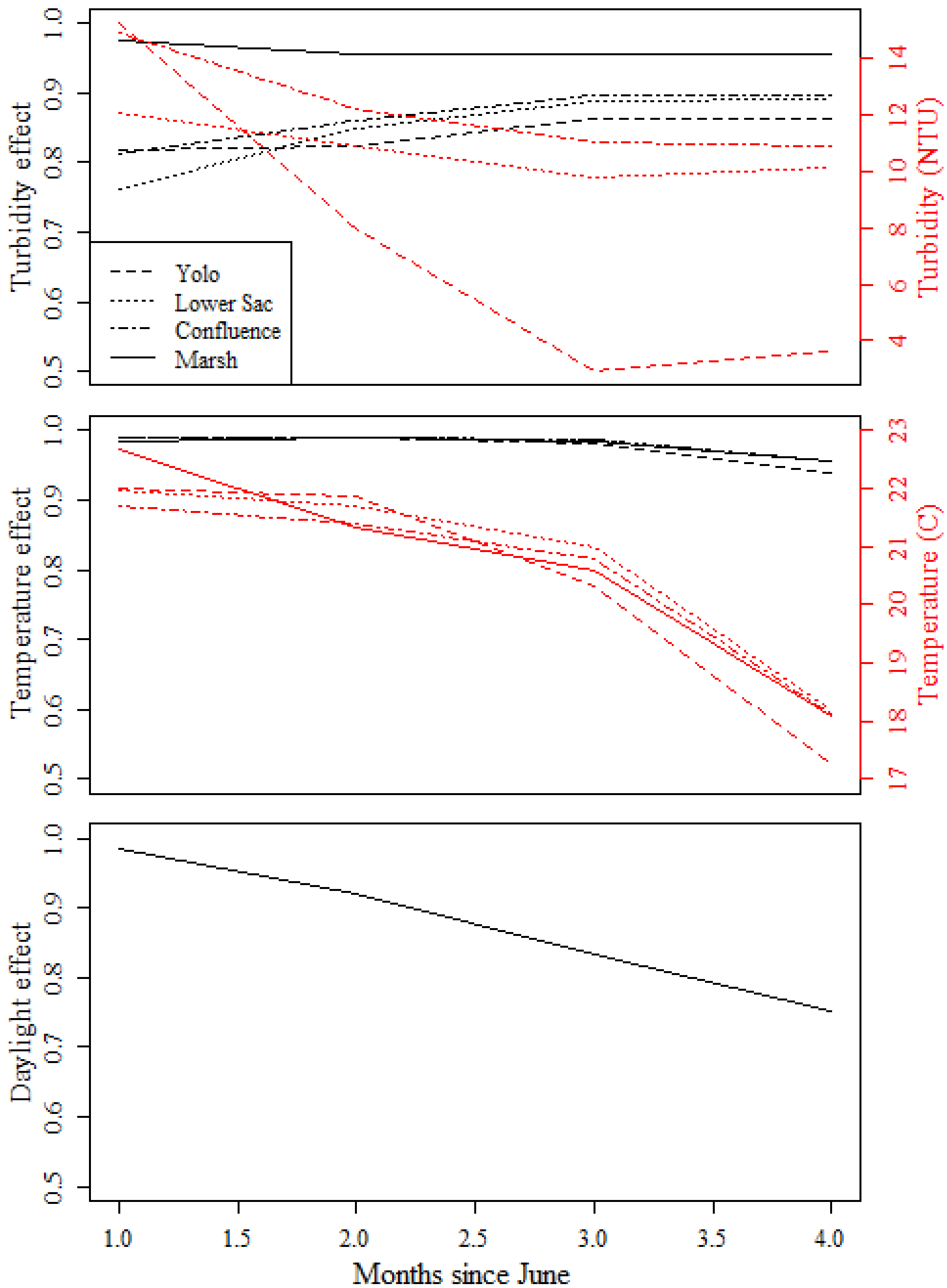


Figure B-6 Posterior distribution of reference growth predictions (black lines) from a von Bertalanffy growth model fit to delta smelt size-at-age data, versus bioenergetics growth model predictions (colored lines) for North Delta actions and baseline scenarios for Below Normal and Dry WYT.

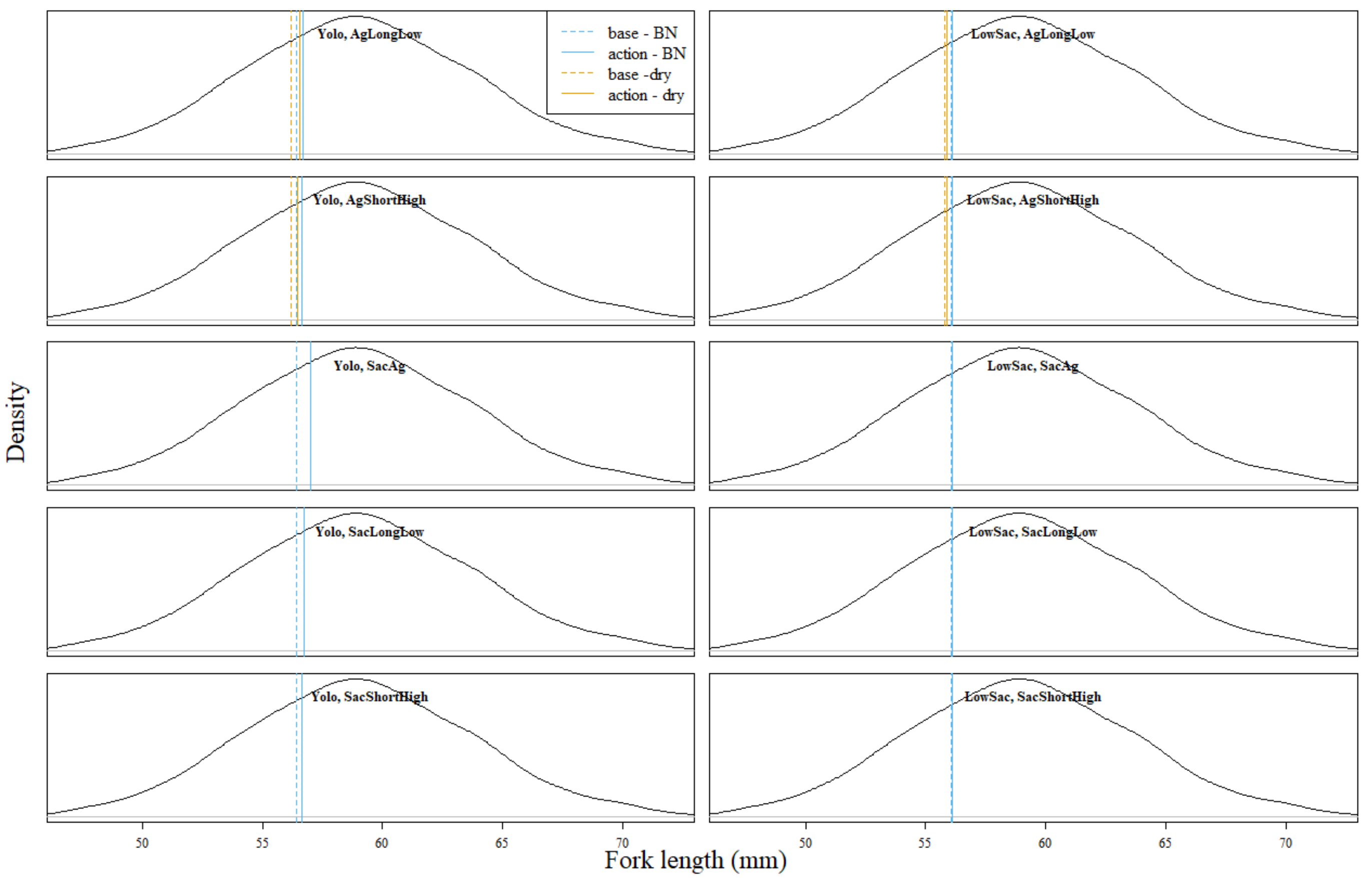
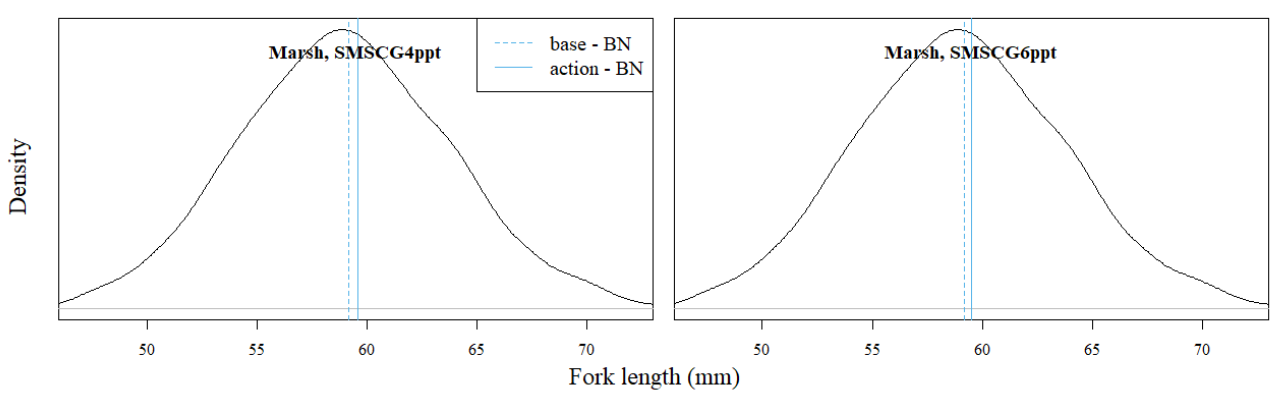


Figure B-7 Posterior distribution of reference growth predictions (black lines) from a von Bertalanffy growth model fit to delta smelt size-at-age data, versus bioenergetics growth model predictions (blue lines) for Suisun Marsh actions and baseline scenarios



Appendix

Von Bertalanffy growth model fit to wild Delta smelt length at age

Methods

Data

Delta smelt were collected from the San Francisco Estuary during June through September of 1999–2005 in the 20mm, Summer Townet, and Fall Midwater Trawl Surveys (ftp://ftp.dfg.ca.gov). Sagittal otolith were sectioned, polished, and analyzed by the James Hobbs Lab (UC Davis). Daily rings from the otolith core to the edge were enumerated by two independent readers, and a dataset consisting of daily ages and associated fork lengths was provided to the US Fish and Wildlife Service, Bay-Delta Office on June 15, 2016.

Model

A von Bertalanffy growth model was fit to delta smelt length-at-age data. The growth model was defined as

(A1) $FL_a = FL_\infty * \left(1 - e^{-k*(a-t_0}\right),$
where fork length *FL* at age *a* were predicted from asymptotic length FL_∞, growth coefficient *k*, and age at *FL* = 0 t_0. *a* were represented as fractional years (*a* = daily age/365). By rearranging Equation 1 and substituting for FL_a a parameter for length at hatch (*a* = 0) FL_0, t_0 in Equation 1 can be calculated directly

(A2) $t_0 = \frac{1}{k} * \ln\left((FL_\infty - FL_0)/FL_\infty\right).$
FL_0 was fixed at the length at hatch estimated by Romney et al. (2019), 5.3 mm FL. Equations 1 and 2 were used to predict *FL* for each individual, assuming that observed lengths were normally distributed. Parameters FL_∞, *k*, FL_0, and error σ were estimated.

Model fitting

The model was fit using R package R2jags (R 2015) and Bayesian statistical software JAGS (Plummer 2003). A burn-in period of 25,000 was followed by 50,000 samples of posterior distributions. As preliminary analysis suggested high autocorrelation within posterior chains, posterior samples were thinned by 50. Model convergence was assessed by comparing the trace plots of six chains of each model parameter and using Gelman and Rubin's diagnostic (Gelman and Rubin 1992). Model convergence was reached if trace plots showed that both chains were sampling stationary parameter distributions that did not shift with additional samples and if Gelman and Rubin's statistic was less than 1.05 for all parameters.

Results and Discussion

A total of 823 delta smelt otoliths were examined and aged. Fitted von Bertalanaffy growth model parameters (Table B-4) indicated a mean asymptotic length of 78.4 mm FL and extremely rapid growth (k = 2.72). Diagnostics indicated adequate model fit; residuals appeared to be normally distributed around 0 at all but the youngest ages (Fig. B-8). The model appeared to overpredict lengths at ages below 0.1 years (less than 40 days), and most ages less than 40 days were observed in a single survey, the 20mm Survey, during a single year, 2000. It is possible that fish were larger at age during later spring of 2000 or that growth patterns changed subsequent to 0.1 years of age. Von Bertalanffy growth models may not be capable of consistently describing growth across early to late life stages; nevertheless, the fitted delta smelt model appeared to adequately describe growth after 0.1 years.

One major limitation of the data was the absence of larger fish sampled between January and May. This resulted from an inability to enumerate daily ages during the seasonal slow growth period, when otolith rings are closely spaced and difficult to distinguish. Presumably, the absence of these larger length samples limited the model's capability to estimate FL_{∞}, and inclusion of samples from older fish would improve estimation of this parameter.

References

Bennett, W. A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3(2).

Gelman, A., and D. B. Rubin. 1992. Inference from iterative simulation using multiple sequences. Statistical Science 7: 457–511.

Plummer, M. 2003. JAGS: a program for analysis of Bayesian graphical models using Gibbs sampling. Proceedings of the 3rd International Workshop on Distributed Statistical Computing, Vienna, Austria.

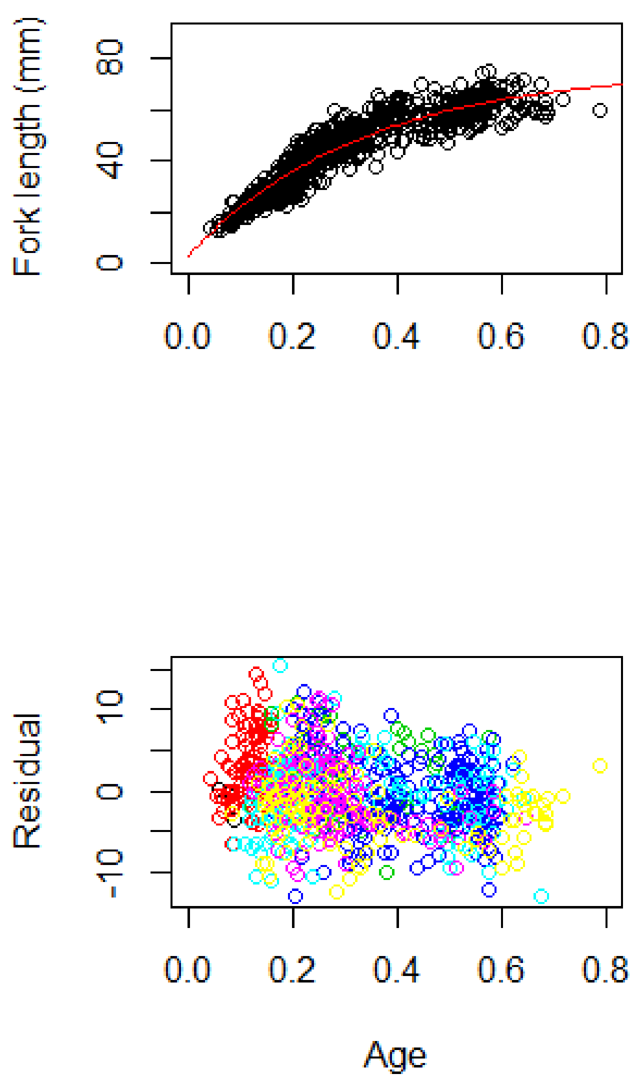
R Development Core Team. 2015. R: A Language and Environment for Statistical Computing. version 3.2.2. Vienna: R Foundation for Statistical Computing. Available at: http://www.R-project.org.

Romney, A. L., Y. R., Yanagitsuru, P. C. Mundy, N. A. Fangue, T. C. Hung, S. M. Brander, and R. E. Connon. 2019. Developmental staging and salinity tolerance in embryos of the Delta Smelt, Hypomesus transpacificus. Aquaculture 511(634191).

Table B-4 Parameter estimates at 95% credible intervals.

Parameter	Posterior mean	95% credible interval
k	2.72	2.57 – 2.87
FL_∞	78.4	76.2 – 80.7
t_0	-0.026	-0.026 – -0.025
FL_0	2.72	2.57 – 2.87

Figure B-8 The top panel shows observed delta smelt length at age (black circles) and the predictions of the fitted von Bertalanffy growth model (red line). The bottom panel shows model residuals versus age, and residuals corresponding to each year of data are colored differently. Ages are represented in units of fractional years.



2. Habitat Suitability Index (HSI) Performance Measure Infosheet

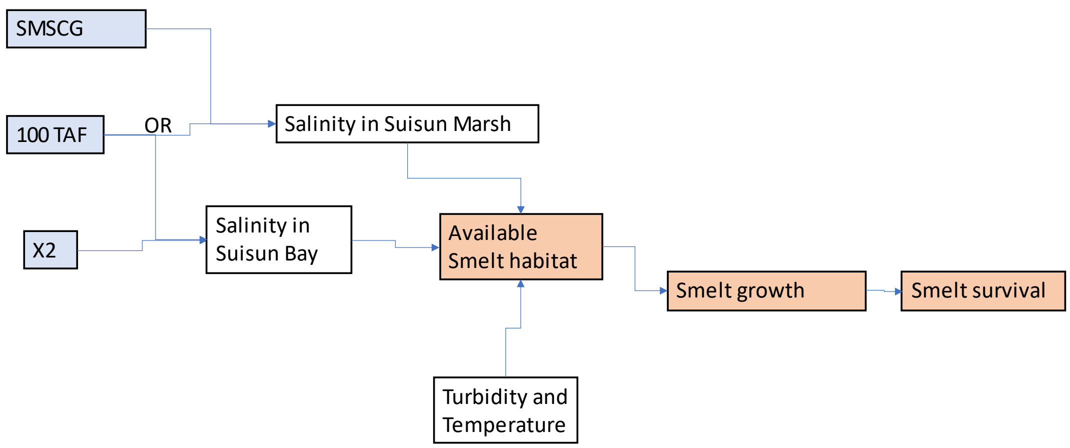
Take-home messages

1. Habitat Suitability Index (HSI) for Delta Smelt in Suisun Marsh is improved when there is more freshwater in Suisun Marsh due to the Salinity Control Gate Action.
2. HSI in Suisun Marsh is lower during dry year than below normal year.
3. North Delta Food Subsidies action (NDFS) is not expected to change salinity, temperature, or turbidity at Suisun Marsh.

PM Summary and Influence Diagram

- Suitable habitat for Delta Smelt can be modeled based on appropriate ranges of temperature, turbidity, salinity, and current speed. Operation of the SMSCGs during the summer and fall is expected to increase suitable habitat in the Marsh by lowering salinity. Turbidity in the Marsh is more frequently in the range of suitable habitat for Delta Smelt, so Marsh habitat will be better than habitat in the Sacramento River. NDFS is not expected to have any measurable impact on available habitat.
- Final scores are average habitat suitability index for the summer (July-October) in Suisun Marsh, since that’s where the largest change in HSI occurred.

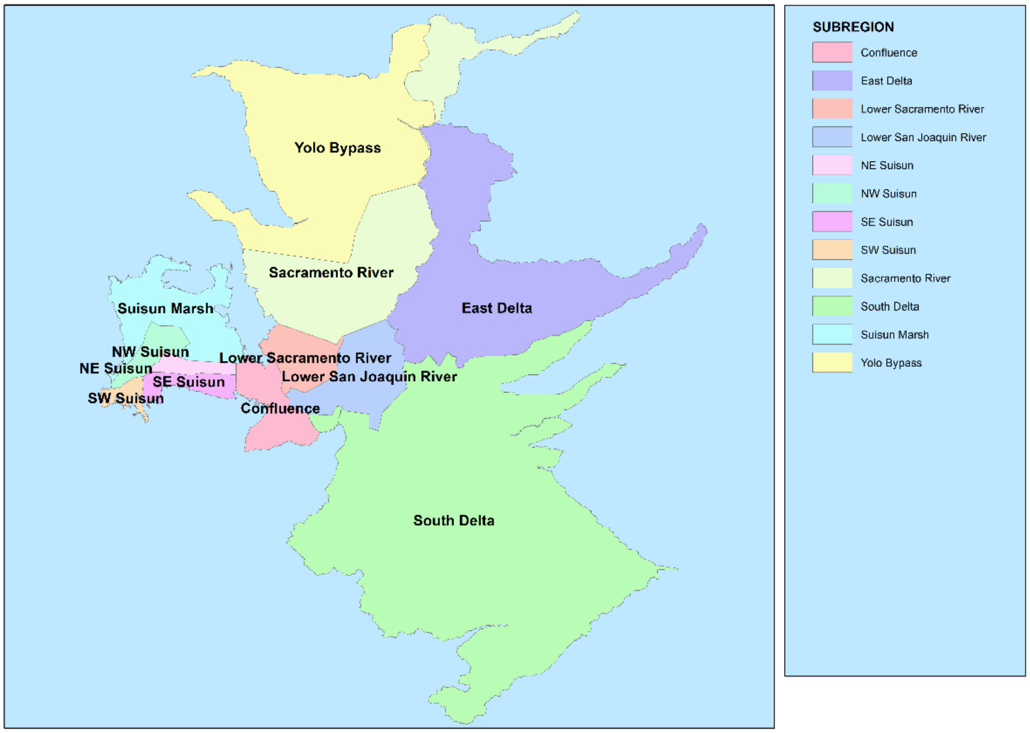
Fig B-9 Influence diagram for HSI PM



Calculations and/or scoring

Suitable Habitat Index was calculated using a methodology derived from Bever et al. (2016) and RMA (2021). The index represents spatially- and temporally-averaged suitability of habitats within the delineated subregions in the Bay-Delta shown in Figure B-10. Spatial averaging was performed both vertically over depth and horizontally over the area of each subregion. The temporal averaging was performed monthly from July to September. Habitat suitability was assessed only over the Below Normal years involving Suisun Marsh Salinity Control Gate actions.

