BAY-DELTA CONSERVATION PLAN

DELTA SCIENCE PROGRAM PANEL

REVIEW OF THE "LOGIC CHAIN" APPROACH

Prepared for
BDCP Steering Committee

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Background

The Bay-Delta Conservation Plan (BDCP) is being prepared through collaboration among several government, non-government, and private-sector entities. The goal of BDCP is to identify actions that will contribute to the recovery and protection of endangered and sensitive species and their habitats in the Sacramento-San Joaquin Delta of California while maintaining or improving water supplies to a diversity of users. To this end, a "logic chain" has been proposed as a framework for linking recovery goals for covered fish species with BDCP goals, objectives, conservation measures, monitoring, and adaptive management.

The review panel convened by the Delta Science Program met in Sacramento on March 2-4, 2010, to evaluate this approach. In this review, we drew heavily from the following documents: Logic Chain Status Report, Chapters 3.3 and 3.4 of the draft BDCP, SAIC Draft Effectiveness Monitoring for Conservation Measures document, Summary Report of the DRERIP Evaluations of BDCP Draft Conservation Measures, Independent Science Advisors' Report on Adaptive Management, and examples of logic chains provided by American Rivers and The Bay Institute.

The Charge

The charge to the review team had three elements. The first was to address whether the logic chain framework is a useful tool for refinement of BDCP goals and objectives. The second was an assessment of the logic chain framework with a focus on determining if the internal logic was sound and if there were critical gaps. The third element was to recommend next steps for populating key logic chains and to consider where additional science was needed in the BDCP process. This report addresses these three elements of the charge to the review team.

Recommendations

Adequacy of the logic chain framework

- The general logic-chain approach should continue to be developed and then applied, as it has the potential to clearly articulate and link goals, objectives, actions, and outcomes.
- The logic chain should be first applied to the covered fish species.
- The revisions to the logic chain structure developed by the review panel should be incorporated, as appropriate, to reduce areas of ambiguity and refine the logic chain.

Assessment of the logic chain framework

- BDCP should distinguish between order-of-magnitude approximations of BDCP goals and objectives that are acceptable in the early planning phase and the more detailed descriptions that will be necessary as the plan is finalized and ready for implementation.
- The projected outcomes should be framed as testable hypotheses linked to specific conservation measures and evaluated against actual outcomes. Outcomes must be quantified, with specified and measurable parameters and appropriate metrics. The analytical methodology to be employed should also be specified. It is important to know with clarity whether a conservation measure is working as intended.
- Use metrics to evaluate the success of outcomes that clearly link to biological functions; consider the judicious use of surrogate metrics. For example, accurate quantification of rare and endangered fish species may not be possible but overall community structure that characterizes native and non-native groups could serve as a surrogate measure.
- Constraints to implementation of the conservation measures (e.g., financial, environmental, logistical) should be considered as part of the planning process rather than as factors to be included only when one comes to implementing conservation measures. This will ensure that expectations about implementation are commonly understood. For example, budgetary requirements to make the necessary monitoring measurements and analyze the resulting data should be developed as soon as possible so that this information can be used in the prioritization of conservation measures.
- The potential impacts of system dynamics, variation, and change (especially those associated with climate variability, climate change, and sea-level rise) on the effectiveness of conservation measures should be explicitly addressed in the logic chain. A steady-state equilibrium, in which the system varies around some stable long-term state (i.e., stationarity), cannot be assumed.
- The adaptive management framework should be developed in greater detail, recognizing that analysis is *not* the endpoint of adaptive management. Adaptive management

approaches should be incorporated into the body of the logic chain rather than relegated to something that is done at the end, after measures have been implemented.

Next steps and science needs

- Rather than developing all logic chains at the same pace, logic chains should be developed in detail for 2-3 species and then evaluated as a proof of concept. These logic chains should be for species for which understanding is high (e.g., splittail). A user-friendly version of the logic chain that describes the approach and its uses in readily understandable terms should be developed now.

- The upper section of the logic chain (problem, recovery/species goals, and recovery/species objectives) should be developed and populated by the responsible regulatory and permitting agencies. This needs to be done immediately, because the application of logic chains to BDCP goals and objectives and the evaluation of hypotheses that feed into adaptive management depend on a clear statement of the problem to be addressed and well-defined recovery/species goals and objectives.

