Chapter 10
Integration of Independent Science in BDCP Development

Contents

Acronyms and Abbreviations

BDCP or the Plan	Bay Delta Conservation Plan
BiOp	biological opinion
CDFW	California Department of Fish and Wildlife
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
EIR	environmental impact report
EIS	environmental impact statement
Fish & Game Code	California Fish and Game Code
FR	Federal Register
HCP	habitat conservation plan
IEP	Interagency Ecological Program
NCCP	Natural Community Conservation Plan
NCCPA	Natural Community Conservation Act
NMFS	National Marine Fisheries Service
OCAP	Operational Criteria and Plan
RPA	reasonable and prudent alternative
USFWS	U.S. Fish and Wildlife Service

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10.1 Background and Regulatory Requirements

The Bay Delta Conservation Plan (BDCP or the Plan) is built upon and reflects the extensive body of scientific investigation, study, and analysis of the Delta compiled over several decades, including the results and findings of numerous studies initiated under the CALFED Science Program, Ecosystem Restoration Program, and Delta Science Program; the long-term monitoring programs conducted by the Interagency Ecological Program (IEP); research and monitoring conducted by state and federal resource agencies; and research contributions of academic investigators[1]. In addition, the Steering Committee[2] considered several other reports on the Delta, including the report of the Governor's Delta Vision Blue Ribbon Task Force (2008), recent reports from the Public Policy Institute of California (Lund et al. 2007, 2008), *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta* (California Department of Fish and Game 2010), and Delta flow criteria recommended by the California State Water Resources Control Board (2010). Development of the BDCP also has been informed by reviews of water management and of the BDCP itself published by the National Research Council (2010, 2011, 2012); by reviews of the effects analysis performed by the Delta Science Panel (Parker et al. 2011, 2012); and by overarching reviews of varied topics such as visions for future management of the Delta (Lund et al. 2007, 2008), the use of historical ecology to understand ecological function and plan suitable restoration for the Delta (Whipple et al. 2012), and current scientific and public views of water management in the Delta (Hanak et al. 2013).

In the Five-Point Policy for habitat conservation plans (HCPs), the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) encourage the use of independent science to help inform the development of HCPs (*Federal Register* [FR] 35242; June 1, 2000). The Natural Community Conservation Act (NCCPA) requires the planning process to include opportunity for independent scientific input to assist with the development of the plan. This independent scientific input would include the following measures (California Fish and Game Code [Fish & Game Code] 2810(b)(5)).

- Recommend scientifically sound conservation strategies for species and natural communities proposed to be covered by the plan.
- Recommend a set of reserve design principles that addresses the needs of species, landscapes, ecosystems, and ecological processes in the planning area proposed to be addressed by the plan.

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[1] The purpose of this chapter is to describe the role of science in development of the plan up till the present. Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*, describes how scientific monitoring, research and independent review will be incorporated into the implementation of the Plan over the course of the permit term.

[2] The BDCP Steering Committee, composed of permit applicants, government agency representatives, and other concerned parties, directed BDCP development from 2006 to 2010.

- Recommend management principles and conservation goals that can be used in developing a framework for the monitoring and adaptive management component of the plan.
- Identify data gaps and uncertainties so that risk factors can be evaluated.

Recognizing the need for and value of independent science input, a number of steps were taken to engage independent scientists at several stages of the planning process. Engagement of independent scientists was managed through a neutral facilitation team established specifically for this purpose, as described in more detail below. Advice and recommendations from independent scientists were captured in Independent Science Advisor reports. All advice provided by independent scientists was given serious consideration during development of the BDCP. The following sections provide more details on the independent science advisory process, recommendations provided, and how these recommendations were incorporated into the BDCP.

10.2 Independent Science Advisory Process

To ensure that the BDCP is based on the best scientific and commercial data available, the Steering Committee sought input and advice from independent scientists on key elements of the BDCP. Early in the planning process, the Steering Committee retained the services of an independent Science Facilitation team, consisting of staff from the Conservation Biology Institute and The Essex Partnership, to facilitate independent science panels consistent with the Five-Point Policy (65 FR 35242) and the Guidance for the Natural Community Conservation Plan (NCCP) Independent Science Advisory Process (California Department of Fish and Wildlife [CDFW] 2002). The Steering Committee also established a Science Liaisons group, consisting of members of the Steering Committee, to work with the Science Facilitators to ensure an appropriate level of independent scientific input into the development of the BDCP. The Science Liaisons and the Science Facilitators worked together to identify potential areas of scientific expertise needed to support BDCP development and to identify issues and questions for the Science Advisors to address. Basic planning guidelines to select and engage independent scientists were developed (Reed et al. 2007). These planning guidelines were refined in 2008 when the Science Liaisons and the Science Facilitators developed a process designed to accommodate different levels or tiers of review based on the scope of the input sought. This tiered approach was outlined in a draft memo in 2008 (Reed et al. 2008).