Figure B-10 Subregions over which the Habitat Suitability Index was calculated.



The habitat suitability index (HSI) is based on four abiotic variables: salinity, temperature, turbidity, and current speed. Two of the HSI variables, salinity and current speed, are readily calculated from results from the 3D Bay-Delta SCHISM model. Assuming that flow boundary conditions are available based on operational forecasts of flow, the model results are regarded to be spatially detailed and sufficiently accurate to inform the structured decision-making process.

Temperature and turbidity, by contrast, are highly dependent on atmospheric forcing, including air temperature, radiation, and wind. In hindcasts, these variables are known and can be used directly in the Bever at al. (2016) and RMA (2021) formulas. In forecasts, however, the uncertainty regarding weather dominates the calculation and any small contribution that might result from individual actions.

In order to accommodate this limitation, a method was developed that used historical quantiles, interpolated over space, to provide probable weighting of these atmospheric-dependent variables. First, we computed windowed

(0.05, 0.25, 0.5, 0.75) quantiles at continuous stations for each day of the year, using the available record and a 19-day window around each date of interest. We verified that this produced results that were sensible with relatively low noise over time. We then interpolated the quantiles spatially using the method of Sangalli et al. (2013), a regularized spline method which respects islands and irregular domains. The interpolated quantiles consider only the distribution of the data, not the mixed distribution of the data and of the interpolation. The interpolator is based on unstructured meshes but is coarser (1km) than the Bay-Delta SCHISM mesh. Nearest neighbor interpolation was used to interpolate to the much more resolved SCHISM mesh.

Once the turbidity and temperature quantiles were available on the SCHISM mesh, marginal probabilities or factors based on the quantiles, in conjunction with the SCHISM-predicted salinity and current speed, were applied to the Bever et al. formulation at each mesh cell to determine the depth-averaged HSI for the cell. For instance, the Bever et al. formula is as follows,

$S_i = 0.67S + 0.33V$, turbidity ≥ 12 NTU (1a)
$S_i = (0.67S + 0.33V)c_t$, turbidity < 12 NTU (1b)

where S is a suitability index based on the fraction of time salinity < 6 PSU (computed with SCHISM), V is a suitability index based on the maximum current speed (computed with SCHISM), and c_t = 0.42 is a penalty associated with low turbidity. Conventionally, one would use only one of the above equations depending on whether turbidity is above or below 12 NTU. However, to reconcile the formula with the turbidity quantiles for a given day, the quantile that was just higher or lower than the 12 NTU threshold was used to create a roughly discretized marginal probability and the two equations weighted accordingly. For instance, if q_{75} was the quantile just under 12 NTU for a given date and location, the formula would be weighted with a 0.75 weight on the penalized value (Eqn 1b) and a 0.25 weight on the unpenalized value (Eqn 1a), reflecting the assumption;

$$S_i = 0.75\times[\ (0.67S + 0.33V)\times 0.42\ ] + 0.25\times[0.67S + 0.33V] \quad (2)$$

We similarly used quantiles for temperature to fit the RMA temperature addition to the Bever et al formula, which is simply a product of the original suitability index, S_i, and a temperature suitability factor. Looking up the quantiles bracketing the threshold value of 24ºC, we determined the final suitability index at a given location and date as follows:

$S_{i,final} = 1.00 \times S_i$, $q_{75} < 24ºC$ (3a)

$S_{i,final} = 0.75 \times S_i$, $q_{50} < 24ºC \leq q_{75}$ (3b)

$S_{i,final} = 0.50 \times S_i$, $q_{25} < 24ºC \leq q_{50}$ (3c)

$S_{i,final} = 0.25 \times S_i$, $q_{5} < 24ºC \leq q_{25}$ (3d)

$S_{i,final} = 0.05 \times S_i$, $24ºC \leq q_{5}$ (3e)

Finally, the daily depth-averaged suitability indices computed at the mesh cells were aggregated over subregion area and on a monthly basis from July to September.

Key assumptions and uncertainties

- Sources, types, magnitude of uncertainty
    - Using historical turbidity and temperature values for a given water year type is the largest source of uncertainty. Salinity and velocity is relatively straightforward to model, but we have very poor predictive power for turbidity and temperature. Actual temperatures occurring in the summer and fall of 2022 may be quite different from previous years.
- Reproducibility

Round 1 results

Action	Score	Comments/rationale
1. Dry Year. NDFA – Ag Flow - high magnitude, low duration	0.156	NDFA is not expected to change habitat suitability
2. Dry Year. NDFA – Ag Flow -low magnitude, high duration	0.156	NDFA is not expected to change habitat suitability
3. Below Normal Year. NDFA – Ag Flow - high magnitude, low duration	0.361	NDFA is not expected to change habitat suitability
4. Below Normal Year. NDFA – Ag Flow- low magnitude, high duration	0.361	NDFA is not expected to change habitat suitability

Action	Score	Comments/rationale
5. Below Normal Year. NDFA – Sac Flow- low magnitude, high duration	0.361	NDFA is not expected to change habitat suitability
6. Below Normal Year. NDFA – Sac Flow - high magnitude, low duration	0.361	NDFA is not expected to change habitat suitability
7. Below Normal Year. NDFA – Sac summer action + Fall ag action. Low magnitude, high duration	0.361	NDFA is not expected to change habitat suitability
8. Below Normal Year. SMSCG – Nonconsecutive. Start when Beldon's >4ppt	0.505	Gates action increases HSI in the Marsh.

Additional information and context for interpreting results

Figure B-11 Plot of Habitat Suitability Index (HSI) by region, scenario, and month for below normal years. The largest change in HSI was for Suisun Marsh, where gate actions increased HSI especially in August and September. There wasn't much difference between the 4 ppt and 6 ppt scenarios.

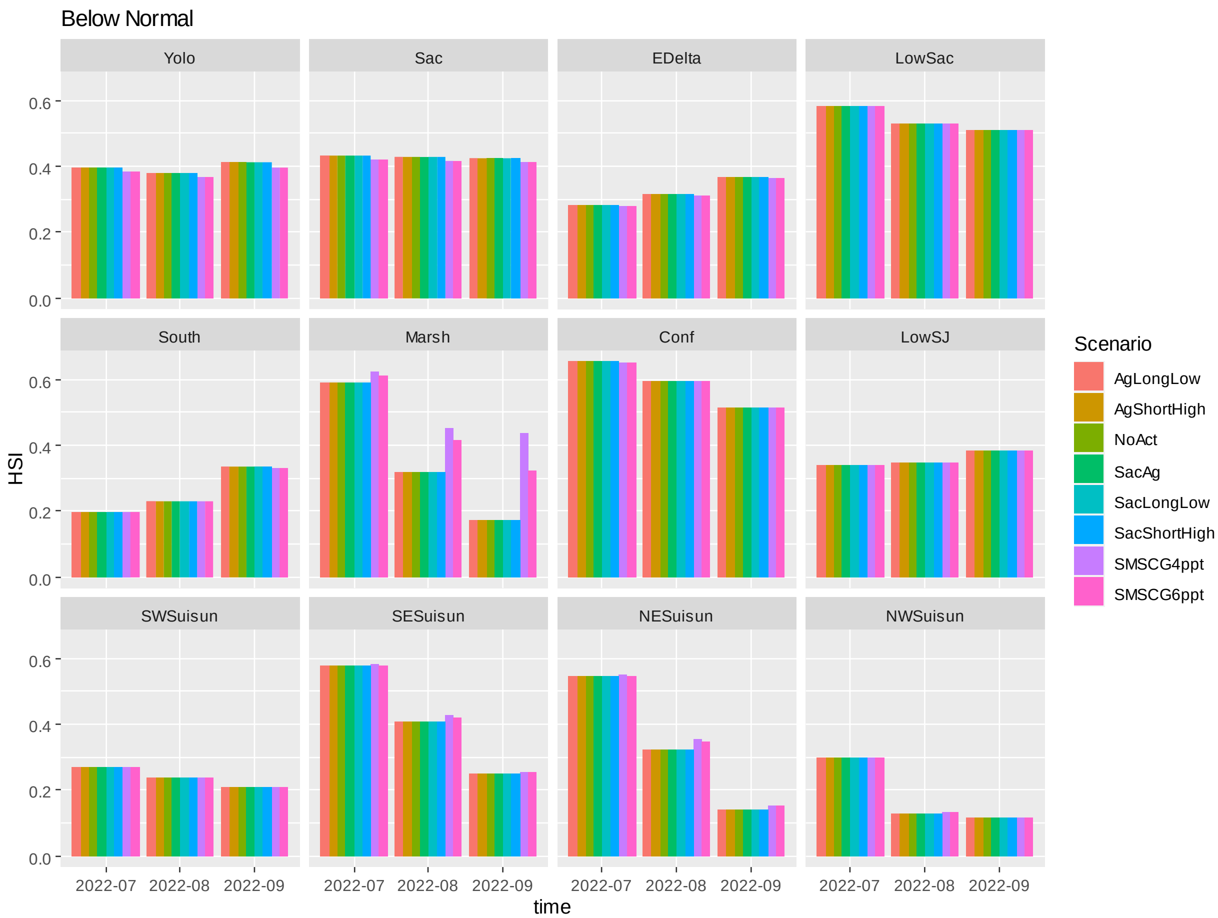
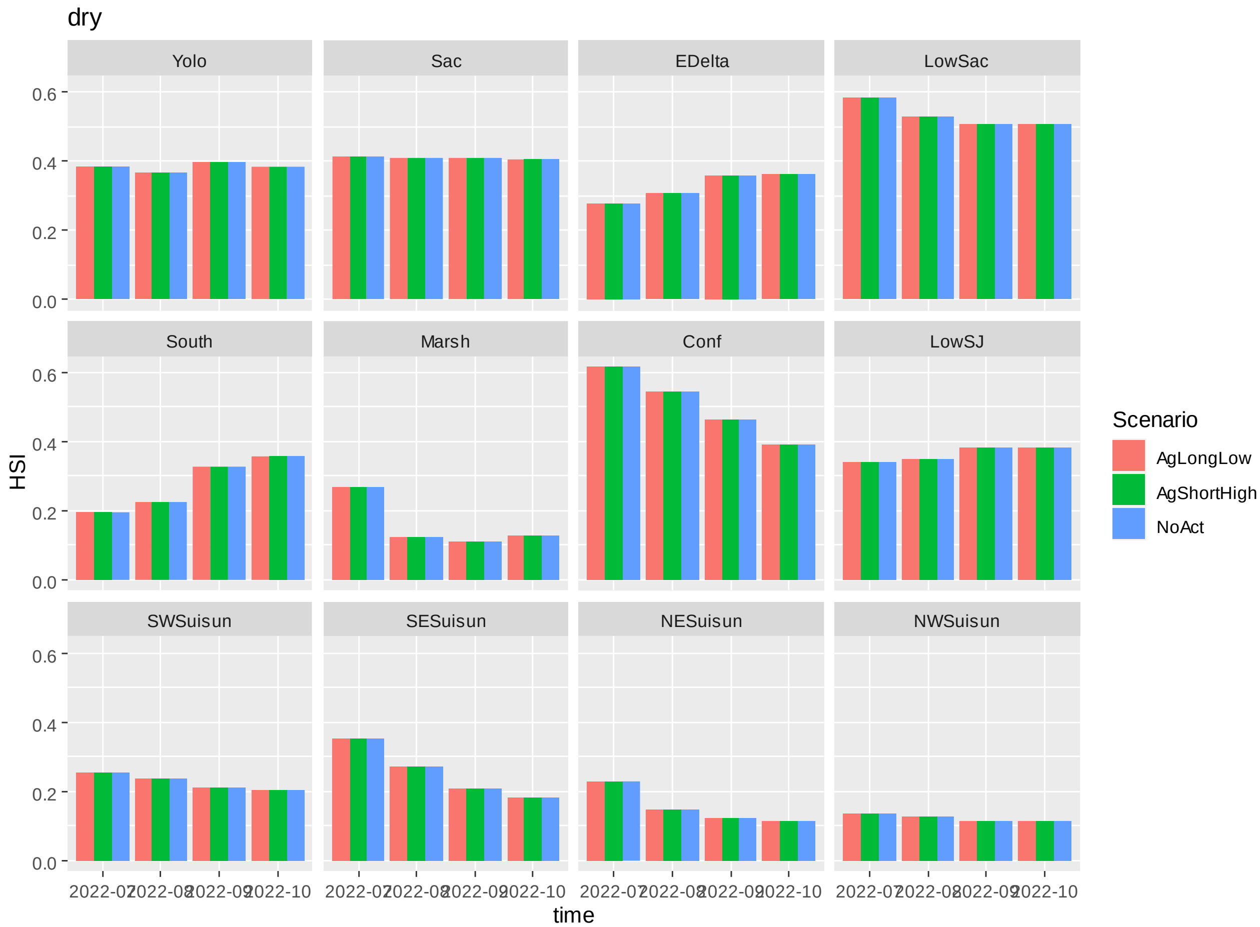


Figure B-12 Plot of habitat suitability index (HSI) for dry year scenarios by month and region. There were no changes to HSI because there were no Gate actions included in the scenarios.



Summary of table of calculated HIS for year type, action scenario, and subregion.

Yr_type	Scenario	Yolo	Sac	EDelta	LowSac	South	Marsh	Conf	LowSJ	SWSuisun	SESuisun	NESuisun	NWSuisun
Below Normal	AgLongLow	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181
Below Normal	AgShortHigh	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181
Below Normal	NoAct	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181
Below Normal	SacAg	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181
Below Normal	SacLongLow	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181

Yr_type	Scenario	Yolo	Sac	EDelta	LowSac	South	Marsh	Conf	LowSJ	SWSuisun	SESuisun	NESuisun	NWSuisun
Below Normal	SacShortHigh	0.395	0.428	0.320	0.541	0.255	0.361	0.589	0.357	0.240	0.412	0.336	0.181
Below Normal	SMSCG4ppt	0.383	0.416	0.317	0.540	0.253	0.505	0.586	0.357	0.240	0.421	0.353	0.183
Below Normal	SMSCG6ppt	0.383	0.414	0.328	0.533	0.280	0.419	0.547	0.364	0.231	0.362	0.290	0.164
Dry	AgLongLow	0.383	0.409	0.326	0.532	0.278	0.156	0.504	0.364	0.226	0.252	0.152	0.123
Dry	AgShortHigh	0.383	0.409	0.326	0.532	0.278	0.156	0.504	0.364	0.226	0.252	0.152	0.123
Dry	NoAct	0.383	0.409	0.326	0.532	0.278	0.156	0.504	0.364	0.226	0.252	0.152	0.123

References

Bever, Aaron J., MacWilliams, Michael L., Herbold, Bruce et al., 2016. Linking Hydrodynamic Complexity to Delta Smelt (*Hypomesus transpacificus*) Distribution in the San Francisco Estuary, USA. *San Francisco Estuary and Watershed Science*, 14(1).

RMA (2021). Numerical Modeling in Support of Reclamation Delta Smelt Summer/Fall Habitat Analysis, Technical Memo, Davis CA.

Sangalli, L.M., Ramsay, J.O., Ramsay, T.O. (2013), Spatial spline regression models.

3. Zooplankton Performance Measure Infosheet

Take-home messages

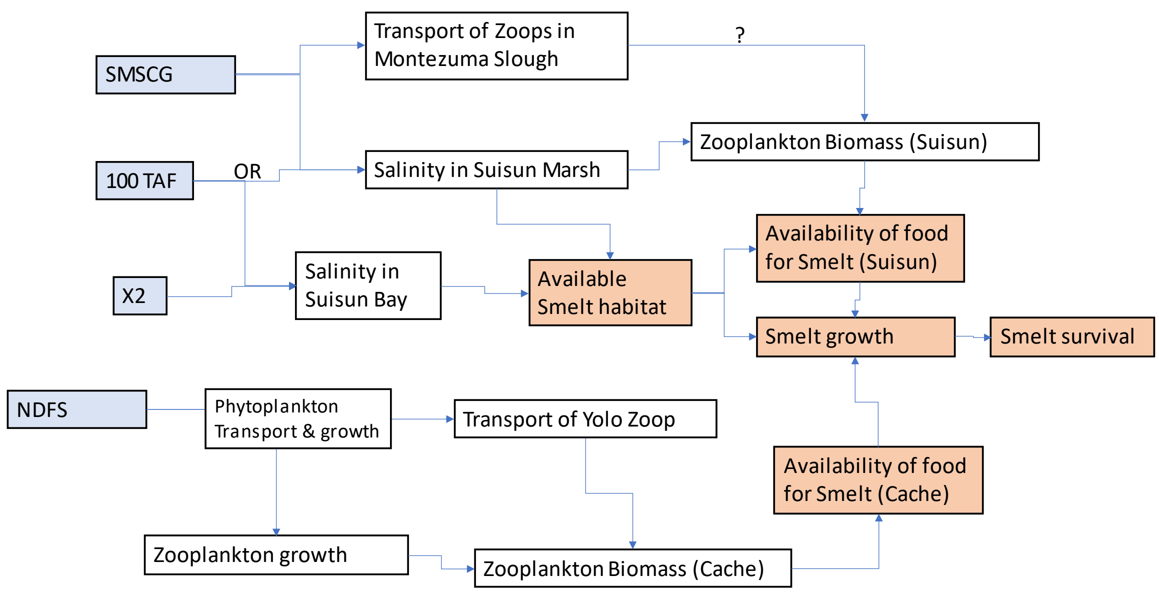
1. Lowering salinity in the Marsh may increase regional food supply by up to 13% Delta-Wide, with over 90% increase in Suisun Marsh, but variability is extremely high.
2. Lower salinity actions create greater food resources
3. NDFS is hypothesized to increase Delta-Wide food supply by up to 8%, with over 90% increase in the Yolo Bypass.
4. We predict higher food in longer actions and higher food with Sacramento actions, but this response has not been detected in monitoring to date.
5. Increased zooplankton density will drive increased Delta Smelt growth and survival. The actions have a relatively small impact on total food resources, but a large impact on local food resources.

PM summary and Influence diagram

We broke this performance measure up into two parts, one for zooplankton in the Suisun area and one for zooplankton in the Cache Slough area. In Suisun, the SMSCG action will alter transport/residence time of zooplankton in Montezuma Slough, but we do not have enough baseline data to predict the impact on smelt food. However, the altered salinity in Suisun will definitely have impacts on biomass community composition in predictable ways (increased biomass of freshwater critters, decreased biomass of marine critters) (Kimmerer and Kayfetz 2017; Kimmerer et al. 2018; Barros et al. 2021). The most important food-related impacts of both a Gates action and an X2/outflow action will be increasing smelt occupancy in these areas (Sommer et al. 2020). Therefore, while zooplankton biomass may or may not change, availability of zooplankton in Suisun to smelt will change with the increase habitat suitability.

For the NDFS, the action is expected to transport phytoplankton from Yolo to zooplankton in Cache Slough and transport zooplankton from Yolo to Cache. Longer pulses with lower magnitude are expected to have the largest increase in zooplankton biomass due to increased residence time and longer periods of positive net flow. Sacramento river water is expected to have more positive impact on zooplankton than agricultural water because of lower contaminants, lower salinity, and higher dissolved oxygen. Previous flow actions have shown mixed results (Davis et al. 2022), however the highest response in downstream phytoplankton occurred during a Sacramento River action (Frantzich et al 2021), so this hypothesis is supported by some data.

Fig B-13 Influence diagram for zooplankton availability PM



Calculations and/or scoring

The scoring was done in 5 steps:

1. We used data from June-October of 2000-2020, that includes data collected by FMWT, and EMP, synthesized by the zooper package (Bashevkin et al. 2022). This incorporates data from the most recent ecological regime (post-POD). Data were summarized by region, month, water year type, and species, to develop a "baseline" for expected zooplankton biomass in each water year type. "Species" were the groups used by the IBMR (Smith et al. 2021), with the addition of

mysids, due to their importance in smelt diets (Slater and Baxter 2014).