- The middle section of the logic chain (BDCP goals and BDCP objectives) should be developed through collaborative efforts. A limited number of experts from the permitting agencies, non-governmental organizations, and the potentially regulated entities should participate in developing this section of the logic chains.

- A science expert workshop should be convened to populate the lower part of the logic chain, focusing on the conservation measures, outcomes, monitoring, metrics, and the form of an adaptive management process once the upper and middle sections of the logic chains have been completed.

- Simulation models and scenario analysis should be used to explore the potential consequences and cost-effectiveness of conservation measures as part of the planning process, before measures are actually implemented.

- The formalisms of other approaches such as cost-benefit analysis, return-on-investment, or ecological risk analysis should be used to help set priorities and evaluate outcomes. Such tools should be used to inform decision making and negotiations, to consider tradeoffs, and to establish priorities among conservation measures.

General Comments

Before dealing with the details of the logic-chain, we offer several general comments as broad guidance for further development of the approach. First, our ability to recover or manage covered species depends on a clear understanding of what factors are limiting or creating stress to populations. These are the factors that must be removed or mitigated by the conservation measures. Such factors may be identified in recovery plans or may require additional information

obtained from the scientific literature and/or expert opinion, and should be refined through the adaptive management process.

Second, there is an underlying (but unstated) assumption of stationarity that runs through the logic chain approach, the draft BDCP documents, and recovery plans. This assumption leads to the expectation that there is a stable "baseline" condition for the Bay-Delta ecosystem and the populations it supports. Given the massive changes in this ecosystem over the past century, this is almost certainly not true now. The potential effects of climate change on sea level, tidal fluxes, Sierra snowfall, and the timing of freshwater runoff make it even less likely to hold in the future. The logic chain and BDCP should explicitly incorporate non-stationary dynamics into the framework.

Third, it is important to incorporate study designs, monitoring protocols, and metrics as part of the logic chain. In particular, consideration of the statistical power required for detecting the effects of conservation measures, coupled with a determination of acceptable levels of response of covered species or other targets to conservation measures, may help to determine the feasibility or priority of particular measures.

Fourth, although it is important to have a clear and logical structure for developing hypotheses about the consequences of conservation measures and the efficacy of these measures in addressing BDCP goals and objectives, the framework should not be so highly structured and prescriptive that it constrains thought or resists the exercising of dynamic adaptive management. The Bay-Delta ecosystem is complex. The responses of covered species to conservation measures will always be clouded by uncertainty – did a species respond to a measure or to something else? Dealing with such uncertainties requires flexibility in planning and implementation.

Evaluation of the Logic Chain

In order to understand the logic and function of the logic chain, the review team chose to delve into the logic chain example for the Delta Smelt (Appendix 2). We reviewed and assessed this example from top to bottom; here are our observations and comments, utilizing the terminology of the example provided.

Problem statement, goals and objectives

The problem statement, goals, and objectives need to match or encompass those in the recovery plan(s). Broad statements for the species/populations as a whole are acceptable at this level.

Conceptual models

This part of the logic chain only references *conceptual* models. Various types of models -- conceptual, statistical, process, simulation, etc. – can be used to identify factors that limit the population as a whole, and different models and types of models consider factors such as population dynamics, hydrology, predation, or habitat availability. These models (or perhaps a nested set of increasingly more specific models) can be used to identify what limiting factors or stressors (if any) occur within the planning area and, therefore, would be addressed by BDCP

actions. In addition, when these models are used, they relate to what has caused the problem, as articulated in the problem statement.

Hypotheses

The "hypotheses" (which as stated in the logic chain are actually assumptions rather than hypotheses) can better be characterized as specific "BDCP goals" with each goal statement articulating how a limiting factor might be addressed *within the BDCP planning area*. One goal statement for each limiting factor (e.g., increase food in the pelagic zone by 15 percent to improve sub-adult survival) specifying season and location would be necessary.