Consistent with the requirements of the NCCPA and the policy directives of the Five-Point Policy (65 FR 35242), the Steering Committee directed the Science Facilitators to convene independent scientists at several key stages of the planning process, enlisting well-recognized experts in ecological and biological sciences to produce recommendations on a range of relevant topics, including approaches to conservation planning for aquatic and terrestrial species in the Delta and developing adaptive management and monitoring programs.

Each of the independent science efforts is summarized in Section 10.3, *Independent Science Reviews,* including a brief summary of major findings and information regarding how recommendations were incorporated into the overall planning process.

The Steering Committee also engaged more than 50 scientists in 2009 to review each draft conservation measure in development at that time using a modified version of scientific evaluation process developed for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (Essex Partnership 2009). The process for this scientific evaluation is described in Section 10.3.4, *Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Evaluation Process*.

10.3 Independent Science Reviews

10.3.1 Initial BDCP Independent Science Advisors

The first group of Independent Science Advisors gathered in September 2007 to provide guidance on the approach to planning for the conservation of aquatic species and ecosystem processes in the Delta. Specifically, the group provided advice on the following elements of the BDCP.

- The application of conservation planning principles within the Plan Area.
- Geographic and temporal scope of the BDCP.
- Addressing facets of Delta ecosystem dynamics.
- Analytical methods used in formulation, methods of analysis.
- Adaptive management and monitoring considerations.

The Science Advisors (Reed et al. 2007) offered the following principles to guide conservation planning.

- Changes in the estuarine ecosystem may be irreversible.
- Future states of the Delta ecosystem depend on both foreseeable changes (e.g., climate change and associated sea-level rise) and unforeseen or rare events (e.g., the consequences of new species invasions).
- The Delta is part of a larger river-estuarine system that is affected by both rivers and tides. The Delta also is influenced by long-distance connections, extending from the headwaters of the Sacramento and San Joaquin Rivers into the Pacific Ocean.
- The Delta is characterized by substantial spatial and temporal variability, including disturbances and extreme events that are fundamental characteristics of ecosystem dynamics. The Delta cannot be managed as a homogeneous system.
- Species that use the Delta have evolved life history strategies in response to variable environmental processes. Species have limited ability to adapt to rapid changes caused by human activities.
- Achieving desired ecosystem outcomes will require more than manipulation of Delta flow patterns alone.
- Habitat should be defined from the perspective of a given species and is not synonymous with vegetation type, land (water) cover type, or land (water) use type.
- Changes in water quality have important direct and indirect effects throughout the estuarine ecosystem.
- Land use is a key determinant of the spatial distribution and temporal dynamics of flow and contaminants, which in turn can affect habitat value.
- Changes in one part of the Delta may have far-reaching effects in space and time.
- Prevention of undesirable ecological responses is more effective than attempting to reverse undesirable responses after they have occurred.
- Adaptive management is essential to successful conservation.

- Conservation measures to benefit one species may have negative effects on other species.
- Data sources, analyses, and models should be documented and transparent so they can be understood and repeated.
- Ecosystem responses, especially to changes in system configuration, can be predicted using a combination of statistical and process models. Statistical models document status, trends, and relationships between responses and environmental variables, whereas process-based models are useful in understanding system responses and for forecasting responses to new conditions.
- There are many sources of uncertainty in understanding a complex system and predicting its responses to interventions and change.

A number of the above principles were used to develop and refine the conservation strategy as well as individual conservation measures and the evaluation of those measures. The biological goals and objectives recognize the importance of environmental gradients and the need to provide for a highly variable system. The conservation strategy focused on developing conservation measures that promote regional strategies that acknowledge particular natural community characteristics, and that promote broader geographical range diversity for key species. Specific modeling tools were developed to predict the outcomes of given actions and combinations of actions as evaluated in the effects analysis (Chapter 5, *Effects Analysis*).

In addition to general conservation principles, the first group of Independent Science Advisors provided a number of more specific recommendations regarding the scope, ecosystem dynamics, analytical methods, and adaptive management and monitoring. With regard to the scope of the BDCP, additional advice was sought regarding geographic scope, and additional species were added to the covered species list, as recommended by the Science Advisors.

Sensitivity analyses were conducted, as recommended by the Science Advisors, to examine the effect on conservation outcomes of anticipated changes in environmental gradients expected to arise from sea level rise, subsidence, climate change-induced alteration in the timing of runoff, human activities, and other processes over the timeframe of BDCP implementation. With regard to ecosystem dynamics, the BDCP was designed specifically to consider relationships between environmental conditions and the covered species in a life cycle context and to anticipate how changes in environmental conditions, including those associated with covered activities and climate change, may propagate through populations of covered species, as suggested by the Science Advisors. For example, bypass flow requirements associated with the proposed new north Delta diversions were carefully designed to minimize or avoid adverse effects on outmigrating juvenile Chinook salmon. Similarly, proposed tidal habitat restoration areas were selected and designed to include a sufficient spatial extent of appropriate elevations to provide for environmental gradients and accommodate sea level rise.