2. We then used generalized additive models on historic data to model change in zooplankton biomass in Suisun (by taxonomic group) versus salinity. (description of models and code available here: https://sbashevkin.github.io/FLOATDrought/Zooplankton-salinity-relationships-in-Suisun.html) These models were then used to predict the change in zooplankton biomass expected in Suisun between the no-action and action scenarios. Individual models were run for each zooplankton taxa to account for differing responses to change in salinity.
3. To predict the change in zooplankton biomass cause by the NDFS, we used conceptual models of relative impact of different flow action types with the RMA copepod model to provide a 'best case scenario" estimate of change in biomass. These conceptual models provided a single value for "percent change" that was applied to the entire zooplankton community. Consultation with subject matter experts (the FLOAT Zooplankton team) resulted in the original values being reduced by ½, since use of the RMA model resulted in values of over 400% increase, which have never been seen during actual flow pulses.
4. Zooplankton IBMR input arrays were averaged by water year type (Dry – 2001, 2002, 2007, 2009, 2013, and Below Normal – 2004, 2010 2012). These values were then adjusted for each scenario using the models derived from steps 2 and step 3 (excluding mysids, which are not used in the IBMR).
5. In a shift from WY 2022 we used unweighted rather than weighted scores. We calculated the difference between the unweighted scores for each scenario and the 'no action' scenario for each water year type to develop the final score (Table B-6, Figure B-16). We decided against using a weighted score this year because the overlap of using HSI here and for the habitat PM was confusing, and the habitat weighting didn't change scores much.

Key assumptions and uncertainties

1. Sources, types, magnitude of uncertainty

A. The estimates of change in zooplankton biomass expected with the various NDFS scenarios are roughly based on expected change in chlorophyll seen in monitoring data collected during the actions, however the zooplankton biomass per change in chlorophyll biomass were based entirely on the RMA copepod model. Data collected during previous flow actions never showed changes as large as those expected in these models (Davis et al. 2022). Furthermore, change in biomass is likely to be different for different taxa, whereas a single value was used for all taxa in our model.

B. The estimates of change in biomass with change in salinity used for the SMSCG action were based on a more comprehensive dataset than used for the IBMR. The IBMR input tables were developed by Wim Kimmerer several years ago (Rose et al. 2013; Smith 2021), and additional years of data are now available. We used the observed relationships between salinity and biomass in the more recent data and applied those relationships to data from previous years, since it would allow for greater continuity in running the IBMR. However, this could also have introduced error.

C. Operation of the SMSCG may change zooplankton biomass in the Marsh by transporting them physically from the river into the Marsh, and may change the residence time and therefore growth potential of zooplankton once in the Marsh. We did not have mechanistic model for what the results of this would do to biomass, so did not include this effect in the model. Future iterations may want to include it.

2. Reducibility

A. The zooplankton biomass calculations and the salinity/biomass relationships are all documented and reproducible. The effect of the different NDFS action types was based partially on expert judgement, and partially on a mechanistic model, so is less reproducible. Different experts may have arrived at different conclusions.

Round 1 results

Table B-5 Score for smelt food availability (as unweighted biomass) with each action.

Action	Score	Comments/rationale
1. Dry Year. NDFA – Ag Flow - high magnitude, low duration [AgShortHigh]	626.28	Agricultural water has poor water quality and higher contaminants, so not as much zoop growth. Higher magnitude flushes things down the system too quickly.
2. Dry Year. NDFA – Ag Flow -low magnitude, high duration [AgLongLow]	626.28	Agricultural water has poor water quality and higher contaminants, so not as much zoop growth. Lower magnitude allows longer residence time for growth.
3. Below Normal Year. NDFA – Ag Flow - high magnitude, low duration [AgShortHigh]	687.77	Agricultural water has poor water quality and higher contaminants, so not as much zoop growth. Higher magnitude flushes things down the system too quickly.
4. Below Normal Year. NDFA – Ag Flow- low magnitude, high duration [AgLongLow]	692.82	Agricultural water has poor water quality and higher contaminants, so not as much zoop growth. Lower magnitude allows longer residence time for growth.
5. Below Normal Year. NDFA – Sac Flow- low magnitude, high duration [SacLongLow]	695.58	Sac water has better water quality and lower contaminants, so more zoop growth. Lower magnitude allows longer residence time for growth.
6. Below Normal Year. NDFA – Sac Flow - high magnitude, low duration [SacShortHigh]	711.90	Sac water has better water quality and lower contaminants, so more zoop growth. Higher magnitude flushes things down the system too quickly.
7. Below Normal Year. NDFA – Sac summer action + Fall ag action. Low magnitude, high duration [SacAg]	733.28	A longer, low magnitude flow pulse allows higher residence time for growth but also more time to transport food into Cache Slough and downstream.
8. Below Normal Year. SMSCG – Nonconsecutive. Start when Beldon’s >4ppt [SMSCG4ppt]	783.53	Food in the marsh (which is pretty high) overlaps with good habitat for longer. Lower salinity means more Pseudodiaptomus and mysids.
11. No action [NoAct]	679.58	—

Additional information and context for interpreting results

Table B-6 Results of zooplankton modeling. Unweighted biomass is the average total zooplankton biomass across the Delta based on historical data in ug/L. Weighted biomass is the unweighted biomass multiplied by the habitat suitability index for each region and then added across months and regions. Scenario abbreviations are listed in Table B-5.

Scenario	Yr_type	Unweighted BPUT	Difference in unweighted BPUT
AgLongLow	Below Normal	692.82	13.25
AgShortHigh	Below Normal	687.77	8.19
NoAct	Below Normal	679.58	0.00
SacAg	Below Normal	733.28	53.70
SacLongLow	Below Normal	711.90	32.32
SacShortHigh	Below Normal	695.58	16.00
SMSCG4ppt	Below Normal	783.53	103.95
SMSCG6ppt	Below Normal	737.99	58.41
AgLongLow	Dry	626.28	15.12
AgShortHigh	Dry	619.70	8.54
NoAct	Dry	611.16	0.00

Figure B-14 ***Predicted biomass of each zooplankton taxa by month in Suisun Marsh for each action.***

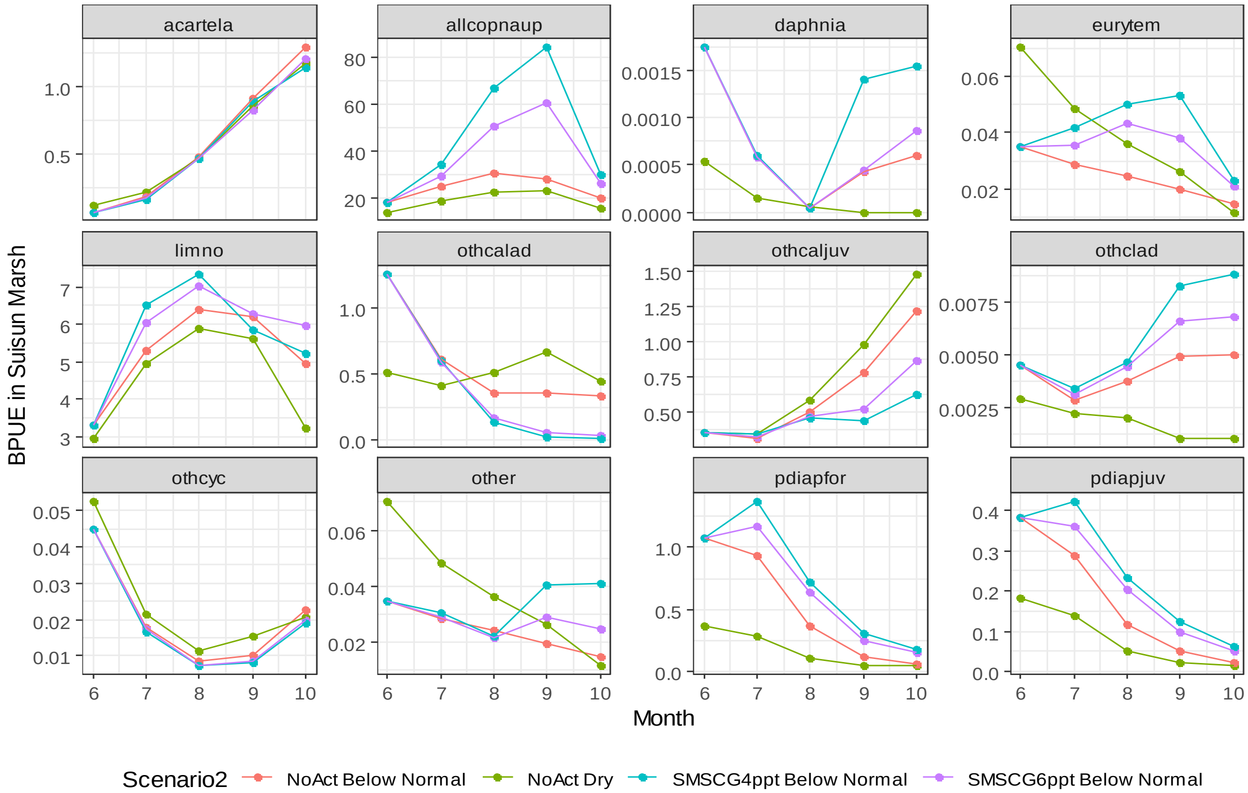


Figure B-15 Change in zooplankton biomass with different scenarios in the Yolo region.

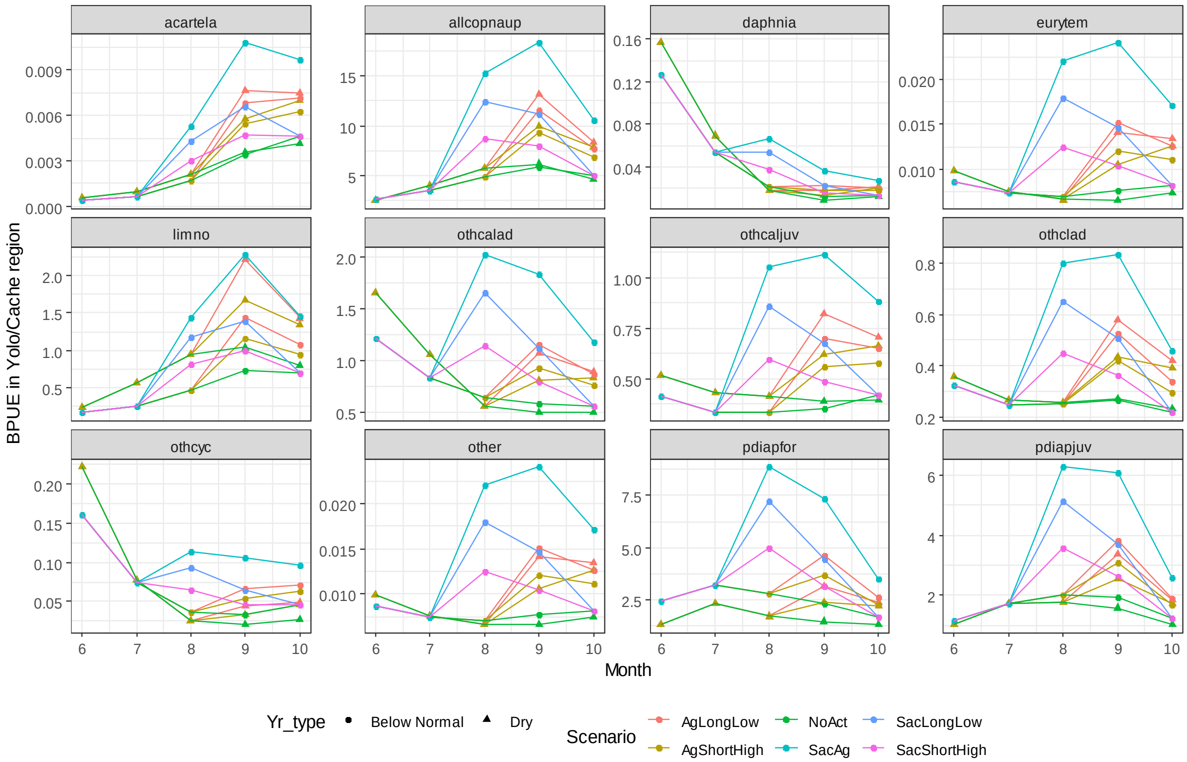
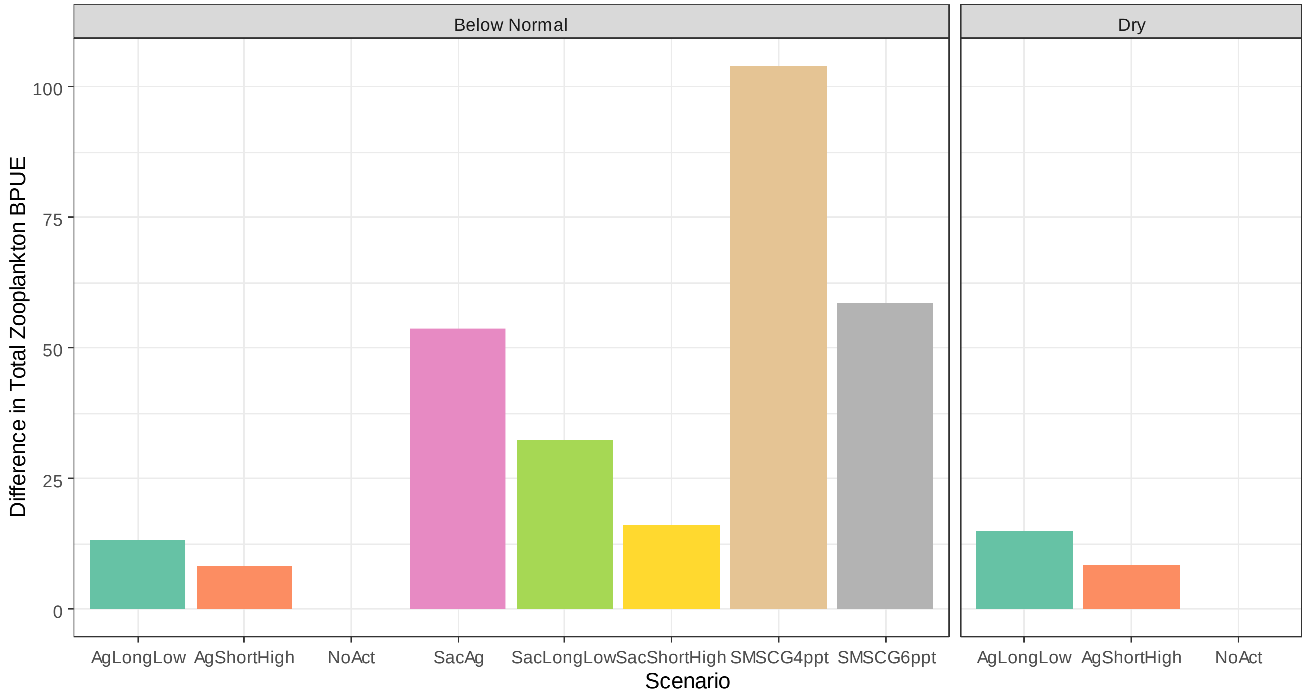


Figure B-16 Difference in unweighted zooplankton BPUE between a no-action scenario and scenarios with each action.



References

Barros, A. 2021. Zooplankton Trends in the Upper SFE, 1974-2018. IEP Newsletter 40(1):5-14.

Bashevkin, S.M., R. Hartman, M. Thomas, A. Barros, C.E. Burdi, A. Hennessy, T. Tempel, and K. Kayfetz. 2022. Interagency Ecological Program: Zooplankton abundance in the Upper San Francisco Estuary from 1972-2020, an integration of 5 long-term monitoring programs ver 3. Environmental Data Initiative. https://doi.org/10.6073/pasta/89dbadd9d9dbdfc804b160c81633db0d

Davis et al. 2022. North Delta Food Subsidy Synthesis: Evaluating Flow Pulses from 2011-2019. Department of Water Resources, Division of Integrated Science and Engineering. Draft.

Frantzich, J., B. E. Davis, M. MacWilliams, A. Bever, and T. Sommer. 2021. Use of a Managed Flow Pulse as Food Web Support for Estuarine Habitat. San Francisco Estuary and Watershed Science 19(3):art3. doi:https://doi.org/10.15447/sfews.2021v19iss3art3

Kayfetz, K., and W. Kimmerer. 2017. Abiotic and biotic controls on the copepod *Pseudodiaptomus forbesi* in the upper San Francisco Estuary. Marine Ecology Progress Series 581:85-101. doi:https://doi.org/10.3354/meps12294

Kimmerer, W. J., T. R. Ignoffo, K. R. Kayfetz, and A. M. Slaughter. 2018. Effects of freshwater flow and phytoplankton biomass on growth, reproduction, and spatial subsidies of the estuarine copepod *Pseudodiaptomus forbesi*. Hydrobiologia 807(1):113-130. doi: https://doi.org/10.1007/s10750-017-3385-y

Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett. 2013. Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: II. Alternative baselines and good versus bad years. Transactions American Fisheries Society 142:1260-1272.

Slater, S. B., and R. D. Baxter. 2014. Diet, prey selection and body condition of age-0 Delta Smelt, *Hypomesus transpacificus*, in the upper San

Francisco Estuary. San Francisco Estuary and Watershed Science 14(4). doi:http://dx.doi.org/10.15447/sfews.2014v12iss3art1

Smith, W. 2021. A Delta Smelt Individual-Based Life Cycle Model in the R Statistical Environment. V3. Software documentation.

Sommer, T., R. Hartman, M. Koller, M. Koohafkan, J. L. Conrad, M. MacWilliams, A. Bever, C. Burdi, and M. P. Beakes. 2020. Evaluation of a large-scale flow manipulation to the upper San Francisco Estuary: Response of habitat conditions for an endangered native fish. Plos ONE 15(10). doi:https://doi.org/10.1371/journal.pone.0234673

Twardochleb, L., A. Maguire, L. Dixit, M. Bedwell, J. Orlando, M. MacWilliams, A. Bever, and B. Davis. 2021. North Delta Food Subsidies Study: Monitoring Food Web Responses to the North Delta Flow Action, 2019 Report. Department of Water Resources, Division of Environmental Services, West Sacramento, CA.

4. Contaminants Performance Measure Infosheet

Take-Home Messages

1. Although there were a wide range of scores between Respondents for each alternative the results from the 2023 Expert Elicitation were similar to the 2022 Expert Elicitation with the Sac Long-low action consistently performing better across all PMs then the other alternatives.
2. Only Sacramento Long-Low has a positive mean score; all other alternatives have a negative mean score.
3. Respondents felt that the Agricultural Long-Low and Short-High actions would cause a performance decrease of at least 10% for zooplankton quality (7 out of 8) and survival (6 out of 8).
4. Predicted effects were generally worse overall for zooplankton endpoints than for Delta Smelt.
5. The respondents felt that scores would be affected by water year with 6/7 saying lower score in a AN year and only 1 saying it would lower in a DY.

PM Summary

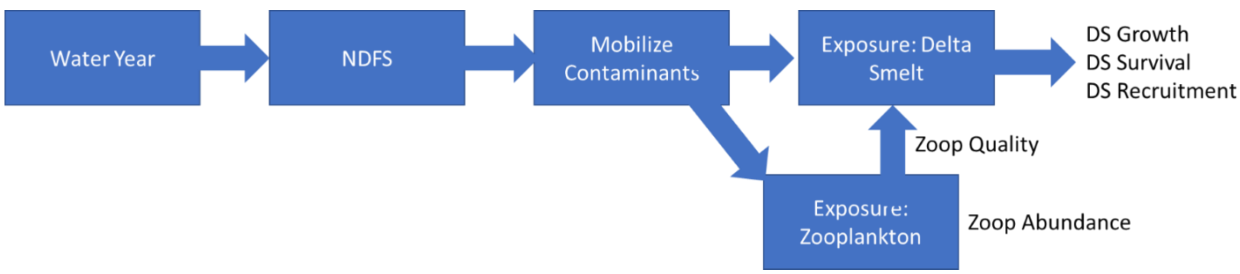
- Scores are based on % change in performance and reflect direct effects of contaminants only (i.e. not indirect effects of contaminants, and not effects unrelated to contaminants). Scores for specific endpoints assume a Below Normal year.
- Implementation of the NDFS is expected to change the loading and concentration of contaminants into the Cache Slough Complex (Orlando et al. 2020; Davis et al. 2022).
- Contaminant concentration and composition are expected to be different depending on the source water (Davis et al. 2022) with the water from the Sacramento being a mixture of urban and agricultural sources of the Sacramento River watershed while the Agricultural return water comprising of predominantly rice field pesticide and

nutrient application in the Colusa Basin Drain (Byard 1999; Orlando et al. 2020).