The limiting factors framed as goals do not need to be directly tested as formal hypotheses. The process relies on the models (above) or the wider knowledge base to identify the limiting factors and assumes that alleviating those factors will in fact address the problem.

Desired change

To link with the goal statements described above, the "desired change" category would be logically called "BDCP objectives." The level of quantification of the objectives depends on whether they will be used to develop prioritizations in the early planning phase (in which case they can be order-of-magnitude approximations) or if they are part of the finalized plan. If the latter, the objectives would need to be the so-called "SMART objectives" that are specific, measurable, achievable, relevant and time-based.

In some cases, the terminology "thresholds of change" has been used instead of "desired change," suggesting that there is a lower threshold of detectability of an effect or an upper threshold beyond which additional changes have no additional beneficial effects. These levels define an envelope of effects or change that is either detectable or relevant. We find the use of this terminology confusing and, in some instances, inaccurate. It needs to be clear whether this is something to be achieved (like a target) or exceeded (like a minimum acceptable achievement).

Conservation Measures

The conservation measures are the BDCP conservation measures or actions. They relate directly to the BDCP goal and objective statements and reduce the limiting factors within the BDCP planning area. Linking proposed conservation measures to BDCP goals and objectives will help to show gaps, such as objectives for which no appropriate measure exists.

Once the conservation measures have been described, a clear prioritization process would be useful, as not all measures will be logistically, financially, or politically feasible. Such prioritization could be based on an evaluation of cost effectiveness of measures relative to their outcomes and the linkages between implementation, analysis, and adaptive management. Negative consequences and the timing of actions (sequencing) would also need to be considered.

Outcomes

The projected outcomes currently are not framed as quantitative, testable hypotheses. It is at this level of the logic chain where such hypothesis testing should occur. Stated as such, these

hypotheses would drive the analytical approaches for evaluating the hypotheses and the form and structure of monitoring (i.e., gathering the information to evaluate or test the hypotheses).

The monitoring design (or experimental design) may vary among different conservation measures or be applied in different ways to different places for the same conservation measure (i.e., a real experiment). It will be critical to determine what level of measurement, monitoring, and analysis would be considered not too little (to demonstrate an effect), nor not too much (a huge investment in limited resources), but just right (the Goldilocks approach). Costing of the analytical methods and monitoring would be a consideration in the prioritization of conservation measures mentioned above. The monitoring structure will in turn lead to the selection of appropriate metrics and consideration of such key attributes as spatial and temporal resolution, statistical power, analytical framework to employ, and best representation and visualization of results.

Analysis

The analysis box in the Delta smelt logic chain provided would benefit from being more detailed and expanded to include the adaptive management loop. Adaptive management is not the same thing as the hypothesis testing that is included as part of the logic chain. Implementation of conservation measures leads to actual outcomes that must be monitored and analyzed. The comparison of projected outcomes (the hypotheses) with the actual outcomes is the focus of analysis. These results then feed into the adaptive management loop and back into other components of the logic chain (see next section). This is also where the system metrics may come in - how do the outcomes relate back not only to the specific objectives (e.g., food supply), but to the broader objectives (e.g., population growth, survival).