With regard to analytical methods, the Science Advisors recommended several specific approaches to hydrodynamic modeling, including the use of models that accurately reproduce tidal flows in the system for analysis of Delta transport and dispersion, and the use of data that span as broad a range of hydrologic and operational conditions as possible. Several detailed two- and three-dimensional models were used to analyze the effects of potential conservation actions, particularly with regard to issues of transport, dispersion, residence time, and sea level rise.

With regard to adaptive management and monitoring, the Science Advisors recommended that the Steering Committee convene a group of science advisors to work with the planning team to develop an appropriate adaptive management and monitoring strategy to support implementation of the BDCP. The Steering Committee convened such a group in 2009, as described in Section 10.3.3, *Independent Science Advisors on Adaptive Management*.

A few recommendations were not implemented because they were not deemed practical or other alternate tools were available to address the underlying issue intended by the recommendation. For example, recommendations related to the development of new planning tools (e.g., hydrodynamic, ecosystem, species models) were not deemed practical because they could not be developed to a usable form within the timeframe of BDCP development. These planning tools, however, could be designed during BDCP implementation to inform development and implementation of specific actions in fulfillment of the conservation measures. The BDCP adaptive management program (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*) calls for the development and use of such models.

10.3.2 Independent Science Advisors for Nonaquatic Resources

A second group of Science Advisors convened in September 2008 to consider approaches to planning for the conservation of nonaquatic resources in the Plan Area. The group provided recommendations to the Steering Committee on various issues.

- Nonaquatic species to be considered for regulatory coverage under the BDCP.
- Terrestrial natural communities that should be addressed under the BDCP.
- Landscape-level approaches to conservation planning for nonaquatic resources.
- Additional sources of information to be developed to support the nonaquatic resource elements of the BDCP.
- Conservation strategies that may be considered to address terrestrial and nontidal wetland communities and dependent wildlife and plant species.

The Science Advisors (Spencer et al. 2008) offered specific advice on the species selection process, including consideration of listing status, occurrence in the Plan Area, potential to be affected by BDCP covered activities, and sufficiency of information. The Science Advisors offered suggestions regarding potential covered species additions and deletions, as well as suggestions regarding potential planning species[3]. The Science Advisors also offered specific suggestions regarding proposed conservation measures and design considerations regarding the refinement of the conservation strategy for nonaquatic resources. General principles suggested in considering the selection, design, and implementation of conservation measures are listed below.

- Develop conservation measures hierarchically, working from ecosystem to community to species-level considerations. Do not plan conservation measures for specific covered species or communities in isolation, without considering their relationships with other species and communities in the broader ecosystem.
- Design reserve or management areas to achieve mosaics of community types within areas large enough to support the most area-dependent covered (or planning) species and desired

[3] *Planning species* refers to those species for which regulatory coverage may not be necessary, but that can serve as indicators of ecological conditions or processes in covered communities (Spencer et al. 2008).

ecological services, and to accommodate future shifts due to climate change (e.g., sea level rise, changing runoff patterns, shifting climate "envelopes").

- Strive for representation of all community types in habitat mosaics well distributed across the Delta, but considering site-specific conditions. Where possible, maintain or create "soft edges" or natural transitions along environmental gradients, as opposed to abrupt transitions or "hard edges" between community types.
- Bigger is better for habitat conservation and restoration sites, but do not ignore small areas that support rare communities or species. For example, small areas of seasonal wetlands, inland dunes, or alkali flats support disproportionate numbers of imperiled species.
- Seek to preserve and enhance natural heterogeneity in elevation, water depth, flooding frequency, nutrient conditions, vegetation types, and adjacency of different habitat types within and among the conserved, restored, or maintained habitat mosaics.
- Enhance and preserve habitat connectivity where possible to maximize potential for natural range shifts, population expansions, escape from disturbance events (fires, floods), and maintenance of ecological processes, and to avoid isolating small populations of those species having limited dispersal abilities.
- Strive to create self-sustaining systems, but recognize that some communities and species may need active or perpetual management. For example, some invasive, nonnative species may require prolonged control efforts to sustain covered species or communities that they adversely affect.

Suggestions regarding covered species and design principles were used to refine the covered species list and to refine the proposed conservation measures. The species recommended for coverage by the Science Advisors were evaluated and added to the list of covered species if they were likely to become listed over the term of the BDCP. Recommended additions to the covered species list that were not included (because they did not meet the selection criteria) are still expected to benefit from implementation of the ecosystem-level and natural community-level conservation measures. As suggested by the Science Advisors, the biological goals and objectives and the conservation measures were both structured to work from landscape- to natural community- to species-level considerations. Very few of the conservation measures are oriented toward a specific covered species, and then only when proposed landscape or natural community-scale actions are not sufficient to address a specific species need. Similarly, all proposed habitat restoration actions have been designed to preserve and enhance natural heterogeneity in elevation, water depth, flooding frequency, nutrient conditions, vegetation types, and adjacency of different habitat types, as recommended by the Science Advisors.