- The PMs are the direct effects of the contaminants on Delta Smelt Growth, Survival, and Recruitment and Zooplankton Abundance and Quality which are being scored by Expert Elicitation

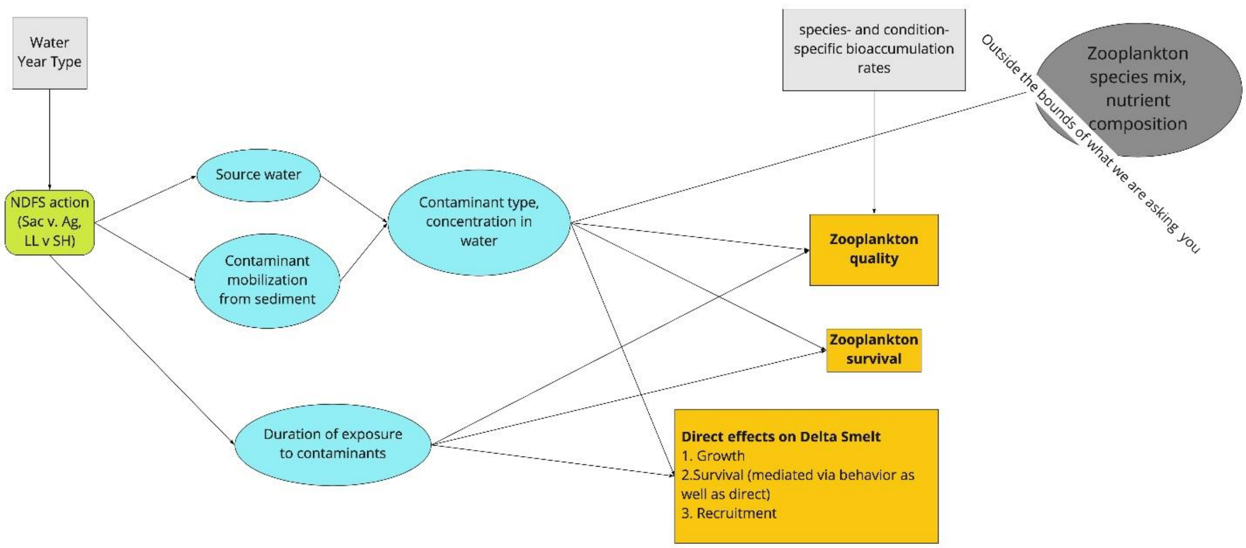
Influence diagram

Fig B-17 Simple influence diagram for Contaminants PM



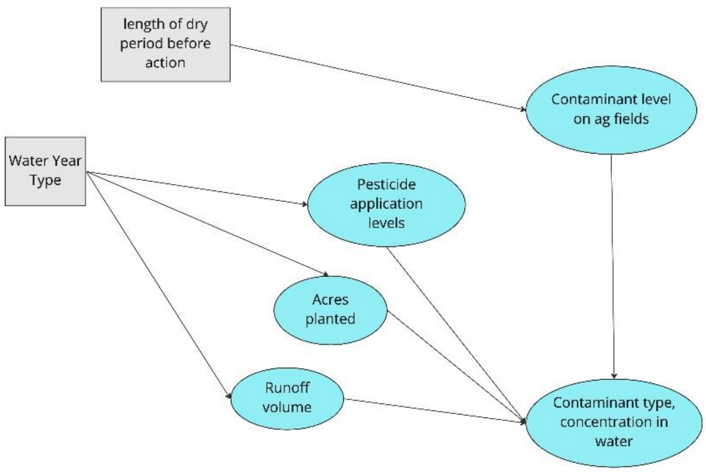
Based on comments from the first round of elicitation, elicitors developed a more refined conceptual model which the entire respondent group discussed ahead of the second round of elicitation. The final model, agreed on by all respondents, is below.

Fig B-18 Refined influence diagram for Contaminants PM. Contaminant type and concentration are a function of both sources water and contaminant mobilization. and duration of exposure is included as an additional determinant of effects on zooplankton and Delta Smelt. The diagram indicates possible importance of species- and condition-specific bioaccumulation rates and changes in zooplankton species mix and nutritional content but indicates that both are not considered.



We did not have time for respondents to fully score actions for Dry and Above Normal WYTs while providing for the same level of discussion; instead, we asked respondents whether they thought scores would be different under different water year types. Based on comments from the first round of elicitation, elicitors developed a conceptual model for effects of water year type on contaminant effects. This model (below) received less thorough discussion than the conceptual model linking NDFS actions to effects, but respondents expressed general agreement about this model. The Respondents noted they considered that land use practices would change regarding Water Year and that the length of prior dry years may impact first flush conditions following a wet period. For example, wet years following dry periods have greater contaminant loading comparatively (Sansalon and Buchberger 1997; Kaushal et al. 2014)

Fig B-19 Conceptual model for how water year type and antecedent conditions might influence contaminant exposure through human behavior (acres planted, pesticide application levels) as well as runoff volume and contaminant accumulation on agriculture fields.



Calculations and/or scoring

Expert Elicitation was used to evaluate different alternatives of NDFS that include the Agriculture and Sacramento River actions. Details of the elicitation (materials provided to the respondents, respondent names, etc.) are available in appendices to this infosheet.

Experts were asked to rate each of five alternatives relative to the No Action Alternative for each of five performance metrics using the following scale:

- **-2** = 50% or greater reduction in performance metric relative to the No Action Alternative, equivalent to an EC_{50}, where the effect is the relevant Performance Metric being evaluated
- **-1** = 10 - 49% reduction in performance metric relative to the No Action Alternative, equivalent to at least an EC_{10}**,** but less than EC_{50}
- **0** = insignificant (i.e. less than 10%) effect on performance metric relative to the No Action Alternative
- **1** = 10 - 49% increase in performance metric relative to the No Action Alternative
- **2** = 50% or greater increase in performance metric relative to the No Action Alternative

Performance metrics were

1. Zooplankton quality
2. Zooplankton survival
3. Delta Smelt growth
4. Delta Smelt survival
5. Delta Smelt recruitment

The first meeting with respondents took place December 14, 2022. Respondents received presentations on the DCG SFHA decision context and process, the NDFS alternatives, what is known from past implementation of NDFS alternatives, and the structure and purpose of the elicitation. After a period of discussion and information-sharing, respondents were given numbers and asked to provide scores and comments individually on coded data sheets. Most completed scoring during the meeting time, but all respondents were given until late December to complete scoring and comments. The elicitor group compiled and analyzed scores and responses, and created conceptual diagrams representing all factors discussed by respondents in their comments. A second meeting with the respondents took place on January 30, 2023. Results, analysis, and models were discussed with respondents. The group explored differences in scores to determine whether differences reflected different mental models, different interpretations of terms or questions, or different information. Based on this the group clarified two PMS as described below in this section, as well as uncertainties, assumptions, and other contextual factors as presented elsewhere. Following this discussion respondents were asked to re-score all alternatives.

1. *Defining "zooplankton quality."* Some respondents asked about effects of contaminants on zooplankton community structure, since different species may have different food value for delta smelt, and also about contaminant effects on nutritional quality of zooplankton overall. We emphasized that this elicitation focuses on *direct* effects of contaminants only; there are certainly indirect effects pathways that are not addressed in the current consequences evaluation. For the purposes of this evaluation, **we are defining "zooplankton quality" to focus on contaminant concentration and zooplankter biomass.**

2. *Defining "zooplankton survival."* Some respondents asked about differential mortality of different species. We asked respondents to generate scores based on **average mortality rates across species.**

We did not have time for respondents to fully score actions for Dry and Above Normal WYTs while providing for the same level of discussion; instead, we asked respondents whether they thought scores would be different under different water year types. During the first round of elicitation, we simply asked if their scores would be different. Results indicated a need for more a more precise question; for the second round of elicitation, we asked whether scores would be at least one point greater, one point lower, or unchanged.

Key assumptions and uncertainties

Contaminant exposure from sediment mobilization vs. duration of exposure. Respondents discussed the extent to which sediment mobilization contributes to contaminant exposure of aquatic organisms. Some felt that if contaminants are particulate-bound, they are essentially unavailable to zooplankton, so it would be important to know the extent to which contaminants in the sediment would be solubilized. Others suggested the possibility of zooplankton eating particles with bound contaminants. Other respondents felt that short-high actions were analogous to storm pulses, in which case the duration of exposure is less important than the high toxicity of the initial pulse.

Multiple factors influence contaminant effects. In the group discussion between the two rounds of elicitation respondents discussed a range of factors that influence the effects of contaminant exposure beyond simply the concentration of contaminants.

- The specific identity of contaminants matters. For example, one respondent commented that although overall contaminant concentrations were lower in Sacramento River water, they would want to know specifically about pyrethroid concentrations to provide a score. This uncertainty is moderately reducible based on existing data.
- The mix of contaminants also matters. One respondent has searched for data on effects of contaminant mixtures and found little that is relevant for this decision. He also said there is no single chemical that is always the most toxic; it depends on the mix of chemicals.

Theoretically uncertainty around interactive effects of contaminants with other contaminants and with environmental factors like salinity and temperature could be reduced through experiments, although given the number of different contaminants the number of interactions is quite large.

- Some respondents suggested considering using "toxic units" rather than concentration as a way to capture the combination of concentration and toxicity on Delta Smelt survival and Zooplankton abundance. Respondents were unsure what the research showed on whether and how T.U.s can be combined to assess the effects of contaminant mixtures. One respondent thought that T.U.s could be added to assess lethality but probably not for sublethal effects.
- Different toxicants have different adverse effects pathways therefore it is not clear what will be the predicted interaction and cumulative effects of contaminant exposure with different adverse effects pathways.
- Timing of exposure relative to life history stage matters, with earlier life stages typically more sensitive than later ones.
- There is little data on the effects of individual contaminant on delta smelt themselves; respondents are drawing on information from other species which is standard practice regarding novel species and applying contaminant toxicity data. Even for closely related species the type and severity of effects can be quite different. Reducing this uncertainty would be difficult without experiments involving exposing large numbers of Delta Smelt to a variety of toxicants.

Round 2 results

The complete results for Round 2 of the elicitation can be found here, on the DCG SharePoint. The first tab includes scores only; subsequent tabs provide scores and comments for each PM.

Consequences for Below Normal Water Year Type

Mean scores from 8 respondents in a Below Normal Year

Performance Metric	Ag Long-Low	Ag Short-High	Sac Long-Low	Sac Short-High	Sac-Ag
Zooplankton Quality	-0.88	-1.25	0.38	-0.25	-0.38
Zooplankton Survival	-0.75	-0.88	0.25	-0.25	-0.13
Delta smelt growth	-0.63	-0.75	0.13	-0.25	-0.25
Delta smelt survival	-0.13	-0.63	0.00	-0.25	-0.29
Delta smelt recruitment	-0.50	-0.57	0.13	-0.13	-0.29

Mean scores from 8 respondents in a Dry Year

Performance Metric	Ag Long-Low	Ag Short-High	Sac Long-Low	Sac Short-High	Sac-Ag
Zooplankton Quality	-.64	-.93	.36	-.21	-.21
Zooplankton Survival	-.5	-.64	.36	-.21	.07
Delta smelt growth	-.36	-.64	.21	-.21	-.07
Delta smelt survival	.07	-.5	.21	-.07	0
Delta smelt recruitment	-.36	-.29	.36	.07	0

Mean scores from 8 respondents in Above Normal Year

Performance Metric	Ag Long-Low	Ag Short-High	Sac Long-Low	Sac Short-High	Sac-Ag
Zooplankton Quality	-1.57	-1.86	-.57	-1.14	1.14
Zooplankton Survival	-1.43	-1.57	-.57	-1.14	-.86
Delta smelt growth	-1.29	-1.57	-.71	-1.14	-1.0
Delta smelt survival	-.86	-1.43	-.71	-1	.93
Delta smelt recruitment	-1.29	-1.21	-.57	-.86	-.93

Consequences for Effect of Water Year Type (average of 7 respondents)

Year Type	Score	Rationale (example expert responses)
Dry Year	-0.71	dry years tend to have increased pesticide use and release into water for both ag and urban settings (leading to higher concentrations compared with tox thresholds - might expect more likelihood of a negative effect on Delta smelt metrics) in a dry year, more contaminants are available for pulsed flow actions to remobilize, so they would become available with the pulse
Above Normal Year	0.21	extra water earlier in the year would flush a portion of the contaminant burden of the system out dilution by higher rainfall runoff No change in metrics expected

Additional information and context for interpreting results

Respondent group evaluation yielded more complex mechanisms for consideration that resulted in a more complex conceptual model for contaminant risk.

There were several aspects of scoring that were cognitively challenging for respondents, which adds to uncertainty around scores. Some noted their scores may have been affected by looking at cumulative direct and indirect effects of the action and not solely on the direct effects of contaminants.

> *Challenge: ignoring beneficial aspects of NDFS actions*. One aspect of scoring respondents found challenging was *not* considering the beneficial aspects of actions for zooplankton and delta smelt. In the discussion between rounds one and two we emphasized that beneficial consequences of NDFS options on zooplankton and smelt were being evaluated separately using existing models. The purpose of this elicitation is to account for the fact that those other models do not consider potential effects of contaminants. There was some discussion of ways to address this in future elicitations, such as eliciting some sort of "correction factor" for other performance metrics.

References

Byard, J. L. (1999). The impact of rice pesticides on the aquatic ecosystems of the Sacramento River and Delta (California). Reviews of Environmental Contamination and Toxicology: Continuation of Residue Reviews, 95-110.

Davis, B., Adams, J., Bedwell, M., Bever, A., Bosworth, D., Flynn, T., Frantzich, J., Hartman, R., Jenkins, J., Kwan, K., MacWilliams, M., Maguire, A., Perry, S., Pien, C., Treleaven, T., Wright, H., Twardochleb, L. 2022. North Delta Food Subsidy Synthesis: Evaluating Flow Pulses from 2011-2019. Department of Water Resources, Division of Integrated Science and Engineering. *Draft.*

Kaushal, S.S., Mayer, P.M., Vidon, P.G., Smith, R.M., Pennino, M.J., Newcomer, T.A., Duan, S., Welty, C. and Belt, K.T., 2014. Land use and climate variability amplify carbon, nutrient, and contaminant pulses: a review with management implications. JAWRA Journal of the American Water Resources Association, 50(3), pp.585-614.

Orlando, J.L., De Parsia, M., Sanders, C., Hladik, M., Frantzich, J. Pesticide concentrations associated with augmented flow pulses in the Yolo Bypass and Cache Slough Complex, California. US Geological Survey; 2020.

Sansalone, J.J., Buchberger, S.G., 1997. Partitioning and first flush of metals in urban roadway storm water. J. Environ. Eng. 123, 134–143.

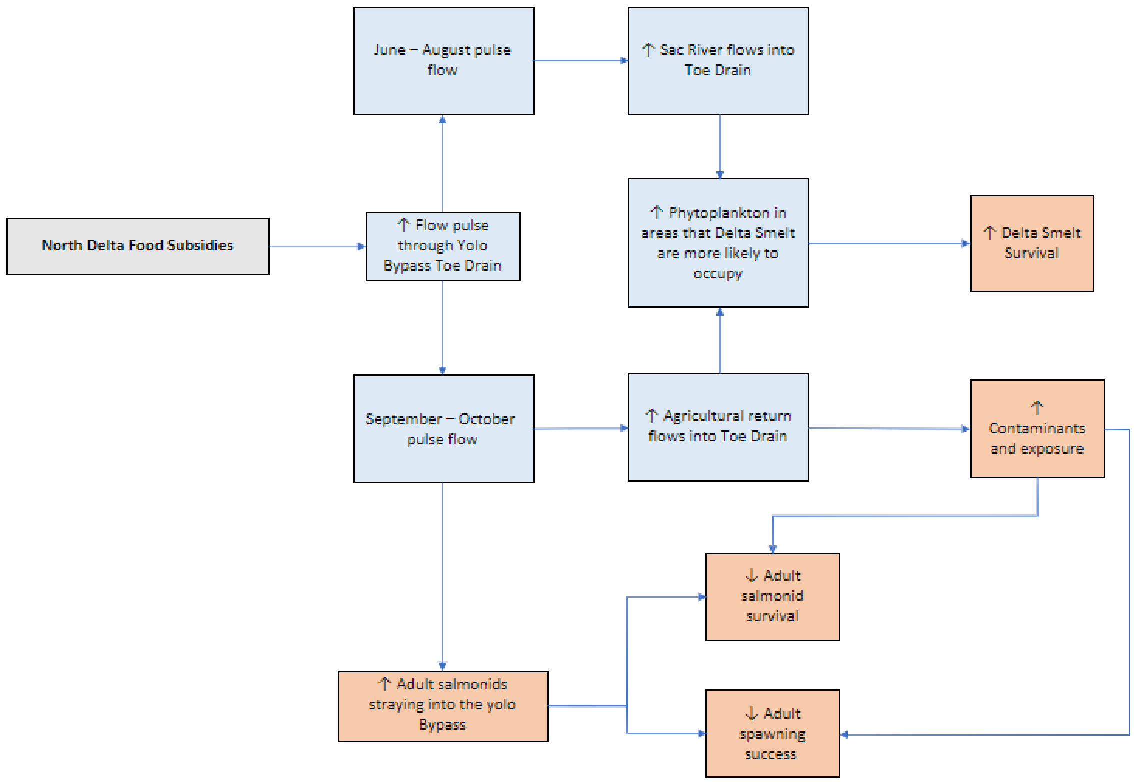
5. Effects to Other Species Performance Measure Infosheet

PM Summary

1. The effects of an NDFS action on individual and populations of Spring Run, Winter Run, and Fall Run Chinook Salmon, Steelhead and Green Sturgeon were scored using 2022's expert elicitation results, and 2023 minor improvements.
2. Winter Run and Spring run results summed to little or no negative effects of any NDFS action (i.e. Sacramento River flow pulse (SAC) or Agriculture drainage pulse (AG)).
3. Fall Run and Steelhead had greater negative effects on individuals with lessened effects on the population level, with an AG-pulse of 4 weeks more negative than a SAC-pulse of 4 weeks.
4. Green Sturgeon scores are provided but will not be included as sub-PMs in this 2023 consequence table.

Influence diagram

Figure B-20 Conceptual diagram presented to 2022 expert elicitation respondents from CDFW, Cramer Fisheries Sciences, and NMFS.



Calculations and/or scoring

1. 2023 Scoring

   A. Calculated the overall average score for individual and population level salmonid effects (adult averages and juvenile averages) that were provided in the 2022 elicitation in addition to DWR scores provided 2023. Each individual and population level scores included the average from 1-4 agencies (e.g., CDFW, NMFS, Cramer Fish Sciences, and DWR), and no weighting occurred.

   B. While it is unlikely, though not impossible, that juveniles would be present during action period (July -October), final scores included the average of adult and juveniles. Stage specific averages are provided in the scoring spreadsheets.

   C. A general 4-week managed pulse using Sacramento River or Agriculture drainage action were evaluated, and not 2023 alternatives including short or long durations, and low or high intensities.

2. 2022 Scoring: the following describes the constructed scale descriptions for the 2022 expert elicitation scoring and inputs.

   A. Individual effects score (-3 to 1).

Score	Description of Individual Effect Score
1	Overall, the action would benefit the salmonid in question.
0	Overall, the action would not affect the salmonid in question.
-1	Overall, the action would negatively affect the salmonid in question, with minor sublethal effects (occurring in up to 100% of exposed individuals) and/or low likelihood (occurring in <10% of exposed individuals) of serious sublethal or lethal effects.
-2	Overall, the action would negatively affect the salmonid in question, with intermediate likelihood (occurring in 10%-50% of exposed individuals) of serious sublethal or lethal effects.
-3	Overall, the action would negatively affect the salmonid in question, with high likelihood (occurring in >50% of exposed individuals) of serious sublethal or lethal effects.

   B. Population effects score (-3 to 1). For the purpose of the elicitation, respondents were asked to consider the population to refer to the "annual cohort" (either of up-migrating BY 2022 adults or out-migrating juveniles from BY 2021 or earlier). For example, if you expect the action to affect all up-migrating winter-run Chinook salmon adults, that would be an effect to 100% of the "population", rather than to ~33% of the population (assuming a 3-year average age of return and thus that ~2/3 of the overall adult population is in the ocean).

Score	Description of Population Effect Score
1	Overall, the action would benefit the salmonid in question.
0	Overall, the action would not affect the salmonid in question.
-1	Overall, the action would negatively affect the salmonid in question, with minor sublethal effects (occurring in up to 10% of the population) and very low likelihood (occurring in <1% of the population) of serious sublethal or lethal effects.