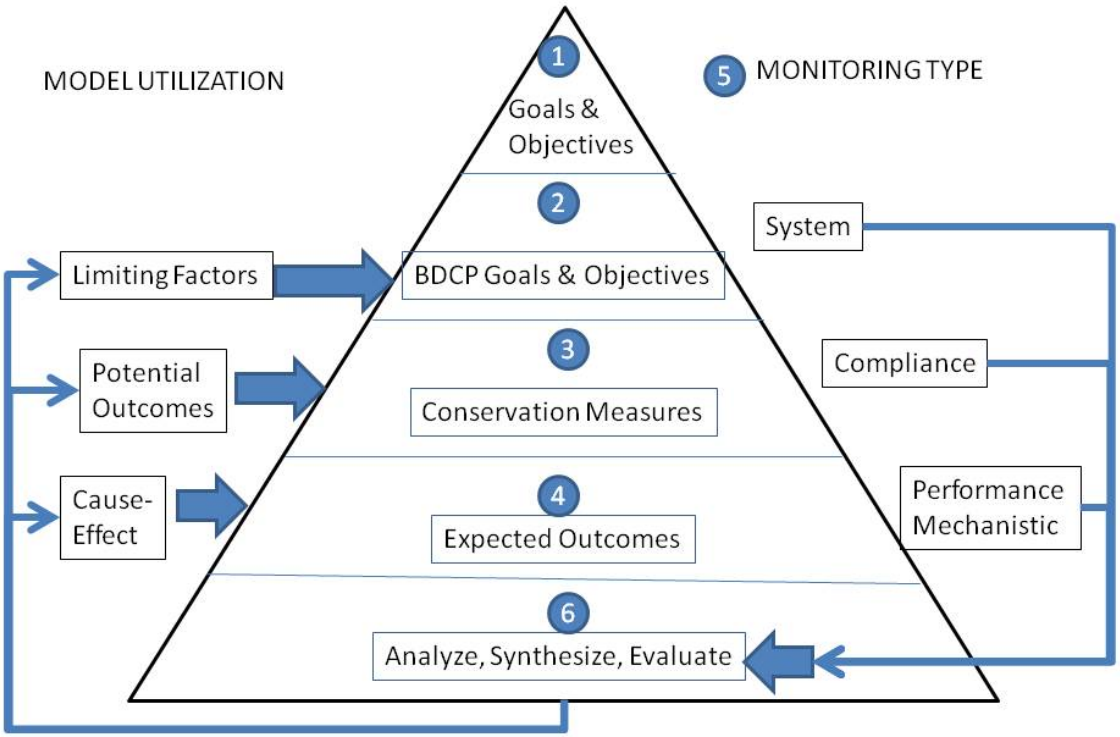
The adaptive management phase involves not only the analytical element, but the synthesis/interpretation component – what does analysis comparing projected and actual outcomes mean in terms of the objectives, identification of limiting factors, goals, or problem statement? To be effective, adaptive management needs to be part of the process, not an add-on at the end or a post-facto component once the actions have been taken. The details of adaptive management are missing from the logic chain.

There are two aspects of the hypothesis testing/analysis/interpretation components that must be distinguished: (1) the “virtual,” in which the analysis is conducted as a sophisticated conceptual or analytical modeling exercise, to explore the *anticipated* consequences of a conservation measure and the adaptive management loop; and (2) the “real,” in which the conservation measure has been implemented and we are looking at what *actually* results.

An Alternative Approach

Although there is much of value in the logic-chain approach, our evaluation and comments suggest that there is room for improvement, especially to clarify some of the logical relationships in the logic chain. We offer here an alternative approach that incorporates elements of the logic

chain. The following diagram traces the main elements of this approach; the following comments are keyed to the numbered sections in the diagram.



1. At the top of triangle are the recovery/species goals and objectives. Because the BDCP needs to contribute to recovery of the covered species, there must be a clear link to the needs of those species. This is best defined by existing recovery plans for the species. If a recovery plan is not available, the responsible agencies should provide guidance on appropriate goals and objectives for the species as a whole.

2. The contribution to recovery made by BDCP is not predefined. Expert opinion and conceptual models of the species can be used to identify limiting factors/stressors for the species; BDCP should further select those limiting factors/stressors that can be addressed by the potentially regulated entities (PREs) and that occur within the planning area. From this subset of limiting factors, BDCP can then identify more specific goals and objectives that are within its scope and that are scaled by the level of effort envisioned for the Plan.

3. Conservation Measures must be identified that have the capacity to achieve the BDCP goals and objectives. Candidate measures can be screened using simple models (e.g., conceptual, statistical) to assess potential outcomes, both positive and negative. After

screening an initial list of conservation measures, some BDCP goals and objectives may appear unlikely to be addressed; additional conservation measures should then be developed and/or the BDCP goals and objectives should be revisited to ensure that their scale and scope generally match with the level of effort envisioned for the Plan.