10.3.3 Independent Science Advisors on Adaptive Management

The third group of Science Advisors met in December 2008 and provided input on approaches to the development of an adaptive management plan and decision-making process for the BDCP, informed by data and information generated by monitoring and research efforts. This group built upon guidance on adaptive management that was provided in the initial Independent Science Advisors report (Reed et al. 2007), offering more specific advice based on progress that had since been made in the development of the BDCP.

The Science Advisors (Dahm et al. 2009) recommended adoption of an adaptive management framework, and offered eight principles for adaptive management.

- The scope and degree of reversibility of each proposed action (i.e., conservation measure) determines the form of adaptive management that can be applied (e.g., active or experimental adaptive management versus passive adaptive management).
- The knowledge base about the ecosystem is key to decisions about what to do and what to monitor, and includes all relevant information, not just that derived from monitoring and analysis within the context of the BDCP.
- Program goals should relate directly to the problems being addressed and provide the intent behind the conservation measures; objectives should correspond to measurable, predicted outcomes.
- Models should be used to formalize the knowledge base, develop expectations of future conditions and conservation outcomes that can be tested by monitoring and analysis, assess the likelihood of various outcomes, and identify tradeoffs among conservation measures.
- Monitoring should be targeted at specific mechanisms thought to underlie the conservation measures, and must be integrated with an explicitly funded program for assessing the resulting data.
- Prioritization and sequencing of conservation measures should be assessed at multiple steps in the adaptive management cycle.
- Specifically targeted institutional arrangements are required to establish effective feedback mechanisms to inform decisions about whether to retain, modify, or replace conservation measures.
- A dedicated, highly skilled agent (person, team, office) is essential to assimilate knowledge from monitoring and technical studies and make recommendations to senior decision makers regarding programmatic changes.

Each of the eight principles above has been incorporated into the BDCP (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*), including the overall form of the adaptive management framework, plans for an explicitly funded monitoring and research program, clear institutional arrangements to establish feedback mechanisms to support decision making, and establishment of an Adaptive Management Team responsible for administration of the Adaptive Management and Monitoring Program.

10.3.4 Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Scientific Evaluation Process

In 2008 and 2009, the Steering Committee undertook a rigorous process to incorporate new and updated information and to evaluate a wide variety of issues and approaches as it formulated a cohesive, comprehensive conservation strategy. This effort included an evaluation conducted early in 2009 by multiple teams of experts of draft conservation measures in development at that time, using the CALFED Ecosystem Restoration Program DRERIP scientific evaluation process.

In October 2008, the Steering Committee developed early drafts of conservation measures related to water operations, habitat restoration, and other stressors. The DRERIP scientific evaluation process was used to evaluate these draft conservation measures. The DRERIP scientific evaluation process was developed specifically to aid in planning and decision making regarding potential ecosystem restoration projects in the Delta. The process entails engaging teams of experts to work through a structured, step-by-step examination of the scientific efficacy of proposed restoration actions by analyzing both potential positive and negative outcomes that might result from a given action.

To conduct the DRERIP scientific evaluations, the Steering Committee engaged 52 technical experts assembled into five teams to address related groupings of conservation measures. The DRERIP technical team meetings were limited to specific technical experts trained in the DRERIP scientific evaluation process. The teams conducted the evaluations from January through April 2009 on 32 draft conservation measures that could be evaluated using the process. The evaluations were conducted using a series of peer-reviewed DRERIP ecosystem (processes, habitats, and stressors) and species life history conceptual models developed specifically for the Delta and additional relevant sources of information (e.g., published literature, recently collected data). The conceptual models describe much of the current scientific understanding regarding how the Delta ecosystem works (Essex Partnership 2009).

The results include an assessment of the likely magnitude of the ecological outcomes and the certainty of those outcomes that could be associated with implementing each evaluated conservation measure. However, because the DRERIP process was designed to evaluate restoration actions independently, it does not provide for a direct assessment of the combined magnitude and certainty of positive and negative ecological outcomes that would be associated with the contemporaneous implementation of multiple conservation measures under the BDCP. To address this need, the Steering Committee established the Synthesis Team, composed of Steering Committee member representatives and technical experts that participated in the DRERIP evaluations to conduct an assessment of the likely synergistic ecological effects of concurrent implementation of multiple conservation measures based on the evaluation results for individual conservation measures. The Synthesis Team conducted their evaluation from March through April 2009 and provided recommendations to the Steering Committee for refining conservation measures, sequencing implementation of conservation measures, and adjusting DRERIP results for individual conservation measures based on their synergistic effects with implementation of other conservation measures (Essex Partnership 2009).