Score	Description of Population Effect Score
-2	Overall, the action would negatively affect the salmonid in question, with minor sublethal effects (occurring in up to 50% of the population) and/or low likelihood (occurring in <10% of the population) of serious sublethal or lethal effects.
-3	Overall, the action would negatively affect the salmonid in question, with minor sublethal effects (occurring in >50% of the population) and/or intermediate to high likelihood (occurring in >50% of the population) of serious sublethal or lethal effects

Key assumptions and uncertainties

1. Sources, types, magnitude of uncertainty
   A. We assumed that the scores for the four-week SAC or AG actions apply to the duration and intensity alternatives (e.g., long-low and short-high) since previous elicitation scores did not include those specific alternatives. However, a general evaluation of a 4-week pulse will likely have overlap given the operation ranges of 2-4 weeks (short) and 4-6 weeks (long), but intensities would vary and were not accounted for in evaluations.
   B. We assumed Above Normal and Dry WY scores would be the same as Below Normal (when Above Normal or Dry WY scores were not available). Only an AG-action was included in the Dry year elicitation scores in 2022 (compared to inclusion of a SAC alternative in 2023), and no AN evaluation occurred; however, DWR did score a SAC action in a Dry year which was included. It is assumed the relative difference across action alternatives (Sac v. Ag) would be similar.
   C. Assumed similar understanding of action alternatives across elicitation respondents.
   D. Assumed evaluation was in reference to a no-action alternative which includes a non-managed seasonal pulse in the bypass with existing conditions and potential exposures to water quality stressors.
2. Reducibility
   A. While there is some uncertainty in reproducibility, given differences in agency respondents and level of understanding of the NDFS

action, Yolo Bypass, and salmonids, relative scores would likely be similar in another elicitation.

B. Because we didn't do a second round in WY 2022, or pursue a new elicitation in WY 2023, it is also possible that respondents might revise their absolute score levels. Again, we believe relative scores would likely be similar in another elicitation.

Results

Final Scores for Below Normal & Above Normal alternatives (all based on WY 2022 Below Normal scoring): See Additional Information section below for Stage-Specific scores.

		AG - 4 wk pulse	**SAC - 4 wk pulse**
Species	**Level**	**Average score (stage-agnostic and stage-specific averaged together)**	**Average score (stage-agnostic and stage-specific averaged together)**
Spring Run	Individual	-0.25	0
	Population	0	0
Fall Run	Individual	-1.5	-0.63
	Population	-1.17	-0.33
Steelhead	Individual	-1.2	-0.25
	Population	-0.6	0
Winter Run	Individual	0	0
	Population	0	0
Green Sturgeon	Individual	-1.5	0
	Population	0	0

Final Scores for Dry alternatives (SAC action scores partially based on WY 2022 Below Normal scoring): See Additional Information section below for Stage-Specific scores.

		AG - 4 wk pulse	SAC - 4 wk pulse
Species	**Level**	**Average score (stage-agnostic and stage-specific averaged together)**	**Average score (stage-agnostic and stage-specific averaged together)**
Spring Run	Individual	-0.25	-0.08
	Population	0	0
Fall Run	Individual	-1.5	-0.38
	Population	-1.17	0
Steelhead	Individual	-1.2	-0.13
	Population	-0.6	0
Winter Run	Individual	0	0
	Population	0	0
Green Sturgeon	Individual	-1.5	0
	Population	0	0

Additional information and context for interpreting results

Dry Year results (only AG alternative):

		AG- 4 wk pulse		
Species	**Level**	**Average score (juveniles/sub -adults)**	**Average score (adults)**	**Average score (stage-agnostic and stage-specific averaged together)**
Spring Run	Individual	0.25	0	-0.25
	Population	0	0	0
Fall Run	Individual	-0.5	-1.5	-1.5
	Population	NA	-1.5	-1.17
Steelhead	Individual	0	-2	-1.2
	Population	0	-1	-0.6
Winter Run	Individual	0	0	0
	Population	0	0	0
Green Sturgeon	Individual	-2	-1	-1.5
	Population	0	0	0

Below Normal Year results:

		AG - 4 wk pulse		SAC - 4 wk pulse	
Species	**Level**	**Average score (juveniles/sub-adults)**	**Average score (adults)**	**Average score (juveniles/sub-adults)**	**Average score (adults)**
Spring Run	Individual	-0.25	0	0	0
	Population	0	0	0	0
Fall Run	Individual	-0.5	-1.5	-0.5	-1
	Population	NA	-1.5	NA	-1
Steelhead	Individual	0	-2	0	-0.5
	Population	0	-1	0	0
Winter Run	Individual	0	0	0	0
	Population	0	0	0	0
Green Sturgeon	Individual	-2	-1	0	0
	Population	0	0	0	0

6. Resource Cost Performance Measure Infosheet

Take home messages

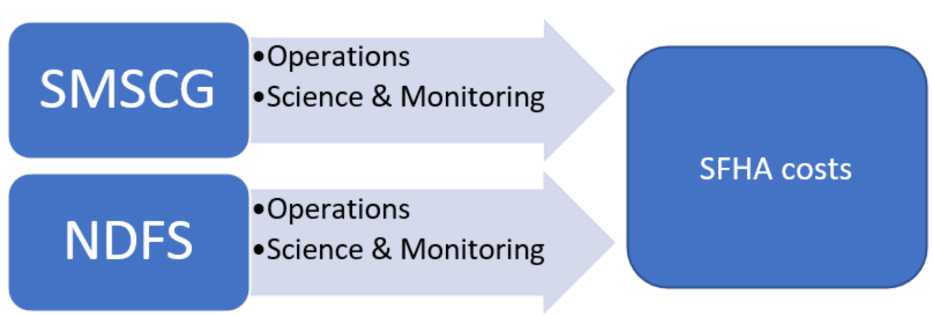
- All actions will be accompanied by science and monitoring that will increase costs by approximately 100K-200K, chiefly through re-directing staff time.
- NDFS actions will require additional coordination and planning, costing approximately 100K for ag actions and 200K-250K for Sac actions.
- Any cost below 500K is a very, very small percentage of the State Water Project's annual budget.

PM Summary

Resource Costs were identified as a decision objective for the 2022 SFHA SDM. Costs include direct management costs for staff, operations used to implement actions, and science and monitoring including field and lab work, contracting costs, analysis, and reporting. The performance metric used for evaluating costs is USD/year.

Influence diagram

Fig B-21 Influence diagram for Resource Costs PM



Calculations and/or scoring

1. Operations and science and monitoring costs were derived from DWR’s PPM/RM platform for SMSCG and NDFS for 2022-2024 planning. Action planning, implementation, and reporting cross CY and FYs, therefore, estimated values were calculated using the average of Jul-Dec 22 + Jan-Jun 23 budgets (labor and OEE) and Jul-Dec 23 and Jan-Jun 24.
2. Further discussion of costs across various scenarios occurred with project leads.
3. Additional costs for scenarios not implemented previously were estimated (e.g., NDFS Sac+Ag action).

Key assumptions and uncertainties

- Assumptions
    - Monitoring costs similar across water year types and no action (baseline monitoring)
    - PPM/RM budgets plan for maximum costs
- Uncertainties
    - Resources available annually
        - IEP long-term surveys
        - Continued contract support
    - Monitoring improvement costs (e.g., AD MGT recommendations, directed studies, effects to other species monitoring)
    - NDFS operation costs similar for short or long duration
    - SMSCG boat lock operator staffing through summer or not
    - Interagency costs for planning and coordination

Round 1 results

Action	Difference from No-Action	Comments/rationale
1. Dry Year. NDFA – Ag Flow - high magnitude, short duration	$100k	2022 (814k) 2023 (788k) Ave 801 for Science & Monitoring Difference from no-action includes increased coordination and planning -Uncertain KLOG, Wallace, FTC external costs?
2. Dry Year. NDFA – Ag Flow - low magnitude, long duration	$100k	assumes operation costs at KLOG are the same for long duration. 100k increase for coordination and planning of action
3. Below Normal Year. NDFA – Ag Flow - high magnitude, short duration	$100k	100k increase for coordination and planning of action
4. Below Normal Year. NDFA – Ag Flow-low magnitude, long duration	$100k	100k increase for coordination and planning of action
5. Below Normal Year. NDFA – Sac Flow-low magnitude, long duration	$250k	Ave. Ag costs + Sac operations (GCID/RD108 pumping) which can be ~150-200k +increased planning and coordination staff costs (~100k).
6. Below Normal Year. NDFA – Sac Flow - high magnitude, short duration	$250k	Uncertain duration costs - if GCID and RD108 pumping at lower rates for longer duration in #5, or stable pumping and Wallace/KLOG ops to increase pulse duration
7. Below Normal Year. NDFA – Sac summer action + Fall ag action. Low magnitude, high duration	$500k	Ave. Ag costs + Sac operations (GCID/RD108 pumping costs. $250k) + additional 2 months monitoring and science (labor & OEE, $250k)

Action	Difference from No-Action	Comments/rationale
8. Below Normal Year. SMSCG – Nonconsecutive. Start when Beldon's >4ppt	$250k	2022 (379k) 2023 (441k) Normal ops ($88.6k): flashboards taken out for boat passage. Removing flashboards cost 37k + 45k to put back in (covered w/ normal ops). Gates in summer (boards taken out in May), but if taken out in June not cost efficient so need a boat lock operator staff during all summer (~$104k). Currently Delta Field Division pays boat op staff through IEP FC not AM FC. Add potentially Smelt budget if cages deployed ($150-200k). Ave. Sci & Monit (410k baseline) +ops ($104k) + cages (150k)
9. Below Normal Year. SMSCG – Nonconsecutive. Start when Beldon's >6ppt	$250k	Same at 4ppt Ave. Sci & Monit (410k baseline) +ops ($104k) + cages ($150k)
11. No action	0	Total costincludes SMSCG and NDFS baseline monitoring costs. ~$1.2 mil planned in DWR PPM budgets. No-action may result in reduced planning and coordination costs. 2021 no action year spent ~1 mil (~200k less than planned).

Additional information and context for interpreting results

- No SFHA = Estimated $1 mil (baseline monitoring costs), set to 0 at the alternative scoring.
- SFHA (NDFS Ag + SMSCG) = ~$1.35 mil (same as no Action + special study and increased coordination (e.g. smelt cages))
- SFHA (NDFS Sac + SMSCG) = ~$1.5 mil
- SFHA (NDFS Sac/Ag + SMSCG) = ~$1.75 mil

7. Learning Performance Measure Infosheet

Take Home Messages

1. There are multiple types/goals of learning and pathways for learning; this PM addresses only learning withing the current decision frame.
2. Other learning goals and pathways do matter, and have been informed by this SDM process. This includes discussions about reframing the decision problem, revising or refining objectives, PMs, and how consequences are estimated, options for continuing to strengthen the linkage between science and monitoring recommendations and SFHA decision making, etc.
3. Learning potential (reflecting the current state of knowledge) was more informative than learning increment (how much would be learned through taking action) or learning about feasibility.

Context

When DCG was deliberating about recommendations during the WY 2022 SDM effort, some DCG members brought up learning as a reason to implement an NDFS action. This included learning about effectiveness of the actions and learning about the feasibility of doing a combined Sac-Ag action.

More broadly, DCG deliberations have highlighted that while we have estimated consequences for delta smelt growth, zooplankton, habitat, contaminants, and effects on other species, our uncertainty about model structure and parameterization is profound and our confidence in these numbers is low. Making decisions in the face of such uncertainty is challenging, to say the least!

Given that some DCG members are considering learning in their evaluation of alternatives, there is a utility to formalizing learning as an objective. This makes explicit what learning is important for what reasons and allows a more formal evaluation of consequences, thus making risks, benefits, and tradeoffs related to learning more transparent.

Goals of Learning

Learning is less about improving the expected outcome of this year's decision and more about improving the quality of future decisions. This could be improving decision quality by changing the framing, developing new and better alternatives, gaining certainty/clarity on consequences and risks, or gaining certainty/clarity on feasibility. There are at least three purposes of learning that have come up in DCG and learning sub-group discussions:

1. **More informed SFHA decisions within the current decision frame.** WY2022 SFHA decisions came down to making trade-offs (are the potential gains of the action worth the potential costs?) in the face of uncertainty. The value of learning from this perspective would be increasing the ability of DCG members to evaluate risks and trade-offs in future rounds of SFHA decision-making through increased precision and accuracy or refined probabilities in consequence estimation.
2. **Learning to inform optimization of the NDFS itself.** There has never been a Sac-Ag action, so we know little about feasibility or effects of this action; implementing a Sac-Ag action would be a first step towards addressing this knowledge gap. There may also be aspects of how Sac or Ag actions are implemented that could be further optimized through additional learning and experience. The value of learning from this perspective would be increasing the performance of decision alternatives relative to ecological objectives or creating new alternatives.
3. **Learning to inform development and implementation of related actions** elsewhere in the Delta. Some alternatives may generate data or insights relevant to other efforts. For example, data on delta smelt growth could inform life cycle models.
4. **Knowing when to pivot to other actions.** Learning would help to better understand whether effectiveness of current SFHAs is low enough that we would want to put significant effort toward developing other actions. This falls outside the current decision frame but is of interest to many DCG members.

Pathways for learning

Decision-relevant learning can occur through a variety of means, including:

1. Background monitoring of the system regardless of what SFHAs are implemented.
    A. This is ongoing. Enhanced or new monitoring approaches may be suggested to enhance learning; to date these discussions have occurred mostly within the SMWG.
2. Experiments or targeted studies that are designed to fill information gaps. Some of these may be independent of SFHA implementation; others may require the implementation of specific management actions.
    A. To date, detailed discussion about monitoring, experiments, and targeted studies have occurred primarily in the SMWG rather than the full DCG, as well as in CAMT.
3. Improved qualitative or quantitative modeling.
    A. To date, this has occurred as part of improving consequences assessment (e.g. expert elicitation for contaminants and effects on other species; changes to growth modeling), or outside of DCG (e.g. CAMT).
4. Implementation of management actions. Although such actions are designed to achieve management rather than learning outcomes, there may be times when a potentially risky or non-optimal action may be taken to enhance learning outcomes. An essential component of learning-by-doing is having monitoring and evaluation in place to assess relevant outcomes.
    A. Within the current framing of DCG's SFHA decision, this would be the primary utility of a learning PM: to help DCG members more formally assess the relative learning benefit(s) of different alternatives.
5. Deliberation and discussion associated with each round of the PrOACT process may generate insights that lead to the development of new or refined alternatives, new or refined objectives and PMs, or even problem reframing.
    A. This may not be relevant to the comparison of current alternatives but may be important to recognize as a means for improving future

decision making. E.g., including effects to other species risk as a decision objective stimulated discussion that led to the suggestion of developing modified Ag actions in which the initial pulse of water that's particularly low in dissolved oxygen would be diverted through Knights Landing Outfall Gates

Characterizing uncertainties:

Two categories of uncertainty were raised during DCG's WY 2022 deliberations: uncertainty around the consequences of an alternative, and uncertainty around the feasibility of the Sac-Ag action, which has never been implemented.

Decision relevance

Interest in learning about feasibility was explicitly cited as a factor in at least one DCG member's alternative preference in WY 2022 and is likely to be relevant for WY 2023 as well.

Habitat and water cost PMs did not differ among NDFS alternatives in the WY 2022 analysis. Other PMs either did differ (food, growth, contaminants, and operational costs) or were not fully assessed (effects on other species). Although WY 2022 PM scores didn't include a formal expression of the degree of uncertainty, there is large uncertainty related to each of these PMs. Thus, the decision-relevant uncertainties include effects of NDFS alternatives on

- Delta Smelt Food and Growth
- Contaminant Risk
- Operational Costs
- Effects on other Species

The SMWG has proposed new science and monitoring studies to address some of these uncertainties (see the SFHA MSP and 9-9-22 SMWG presentation by Laura Twardochleb), specifically the extent to which phytoplankton and zooplankton transported by NDFS flow pulses translate into increased smelt growth. These would be addressed via stable isotope studies on prey and caged fish.

Reducibility

Some uncertainties are irreducible, such as uncertainties related to stochastic factors. These uncertainties must be accepted and addressed through a risk framework.

For uncertainties that could theoretically be reduced or eliminated the question is whether it is worth doing so. What would it take to meaningfully reduce uncertainty? Since the primary decision here is about which NDFS alternative, if any, to implement, the question becomes: how much would implementing each NDFS alternative contribute to reducing uncertainty?

Below is a brief summary of what we know about the reducibility of uncertainty related to decision-relevant PMs.

- Growth: We have no data on the actual effects of NDFS on delta smelt growth. The modeled growth increments related to NDFS alternatives are so small that they would fall within the range of measurement error, making them essentially irreducible from a data perspective if models are correct. That said, if growth effects are higher than predicted, cage studies could produce really useful information.
    - Special studies: the DCG has expressed support for cage studies to provide field measurements of delta smelt growth.
- Food: There are enough data related to NDFS and zooplankton to support a power analysis (Brandon et al. 2022). The report concluded: "Simulation results also suggest the power to detect differences in total zooplankton CPUE was generally low for the NDFS action, even for relatively high effect sizes... Power to detect moderate changes in biomass remained low regardless of increasing sample size or increasing number of action years. Future efforts aimed at detecting the effects of managed outflow actions on prey biomass in the estuary and delta should focus on long term monitoring efforts (i.e. adding more years of data)."
    - Special studies: The DCG has expressed support for stable isotope studies to look for evidence that managed pulses led to increased food availability in Cache Slough. This will require some years with no action to map the isoscape.
- Contaminant Risk: A large chunk of the uncertainty here is related to the effects of contaminants on Delta Smelt. Choice of SFHA would do

little to reduce this uncertainty. There is also uncertainty related to how much mobilization there would be of contaminated sediments; without special studies, this would also not be reduced.

  - Special studies: The DCG has not recommended special studies targeting contaminants at this time, although the cage studies could provide some information on direct effects of contaminants on delta smelt and prey.

- Operational Costs: Most cost uncertainty is related to stochastic factors and is not very reducible.
- Effects on Other Species: Discussion of effects on other species has focused mostly on how redistribution of stored water would affect adult salmonids stranding and egg mortality. The complexity of water management decisions in the Delta makes it difficult to link particular alternatives with specific reservoirs. Additionally, NDFS is assumed to have negligible water costs because it involves the redistribution of water that's already in the system. Effects related to water quality parameters currently being monitored in relevant location (e.g. dissolved oxygen at Ridge Cut Slough) will be reduced slowly over time.
- Feasibility: For actions that have never been implemented, uncertainty related to feasibility is highly reducible.

Calculations and/or scoring

The learning subgroup considered a variety of options for a learning PM. There continues to be strong interest by some DCG members in a quantitative value of information analysis. Although analytically appealing, this approach would be challenging for this decision given that there are no probabilities or probability distributions currently associated with consequence estimates. Additionally, the range of learning goals suggests that a broader "value of learning" approach (*sensu* McDaniels and Gregory 2004) may be appropriate for decisions focused primarily on NDFS implementation.

The learning objective has been broken into two sub-objectives: *learning about feasibility* and *learning about effectiveness*.

Learning about feasibility was scored on a 1 – 3 scale, with 1 being little to no learning and 3 being high learning.

Learning about effectiveness has been broken into two components: "*learning potential*" and "*learning increment*." Individual scores were summed for a total effectiveness score.

1. *Learning potential* was scored on a 1 – 5 scale based on the number of the times an action had been implemented or a similar flow pulse occurred through unmanaged flows since monitoring began in 2011 (Table B-6; see Action Specification sheet for more details about past flow pulses). Lower scores indicate a greater amount of existing data (i.e. lower learning potential).

Table B-6 Number of times different actions or pulse types have been studied (i.e. have monitoring data). Actions that have never been implemented include Ag short/high, Ag long/low, and Sac long/low.

Action	Critically Dry	Dry	Below Normal	Above Normal	Wet	Total
No action	3	1			1	**5**
No action, similar to long-low	1	1			1	**3**
Ag long/high			1		1	**2**
Sac short/high			1			**1**
Repair short-long/high			1			**1**

1. *Learning increment* reflects how much additional learning would be gained by implementing the alternative in question. Assumptions related to scoring are as follows:
   A. Assume similar learning regardless of water year type. There could be learning related to antecedent conditions, (e.g. the effectiveness in a wet year following a dry year, like 2016), but this was not addressed this year

B. Contaminants, food, growth, effects on other species:
   i. With no special studies: assume learning increment is relatively low because of high variability in system, confounding factors.
   ii. With cage studies:
      a. Food, growth: assume medium learning increment
      b. Contaminants: maybe medium-low?
      c. Effects on other spp: still low
C. Because of the coarse scale, we have lumped learning about contaminants, food, growth, and effects on other species into a single number using the above assumptions
D. For this round of analysis, we will lump feasibility and ops cost

Results: Feasibility

Table B-7 Learning about feasibility. Higher = better

Action	Feasibility	Comments
No action	1	—
Ag long/low	2	Assuming operation capacity to coordinate and control flow rates (e.g., KLOG, Wallace Weir)
Ag short/high	1	—
Sac long/low	2	—
Sac short/high	1	—
Sac-Ag	2	Assume it’s as feasible as component actions

Results: Effectiveness, with special studies

Table B-8 Learning about effectiveness with special studies. Higher = better

Action	Learning potential	Learning increment, special studies	Effectiveness, with studies
No action	1	1	**2**
Ag long/low	2	2	**4**
Ag short/high	2	2	**4**
Sac long/low	3	2	**5**
Sac short/high	3	2	**5**
Sac-Ag	4	2	**6**

Results: Effectiveness, without special studies

Table B-9 Learning about effectiveness without special studies. Higher = better

Action	Learning potential	Learning increment, no special studies	Effectiveness learning, no studies
No action	1	1	**2**
Ag long/low	2	1	**3**
Ag short/high	2	1	**3**
Sac long/low	3	1	**4**
Sac short/high	3	1	**4**
Sac-Ag	4	1	**5**

References

Brandon, J., C. Lee, A. Smith, S. Acuña, and A.A. Schultz. 2022. Chapter 9: Detecting responses of Delta Smelt prey biomass to freshwater outflow management action in a highly altered estuarine system: using power analysis to evaluate environmental monitoring sampling. Pages 239-266 in Bertrand, N.G., K.K. Arend, and B. Mahardja. Directed Outflow Project: Technical Report 3. U.S. Bureau of Reclamation, Bay-Delta Office, California-Great Basin Region, Sacramento, CA. June 10, 2022, 284 pp.