4. Once the types and overall scale of the conservation measures have been determined, they can be further developed to the 'project level' and more specific expected outcomes identified. At this level of specificity, models of all types can be used to apply cause-effect relationships and find outcomes that achieve BDCP goals and objectives (and identify any potential negative outcomes). Where cause-effect relationships are weak or there is disagreement over the nature or magnitude of outcomes, testable hypotheses can be developed linking the action to the outcome and projects designed to test the hypotheses. The analytical framework for testing these hypotheses (and the necessary mechanistic monitoring) should be developed at this stage, prior to implementation of the projects.

5. Monitoring informs all of these steps. System-level monitoring informs whether goals and objectives for BDCP and the species are being achieved. Compliance monitoring ensures that measures (e.g., actual Old and Middle River (OMR) flows, elevation of grade or fill, water quality standards) are being implemented as expected. Performance monitoring is used to tell whether a conservation measure is achieving the expected outcomes, and mechanistic monitoring provides diagnostic information on why the expected outcomes are or are not being achieved. These types of monitoring are described in the Independent Advisors' Report on Adaptive Management.

6. Once projects have been implemented and monitoring data are available, the key adaptive management step of Analyze, Synthesize and Evaluate must be conducted to: a) assess performance; b) inform adjustments to implemented projects and future actions; c) incorporate information as part of the knowledge base and; d) utilize information in models for future use in the planning process. This is the essence of adaptive management.

Linking Conservation Measures to Outcomes: Issues of Study Design, Quantification, Metrics, and Monitoring

Specific conservation measures provide the opportunity to develop clear hypotheses that predict outcomes, require rigorous quantification, and lead to well-designed studies with defined metrics and monitoring approaches. Conservation measures exert themselves at a variety of spatial scales. For example, reduction in a specific stressor might produce a response at the scale of the entire Delta while a habitat restoration project will impact a specific location. Study designs must necessarily consider the spatial component of the conservation measures and monitor appropriate

response variables to the action. Study designs also must consider appropriate analytical frameworks for comparing responses to the actions. Will evaluation of the conservation measure be compared to a long-term trend, a control site, or a change in trajectory within a specific location? Scientists should be engaged to address the challenges of designing studies that effectively evaluate whether implemented conservation measures are yielding desired outcomes. This is an area where scientific expertise should be focused rather than on identifying overarching goals and objectives.

Well-designed studies linked to specific conservation measures are critical for developing the larger integrated monitoring framework. Finite resources will be available to evaluate the effectiveness of conservation measures agreed upon through BDCP. The sooner that study designs with designated metrics and monitoring locations are developed for each conservation measure to be implemented, the more readily can decisions be made on the best package of metrics to deploy, the locations for these measurements, and the analytical framework for data analyses. These decisions are integral to application of adaptive management, communication of outcomes from specific conservation measures, and informing decision-makers on management actions. These steps must be carried out within the context of the overall planning effort and not left until later.

The Role of Adaptive Management

In a system as complex as the Bay-Delta, involving multiple constituencies and numerous projects that entail huge investments, it is essential to avoid costly mistakes. The focus of the logic-chain approach on defining meaningful goals and objectives for BDCP is an important part of a successful planning process. It is also an essential element of adaptive management, which itself must be a core part of BDCP. Much has been made of adaptive management and its role in effective conservation and management. *Real* adaptive management, however, is rarely undertaken. In particular, the part of the process that involves assessment and synthesis of information gained after actions have been taken is often neglected or short-circuited, and the critical phase of linking that knowledge to decisions about whether to continue, modify, or stop actions, refine objectives, or alter monitoring efforts is usually missing. The report of Independent Science Advisors on Adaptive Management to the BDCP Steering Committee provides detailed guidance that should be incorporated into any logic-chain approach in BDCP.

Several aspects of adaptive management merit particular attention in relation to the logic-chain approach. First, adaptive management must begin with a clear definition of the problem to be addressed and the goals and objectives to be met. The hierarchical structure of logic plans helps to bring clarity to these statements of goals and objectives. Second, models can play a valuable role in adaptive management. Many of the conservation measures being proposed for the Bay-Delta are large and expensive; simulation or scenario models can be used to explore the likely

outcomes of these measures before actually implementing the measures, and this information can be used in an adaptive-management framework to adjust goals, objectives, hypotheses, or measures as appropriate. Third, the adaptive-management phases of assessment, synthesis, translation, and communication must be integral parts of either model-based or actual implementations of adaptive management. Little is accomplished by producing model output or monitoring following the implementation of conservation measures if the resulting information does not make its way, in a carefully evaluated and readily comprehensible form, into the decision-making process.