The results of this analysis were incorporated into the BDCP and influenced the selection and definition of many conservation measures, particularly the other stressors measures (CM13 to CM21), as well as the sequencing of restoration set forth in Chapter 6, *Plan Implementation*. The results of the scientific evaluation also were used to inform development of the effectiveness monitoring for conservation measures and directed research (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*).DRERIP evaluation results include assessments and sources of uncertainty surrounding the magnitude of ecological outcomes that could be expected with the implementation of each conservation measure. Effectiveness monitoring and directed research will be developed to collect the information necessary to address these sources of uncertainty and to inform the need for future adjustments to conservation measures to improve their performance over time through the adaptive management decision-making process (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*).

10.3.5 Independent Science Input on Logic Chain Approach

The Delta Science Program provided assistance in assembling a fourth group of Science Advisors in February and March 2010 and a fifth group in July and August 2010 to evaluate and provide recommendations on the logic chain planning structure. The logic chain was proposed as a framework to link recovery goals for covered fish species with biological goals, objectives, conservation measures, monitoring, and adaptive management. Two science reports on the logic chain were prepared (Dahm et al. 2010; Reed et al. 2010).

In the first report, dated March 19, 2010 (Dahm et al. 2010), the Science Advisors initially assessed the value of the logic chain as a tool, its internal consistency, and next steps for input of information into the logic chain. The group stated that the logic chain was a useful tool for clearly articulating and linking goals, objectives, actions, and outcomes but recommended an alternate approach, as follows.

- Clarify the links in the chain and reduce areas of ambiguity.
- Distinguish between order-of-magnitude approximations of goals and objectives that are acceptable in early planning and the more detailed descriptions developed later.
- Frame projected outcomes as testable hypotheses linked to specific conservation measures.
- Use metrics to evaluate the success of outcomes that clearly link to biological functions and consider the judicious use of surrogate metrics.
- Consider constraints to implementation of conservation measures.
- Consider the potential impacts of system dynamics, variation, and change over time.
- Provide more detail to the adaptive management framework.

As next steps, the Science Advisors (Dahm et al. 2010) recommended developing logic chains for a few species initially, leaving recovery goal development to responsible regulatory agencies, focusing on development of the biological goals and objectives, and convening a workshop to develop monitoring metrics. In response to this recommendation, the Steering Committee convened a Logic Chain Group that developed example logic chains for two fish species (longfin smelt and winter-run Chinook salmon). These two examples and the lessons learned from their development formed the basis for a second independent logic chain review.

In the second report, dated August 23, 2010 (Reed et al. 2010), the Science Advisors assessed the two populated logic chains to evaluate internal logic, measurability, and linkages and consistency in approach. The group also recommended alternative strategies and metrics for goals and objectives and alternative ways to frame goals and objectives to be more practical and provided advice on constructing an integrated monitoring program linked to the logic chains. Reed et al. (2010) made the following recommendations.

- Simplify the logic chain structure to reduce the number of objective statements and to focus on biological goals and objectives.
- Identify stressors that are outside of BDCP management.
- Focus biological goals and objectives on measures of individual and population-level performance, such as habitat-specific estimates of growth and survivorship, quantitative estimates of abundance, and quantitative measures of movement and/or distribution.

- Take care in populating the compliance and performance monitoring actions and consider three monitoring levels separately, the global goal, the "covered activity" level, and compliance.
- Link implementation of conservation measures, through monitoring and evaluation, to the adaptive management program.

In response to the recommendations from the second logic chain review, the Steering Committee directed staff to complete logic chains for all covered fish species in accordance with the guidance provided by the review panel. Draft logic chains were completed in October 2010, and a technical workshop was organized, as recommended by the review panel, to review and refine the drafts. Some of this material was subsequently incorporated into the Plan. In particular, the logic chain development had a lasting influence on the Plan by helping to drive development of a unified, formal, model-based analysis framework that is most apparent in the analytical framework for the effects analysis (Chapter 5, Section 5.2, *Methods*).

10.3.6 Independent Science Advisors for Aquatic Resources

Independent Science Advisors were next convened in 2011 to refine biological goals and objectives for covered fish species. The Science Advisors first issued a summary report (Anderson et al. 2011) with the following determinations.