McDaniels, T.L., & Gregory, R. (2004). Learning as an objective within a structured risk management decision process. Environmental Science and Technology, 38 (7), 1921–1926.

Appendix C. Contaminant Expert Elicitation Summary

Round 1 Elicitation

The following information/document was shared with experts at IEP Contaminants Project Work Team on December 14th, 2022. Additionally, a PowerPoint presentation describing the NDFS action and previous findings was provided.

Contaminant Expert Elicitation 2023

Background: The Summer Fall Habitat Action (SFHA) includes a suite of Actions intended to improve habitat and food in the San Francisco Bay-Delta Estuary, thereby improving Delta Smelt growth, survival, and recruitment. While the proposed Actions are aimed to benefit Delta Smelt, they may unintentionally result in negative effects such as increased or mobilized contaminants; however, these effects are uncertain.

Purpose: To elicit expert judgment on how the proposed Actions (described below) for the 2023 SFHA year will affect contaminant risk to a set of endpoints; including scores to evaluate in a structured decision model, rationale behind those scores, and a description of sources, magnitude, and reducibility of uncertainty to inform both this year's decision and future research or elicitation processes.

Approach: Two groups will be formed, including 1) an Elicitor Group to formulate the questions and provide descriptions of the 2023 proposed Action and their potential effects on contaminant concentrations, and 2) a Respondent Group to review the actions (alternatives) and provide estimates for performance metrics on Delta Smelt and zooplankton.

Action:

- North Delta Food Subsidy (NDFS) Action
    - Use redirected Sacramento River (SAC Action) or Agricultural Return (AG Action) water (~20-25 TAF for 2-6 weeks) that will result in net positive flow from the Yolo Bypass into the Cache Slough Complex
    - Hypothesized to increase plankton densities in the North Delta resulting in improved growth and survival of Delta smelt.
    - Alternatives
        - No Action
        - **Ag short-high**: NDFS with AG Action in August/September with high intensity, short duration (e.g., 800 cfs for 2 weeks)?
        - **Ag long-low**: NDFS with AG Action in August/September with low intensity, long duration (e.g., 400 cfs for 4 weeks)?
        - **Sac short-high**: NDFS with SAC Action in July/August with high intensity, short duration?
        - **Sac long-low**: NDFS with SAC Action in July/August with low intensity, long duration?
        - NDFS with sequential implementation of the SAC Action in August and AG Action in August/September with low intensity, long duration?
    - Water Year Type and Alternatives considered
        - Dry – alternatives 2-6
        - Below Normal– alternatives 2-6 above
        - Above Normal - only alternatives 4-5 above

Performance Metrics

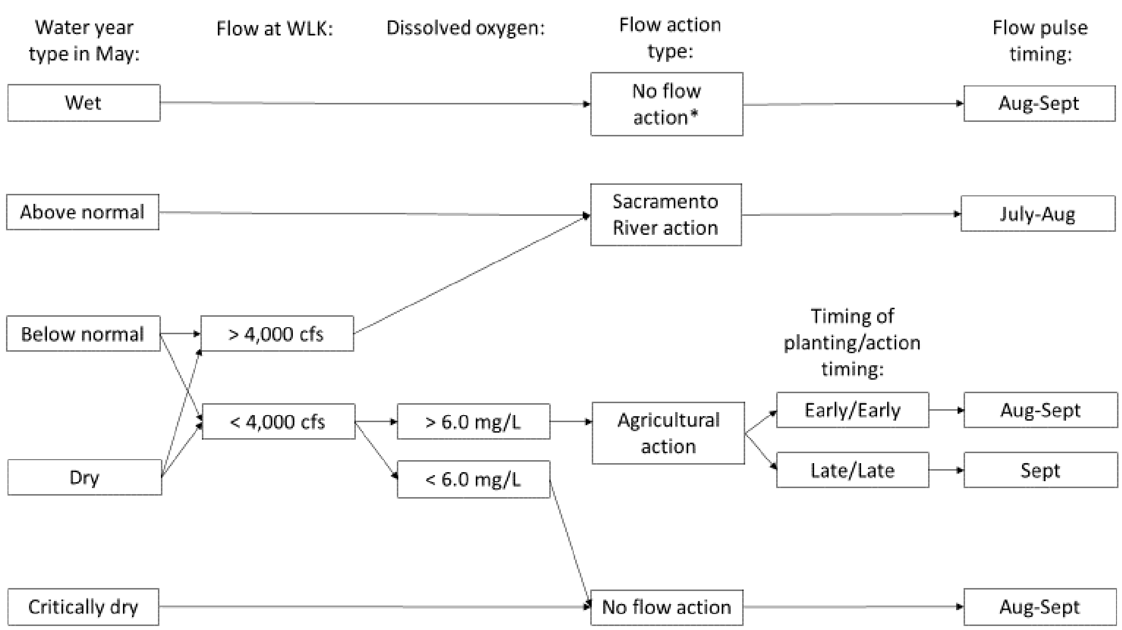
- All performance metrics will be contrasted with a No Action Alternative. The Respondent will provide their opinion on whether there is a significant change due to the action in comparison to the No Action Alternative.
- The five performance metrics are delta smelt survival, growth, and recruitment, and zooplankton abundance and quality.
- Delta smelt metrics for **Survival** and **Growth** should reflect only the **direct acute term effects** of contaminants on Delta smelt.

- Delta smelt **Recruitment** should reflect only the **direct long-term effects** on DS Recruitment from sublethal effects from contaminants.
- Zooplankton **Abundance** should reflect only the **direct acute effects** of contaminants on survival.
- Zooplankton **Quality** should reflect only the **direct acute effects** on the composition of zooplankton that would lead to a change in availability of preferred prey for Delta smelt.

Fundamental Question

- Will the NDFS Action significantly increase, decrease, or not significantly affect the performance metrics for Delta Smelt (growth, survival, and recruitment) and zooplankton (survival and quality) relative to the No Action alternative?

Figure C-1 Conceptual decision chart for conducting a Sacramento River (SAC) vs. Agricultural (AG) NDFS action. SAC action alternatives are dependent on flow (>4000-5000 cfs) at Sacramento River below Wilkins Slough (WLK). Modified from Twardochleb et al. 2022, North Delta Food Subsidies Study 2021-2023 Operations and Monitoring Plan.



Response

- Experts will be solicitated independently to respond to the above questions regarding the Actions effect on Performance Metrics relative to No Action
- Experts will respond to each question (using the provided tables) with a score from -2 to 2 with
  - -2 = 50% or greater reduction in performance metric relative to the No Action Alternative, equivalent to an EC_{50}, where the effect is the relevant Performance Metric being evaluated
  - -1 = 10 - 49% reduction in performance metric relative to the No Action Alternative, equivalent to at least an EC_{10}**,** but less than EC_{50}
  - 0 = insignificant (i.e. less than 10%) effect on performance metric relative to the No Action Alternative
  - 1 = 10 - 49% increase in performance metric relative to the No Action Alternative
  - 2 = 50% or greater increase in performance metric relative to the No Action Alternative

Proposed assumptions and effect of Actions on contaminants

- NDFS Action Assumptions on Contaminants
  - Compared to No Action Alternative the contaminants in the Cache Slough Complex will change based on how much water is entering the Cache Slough Complex and how much is exiting the Cache Slough Complex.
  - The Contaminants entering from the AG Action is of higher concentration and number than in the Cache Slough Complex
  - The Contaminants entering from the SAC Action is of lower concentration and number than in Cache Slough Complex
  - The High Intensity/ Low Duration action have a greater probability of mobilizing more contaminants compared to a Low Intensity/ Long Duration action.

Figure C-2 Map of the North Delta Foodweb Subsidy area, including the Colusa Basin Drain, Yolo Bypass, Toe Drain and the into the Cache Slough Complex.

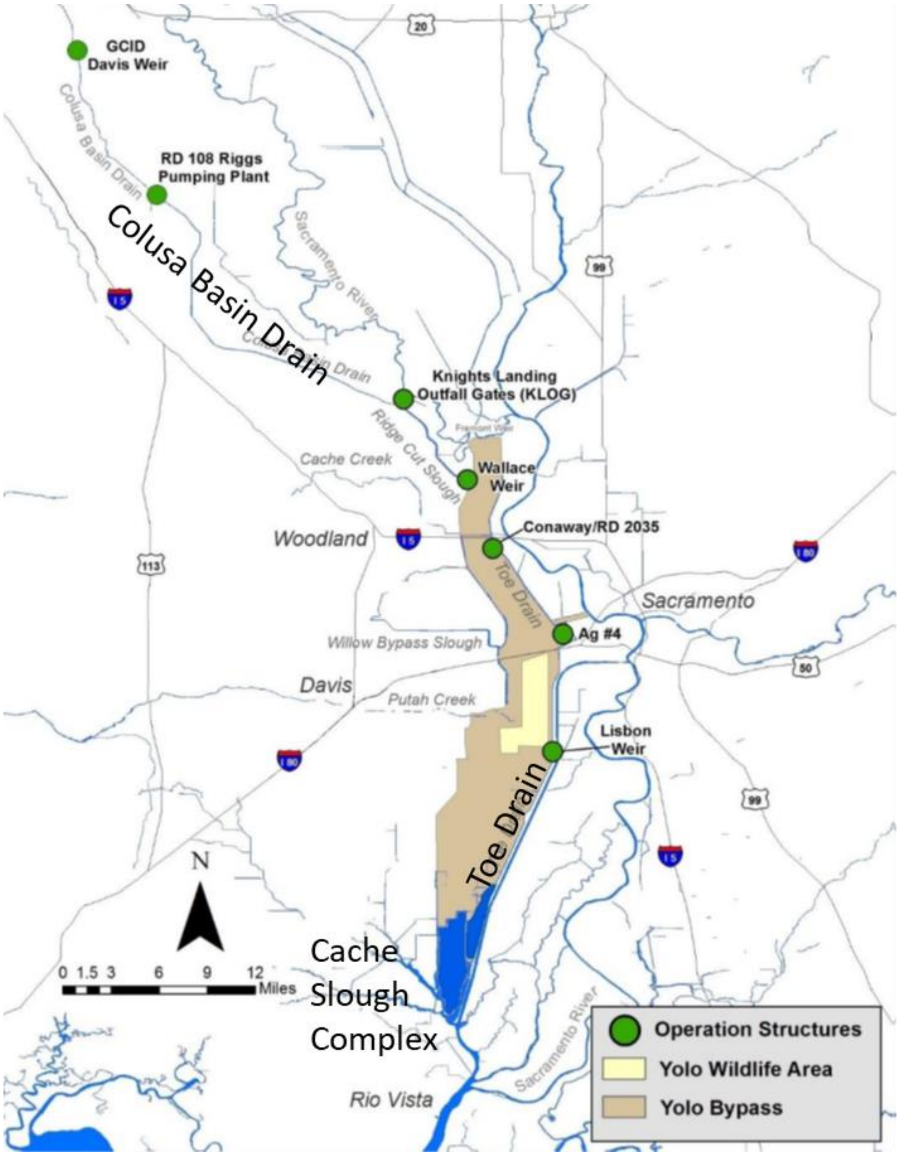
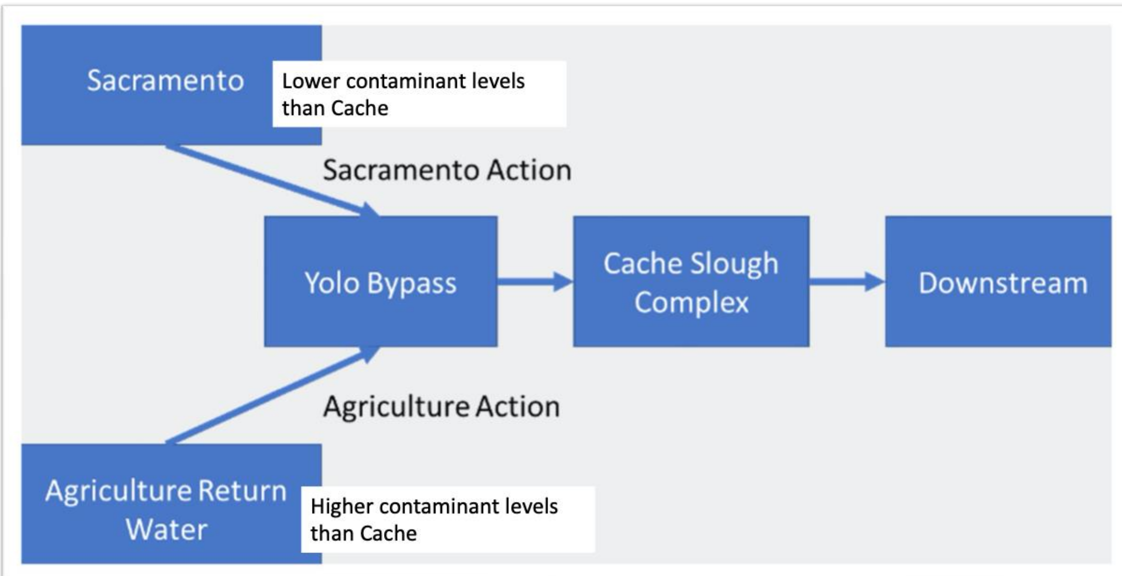


Figure C-3 Box model for the North Delta Foodweb Subsidy. Sacramento Action model begins with the water from the upper Sacramento to the Yolo Bypass to Cache Slough Complex and then Downstream. The Agriculture Action begins with the Agricultural return water to the Yolo Bypass to Cache Slough Complex and then Downstream.



Round 1 Survey Results

Table C-1 A summary of round 1 elicitation scores for each expert (e.g., E1, E2,) performance measure (e.g., zooplankton and delta smelt) and NDFS action alternative (e.g., Ag Long-Low). The average scores in a Below Normal water year were used for DCG evaluation after Round 2 refinement.

Objective: Zooplankton quality														
Alternative	**Min**	**Max**	**Diff**	**Average**	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Ag Long-Low	-2	2	4	-0.88	-2	-2	-1		-1	2	-1		0	-2
Ag Short-High	-2	1	3	-1.13	-1	-2	-2		-2	1	-2		0	-1
Sac Long-Low	0	2	2	1.25	2	1	0		1	2	1		1	2
Sac Short-High	-1	1	2	0.13	1	0	-1		0	1	-1		1	0
Sac-Ag	-2	2	4	0.38	0	2	-2		-1	2	1		0	1
Objective: Zooplankton survival														
Alternative	**Min**	**Max**	**Diff**	**Average**	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Ag Long-Low	-2	1	3	-0.5	-1	-2	0		-1	1	-1		1	-1
Ag Short-High	-2	1	3	-0.75	-1	-2	-1		-2	1	-2		1	0
Sac Long-Low	0	1	1	0.75	1	0	0		1	1	1		1	1
Sac Short-High	-1	1	2	0.25	1	0	0		1	1	-1		0	0
Sac-Ag	-1	1	2	0.13	0	-1	-1		-1	1	1		1	1
Objective: Delta smelt growth														
Alternative	**Min**	**Max**	**Diff**	**Average**	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Ag Long-Low	-1	0	1	-0.75	-1	-1	-1		-1	0	-1		0	-1
Ag Short-High	-2	0	2	-0.88	0	-1	-2		-1	-1	-2		0	0
Sac Long-Low	0	1	1	0.5	1	1	0		0	0	1		0	1
Sac Short-High	-1	1	2	0	1	0	-1		0	0	0		0	0
Sac-Ag	-2	1	3	0	0	1	-2		-1	0	1		0	1
Objective: Delta smelt survival														
Alternative	**Min**	**Max**	**Diff**	**Average**	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Ag Long-Low	-2	0	2	-0.38	0	-2	0		0	0	0		0	-1
Ag Short-High	-1	0	1	-0.63	0	-1	-1		-1	-1	-1		0	0
Sac Long-Low	0	2	2	0.25	0	2	0		0	0	0		0	0
Sac Short-High	-1	0	1	-0.13	0	0	0		0	0	-1		0	0
Sac-Ag	-1	1	2	-0.13	0	1	-1		-1	0	0		0	0
Objective: Delta smelt recruitment														

Objective: Zooplankton quality														
Alternative	**Min**	**Max**	**Diff**	**Average**	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Ag Long-Low	-1	0	1	-0.5	0	-1	-1		-1	0	-1		0	0
Ag Short-High	-2	0	2	-0.75	0	-1	-1		-1	-1	-2		0	0
Sac Long-Low	0	1	1	0.13	0	1	0		0	0	0		0	0
Sac Short-High	-1	1	2	0	0	0	0		0	0	-1		1	0
Sac-Ag	-1	1	2	-0.13	0	0	-1		-1	0	0		1	0
					Scores									
FINAL QUESTIONS:					E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Different for AN WYT?			1 = yes		2	1	1		0	1	1		0	1
Different for Dry WYT?			2 = no		2	2	1		0	1	1		2	2

Table C-2 Round 1 expert scores with supporting with comments for each zooplankton and delta smelt metric and NDFS alternatives in a Below Normal water year. Scores range from 2 to -2.

Zooplankton Quality

Alter-native	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3	Score E6
Ag Long-Low	-2	Even though pesticide levels in water were not at the LC50 concentrations - few exceeded WQOs, insecticides (especially) concentrated in zoop, and I imagine zoop quality could be affected 50% or more.	-2	From data shown zoo plankton contaminants are being bio accumulated which would make them less quality food. Contaminants would be passed on to Delta smelt.	-1	probably less change in contaminant load here than in the short-high scenario, but still concerning for sublethal impacts (e.g., growth decreases affecting available biomass)	-1	slower flow would theoretically not mobilize as many contaminants as high flow	0	This is more difficult because of my uncertainty about number of organisms and an optimal community structure.	-2	Long pulse of ag water seems to provide habitat availability for zooplankton to grow, but ag water would be high in pesticides to reduce quality of the food	-1	2
Ag Short-High	-1	Same as above, but lower exposure time means less accumulation in zoop, so I would imagine a lower magnitude of effect	-2	As in previous statement zoo plankton exposure to contaminants and their uptake would make them potentially lower quality food and potentially harmful food for the Delta smelt.	-2	assuming short-high would have most contaminant increase and therefore most potential for negative effects	-2	high flow mobilizes more contaminants, more contaminants in ag water	0	This is more difficult because of my uncertainty about number of organisms and an optimal community structure.	-1	Short, high pulse would not be enough time for zooplankton quality to respond to habitat availability before drainage & as above contaminants would negatively affect zooplankton quality	-2	1

Alter-native	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3	Score E6
Sac Long-Low	2	The dilution of contaminants in water would increase the quality of zoop significantly. Given that concentrations in water appear to be magnified in zoop, this could be a >50% effect.	1	It seems from the brief data that the Sacramento River water has less contaminants and the increased	1	decreased contaminants may help zooplankton grow (assuming pesticides in sac water are the same as in local - if more pyrethroids from urban use, maybe not and I would put this as 0)	1	less contaminants in sac water, not as mobilized with slower flow	1	This is more difficult because of my uncertainty about number of organisms and an optimal community structure.	2	Long pulse of water would likely provide habitat availability for zooplankton to grow, and impacts of contaminants may not be as impactful from Sac source water via dilution	0	2
Sac Short-High	1	Same as above, but to a lesser extent with less dilution	0		0	less positive effect of decreased contaminant load if short-high?	-1	more contaminants being mobilized	1	This is more difficult because of my uncertainty about number of organisms and an optimal community structure.	0	Short, high pulse would likely not be enough time for zooplankton quality to respond to habitat availability before drainage	-1	1
Sac-Ag	0	From a contaminants perspective, I imagine concentrations/effects to be similar to baseline (NAA)	2		-1	back-to-back changes may increase stress on organisms	1	slower flow would be good, have the benefit of both water types	0	This is more difficult because of my uncertainty about number of organisms and an optimal community structure.	1	Long pulse of ag-sac water seems to provide habitat availability for zooplankton to grow, and impacts of contaminants may not be impactful from Sac source water. Sac mixed with ag may provide such increased total volume of water that contaminants effect reduced toxicity.	-2	2