Prioritization and Sequencing

The successful development of quantifiable objectives for BDCP will provide added benefits by allowing the expected outcomes of individual conservation measures to be compared to one another and used with other data to prioritize and sequence implementation. Measures with more significant outcomes and a broader range of species to benefit will be identified. Together with cost information (including the potential for negative outcomes), this information can be used by BDCP to develop a prioritized list of conservation measures, with the order of implementation being dependent upon decision criteria such as risk tolerance, availability of funds, cost relative to expected benefit, water requirements, and ease of implementation. For example, an implementation plan could sequence high-priority projects based on costs and reliability of benefits to seek to achieve early successes at minimal cost. Well-developed decision-support tools, such as ecological risk assessment or return-on-investment analysis, should be incorporated into the prioritization process.

APPENDIX 1

Specific Questions to the Panel and Panel Responses

The charge to the Review Panel included several specific questions. Here are our answers; the main body of the report describes our responses, evaluations, and suggestions in greater detail.

Purpose

- Does the framework reflect the recommendations made in February 2009 by the BDCP Independent Science Advisors' Report on Adaptive Management? *No*
- Can the framework adequately serve as a basis for refining the BDCP goals and objectives and developing an adaptive management plan? *Yes, if developed fully*
- Is the logic framework clearly defined and described? *Only partially*
- Is it internally consistent? *It is not consistent in how hypothesis testing is being employed*
- Is it clear for what purpose and how the framework might be used? *Yes, although greater clarity in linking BDCP goals and objectives to conservation measures and outcomes would be an improvement*

Approach

- Are the linkages between elements of the framework clear? *Yes*
- Is the relationship between recovery plan goals and BDCP goals and objectives clear? *No*
- What level of detail is necessary for the goals and objectives and for the framework in general? *Recovery/species goals and objectives can be stated qualitatively if sufficient detail is not available; BDCP objectives can be stated qualitatively or with order-of-magnitude approximations in the early planning stages, but with greater quantification as the plan is finalized for implementation; expected outcomes to conservation measures should be stated in sufficient quantitative detail to permit measurement, analysis, and testing of hypotheses.*
- Is the current use of conceptual models and hypotheses clear and helpful? *Only partially; currently the hypotheses are in the wrong place in the logic chain.* If not, how might this be changed or refined? *We have offered a refinement of the logic chain approach that improves clarity*
- What are the next steps regarding populating the logic chain? *General goals and objectives should be defined and populated by the appropriate regulatory agencies; it should be an immediate priority to develop clearer, more concise language and to find consensus on goals and objectives within the BDCP steering committee*
- What, if any, future role/need is there for additional scientific input? *The hypotheses linking conservation measures to projected outcomes, the design of studies to assess these linkages, and the framework for implementing adaptive management would benefit from additional scientific input*