- The goals and objectives already articulated for some species provide a good starting point for further refinement.
- Goals and objectives must use clearly defined, and agreed upon, terms (i.e., a glossary). To the extent possible they must be clear, concise, obtainable, and measurable.
- Quantitative objectives may not be possible for many of the listed fish species.
- There are presently a few situations where quantitative objectives can be determined. This will change in the future as improved understanding and predictive tools become available.
- Quantitative objectives can be expressed in various ways, including the reduction of stressors, responses of fish abundance, spatial distribution, and key population dynamic processes (growth, survival, reproduction, and migration).
- Establishing baseline reference conditions that can be used as a foundation for the future refinement of objectives and the plan as a whole is essential.
- Determining the objectives that address some of the stressors for a few of the listed species (e.g., delta smelt) will be controversial and developing objectives for these may be dependent on more focused discussion and/or the development of additional analyses.
- The approaches to the development of quantitative objectives included here are for illustrative purposes and require review and refinement before becoming the basis for a conservation plan.
- Extending and applying the illustrative approaches to developing quantitative objectives is best achieved by experts working closely with a team of independent advisors; for the plan to be successful, stakeholders must 'own' the objectives.
- Development of conservation measures to achieve objectives developed for individual species must consider effects on other species, both positive and negative.

The Science Advisors initially recommended specific objectives for three species: winter-run Chinook salmon, Sacramento splittail, and delta smelt, followed by recommendations for the remaining fish species. Further development and final formulation of biological goals and objectives for covered fishes occurred in consultation with CDFW, NMFS and USFWS biologists, as described in Appendix 3.A, *Background on the Process of Developing the BDCP Conservation Measures*.

10.3.7 National Research Council Reviews of the BDCP

The National Research Council has issued three reports addressing the Sacramento River-San Joaquin River Delta and the role of the BDCP in management of the area, in 2010, 2011, and 2012.

10.3.7.1 National Research Council 2010 Report

A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay-Delta (National Research Council 2010), was focused on the operational criteria and plan (OCAP) biological opinions (BiOps). It is relevant to the BDCP insofar as the BDCP implements many measures of the reasonable and prudent alternatives (RPAs) and addresses the same environmental problems. Moreover, the report identified many issues that were subsequently found to be among the most challenging in the BDCP development process, primarily due to large uncertainties surrounding them. This report included the following conclusions and recommendations.

- "Although there are scientifically based arguments that raise legitimate questions about this action, the committee concludes that until better monitoring data and comprehensive life-cycle models are available, it is scientifically reasonable to conclude that high negative [Old and Middle River] flows in winter probably adversely affect smelt populations. Thus, the concept of reducing [Old and Middle River] negative flows to reduce mortality of smelt at the [State water Project] and [Central Valley Project] facilities is scientifically justified" (National Research Council 2010:4).

  This finding has been borne out by subsequent investigations. *CM1 Water Facilities and Operation* includes provisions to reduce Old and Middle River negative flows.

- "The X2 action is conceptually sound in that to the degree that the amount of habitat available for smelt limits their abundance, the provision of more or better habitat would be helpful. However, the derivation of the details of this action lacks rigor. … [H]ow specific X2 targets were chosen and their likely beneficial effects need further clarification. It also is critical that the adaptive-management requirements included in the RPA be implemented in light of the uncertainty about the biological effectiveness of the action and its possibly high water requirements" (National Research Council 2010:5-6).

  This finding has also been supported by further work detailed in the effects analysis in Chapter 5, *Effects Analysis*. The recommendation regarding adaptive management is reflected in the BDCP in the form of the fall outflow decision tree presented in *CM1 Water Facilities and Operation*, which provides for further research and monitoring to resolve the remaining uncertainties and use that knowledge to prescribe initial water operations criteria.

- "the relationship between tidal habitats and food availability for smelt is poorly understood. … The committee recommends that this action [RPA requirement for tidal habitat restoration] be implemented in phases, with the first phase to include the development of an implementation and adaptive management plan (similar to the approach used for the floodplain habitat action in the NMFS 2009 BiOp), but also to explicitly consider the sustainability of the resulting habitats, especially those dependent on emergent vegetation, in the face of expected sea-level rise" (National Research Council 2010:6).

This recommendation was also influential in development of the conservation strategy, particularly *CM4 Tidal Natural Communities Restoration*. The BDCP, compared with the USFWS 2008 and NMFS 2009 BiOps, provides a more extensive rationale of the basis for tidal habitat restoration in support of covered fishes, phases the restoration over a 40-year period, provides for extensive research and monitoring under the umbrella of an adaptive management program, and explicitly accommodates environmental changes associated with sea level rise.

- With regard to the NMFS 2009 BiOp, the report concluded "most, if not all, of the actions in this RPA had a sound conceptual basis, the biological benefits and water requirements of several of the actions are, as with the delta smelt actions, likely quite sensitive to the specific triggers, thresholds, and flows specified. As a result, the committee recommends that the specific triggers, thresholds, and flows receive additional evaluation that is integrated with the analyses of similar actions for delta smelt" (National Research Council 2010:7).

  The BDCP incorporates this recommendation primarily by providing a single comprehensive effects analysis that evaluates the effects of covered activities on both salmonids and smelts (as well as on the other covered species), and also by formulating biological goals and objectives for the salmonids that are based upon a detailed appraisal of the triggers, thresholds, and flows specified in those objectives and in the water operations criteria.