Zooplankton Survival

Alternative	Score E1	Comments E1	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E2	Score E3	Score E6
Ag Long-Low	-1	High concentrations in zoop, and must consider that the community that perished would not have been sampled. Still, I don't know if I would expect as much as 50% effect.	-1	same reasoning as for quality: probably less change in contaminant load here than in the short-high scenario	-1	contaminant pulse during flow action would be enough to affect survival, but slower flow may offset this response	1	So, this is the number of each species? Does this mean a lot of one species?	-1	Long pulse of ag water seems to provide habitat availability for zooplankton to grow, but ag would be high in pesticides and likely reduce survival	-2	0	1
Ag Short-High	-1	The short duration exposure may still be sufficient to cause >10 mortality in zoop populations, though I would expect less than the long exposure scenario	-2	assuming short-high would have most contaminant increase and therefore most potential for negative effects	-2	estimate largest effect on survival with theoretical biggest contaminant pulse flow potential	1	So, this is the number of each species? Does this mean a lot of one species?	0	Short, high pulse would not be enough time for zooplankton quality to respond to habitat availability before drainage but if so might negatively affect zooplankton survival. Score of 0 to -1	-2	-1	1
Sac Long-Low	1	Most positive effect on zoop survival	1	decreased contaminants may help zooplankton thrive (assuming pesticides in sac water are the same as in local - if more pyrethroids from urban use, maybe not and I would put this as 0)	1	better water quality with slower flow may benefit zooplankton survival, with less contaminants in water source	1	So, this is the number of each species? Does this mean a lot of one species?	1	Long pulse of ag water seems to provide habitat availability for zooplankton to grow, and impacts of contaminants may not be as impactful from Sac source water so survivability increases	0	0	1
Sac Short-High	1	Significant positive effect on zoop survival, but not as great as with the Sac Long-Low	1	same reasoning as sac long-low	-1	higher flow with more contaminants mobilized during action would likely affect survival	0	So, this is the number of each species? Does this mean a lot of one species?	0	Short, high pulse might be enough time for zooplankton survival to improve but not as much as slow pulse.	0	0	1

Alternative	Score E1	Comments E1	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E2	Score E3	Score E6
Sac-Ag	0	From a contaminants perspective, I imagine concentrations/effects to be similar to baseline (NAA)	-1	back-to-back changes may increase stress on organisms	1	zooplankton survival benefit from initial Sac-action may help survival with subsequent ag-action and slower flow	1	So, this is the number of each species? Does this mean a lot of one species?	1	Long pulse of ag water seems to provide habitat availability for zooplankton to grow, and impacts of contaminants may not be impactful from Sac source water. Sac mixed with ag source water may provide such increased total volume of water that contaminants effect reduced.	-1	-1	1

Delta Smelt Growth

Alternative	Score E1	Comments E1	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E2	Score E3	Score E5	Score E6
Ag Long-Low	-1	Not considering the potential increase for food and just the potential impacts of contaminants, this could have a sig negative effect on growth from a contaminant's perspective	-1	I have DS data from a 3-year study that demonstrates ag-sourced flow negatively affected growth	0	I am torn between a 0 and 1. The water quality (broadly defined) is still an issue	-1	Assuming no increased zoop survival and potential for contaminants to be bioaccumulated and affect quality , impact to DS growth would be negatively affected.	-1	-1	-1	0

Alternative	Score E1	Comments E1	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E2	Score E3	Score E5	Score E6
Ag Short-High	0	Lower exposure time relative to Long-Low, I don't believe the concentrations and duration of exp would amount to sig effects rel to baseline (NAA)	-2	I have DS data from a 3-year study that demonstrates ag-sourced flow negatively affected growth	0	I am torn between a 0 and 1.	0	Assuming no increased zoop survival, due to short pulse impact to DS growth would be zero.	-1	-2	-1	-1
Sac Long-Low	1	Most positive effect on DS growth	1	Sac-sourced slower flow has potential to increase growth	0	I am torn between a 0 and 1.	1	Potential increased zooplankton providing more food and positive affect on DS growth.	1	0	0	0
Sac Short-High	1	Significant positive effect on DS growth, but not as great as with the Sac Long-Low	0	high flow may have negative effects, but may be balanced from low contaminants for this chronic endpoint	0	I am torn between a 0 and 1.	0	Assuming no increased zoop survival and contaminants likely similar to baseline, impact to DS growth would be zero.	0	-1	0	0
Sac-Ag	0	From a contaminants perspective, I imagine concentrations/effects to be similar to baseline (NAA)	1	I like the low flow aspect, and the mix of both water types may end up being a benefit for DS growth.	0	I am torn between a 0 and 1.	1		1	-2	-1	0

Delta Smelt Survival

Alternative	Score E1	Comments E1	Score E7	Comments E7	Score E9	CommentsNE9	Score E10	Comments E10	Score E2	Score E3	Score E5	Score E6
Ag Long-Low	0	I wouldn't expect contaminant concentrations, even in the ag flows, to amount to levels that would cause 10% or greater mortality in DS	0	Hard to say about survival but I think that contaminant concentrations may be too low to acutely affect survival	0	Given the low population number and water quality issues I am not sure that a reduction in contaminants will be helpful in increasing survival.	-1	Assuming no increased zoop survival and potential for bioaccumulation of contaminants by zoops may have negative impact to DS survival.	-2	0	0	0
Ag Short-High	0		-1	higher contaminant pulse may affect survival during that peak concentration, but may not be high enough to acutely affect survival	0	Same note as above.	0	Assuming no increased zoop survival and potential for bioaccumulation of contaminants by zoops may have negative impact to DS survival but with short high pulse may not be enough time to affect zoop survival and quality so likely similar to baseline.	-1	-1	-1	-1

Alternative	Score E1	Comments E1	Score E7	Comments E7	Score E9	CommentsNE9	Score E10	Comments E10	Score E2	Score E3	Score E5	Score E6
Sac Long-Low	0	Though Sac flows should theoretically dilute concentrations of contaminants in water, because the baseline concentrations do not likely amount to lethal levels for DS, I would not expect the dilution to have measurable effects on DS mortality (related to contaminants)	0	contaminant concentrations may be too low to acutely affect survival	0	Same note as above.	0	Although zoop populations may be greater and quality is improved over baseline, I expect this action to have a 0 to 1 effect on DS survival overall.	2	0	0	0
Sac Short-High	0	Same as above	-1	higher contaminant pulse may affect survival during that peak concentration, but may not be high enough to acutely affect survival	0	Same note as above.	0	Assuming no increased zoop survival, impact to DS survival would be zero.	0	0	0	0
Sac-Ag	0	From a contaminants perspective, I imagine concentrations/effects to be similar to baseline (NAA)	0	contaminant concentrations may be too low to acutely affect survival	0	Same note as above.	0	Although zoop populations may be greater and quality is similar to baseline, I expect this action to have a zero effect on DS survival overall.	1	-1	-1	0

Delta Smelt Recruitment

Alter-native	Score E1	Comments E1	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E2	Score E3	Score E5	Score E6
Ag Long-Low	0	I wouldn't expect contaminant concentrations, even in the ag flows, to amount to levels that would cause 10% or greater effect on recruitment.	-1	see answers from DS growth; I would imagine this chronic endpoint would be similarly affected	0	I assume recruitment into the next year class from that region? so that is an improvement in survival of the individual.	0	Assuming no increased zoop survival and poorer quality, impact to DS recruitment would be less than 10%.	-1	-1	-1	0
Ag Short-High	0		-2	see answers from DS growth; I would imagine this chronic endpoint would be similarly affected	0		0	Assuming no increased zoop survival, impact to DS recruitment would be zero.	-1	-1	-1	-1
Sac Long-Low	0	Though Sac flows should theoretically dilute concentrations of contaminants in water because the baseline concentrations do not likely amount to lethal levels for DS, I would not expect the dilution to have measurable effects.	0	see answers from DS growth; I would imagine this chronic endpoint would be similarly affected	0		0	Although zoop populations may be greater and quality is improved over background, I expect this action to have 0 to 1 effect on DS recruitment.	1	0	0	0
Sac Short-High	0	Same as above	-1	see answers from DS growth; I would imagine this chronic endpoint would be similarly affected	1	But perhaps lower than 10 percent	0	Assuming no increased zoop survival, impact to DS recruitment would be zero.	0	0	0	0
Sac-Ag	0	From a contaminants perspective, I imagine concentrations/effects to be similar to baseline (NAA)	0	see answers from DS growth; I would imagine this chronic endpoint would be similarly affected	1	But perhaps lower than 10 percent	0	Although zoop populations may be greater and quality is likely similar background/baseline, I expect this action to have zero effect on DS survival overall therefore zero effect on DS recruitment.	0	-1	-1	0

Difference by Water Year Type

Yes (Y) or No (N)	E1	comments E1	E3	Comments E3	E6	Comments E6	E9	Comments E9	E10	Comments E10	E2	E7
Do you think any of your scores would be different for an **Above Normal** water year type?	N	It's possible that the level of effect will differ somewhat, but should be similar	Y	Lower impact if more water because there would have been more contaminants flushed out in prior months.	Y	I would anticipate reduced contaminant effects in an above normal water year type due to dilution effects.			Y	An above normal year may provide better water quality overall after first flush thus improving both zoop quality and quantity helping DS survival and recruitment	Y	Y
Do you think any of your scores would be different for a **Dry** water year type?	N	It's possible that the level of effect will differ somewhat, but should be similar	Y	In dryer years, id anticipate increased harm from flow pulses with added contaminants.	Y	I would anticipate increased contaminant effects in a dry water year type due to reduced dilution effects Ii.e., increased concentration per unit load).	N	Worse results	N	Dry year might cause less zoop quantity and quality thus affecting DS food supply/quality so some scores might change as result	N	Y

Round 2 Elicitation

The following information/document was presented by Jennie Hoffman to experts at the Round 2 meeting on January 30th, 2023.

Contaminants Round 1 elicitation summary for discussion

The primary goal of this elicitation is to provide information to support the DCG's deliberations around what to recommend in terms of the North Delta Food Subsidy Actions in a Below Normal water year. Specifically, we want to estimate consequences for performance metrics related to zooplankton survival and quality and Delta Smelt growth, survival, and recruitment, and better understand any disagreements and uncertainties associated with those estimates. We are also evaluating how scores might be in different water year types.

The focus of Round 1 is making sure respondents are interpreting the questions and the Performance Measures (PMs) in a consistent way and capturing and exploring the mental models behind respondents' scores.

Before Round 2 of scoring, we will review and discuss responses from Round 1. This provides added insight and increases our confidence in the second round of scores.

For Group Discussion

Based on the scores, there is disagreement on

- Scores for different alternatives
- Relative rankings of Sac vs. Ag and long-low vs. short-high
- Whether scores for other water year types would be different

We are not seeking consensus; we are seeking the considered and unbiased judgment of multiple experts who may or may not agree. We do want to make sure that any differences in scores result from differences of scientific opinion rather than from differences in interpretation of the alternatives, performance metrics, or database.

The comments suggest the following areas of discussion/clarification:

1. Underlying mental models. The attached DRAFT conceptual model was created based on what respondents included in their comments.
   A. Does this adequately and accurately capture the thinking behind everyone's scores?
   B. Are there difference of opinion on the strength or importance of different connections?
2. Lack of clarity on what is meant by "zooplankton quality".
   A. PROPOSAL:
      i. We ask you to focus on contaminant loading and biomass.
      ii. Effects on species composition and nutrient density may be beyond the expertise of this group.
3. Effects on Delta Smelt
   A. Focus on ***direct effects*** only.
4. Delta Smelt Recruitment vs. Survival
   A. E9 commented "*I assume recruitment into the next year class from that region? so that is an improvement in survival of the individual.*" Is this suggesting that recruitment scores are heavily correlated with survival scores, and maybe shouldn't be considered separately?
5. Contaminant type in Sacramento River, especially pyrethroids
   A. Brittany to present some data on this.
6. Effect of WYT
   A. Focus only on ***effects of WYT on the effects of the action***, not effects of WYT on zooplankton and smelt more generally.
   B. Think about not whether effects will be different, but whether they would be ***different enough to change the scores.***
7. Any outlier scores
8. Other topics as they arise

Round 2 Survey Results

Following clarification discussion of key points outlined above, mechanisms, and refinement of the conceptual model. Experts were given the opportunity to revise their scores and provide additional rationale and comments. Presented hereafter are tabular summaries of round 2 final scores and expert comments that were incorporated in the 2023 DCG's SDM evaluation.

Table C-3 Average scores in a Below Normal water year type of expert opinion (n=8) effects of NDFS action alternatives to key zooplankton and delta smelt metrics. The color scale demonstrates potential positive (green) or negative (red) effects.

Performance Metric	Ag Long-Low	Ag Short-High	Sac Long-Low	Sac Short-High	Sac-Ag
Zooplankton quality	-0.88	-1.25	0.38	-0.25	-0.38
Zooplankton survival	-0.75	-0.88	0.25	-0.25	-0.13
Delta smelt growth	-0.63	-0.75	0.13	-0.25	-0.25
Delta smelt survival	-0.13	-0.63	0.00	-0.25	-0.29
Delta smelt recruitment	-0.50	-0.57	0.13	-0.13	-0.29
Overall mean	-0.58	-0.81	0.18	-0.23	-0.26

Table C-4 **A summary of round 2 elicitation scores for each expert (e.g., E1, E2,) performance measure (e.g., zooplankton survival, delta smelt survival) and NDFS action alternative (e.g., Ag Long-Low) in Below Normal, Dry, and Above Normal water years. Below Normal scores were refined in Rounds 1 and 2, whereas Dry and Above Normal scores were calculated post-elicitation by adding or subtracting each expert's water type effects score shown in the rows of the table. BN scores were used for final DCG evaluation as in Table 3 above.**

Objective: Zooplankton quality

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Ag Long-Low	-0.88	-1	-2	-1	-1	-1	-1	1	-1	-1.57		-3	-2	-2	-2	0	0	-2	-0.64		-2	-1	-0.5	0	-2	2	-1
Ag Short-High	-1.25	-2	-1	-2	-1	-2	-1	0	-1	-1.86		-2	-3	-2	-3	0	-1	-2	-0.93		-1	-2	-0.5	-1	-2	1	-1
Sac Long-Low	0.38	2	2	-1	0	-1	0	1	0	-0.57		1	-2	-1	-2	1	0	-1	0.36		2	-1	0.5	0	-1	2	0
Sac Short-High	-0.25	1	0	-1	0	-2	-1	1	0	-1.14		-1	-2	-1	-3	0	0	-1	-0.21		0	-1	0.5	-1	-2	2	0
Sac-Ag	-0.38	0	1	-2	-1	-1	0	0	0	-1.14		0	-3	-2	-2	1	-1	-1	-0.21		1	-2	-0.5	0	-1	1	0

Objective: Zooplankton survival

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Ag Long-Low	-0.75	-1	-1	-1	-1	-1	-1	1	-1	-1.43		-2	-2	-2	-2	0	0	-2	-0.50		-1	-1	-0.5	0	-2	2	-1
Ag Short-High	-0.88	-1	0	-2	-1	-2	-1	1	-1	-1.57		-1	-3	-2	-3	0	0	-2	-0.64		0	-2	-0.5	-1	-2	2	-1
Sac Long-Low	0.25	1	1	-1	0	-1	1	1	0	-0.57		0	-2	-1	-2	2	0	-1	0.36		1	-1	0.5	0	0	2	0
Sac Short-High	-0.25	1	0	-1	0	-2	-1	1	0	-1.14		-1	-2	-1	-3	0	0	-1	-0.21		0	-1	0.5	-1	-2	2	0
Sac-Ag	-0.13	0	1	-2	-1	-1	1	1	0	-0.86		0	-3	-2	-2	2	0	-1	0.07		1	-2	-0.5	0	0	2	0

Objective: Delta smelt growth

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Ag Long-Low	-0.63	-1	-1	-1	-1	-1	-1	1	0	-1.29		-2	-2	-2	-2	0	0	-1	-0.36		-1	-1	-0.5	0	-2	2	0
Ag Short-High	-0.75	0	0	-2	-1	-2	-1	0	0	-1.57		-1	-3	-2	-3	0	-1	-1	-0.64		0	-2	-0.5	-1	-2	1	0

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Sac Long-Low	0.13	1	1	-1	0	-1	0	1	0	-0.71		0	-2	-1	-2	1	0	-1	0.21		1	-1	0.5	0	-1	2	0
Sac Short-High	-0.25	1	0	-1	0	-2	0	0	0	-1.14		-1	-2	-1	-3	1	-1	-1	-0.21		0	-1	0.5	-1	-1	1	0
Sac-Ag	-0.25	0	1	-2	-1	-1	1	0	0	-1.00		0	-3	-2	-2	2	-1	-1	-0.07		1	-2	-0.5	0	0	1	0

Objective: Delta smelt survival

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Ag Long-Low	-0.13	0	-1	0	0	-1	0	1	0	-0.86		-2	-1	-1	-2	1	0	-1	0.07		-1	0	0.5	0	-1	2	0
Ag Short-High	-0.63	0	-1	-1	0	-2	-1	0	0	-1.43		-2	-2	-1	-3	0	-1	-1	-0.50		-1	-1	0.5	-1	-2	1	0
Sac Long-Low	0.00	0	0	0	0	-1	0	1	0	-0.71		-1	-1	-1	-2	1	0	-1	0.21		0	0	0.5	0	-1	2	0
Sac Short-High	-0.25	0	0	0	0	-2	-1	1	0	-1.00		-1	-1	-1	-3	0	0	-1	-0.07		0	0	0.5	-1	-2	2	0
Sac-Ag	-0.29	0	0.5	-1	0	-1	0	0	0	-0.93		-0.5	-2	-1	-2	1	-1	-1	0.00		0.5	-1	0.5	0	-1	1	0

Objective: Delta smelt recruitment

Alternative	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10	Avg	E1	E2	E3	E5	E6	E7	E9	E10
Ag Long-Low	-0.50	0	-1	-1	-1	-1	-1	1	0	-1.29		-2	-2	-2	-2	0	0	-1	-0.36		-1	-1	-0.5	0	-2	2	0
Ag Short-High	-0.57	0	0.5	-1	-1	-2	-1	1	0	-1.21		-0.5	-2	-2	-3	0	0	-1	-0.29		0.5	-1	-0.5	-1	-2	2	0
Sac Long-Low	0.13	0	1	0	0	-1	0	1	0	-0.57		0	-1	-1	-2	1	0	-1	0.36		1	0	0.5	0	-1	2	0
Sac Short-High	-0.13	0	0	0	0	-2	0	1	0	-0.86		-1	-1	-1	-3	1	0	-1	0.07		0	0	0.5	-1	-1	2	0
Sac-Ag	-0.29	0	0.5	-1	-1	-1	1	0	0	-0.93		-0.5	-2	-2	-2	2	-1	-1	0.00		0.5	-1	-0.5	0	0	1	0

Scores different for other WYT?

	E1	E2	E3	E5	E6	E7	E9	E10	E1	E2	E3	E5	E6	E7	E9	E10	E1	E2	E3	E5	E6	E7	E9	E10
Dry WYT		-1	-1	-1	-1	1	-1	-1		-1	-1	-1	-1	1	-1	-1		-1	-1	-1	-1	1	-1	-1
AN WYT		0	0	0.5	1	-1	1	0		0	0	0.5	1	-1	1	0		0	0	0.5	1	-1	1	0

Table C-5 Round 2 expert scores with supporting with comments for each zooplankton and delta smelt metric and NDFS alternatives in a Below Normal water year. Scores range from 2 to -2.