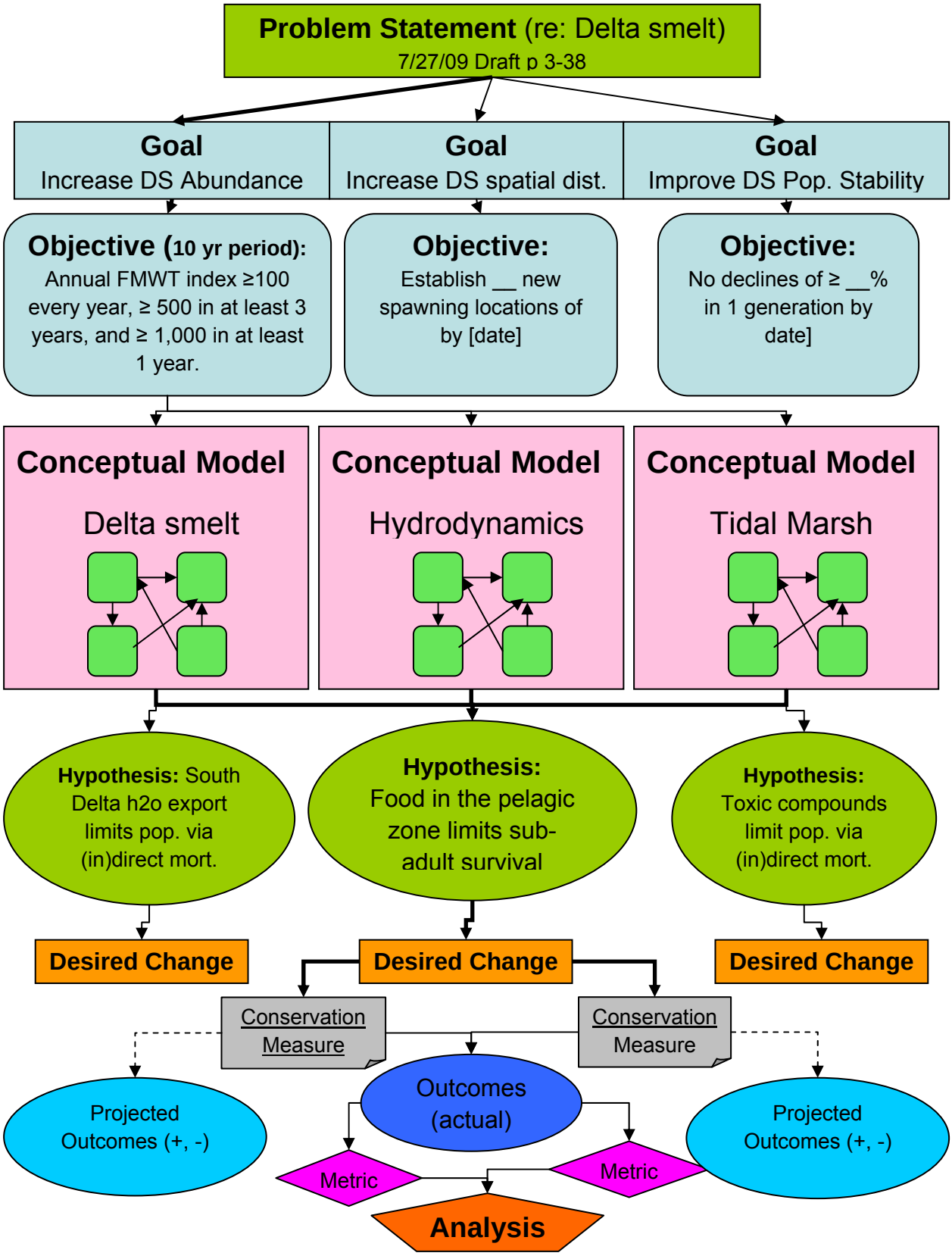
Feasibility

- Is the framework approach feasible to implement? *Yes, if done so in a focused manner*

- If not, what can be done to streamline or phase the approach? *Conduct a complete logic chain assessment for 2-3 species as proof of concept*

APPENDIX 2

The Current Version of the Logic Chain for Delta Smelt
(Appendix B of the Logic Chain provided by American Rivers and The Bay Institute)


Problem Statement (re: Delta smelt)
7/27/09 Draft p 3-38
Goal
Increase DS Abundance
Goal
Increase DS spatial dist.
Goal
Improve DS Pop. Stability
Objective (10 yr period):
Annual FMWT index ≥100 every year, ≥ 500 in at least 3 years, and ≥ 1,000 in at least 1 year.
Objective:
Establish __ new spawning locations of by [date]
Objective:
No declines of ≥ __% in 1 generation by date]
Conceptual Model
Delta smelt
Conceptual Model
Hydrodynamics
Conceptual Model
Tidal Marsh
Hypothesis: South Delta h2o export limits pop. via (in)direct mort.
Hypothesis:
Food in the pelagic zone limits sub-adult survival
Hypothesis:
Toxic compounds limit pop. via (in)direct mort.
Desired Change
Desired Change
Desired Change
Conservation Measure
Conservation Measure
Projected Outcomes (+, -)
Outcomes (actual)
Projected Outcomes (+, -)
Metric
Metric
Analysis