- With regard to the routing of flows through Yolo Bypass, the report concluded that it is "scientifically justified, but the implications for the system as a whole of routing additional flows through the Yolo Bypass for the system were not clearly analyzed. In particular, the consequences of the action for Sacramento River flows and for the potential mobilization of mercury were not clearly described."

  The BDCP addresses each of these issues. The effects analysis identifies the system-wide consequences of routing flows through Yolo Bypass, *CM2 Yolo Bypass Fisheries Enhancement* provides a detailed program for modifying and managing flows through and habitat within the bypass, and *CM12 Methylmercury Management* provides a detailed vision of how methylmercury risks will be managed.

- Finally, the report concluded that "the RPAs lack an integrated quantitative analytical framework that ties the various actions together within species, between smelt and salmonid species, and across the watershed. This type of systematic, formalized analysis, although likely beyond the two agencies' legal obligations when rendering two separate biological opinions, is necessary to provide an objective determination of the net effect of all their actions on the listed species and on water users" (National Research Council 2010:9).

  The BDCP provides such an analytical framework. The next National Research Council (2011) report provided guidance used in development of the BDCP analytical framework.

10.3.7.2 National Research Council 2011 Report

A Review of the Use of Science and Adaptive Management in California's Draft Bay Delta Conservation Plan (National Research Council 2011) was focused on the public administrative draft BDCP released in November 2010. This draft contained a conservation strategy (Chapter 3, *Conservation Strategy*) but no effects analysis (Chapter 5, *Effects Analysis*). The review criticized the administrative draft for shortcomings in four areas: scope, science, adaptive management, and management fragmentation.

With regard to scope, the report stated that, in general, "a successful effects analysis … includes an integrated description of the components of the system and how they relate to each other; a synthesis of the best available science; and a representation of the dynamic response of the system" (National Research Council 2011:4). The effects analysis presented in the current BDCP draft includes these elements. The report also expressed concern that the purpose of the BDCP is not clear, "which makes it difficult for this panel and the public to properly understand, interpret, and review the science that underlies the BDCP" (National Research Council 2011:4) and also that "a systematic and comprehensive restoration plan needs a clearly stated strategic view of what each major scientific component of the plan is intended to accomplish and how this will be done" (National Research Council 2011:6). This weakness is also addressed in the current BDCP draft, which now contains clear statements of both overarching goals (Chapter 1, *Introduction*), of water operations (*CM1 Water Facilities and Operation*) and of specific biological goals and objectives (Chapter 3, Section 3.3, *Biological Goals and Objectives*).

The report also asserted that the absence of alternative development or analysis indicates a *post hoc* rationalization of a preconceived project (National Research Council 2011:4). Multiple alternatives are addressed in the environmental impact report (EIR)/environmental impact Statement (EIS) for the BDCP, and the history of alternative development is addressed in the EIR/EIS Appendix 3A, *Alternatives Development Report*. The development of the conservation strategy (in essence, a consideration of alternative approaches) is described in *Appendix 3.A, Background on the Process of Developing the BDCP Conservation Measures.* The BDCP also contains an analysis of alternatives in Chapter 9, *Alternatives to Take*.

With regard to science, the report's principal concerns dealt with an apparent absence of synthesis, presenting a wide array of technically complex determinations without presenting any unifying discussion of the net consequences for the Plan Area. To address this concern, the BDCP was subsequently revised to incorporate extensive synthesis, providing overview and summary analysis at the scale of individual conservation measures or biological objectives, and at larger scales such as the entire effects analysis and conservation strategy.

The report also provides detailed comments on climate change analysis, asserting that, "Although significant research on climate change vulnerabilities exists in the literature and in various reports produced by numerous agencies and institutions, the panel could not find evidence that such information has been used effectively in the development of the BDCP" (National Research Council 2011:32). The current BDCP draft addresses these and other concerns in *Appendix 2.C, Climate Change Implications and Assumptions,* and *Appendix 5.A, Climate Change Implications*. Furthermore, the document has been revised to describe more explicitly the role of climate change predictions in formulating the conservation strategy and developing the effects analysis.

With regard to adaptive management, the report accurately notes that a clear set of goals and analysis framework are essential for effective adaptive management (National Research Council 2011:7). The panel endorses the adaptive management recommendations of the Independent Science Advisors' Report on Adaptive Management (Dahm et al. 2009), and further suggests that "BDCP developers could benefit significantly from adaptive management experiences in other large-scale ecosystem restoration efforts, such as the Comprehensive Everglades Restoration Program" (National Research Council 2011:7). These recommendations have been followed in the current

BDCP draft, which provides a strong theoretical underpinning for the use of adaptive management, an explicit framework for adaptive management decision making, and specific statements about the monitoring and research actions to be implemented under the adaptive management program.