Zooplankton Quality

Alternative	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E6	Comments E6	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3
Ag Long-Low	-1	Changing score to -1 (from -2) due to benefit of low flow in reducing contaminant concentrations as they partition to organic matter or settle out.	-2	Long pulse of ag water seems to provide habitat availability for zooplankton to grow, but ag water would be higher in pesticides as compared to no action and would likely have a negative effect	-1	same reasoning as before	-1	I'm assuming that the low pulses would have lower concentrations of contaminants than the higher pulses, which could cause fewer acute toxicity effects, but potentially some chronic toxicity effects, in comparison with the shorter pulses. I used the same logic for the subsequent performance measures.	-1	Longer/slower flow may allow for more contaminants to affect zooplankton quality, but I'm not sure if this would impact my score by an entire point... I don't think it would affect zooplankton quality by the equivalent of an EC50	1	I am now using zooplankton growth as the metric-not community structure and so on.	-1	After being clear on only evaluating the effects of contaminants on zoop quality, I reduced this number to account for just the increased exposure of ag pesticides on zoop.	-1
Ag Short-High	-2	Change score to -2 (from -1) due to increased mobilization of contaminants both in the source water but also on location, in the bypass itself.	-1	same comment	-1	changed to -1 - no longer sure the difference between short-high and long-low would be substantial enough to merit different scores	-2	I'm assuming that the high pulses would have higher concentrations of contaminants than the lower pulses, which could cause more acute toxicity effects.	-1	I think this would negatively affect zooplankton quality, but probably not to the degree of an EC50	0		-1	Stayed the same- although i am no longer considering the effect of increased habitat or nutrients on zoop quality, the contaminants present in ag water may reduce the quality of zooplankton	-2
Sac Long-Low	2	Same score, but also considering the benefit of low flow allowing for contaminants to partition to sediment and organic matter, where they are no longer bioavailable.	2	same comment	0	changed to 0 - enough detection of contaminants to which inverts are sensitive to that I don't think there would be a positive effect compared to no action	-1	Same logic as for the ag pulses above, and also based on the graphs that Brittany showed us on 1/30/2023.	0	Changed to 0 from 1; the presence of many chemicals in Sac Water will probably affect zooplankton quality in a negative way, but not more so than no action at all.	1		0	No effect of contaminants on quality of zoop due to this action	-1

Alternative	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E6	Comments E6	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3
Sac Short-High	1	Same score, same comment	0	same comment	0	enough detection of contaminants to which inverts are sensitive to that I don't think there would be a positive effect compared to no action	-2		-1	Same as last time	1		0	No effect of contaminants on quality of zoop due to this action	-1
Sac-Ag	0	Same score, same comment	1	same comment	-1	same reasoning as before	-1		0	Benefits may be gained by both water sources, but probably not more than no action at all.	0	Lower uncertainty now that I understand the goals.	0	No effect of contaminants on quality of zoop due to this action	-2

Zooplankton Survival

Alternative	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3	Score E6
Ag Long-Low	-1	Same score, same comment	-1	same comment	-1	same reasoning as for quality	-1	Same as last time	1	If the low is below a toxicity level, then I am good with this providing an improvement.	-1	Survival may be impacted given increased exposure to ag water	-1	-1
Ag Short-High	-1	Same score, same comment	0	same comment	-1	changed to -1 - no longer sure the difference between short-high and long-low would be substantial enough to merit different scores	-1	I still think this could negatively impact zooplankton survival at peak flow/chemical concentrations, but unlikely to be of the magnitude of an EC50	1	If there is sufficient time for recolonization from other parts of the systems, this may produce a number of zooplankton. It just depends on how high the high is.	-1	Survival may be impacted given increased exposure to ag water	-2	-2
Sac Long-Low	1	Same score, same comment	1	same comment	0	changed to 0 - enough detection of contaminants to which inverts are sensitive to that I don't think there would be a positive effect compared to no action	1	Same, I don't think chemical concentrations would be high enough to elicit EC50 in survival.	1	I am more certain than before that this can help.	0	It seems based on the pesticide data that zooplankton are already being exposed to the levels of pesticides at the level of the Sac water, so no increase or decrease in survival would be expected from this action	-1	-1

Alternative	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3	Score E6
Sac Short-High	1	Same score, same comment	0	same comment	0	changed to 0 - enough detection of contaminants to which inverts are sensitive to that I don't think there would be a positive effect compared to no action	-1	Same as last time	1	I am more certain than before that this can help.	0	It seems based on the pesticide data that zooplankton are already being exposed to the levels of pesticides at the level of the Sac water, so no increase or decrease in survival would be expected from this action	-1	-2
Sac-Ag	0	Same score, same comment	1	same comment	-1	same reasoning as before	1	Same as last time	1		0	It seems based on the pesticide data that zooplankton are already being exposed to the levels of pesticides at the level of the Sac water, which could be diluting the ag water, so no increase or decrease in survival would be expected from this action	-2	-1

Delta Smelt Growth

Alternative	Score 1	Comments E1	Score 2	Comments E2	Score 5	Comments E5	Score 7	Comments E7	Score 9	Comments E9	Score 10	Comments 10	Score E3	Score E6
Ag Long-Low	-1	Same score, same comment	-1	Increased contaminants over a long period vs no action could cause sub-lethal effects negatively affecting delta smelt growth., impact to DS growth would be negatively affected.	-1	potential negative effects from ag-sourced water but probably not at the level of EC50	-1	Same as last time	1	Depends on the contaminant concentration--if the total toxicity is lower than an EC10 I think it would be ok.	0	No direct effect of contaminants on DS growth expected as a result of this action	-1	-1
Ag Short-High	0	Same score, same comment	0	Increased contaminants over a short period vs no action would likely not affect delta smelt growth. affected.	-1	potential negative effects from ag-sourced water but probably not at the level of EC50	-1	I still think this could negatively impact DS growth at peak flow/chemical concentrations, but unlikely to be of the magnitude of an EC50	0	Depends on how high is high compared to the toxicity to the Delta Smelt.	0	No direct effect of contaminants on DS growth expected as a result of this action	-2	-2

Alternative	Score 1	Comments E1	Score 2	Comments E2	Score 5	Comments E5	Score 7	Comments E7	Score 9	Comments E9	Score 10	Comments 10	Score E3	Score E6
Sac Long-Low	1	Same score, same comment	1	Long pulse of sac water could provide better habitat availability and quality vs no action and positively affect delta smelt growth.	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative growth effect	0	Probably no difference from no action	1	If kept reasonably low, I am good that this may help. Depends on the mixtures of the contaminants.	0	No direct effect of contaminants on DS growth expected as a result of this action	-1	-1
Sac Short-High	1	Same score, same comment	0	Short pulse of sac water and minimal contaminants would not likely affect delta smelt growth	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative growth effect	0	Same as last time	0	This is very different depending on the high.	0	No direct effect of contaminants on DS growth expected as a result of this action	-1	-2
Sac-Ag	0	Same score, same comment	1	Long pulse of sac/af water could provide better habitat availability and quality vs no action and positively affect delta smelt growth.	-1	back-to-back changes may increase stress on organisms, but probably not at the level of EC50	1	Same as last time	0	Not sure here.	0	No direct effect of contaminants on DS growth expected as a result of this action	-2	-1

Delta Smelt Survival

Alternative	Score E1	Comments E1	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E3	Score E6
Ag Long-Low	0	Note importance of toxic unit approach to understand how the contaminants could be affecting DS survival, also important to do more monitoring	-1	Increased contaminants over a long period vs no action could cause sub-lethal effects negatively affecting delta smelt survival.	0	I'm not convinced the ag water has different enough pesticide concentrations to elicit a negative survival effect	0	Same as last time; I don't think chemical concentrations will be enough to acutely affect DS survival	1	Depends on the contaminant concentration--if the total toxicity is lower than an EC10 I think it would be ok.	0	No direct effect of contaminants on DS survival expected as a result of this action	0	-1
Ag Short-High	0	Same score, same comment	-1	Increased contaminants over a short period vs no action could cause sub-lethal effects negatively affecting delta smelt survival.	0	I'm not convinced the ag water has different enough pesticide concentrations to elicit a negative survival effect	-1	Same as last time, but I think that the reduction in DS survival would be more on the lower range (10ish%) rather than higher (49%)	0	At the high concentration there may not be recolonization by the smelt larvae.	0	No direct effect of contaminants on DS survival expected as a result of this action	-1	-2
Sac Long-Low	0	Same score, same comment	0	Long pulse of sac water and minimal contaminants vs no action habitat quality is likely improved over baseline, I expect this action to have a 0 to 1 effect on DS survival overall.	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative survival effect	0	Same as last time	1	Same as above	0	No direct effect of contaminants on DS survival expected as a result of this action	0	-1
Sac Short-High	0	Same score, same comment	0	Short pulse of sac water and minimal contaminants would not likely affect delta smelt survival.	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative survival effect	-1	Same as last time, see comment for Ag Short-High	1	Same as Ag Short High	0	No direct effect of contaminants on DS survival expected as a result of this action	0	-2
Sac-Ag	0	Same score, same comment	0, 1	Long pulse of sac/ag water could provide better habitat availability and quality vs no action and positively affect delta smelt growth. Score 0-1	0	back-to-back changes may increase stress on organisms, but I don't know that it would be enough to change survival rates	0	Same as last time	0		0	No direct effect of contaminants on DS survival expected as a result of this action	-1	-1

Delta Smelt Recruitment

Alternative	Score E2	Comments E2	Score E5	Comments E5	Score E7	Comments E7	Score E9	Comments E9	Score E10	Comments E10	Score E1	Score E3	Score E6
Ag Long-Low	-1	Increased contaminants over a long period vs no action could cause sub-lethal effects negatively affecting delta smelt recruitment.	-1	potential negative effects from ag-sourced water but probably not at the level of EC50	-1	Low level reduction in recruitment compared to no action at all. Probably in low % range rather than high	1	If there is recruitment from other habitats or enough from the previous year	0	No direct effect of contaminants on DS recruitment expected as a result of this action	0	-1	-1
Ag Short-High	0, -1	Increased contaminants over a short period vs no action could cause sub-lethal effects negatively may or may not affect recruitment	-1	potential negative effects from ag-sourced water but probably not at the level of EC50	-1	Low level reduction in recruitment compared to no action at all. Probably in low % range rather than high	1	This may work because of recruitment from other Delta Smelt habitats.	0	No direct effect of contaminants on DS recruitment expected as a result of this action	0	-1	-2
Sac Long-Low	1	Long pulse of sac water and minimal contaminants vs no action habitat quality is likely improved over baseline, I expect this action to have a 0 to 1 effect on DS recruitment.	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative reproduction effect (assuming this action didn't happen during peak spawning)	0	Unlikely to be different than no action at all	1	Better chance than Ag Long-Low but still a 1	0	No direct effect of contaminants on DS recruitment expected as a result of this action	0	0	-1
Sac Short-High	0	Short pulse of sac water and minimal contaminants would not likely affect delta smelt recruitment.	0	I'm not convinced the sac water has different enough pesticide concentrations to elicit a negative reproduction effect (assuming this action didn't happen during peak spawning)	0	Unlikely to be different than no action at all	1	Better chance than Ag High-Low but still a 1	0	No direct effect of contaminants on DS recruitment expected as a result of this action	0	0	-2
Sac-Ag	0, -1	Long pulse of sac/ag water could provide better habitat availability and quality vs no action and positively affect delta smelt recruitment. Score 0-1	-1	back-to-back changes may increase stress on organisms, but I don't think it would be at the level of EC50s	1	Potential for an increase in recruitment assuming chemical concentrations are low	0	insignificant (i.e. less than 10%) effect on performance metric relative to the No Action Alternative	0	No direct effect of contaminants on DS recruitment expected as a result of this action	0	-1	-1

Difference by Water Year Type

WYT	Score E3	Comments E3	Score E5	Comments E5	Score E6	CommentsE6	Score E7	Comments E7	Score E10	Comments E10	Score E2	Score E9	Average
Dry	-1	in a dry year, more contaminants are available for pulsed flow actions to remobilize, so they would become available with the pulse	-1	dry years tend to have increased pesticide use and release into water for both ag and urban settings (leading to higher concentrations compared with tox thresholds - I might expect more likelihood of a negative effect on Delta smelt metrics)	-1	I am assuming that contaminant concentrations would be higher in a dry year.	1	Probably would have more positive effect on performance metrics as in a dry year there would be less contaminants applied, washed off, found in water column, etc. In terms of contaminants ONLY, not including the negative effects of a dry year (e.g., lack of cooler water available, less snowmelt, etc.)	-1	Would expect heavier influence of contaminants in first flush in a dry year which could potentially decrease performance metrics	-1	-1	-0.71
Above normal	0	for the same reason as above, but opposite impact this time; extra water earlier in the year would flush a portion of the contaminant burden of the system out. But in this case, I don't think it would be more than 1 point	0.5	I would not expect as much change in water quality from an action, leading to potentially less negative effects but not necessarily enough to be more positive compared to no action (more zeros)	1	I am assuming that contaminant concentrations would be lower in a dry year, due to dilution by higher rainfall runoff.	-1	Wet year would affect the amount and types of contaminants applied, the amount found in runoff, and the amount of contaminants found in pulse water, since there would be more of a chance of this taking place.	0	No change in effect on performance metrics expected	0	1	0.21

Appendix D. Swing Weighting

The following describes the Delta Coordination Group's (DCG) swing weighting exercise completed in March 2023

DCG's SFHA decision includes four top-level decision objectives: Delta Smelt, Resource Costs, Effects on Other Species, and Learning. Each of these has sub-objectives representing different components of the top-level objective. We've rolled up most sub-objective scores assuming equal weights on all sub-objectives. For the three Delta Smelt sub-objectives, we're asking DCG members to assign weights. Thus, you will be doing **two** distinct swing weighting tasks:

1. Assigning weights for the contribution of Delta Smelt sub-objectives to overall Delta Smelt utility, and
2. Assigning weights for the contribution of each top-level objectives to overall utility.

For each DCG member, AltaViz will generate an overall utility score for each alternative by normalizing scores for each objective/subobjective, multiplying normalized scores by the weights, and adding up the weighted normalized scores.

In addition, you will be asked to directly rank each of the 6 actions. This direct ranking helps assess the degree of confidence we can have in the weights and can indicate when deeper discussion may be warranted.

Refer to the consequences table (password = smelt, AltaViz how-to video here) to review how each alternative performs on each decision objective, and the PM infosheets as necessary to for more details on how consequences were calculated and associated assumptions and uncertainties. If you need help with any of this, please contact Jennie (hoffrau@gmail.com).

Entering ranks and scores:

This document is for discussion purposes only; you should enter ranks and scores in AltaViz using the links below (for BN: https://bit.ly/3TeiUDn, and for AN https://bit.ly/3JcxI0L)

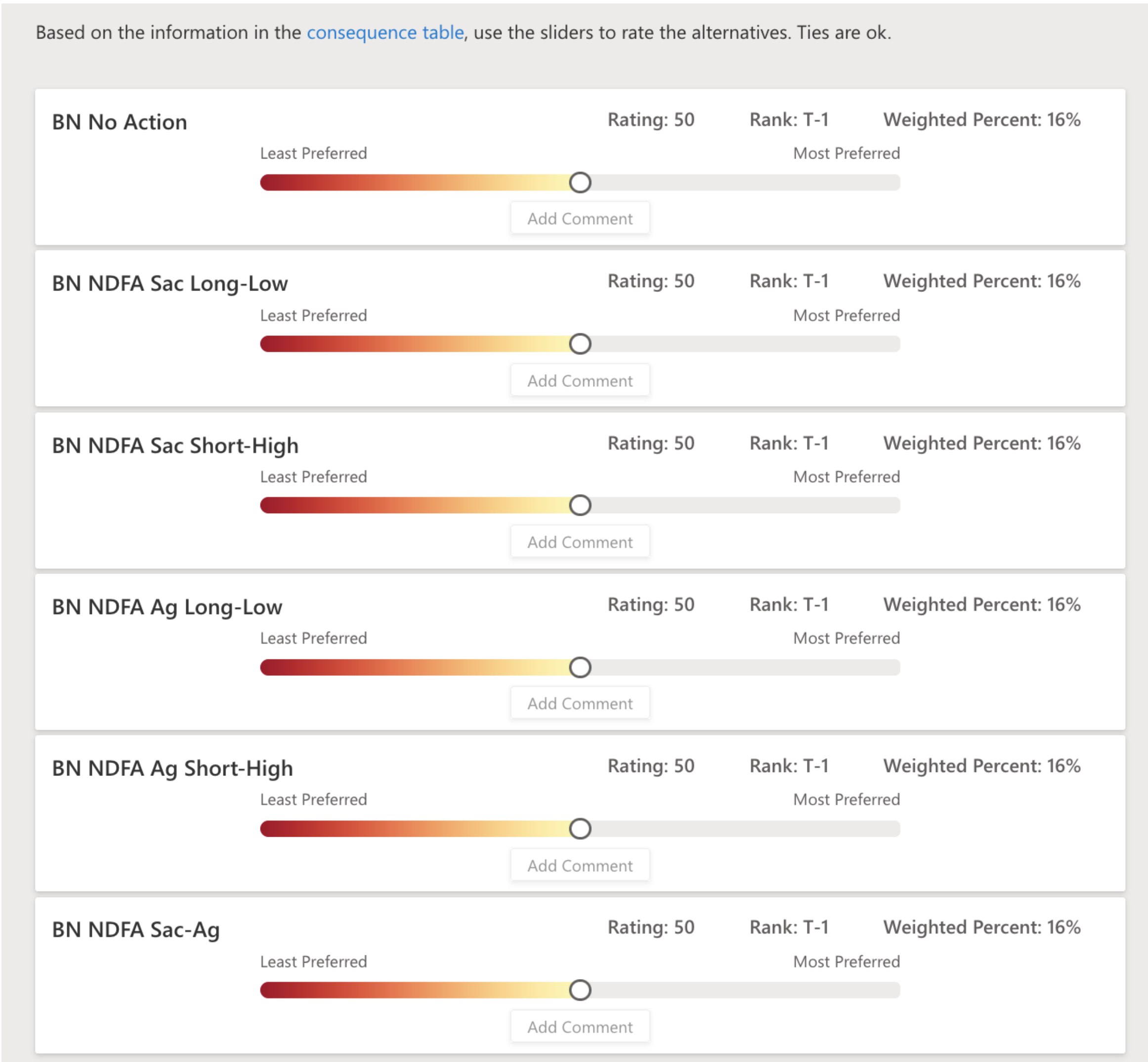
You are welcome to experiment with entering ranks and weights in AltaViz to get a feel for how it works, but only one set of weights per agency will be used. Please make a note of "Agency-final weights" when you enter your name (e.g. enter "DWR-final weights" as the name) once you are satisfied with your scores.

Video tutorial for ranking and weighting is here.

Start with the BN WYT survey: https://bit.ly/3TeiUDn

First: Direct weighting

Figure D-1 Screenshot of the direct weighting screen from the AltaViz tool. Per the instructions, DCG members were asked to rate the six alternatives for a Below Normal water year from most to least preferred, with ties allowed.



Second: weighting sub-objectives

Below is a screenshot of the survey for a BN WYT.

Figure D-2 Screenshot of the swing weighting screen from the AltaViz tool. Per the instructions, DCG members were asked to provide swing weights for each of the three smelt sub-objectives.

Imagine you live in a world where all of the performance measures (PMs) take on their **worst** value. Now suppose that you are able to change all the PMs of one (and only one) objective from their **worst** to their **best** value. Which objective would you choose? Consider both the inherent importance of the objective and the magnitude of the change. Assign 100 points to this objective.

Choose the next most important objective to change from **worst** to **best**. Assign points to reflect the importance of this change relative to the first objective. (For example, if it is half as important, assign it 50 points.)

Continue until you have assigned points to all the PMs. Ties are ok.

Delta Smelt

Objective	Performance Measure	Unit	Worst	Best	Points	Weighted
Delta Smelt Growth and Survival	Growth Increment	mm	0	0.64		-
Zooplankton	Difference in BPUE	Biomass per unit effort	0	53.7		-
Contaminant Effects	Constructed scale	-2 to 2	-0.81	0.18		-

Third: weighting top-level objectives

Figure D-3 Screenshot of the top-level objectives swing weighting screen from the AltaViz tool. Per the instructions, DCG members were asked to provide swing weights for each of the four top-level objectives.

Imagine you live in a world where all of the performance measures (PMs) take on their **worst** value. Now suppose that you are able to change all the PMs of one (and only one) objective from their **worst** to their **best** value. Which objective would you choose? Consider both the inherent importance of the objective and the magnitude of the change. Assign 100 points to this objective.

Choose the next most important objective to change from **worst** to **best**. Assign points to reflect the importance of this change relative to the first objective. (For example, if it is half as important, assign it 50 points.)

Continue until you have assigned points to all the PMs. Ties are ok.

Objective	Performance Measure	Unit	Worst	Best	Points	Weighted
Delta Smelt						-
Delta Smelt Growth and Survival			0	0.64		
Zooplankton	Difference in BPUE	Biomass per unit effort	0	53.7		
Contaminant Effects			-0.81	0.18		
Resource Costs	Operating costs	$1000/year	500	0		-
Effects on other native species	Constructed scale	-3 to 1	-0.35	0		-
Learning	Constructed scale	1 - 11	3	8		-

Now, look at the AN WYT survey: https://bit.ly/3JcxI0L

Figure D-4 Screenshot of the sub-objective swing weighting screen for an Above Normal water year from the AltaViz tool. Per the instructions, DCG members were asked to provide swing weights for each of the three smelt sub-objectives.

Delta Smelt

Objective	Performance Measure	Unit	Worst	Best	Points	Weighted
Delta Smelt Growth and Survival	Growth Increment	mm	0	0.64		-
Zooplankton	Difference in BPUE	Biomass per unit effort	0	53.7		-
Contaminant Effects	Constructed scale	-2 to 2	-1.53	0		-

Figure D-5 Screenshot of the top-level objectives swing weighting screen for an Above Normal water year from the AltaViz tool. Per the instructions, DCG members were asked to provide swing weights for each of the four top-level objectives.

Objective	Performance Measure	Unit	Worst	Best	Points	Weighted
Delta Smelt						-
Delta Smelt Growth and Survival			0	0.64		
Zooplankton	Difference in BPUE	Biomass per unit effort	0	53.7		
Contaminant Effects			-1.53	0		
Resource Costs	Operating costs	$1000/year	500	0		-
Effects on other native species	Constructed scale	-3 to 1	-0.35	0		-
Learning	Constructed scale	1 - 11	3	8		-

You'll notice that all max and min values are the same EXCEPT for contaminants. If this would affect your weights, please go ahead and fill out the AN survey.

If your weights would NOT change, you can skip the AN survey and we can use your BN information.