10.3.7.3 National Research Council 2012 Report

Sustainable Water and Environmental Management in the California Bay -Delta (National Research Council 2012) took a broader view than either of the previous National Research Council reports, considering the general question of water management in the Delta and how it is defined in the context of scarcity, environmental stressors, environmental changes, and institutional or social constraints. Some of the report's recommendations are directly relevant to the BDCP, while others speak to the BDCP's context. The recommendations primarily appear in Chapter 2 of the report and their basic message is that water is increasingly a scarce commodity in California and it is not clear that the "co-equal goals" of "providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem" (National Research Council 2012:35) can be met in the context of that scarcity. To remedy this, the report suggests developing an operational definition of the "co-equal goals" that addresses the allocation of water to each goal. The current draft of the Plan accomplishes this by defining water allocations via the flow criteria specified in *CM1 Water Facilities and Operation*, and by providing an adaptive management mechanism to provide ongoing monitoring and review of the operational success of the Plan in achieving its primary goals.

The report also suggests that a broader array of alternatives and options for managing water is needed in Delta water planning efforts, including improvements in water-use technology, reuse technology, economizing on water use, and various degrees of long-term species protection. Clearly, the full resolution of these issues lies beyond the purview of the BDCP, but the BDCP can make important contributions by clearly defining water allocations (as is done in *CM1 Water Facilities and Operation*), by setting performance goals for conservation of affected species and natural communities (as is done in Chapter 3, Section 3.3 *Biological Goals and Objectives*), and by active participation in regional decision-making processes (as addressed in many sections addressing cooperation with neighboring HCPs and NCCPs, the BDCP's relationship to the Delta Plan, and the BDCP's relationship with other scientific efforts in the Delta).

10.3.8 Independent Science Advisors Reviews of Conceptual Foundation, Analytical Framework, and Effects Analysis

In 2011 and 2012, the Delta Science Program, an arm of the Delta Stewardship Council, convened two panels of independent scientists to review the effects analysis. In October 2011, the first panel met to review the first two appendices supporting the analysis, Appendix 5.A, *Conceptual Foundation and Analytical Framework* (this appendix was later incorporated into Chapter 5, *Effects Analysis*, and other Chapter 5 appendices) and Appendix 5.B, *Entrainment*. In 2012, the second panel was convened to review most of the remaining technical appendices of the effects analysis and early drafts of the conclusions.

The 2011 Science Panel review (Parker et al. 2011) offered 11 recommendations for revisions to the effects analysis. The BDCP was modified to address all of the recommendations. The 2012 Science Panel review (Parker et al. 2012) offered further recommendations on technical appendices. In addition, the review offered two general recommendations:

- "The considerable uncertainty about outcomes of terrestrial and aquatic ecosystem restoration demands that rigorous adaptive management, driven by ecosystem process based monitoring is implemented effectively" (Parker et al. 2012:10). This comment was addressed in part by explicitly discussing the sources and degrees of uncertainty in the effects of BDCP actions in Chapter 5, *Effects Analysis*. This comment also relates to the conservation strategy. It has been addressed there by providing (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*) a strong theoretical underpinning for the use of adaptive management, an explicit framework for adaptive management decision making, and specific statements about the monitoring and research actions to be implemented under the adaptive management program. Conservation measures now contain explicit statements about key uncertainties that need to be resolved via research in order to test assumptions underlying the conceptual model for conservation measure effectiveness.
- "The Panel found a number of Effects Analysis elements that constituted a significant improvement over the Phase 1 review material" (Parker et al. 2012:10). In this point, as in others, the BDCP has been substantially improved through the application of independent science to review and revise the BDCP.

10.4 The Continuing Role of Independent Science in the BDCP

Once BDCP implementation begins, independent science is expected to continue to play an important role with regard to review of research results, improved understanding of key uncertainties, and development of adaptive management decisions. This role is explained in Chapter 3, Section 3.6, *Adaptive Management and Monitoring*.

The BDCP Science Manager and the Adaptive Management Team are tasked to manage independent science review of adaptive management decisions in a manner that ensures their independence and scientific integrity. The Science Manager, as chair of the Adaptive Management Team, will coordinate such efforts with the Delta Science Program, the IEP, the Authorized Entity Group, and the Permit Oversight Group. The Adaptive Management Team will decide when and on what terms to seek independent science review to evaluate technical issues for the purpose of supporting adaptive management decision making. When this occurs, the Science Manager will commission independent scientific review and/or seek other independent input regarding the proposed action, and any alternatives to that action. The Adaptive Management Team will work with the Delta Science Program (which has particular expertise and experience organizing and facilitating independent scientific reviews) or other peer review providers to conduct these independent peer reviews.

Through this mechanism, independent scientific review is expected to remain an important part of the BDCP, helping to identify important new issues, develop creative and appropriate responses, and provide needed review of data and analyses developed during Plan implementation.

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